- FINAL DISSERTATION -

INNOVATION CAPACITY: A SURVEY OF SOUTH AFRICAN CONSULTING ENGINEERING FIRMS

By

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TABLE OF CONTENTS

APPENDICES:

LIST OF FIGURES

LIST OF TABLES

INNOVATION CAPACITY: A SURVEY OF SOUTH AFRICAN CONSULTING ENGINEERING FIRMS

ABSTRACT

Small and medium-sized enterprises (SMEs) have a significant role to play in job creation and bridging the widening gap between the rich and the poor in South Africa. Several factors determine the success of SMEs. One factor that has been largely overlooked in South Africa by researchers is innovation capacity - made up of different capabilities. As a result, there exists a gap in the literature that this study aims to fill. The purpose of this study is to compare the innovation capacity of South African consulting engineering firms and to identify the differences in innovation capabilities across small, medium and large firms, with a focus on SMEs. The innovation capacity survey was distributed using an email invitation to participate in the study, that contained a link to access the survey questionnaire online. The results of the study show that overall, South African engineering consulting firms reported an "average" to "high" innovation capacity; medium and large sized firms performed similarly, and small firms lagged. The study found that there exists a significant hierarchy in performance for entrepreneurial capabilities, risk management capabilities and capabilities for market and customer knowledge, where larger firms reported a higher scoring than smaller firms. More particularly, the study found that small firms lagged medium and large-sized firms strongly on risk management capabilities and capabilities for market and customer knowledge. These results hope to assist policy makers in prioritising lagging capabilities as the point of departure for capability building efforts. In addition, the results should assist entrepreneurs to be mindful of potential blind spots that could be hindering growth. The findings should ideally encourage both practitioners and policy makers to engage in efforts to stimulate the innovation capacity of South African consulting engineering firms either through internal or external interventions. SMEs that are enabled and empowered to be innovative will stand a better chance of fulfilling their developmental role within South Africa's economy.

Keywords: *Innovation, innovation capacity, innovation capability, small, medium and large-sized enterprises, consulting engineering firms, survey, South Africa*

1 CHAPTER 1: INTRODUCTION

Since 2008 the construction industry has contributed approximately 9% to GDP and 9% to formal and informal employment in South Africa (Construction Industry Development Board, 2015:2). However, ever since the Soccer World Cup projects in the year 2010; the construction industry has been in decline (PWC, 2015:3). Despite small and medium-sized enterprises (SMEs) being collectively responsible for 56% of turnover in the private sector construction industry during the December 2015 quarter, jobs are still being shed in the same industry (Mhlanga, 2016:45; Statistics South Africa, 2016).

SMEs that grow have been considered as key contributors to job creation, poverty alleviation, equity and participation, wealth creation and social stability (Nieman & Pretorius, 2004:3; Olawale & Garwe, 2010:729). Consequently, these SMEs have a considerable positive effect on South Africa's sustainable economic growth (Nieman & Pretorius, 2004:3; Olawale & Garwe, 2010:729). South Africa's Total Early-stage Entrepreneurial Activity (TEA) has been volatile over the last 5 years but remains low at a rate of 11% (2017) having grown at 0.9% from 2013 to 2017 (Herrington & Kew, 2017:92; Kelley, Singer & Herrington, 2016:104; Singer, Herrington & Menipaz, 2018:90) In addition, the rate of business discontinuance in South Africa is still high at 6.0% and surpasses the established business rate of 2.2% (Singer *et al.*, 2018:106). There is a net loss of small business activity in South Africa, and consequently, SMEs are unable to fulfil their developmental role in South Africa's sustainable economic growth.

It is estimated that 40% of all new businesses in South Africa fail in their first year of operation, 60% fail in the second year and 90% within the first 10 years from inception. (Bushe, 2019:1). In addition, 75% of all new SMEs in South Africa do not exist for more than 42 months; as a result, these SMEs do not become established enterprises (Olawale & Garwe, 2010:730). The South African rate of established business (2.2%) is 0.9% from the lowest rate globally. Qatar reported the lowest rate of established business at 1.3% (2017) (Singer *et al.*, 2018:37). Most of these enterprises cite a lack of finance and poor profitability as the key reason for business exit; this has been cited not only in 2014, but in 2015, 2016 and 2017 (Herrington, Kew & Kew, 2015:4; Singer *et al.*, 2018:37). The reasons for failure can be further attributed to a low entrepreneurial culture within the country, which manifests

itself in low levels of business-related skills among South African entrepreneurs, inefficient and prohibitive support structures and infrastructure, as well as entrepreneurs who are active in over-traded sectors that are populated with low-profit margin businesses within highly competitive and limited markets (Herrington *et al*., 2015:28).

Entrepreneurial SMEs have been identified as those ventures that contribute to employment and sustainable economic growth (Nieman & Pretorius, 2004:4). Entrepreneurial ventures are distinguished from small enterprises as being innovative, having the potential for growth and possessing strategic objectives within their business models (Ates & Bititci, 2011:5603; Nieman & Pretorius, 2004:6). "Innovation" is defined as creating, developing and adapting new ideas, processes or even products with the objective of amplifying the competitiveness of the enterprise. According to the Global Innovation Index (GII), South Africa's ranking has gone down from 54th in 2016 to 57th in 2017 and 58th in 2018 (Dutta, Reynoso, Litner, Lanvin & Wunsch-Vincent, 2016:281; Dutta, Reynoso, Guadagno, Lanvin, Leon, Saxena & Wunsch-Vincent, 2018:321). It is made clear from the net loss of small business activity that developmental needs are considerable and without locating the cause, the net loss may only be exacerbated (Herrington *et al*., 2015:29). Given the significance of the innovativeness of SMEs, and the multiple studies that have been conducted on the innovativeness of large American enterprises or even small European enterprises, and the like; there remains minimal available literature that has explored and measured the innovation capacity and innovation capabilities of South African SMEs; particularly within the construction industry (Forsman, 2011:739-750; Forsman & Rantanen, 2011:27-50; Gemünden & Rohrbeck, 2010:231-243). Innovation capacity is defined as the ability to take advantage of opportunities to better satisfy customer needs through the deployment of resources (Forsman, 2011:740; Sok, O'Cass & Miles, 2015:2). These resources can be described as the supply of features owned by the enterprise, which contribute to the enterprise's competitive advantage (Forsman, 2011:740; Park & Ryu, 2015:340). The innovation process takes place both internally and externally to the enterprise (Cantner, Conti & Meder, 2010:1939; Radas & Božić, 2009:439). The internal factor of a firm's innovation capacity is innovation capability which is premised on the basis of absorptive capacity, and the external factor is social capital (Forsman, 2011: 740; Vicente, Abrantes & Teixeira, 2015:30). In the quest for innovation, enterprises are immersed in networks of relationships with a miscellaneous range of competitors, agents, suppliers and research centres, which assist

the enterprise's innovation (Cantner *et al*., 2010:1939). The benefits of being in such networks are through the "spillovers" of knowledge and technology (Cantner *et al*., 2010:1940). However, the internal process of absorptive capacity influences the degree to which these spillovers benefit the enterprise (Cantner *et al.*, 2010:1940). Specific innovation capabilities drive the innovation capacity of an enterprise; which, according to Forsman (2011:740), takes form through the internal and external factors of innovation capacity. These capabilities are knowledge manipulation, collaboration, risk susceptibility, customer orientation, market knowledge, and management capabilities to capitalise on the opportunities and apply the changes from spillovers (Forsman, 2011:740).

It has been found that smaller firms do not necessarily have an innovation advantage but that the type of innovation depends on the dynamics of the industry and the economy in which it operates (Forsman, 2011:741; Vicente *et al.*, 2015:3). Consulting Engineers South Africa (CESA) is a voluntary association of consulting engineering firms with a member base across the country in excess of 560 companies. CESA defines SMEs only by total annual turnover and has access to the most accurate database of South African consulting engineering firms. CESA's definition for firm size shall be adopted for the purpose of this study thereby making the results relevant and beneficial for the majority of the industry (CESA, 2017):

- A small consulting engineering firm has an annual turnover less than or equal to R11.5 million
- A medium consulting engineering firm's annual turnover is more than R11.5 million but less than R35 million
- A large consulting engineering firm's annual turnover more than or equal to R35 million

This study is conducted to enhance the body of knowledge that is available to academics on the topic of innovation development within the construction industry. The findings are to assist practitioners in identifying discrepancies in innovation capabilities to bridge these discrepancies and build their firms' innovation capacity. In addition, the results of the study will assist policy makers in identifying which innovation capabilities are lagging among consulting engineering firms within the construction industry and therefore require a more enabling environment. The purpose of this study is to compare the innovation capacity of South African consulting engineering firms and to identify the differences in innovation

capabilities across firm size, with a focus on SMEs. The proposed study aims to answer the following research questions:

- What is the degree of innovation capacity of small, medium and large-sized South African consulting engineering firms?
- Are there significant differences in the innovation capabilities of small, medium and large-sized South African consulting engineering firms?

The section that follows addresses an overview of the current literature that is available on the topic of innovation capacity and innovation capability, followed by the methodology applied to carry out the study, the results and findings and the subsequent conclusion thereof.

2 CHAPTER 2: LITERATURE REVIEW

2.1 INNOVATION CAPACITY

Innovation capacity is a broad concept that highlights both the internal and external aspects of an enterprise (Smith, Courvisanos, Tuck & McEachern, 2011:9). The authors define innovation capacity as the propensity of an enterprise to spot new developments and technologies, and to attain and capitalise on this knowledge and information. If one takes a standpoint from a resource perspective, innovation capacity is defined as the human and interpersonal efforts, as well as the intermediate reframing of assets that facilitate an enterprise to participate in activities needed for innovation (Jørgensen & Ulhøi, 2010:399). According to Forsman (2011:740), innovation capacity is the capability of an enterprise to progress its resources and capabilities to discover and take advantage of opportunities to better satisfy customer needs; thus, innovation capacity is driven by resources and different capabilities. For the purposes of this study; Forsman's (2011:740) definition will be adopted because this conceptualisation incorporates the internal and external aspects of the enterprise and it describes innovation capacity as being necessary for the innovation process that satisfies customer needs. The literature has pointed out that innovation capacity differs from industry to industry, depending on the firm size (Enkel & Heil, 2014:244; Forsman, 2011:741; Spithoven, Clarysse & Knockaert, 2011:13; Vicente *et al.*, 2015:30).

The stronger a firm's innovation capacity, the better the innovation process and performance (Kostopoulos, Papalexandris, Papachroni & Ioannou, 2011:1335; Smith *et al.*, 2011:8).

Smith *et al.* (2011:8) link human capital and technological capital as incentives that develop innovation capacity; of which learning plays a role in the innovation process. In emphasising innovation capacity, the 2014 GII focuses on human capital as a contributor to the increase in innovation capacity (Bernard, Dutta, Reynoso & Wunsch- Vincent, 2014:4). Bernard *et al.* (2014:6) describe human capital as the "stock of knowledge or skills" of educated people. Bernard *et al.* (2014:6) further view education as a mechanism to hasten the technological process of an enterprise. The innovation capacity of an enterprise increases through the acquisition of knowledge by the human capital of the enterprise, through the building of networks and through collaboration across borders in the form of social capital (Bernard *et al.*, 2014:7). Social capital are networks of the enterprise which directly and indirectly provide the enterprise with knowledge for innovation (Cantner *et al.*, 2010:1940). Smith *et al.* (2011:24) further tie human capital with social capital through knowledge management in the form of collaboration, networks, knowledge sharing, and learning.

The GII measures innovation according to two indices made up of pillars. The first index is the Innovation Input Sub-Index – in terms of which South Africa is ranked 48th out of 126 countries in 2018; up from 49th out of 127 countries in 2017 and down from 47th out of 128 countries in 2016 (Dutta *et al.*, 2016:22; Dutta *et al.*, 2018:321). The second index is the Innovation Output Sub-Index – in terms of which South Africa is ranked 65th out of 126 countries in 2018; up from 69th out of 127 countries in 2017, and up from 71st out of 128 countries in 2016 (Dutta *et al.*, 2016:25; Dutta *et al.*, 2018:321). Dutta *et al.* (2018:15) describe the 5 input pillars as capturing the elements of the national economy which enable innovative activities; and are comprised of:

- institutions (political and regulation environment);
- human capital and research (education and research and development (R&D));
- infrastructure (information and communication technology);
- market sophistication (investment and competition); and
- business sophistication (knowledge workers, knowledge absorption, and innovation linkages).

The output pillars provide information about outputs resulting from innovative activities within the economy; and are comprised of:

• knowledge and technology outputs (knowledge creation, knowledge impact, knowledge diffusion); and

• creative outputs (intangible goods, creative goods and services, online creativity).

In addition, the Innovation Efficiency Ratio is the ratio of the Output Sub-Index score to the Input Sub-Index score (Dutta *et al.* 2018:15). This ratio shows a country's return of innovation output given its investment into innovation input – of which South Africa is ranked 83rd out of 126 countries in 2018, up from 97th out of 127 countries in 2017 and up from 99th out of 128 countries in 2016 (Dutta *et al.*, 2016:281; Dutta *et al.*, 2018:321).

The overall GII score is an average of the Input and Output Sub-Index scores (Dutta *et al.* 2018:15) Overall, South Africa was ranked 58th in 2018; down from 57th in 2017 and down from 54th in 2016 (Dutta *et al.*, 2016:281; Dutta *et al.*, 2018:321). The literature shows that South Africa's deteriorating performance in terms of the Global Innovation Index is attributed to its lagging position in the Innovation Output Sub-Index and its weakened position in the Innovation Input Sub – Index.

For an enterprise to acquire and transfer technology, its human capital requires knowledge and skills that are gained through formal education and R&D activities (Schaaper, 2014:70). Smith *et al.* (2011:10) describe external tertiary education and training, as well as internal learning and development as the basis for building innovation capacity. Skills for facilitating innovation are subject-based knowledge, thinking and creativity, and behavioural and social skills (Scott & Vincent-Lancrin, 2014:78). Sibisi and Walwyn (2014:118) emphasise the need for enterprises to enhance and acquire adaptive capabilities for global knowledge; to use on local conditions, and to target international markets. The retention of key innovators in an enterprise and country is important and should be done through empowering workers with education and training, and for intellectual property rights regulations to be put in place in a country (Sibisi & Walwyn, 2014:119).

To conclude, innovation capacity makes use of different capabilities of an enterprise to progress its resources and take advantage of opportunities that better satisfy customer

needs (Forsman, 2011:740). In measuring innovation capacity, Forsman (2011:740) observed R&D investment, innovation capabilities and external input to measure the degree of innovation capacity, however for the purpose of this study innovation capacity will be measured by the degree of innovation capabilities alone; these capabilities will be discussed in detail below.

2.2 INNOVATION CAPABILITIES

The term “capability” brings to the surface many conceptual definitions. However, there stands consensus on “capability” being a capacity for the deployment of resources (Forsman, 2011:740; *Sok et al.*, 2015:2). For this reason, “capability” is a sub-dimension that affects the overarching construct of innovation capacity (Forsman, 2011:740; Sok *et al.*, 2015:2). Sok *et al.*’s (2015:3) definition of capabilities goes on to describe them as “bundles of interrelated processes and routines”. This statement, therefore, suggests that capabilities are embedded within the enterprise. This view is consistent with Vicente *et al.*’s (2015:30) view which conceptualises capabilities as being entangled, multi-dimensional, and embedded in organisational routines and practices. Innovation capabilities, therefore, describe the deployment of resources through embedded, multi-dimensional organisational practices, processes and routines; in so far as it transforms an enterprise’s resources into the innovation objectives of the enterprise (Forsman, 2011:740).

Resources are conceptualised as being a supply of features that are owned by the enterprise and are, therefore, controlled by that enterprise (Forsman, 2011:740). This definition concurs with Park and Ryu (2015:341) as well as Sok *et al.* (2015:3) who conceptualise resources as being controllable assets which are entrenched within the enterprise’s culture, and/or are protected by the law through legal property rights. In line with the Resource-Based view; to the extent that resources are valuable, rare, inimitable, non-substitutable and exploitable; resources determine the competitiveness of enterprises (Park & Ryu, 2015:340; Sok *et al.*, 2015:2). It can, therefore, be stated that resources contribute to an enterprise’s performance through its ability to contribute to innovativeness (Park & Ryu, 2015:339; Sok *et al.*, 2015:18; Vicente *et al.*, 2015:30).

SMEs are most likely to have limited tangible resources compared to their larger counterparts (Ates & Bititci, 2011:5602; Park & Ryu, 2015:340). Due to this, SMEs are urged to possess intangible resources as these can supply a much larger contribution towards competitive advantage (Park & Ryu, 2015:340). Intangible resources are embedded within the enterprise and are difficult to point out. These resources are, therefore, more difficult to imitate and, because they contribute to overall innovative performance, they are valuable (Alegre, Sengupta & Lapiedra, 2011:464; Park & Ryu, 2015:340). In fact, Alegre *et al.* (2011:464) as well as Halme and Korpela (2014:547-548) have found that limited resources can be advantageous for innovation development. The authors attribute this to the different resource combinations that exist for the creation of innovative offerings; and so, the size of the enterprise has an insignificant bearing on the innovation development of an enterprise. Park and Ryu (2015:341), Sok *et al.* (2015:17), and Vicente *et al.* (2015:42) conclude that innovation capabilities and their ability to bring competitive advantage should not be viewed in isolation. The authors further explain that resources are to be deployed in such a way that strategically leverages an enterprise's capabilities and is complementary to those capabilities. As such, the ability to deploy a resource is more important than the actual resource. Innovation capabilities are peculiar attributes of enterprises which should be linked to their dimensions and seen as a whole to explain an enterprise's competitiveness (Vicente *et al.*, 2015:42). It is this characteristic of interdependence that dictates an enterprise's competitiveness (Park & Ryu, 2015:341). The dimensions of innovation capabilities will be discussed in detail below.

2.2.1 Dimensions of innovation capabilities

Forsman's (2011) study identified dimensions as being reflective of the degree of innovation capability possessed by small and medium manufacturing and service enterprises. The items generated for Forsman's study were based on concepts introduced in previous studies that identified innovation typologies (Forsman, 2011:739). The items generated are capabilities for knowledge exploitation, entrepreneurial capabilities, risk management capabilities, networking capabilities, development capabilities, change management capabilities and market and customer knowledge (Forsman, 2011:744; Forsman & Rantanen, 2011:35). These seven capabilities are discussed below.

- **Knowledge exploitation**

Knowledge exploitation refers to the ability to be aware of external knowledge that is relevant to current practice, internalize and assimilate this new knowledge and can exploit the knowledge for innovation purposes as needed (Alegre *et al.*, 2011:457; Forsman & Rantanen, 2011:49). “Knowledge exploitation” was formed from the need for the enterprise’s employees to assimilate information and knowledge from external association in research and development (Forsman, 2011:740; Kostopoulos *et al.*, 2011:1336; Spithoven *et al.*, 2011:11). This term was extended to the ability to use capabilities to absorb innovation stimuli of technology and humans (Smith *et al.*, 2011:10). Cohen and Levintha (in Forsman, 2011:740; Forsman & Rantanen, 2011:32; Kostopoulos *et al.*, 2011:1335; Lewin, Massini & Peeters, 2014:1346; Spithoven *et al.*, 2011:12) conceptualise absorptive capacity as “the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends”. It is further argued that absorptive capacity promotes the speed, frequency, and magnitude of innovation (Kostopoulos *et al.*, 2011:1336; Spithoven *et al.*, 2011:12).

Enterprises need to be able to integrate current knowledge with information from their environment; an ability that enhances the open innovation process. This requires the deliberate use of external and internal knowledge to escalate internal innovation and increase the market capacity for the external use of innovation (Han, Oh, Im, Chang, Oh & Pinsonneault, 2012:292). Open innovation can be categorised in two ways: inbound open innovation, where firms monitor, share, and use information from their environment to improve R&D and innovation; and outbound open innovation, where firms look to external firms to commercialise technology (Castro, 2015:2; Lewin *et al.*, 2014:1347; Spithoven *et al.*, 2011:11).

Although R&D activites of SMEs are often informal - because they stem from daily business developments and collaboration, Spithoven, Vanhaverbeke and Roijakkers (2013:556) refute the idea that larger firms have superior absorptive capacity to be able to sense, assimilate and intergrate new knowledge (Forsman, 2011:740). Large companies are involved in more open innovation activities; whereas SMEs have a higher intensity of open innovation activities - the ratio of open innovation activities over employment is much higher

for SMEs. Both SMEs and large firms benefit from the positive effect that open innovation has on the introduction of new offerings (Spithoven *et al.*, 2013:555).

- **Entrepreneurial capabilities**

Entrepreneurial capabilities describe the ability to be aware of new opportunities, seize the new opportunity for developing new solutions and exploit opportunities for creating new profit (Forsman & Rantanen, 2011:49). In accordance with entrepreneurial capabilities and absorptive capacity; dynamic innovation capabilities are the ability to transform knowledge into competitive advantage (Forsman, 2009:503). Dynamic capabilities can be further disaggregated into the capacity to sense and shape opportunities and threats, to seize opportunities and to maintain competitiveness through the enhancement, combination, reconfiguration and protection of the enterprise's intangible and tangible resources (Forsman & Rantanen, 2011:32; Teece, 2007:1319). An entrepreneurial managerial style should ideally encourage firms to engage in idea generation, opportunity-seeking, organisational learning and process improvement thereby improving enterprise performance (Ates, Garengo, Cocca & Bititci, 2013:37; Zortea-Johnston, Darroch & Matear, 2012:148).

The literature further studies entrepreneurial orientation as being comprised of at least three dimensions; namely: innovativeness, proactiveness and risk-taking (Ambad & Wahab, 2013:102; Rose, 2018:80). While there is evidence that the dimensions of innovativeness and proactiveness positively affect the financial and non-financial performance of SMES; risk-taking did not show any relation to SME performance (Rose, 2018:80-81). On the other hand, innovativeness and risk-taking showed a positive effect on the performance of large firms whereas proactiveness only enhances the performance of large firms when the environment is unfavourable (Ambad & Wahab, 2013:102).

- **Risk management capabilities**

Risk management capabilities describe the ability to assess risk, being willing to take risk and the actual ability to take risk (Forsman & Rantanen, 2011:49). Smaller enterprises are often found to be more agile than their larger counterparts; however, they are also highly vulnerable to major shocks stemming from the external environment (Forsman & Rantanen,

2011:29; Smit & Watkins, 2012:6324). Despite this observation, larger firms are more likely to implement risk management given their increased complexity, wider range of risks and access to more resources (Zhao, Hwang & Low, 2015:355). It is imperative that SMEs make risk management a priority if they are to identify risk, buffer against risk and be better equipped to utilise their existing resources in times of uncertainty to ensure survival (Smit & Watkins, 2012:6324).

SME owner-managers are often the individuals who lead the activities in the SMEs (Ates & Bititci, 2011:5603). These owner-managers need to be more cognisant of external and internal risks that face the enterprise and embed a structured and proactive approach to dealing with risk to effectively manage the resources of the enterprise (Ates & Bititci, 2011:5604; Smit & Watkins, 2012:6328). A risk management strategy allows for the objective evaluation of actions which in turn offers the enterprise benefits such as the reduction of cost, a reduction in the over-management of risks and an alignment between the SME's mission and objectives (Smit & Watkins, 2012:6328). Taken in totality; a risk management strategy may provide for the ultimate survival of the enterprise when shocks from the environment occur (Smit & Watkins, 2012:6324).

- **Networking capabilities**

Networking capabilities refer to whether or not the enterprise adopts a networking orientation, if the enterprise is able to create collaborative relationships, and exploit the networks in the existing enterprise (Forsman, 2011:740; Forsman & Rantanen, 2011:49). The social capital network of an enterprise refers to the macro-components of the enterprise, such as its suppliers, competitors, and agents, which directly and indirectly provide the enterprise with knowledge for innovation (Cantner *et al.*, 2010:1940). Smith *et al.*'s (2011:23) conceptualisation of social capital network concurs with that of Cantner *et al.* (2010:1940) and it is described as embedded knowledge from the interaction among individuals through their networks of interrelationships.

Social capital is beneficial when the society is diverse because enterprises learn from each other, collaborate and assist each other in the achievement of goals (Martínez-Fernández & Molina-Morales, 2010:261). Social capital in the form of cross-industry collaboration is

based on the approach of analogical thinking where the transfer of applications and technology takes place from one industry to another (Enkel & Heil, 2014:243). An important factor to note in social capital is geography, because proximity intensifies the exchange of knowledge (Cantner *et al.*, 2010:1940). Furthermore, cognitive distance affects the perception and interpretation of knowledge, which influences collaboration between social networks; therefore, high cognitive distance results in exploratory innovation (Enkel & Heil, 2014:244). Exploratory innovation are radical innovations developed from the necessary synthesis of new knowledge and the enterprise's existing knowledge base to create an offering that is essentially a new product (Enkel & Heil, 2014:242).

The benefits of networking are categorised into two classes, namely tangible and intangible benefits (Forsman, 2011:740). Improved returns and market share, along with competitive advantage are some of the tangible benefits of social networking, whereas the formations of capabilities are the intangible benefits of social networking (Forsman, 2011:740). Establishing networks offers SMEs the advantages of larger firms. Social capital networks help SMEs access the market, complementary skills, capabilities, knowledge and resources that are not internally available due to their size and age (Ates & Bititci, 2011:5602; Gronum, Verreynne & Kastelle, 2012:272; Jørgensen & Ulhøi, 2010:397; Park & Ryu, 2015:340). Networks are a means of gaining knowledge for sustainable innovation, because knowledge sharing enhances an enterprise's innovation capacity (Jørgensen & Ulhøi, 2010:397).

- **Development capabilities**

Development capabilities refer to the ability to create new innovations that are different from what the competition is offering customers, being able to improve on existing products and services offered by the enterprise and being able to exploit the innovations that have been developed by others (Forsman & Rantanen, 2011:49). Forsman (2009:502) and Forsman and Rantanen (2011:30) state that innovations have been studied as a typology which makes the distinction between incremental and radical innovation. The authors go on to describe incremental innovation as the enhancement of existing processes, making operations more effective and improving quality or reducing cost. On the other hand, radical innovations are characterised as discontinuations in technology and the market.

This typology above can be further analysed based on market-driven innovations and driving markets innovation (Zortea-Johnston *et al.*, 2012:146). The authors exemplify market driven innovations as being customer-focused and unlikely to produce radical ideas. Since customers often perceive their needs from a frame of the known and familiar, it limits their ability to thoroughly articulate their needs and wants. Conversely, the authors describe driving markets innovations as those innovations that create new customers, redefine the market, lead existing customers and meet the concealed needs and wants of customers. It is stated that those enterprises that adopt a market driven innovation orientation as opposed to a driving market innovation orientation are likely to strain their competitive advantage and therefore their long-term survival due to their inability to create radical change in the market (Zortea-Johnston *et al.,* 2012:146).

Chang & Taylor (2016:60) found that in their meta-analysis the participation of customers in the development of a new product improves financial performance and accelerates time to market when the customer is involved only in the ideation and launch stages. Conversely, customer participation in the development phase deteriorates financial performance and delays time to market. Smaller firms are encouraged to use customer participation and apply customer knowledge in the developmet of new products as leverage to make up for their general lack of resources relative to large firms (Chang & Taylor, 2016:60).

- **Change management capabilities and market and customer knowledge**

Change management capabilities are the abilities to quickly implement change based on market and customer knowledge. Market and customer knowledge is the capability to acquire new customers, expand into new markets and increase sales to current customers (Forsman & Rantanen, 2011:49). According to Ates *et al.* (2013:47) as well as Ates and Bititci (2011:5614), internal and external change initiatives should be implemented with careful consideration given to planning and communication. The authors go on to explain that in implementing critical change steps; owner-managers tend to neglect the soft aspects of change such as culture, leadership and vision. The authors advise that SMEs should adopt a strategic and long-term perspective of change as opposed to treating change as the management of a project that is short-term and more operational in nature. In addition, owner-managers are urged to proactively manage change and not wait for external features

in the environment - such as customer complaints; to impose the changes. SMEs are said to be more flexible than their larger counterparts and should as a result be able to adapt and conform to the market more easily (Smit & Watkins, 2012:6324).

3 CHAPTER 3: RESEARCH METHODOLOGY

3.1 GENERAL DESCRIPTION OF THE PROPOSED RESEARCH DESIGN

The purpose of the study is to compare the innovation capacity of small, medium and large sized South African consulting engineering firms. Basic (pure) research is undertaken with the primary objective of producing new knowledge and understanding specific phenomenon (University of Pretoria, 2015a:1). This study is basic (pure) in nature as it is undertaken to produce new knowledge and understanding of the degree of innovation capacity that is present in South African consulting engineering firms. This is achieved by observing and measuring the innovation capabilities of South African consulting engineering firms as is, without manipulating these variables. These capabilities are namely; knowledge exploitation, entrepreneurial capabilities, risk management capabilities, networking capabilities, development capabilities, change management capabilities and market and customer capabilities. Through the observation and measurement of these capabilities; the degree of innovation capacity has been gauged. This research is non-experimental (ex post facto) because of its quantitative descriptive status that compels the researcher to simply observe and measure without intervention and manipulation of variables to test cause-effect relationships (University of Pretoria, 2015a:6).

Cross-sectional studies only create a snapshot of reality at a specific point in time (University of Pretoria, 2015a:7). The intention of the study is to survey each respondent to the study only once. This cross-sectional study has created a snapshot of the reality of innovation capacity at the particular point in time when the survey was conducted. As such, the study does not intend to examine changes in the degree of innovation capacity over time like a longitudinal study would (University of Pretoria, 2015a:7).

Communication studies refer to studies in which data are collected via direct or indirect communication with participants to the study at hand (University of Pretoria, 2015a:7). To

explore the degree of innovation capacity in South African consulting engineering firms, quantitative data was collected through direct and indirect communication with respondents through self-completion questionnaires and follow-up phone calls.

Field conditions describe studies taking place in natural, “real world” environments where usual behaviour is expected (University of Pretoria, 2015a:8). The study was conducted in field conditions; no artificial environments were created for the purpose of the study.

Primary data is described as raw, unanalysed data that a researcher collects for the primary purpose of the particular research study at hand (University of Pretoria, 2015a:8). Participants’ completed questionnaires that generated raw, unanalysed quantitative data. The researcher collected this primary data and analysed it to deduce the degree of innovation capacity of small, medium and large-sized South African consulting engineering firms.

A disadvantage of the study can be described as the risk of a modified participant routine. A modified participant routine occurs when participants to a study are aware that they are taking part in a study. As a result, they may alter and adjust responses to create a favourable impression of themselves (University of Pretoria, 2015a:9). It is a requirement of the University of Pretoria that participants to a study be informed beforehand of the content of the study and that consent be obtained before the participants take part in the study (University of Pretoria, 2015a:9). This requirement presented the risk for participants to the study to modify their routine and create a favourable impression of themselves.

3.2 RATIONALE FOR USING A QUANTITATIVE RESEARCH APPROACH

The term “quantitative research” describes research that is primarily involved with gathering numeric data for the purposes of quantitative analysis. This type of research involves measuring concepts in numeric terms in order to make inferences from the data (University of Pretoria, 2015a:2).

The rationale for making use of a quantitative research approach is based predominantly on other leading researchers having used a similar approach. Forsman and Rantenan

(2011:27) have made use of a quantitative research approach to explore the differences in innovation capacity and the diversity of developed innovations across four enterprise categories within both small manufacturing and service enterprises. Forsman (2011:739) used the same quantitative approach to explore the kinds of innovations that have been developed in small manufacturing and service enterprises and to explore the degree of innovation capacity of those small enterprises. A quantitative approach has been validated by the said researchers as being appropriate for measuring innovation capacity (University of Pretoria, 2015b:44). This study followed the quantitative approach taken by the aforementioned leading researchers. This study followed precedent and used a quantitative research approach to measure the innovation capacity of small, medium and large-sized South African consulting engineering firms.

3.3 ETHICAL IMPLICATIONS

Appendix A (p. 52) includes a copy of the approval for the undertaken study from the University of Pretoria's Research Ethics Committee. This study involved a survey of adult small, medium and large- sized South African consulting engineering firm owners and/or managers; no unique ethical implications were applicable.

3.4 SAMPLING DESIGN

3.4.1 Target population and units of analysis

The target population for the study conducted was consulting engineering firms operating in South Africa. CESA defines SMEs only by total annual turnover; its's definition for firm size has been adopted for this study (CESA, 2017):

- A small consulting engineering firm has an annual turnover less than or equal to R11.5 million
- A medium consulting engineering firm's annual turnover is more than R11.5 million but less than R35 million
- A large consulting engineering firm's annual turnover more than or equal to R35 million

The first research question asks to measure the degree of innovation capacity of South African consulting engineering firms. For the first research question; the units of analysis are the individual responses of participants. The second research question asks if there are significant differences in the innovation capabilities of small, medium and large-sized South African consulting engineering firms. The units of analysis for the second research question are the three categories of firms; namely, South African small, medium and large-sized consulting engineering firms.

3.4.2 Sampling method

The study made use of a probability sampling method because every participant had a known and equal chance of being included in the sample (University of Pretoria, 2015c:2).

In order to provide adequate data for uncovering and analysing differences in the innovation capabilities of the sub-populations or strata; namely, small, medium and large-sized consulting engineering firms, a comparison of these categories of firms is required (Cooper & Schindler, 2014:351). Stratified random sampling will be used as the probability sampling method to increase the sample's statistical efficiency and provide adequate data for analysing the two strata (Cooper & Schindler, 2014:351). Stratified random sampling is the process by which a sample is constrained to comprise of elements from each of the segments of the population (Cooper & Schindler, 2014:351). This method is useful when the researcher wants to study the characteristics of certain population subgroups or wants to draw conclusions about the activities within the internally homogenous and externally heterogeneous strata (Cooper & Schindler, 2014:351). Proportionate sampling will be used so the size of each sample drawn from each sub-population or stratum will be proportionate to the size of the stratum in the target population. This will help ensure that all population sub-groups or strata are adequately represented in the sample (University of Pretoria, 2015c:7).

A disadvantage associated with Stratified sampling is that increased error may result if the subgroups are selected at different rates (Cooper & Schindler, 2014:357). In addition, the cost of sampling may become expensive if the strata on the population have to be created (Cooper & Schindler, 2014:357; University of Pretoria, 2015c:7).

The sampling frame was drawn from CESA's membership list. CESA distributed the link by email to 540 member firms, from which follow-up phone calls were made to realise a total of 167 responses. Therefore, the response rate was 30.9%, of which 94 questionnaires were 100% complete.

3.5 DATA COLLECTION

3.5.1 Survey method

Data was collected over a 6 month period, spanning from 26 February 2018 to 10 September 2018 and following a 2-phase process. In both phases, no incentives were given to the respondents to encourage the completion of the questionnaire; however CESA has requested a copy of the results of the study.

- **Phase 1:**

A web-based online survey hosted by Qualtrics was selected as the instrument of collection. On 26 February 2018, CESA distributed the invitation to participate in the study to Mandated Principals and Office Heads (in charge of any branch offices the firms may have) of their 540 member firms via email. The email contained a hyperlink which redirected respondents to the questionnaire (see Appendix A p 42-50) hosted on the Qualtrics webpage. The invitation to participate in the study was also included in CESA's newsletter which was sent out mid-March 2018.

The rationale for using a web-based online survey method was two-fold. Firstly, only CESA had access to the database of all professionally registered consulting engineering firms in South Africa and due to confidentiality clauses of their members; they cannot share information regarding the database. A web-based online survey allowed for CESA to distribute the survey directly while keeping the confidentiality of their members. Secondly, self-administered surveys have been used previously by leading researchers such as Forsman to measure differences in innovation capacity; it was only appropriate that this study also followed suite (Forsman, 2011).

However, there were a couple of disadvantages to the chosen survey method. To protect the confidentiality of CESA's members, the association is unable to share members' contact details. As a result, the study had very limited opportunity to stimulate the response rates through direct means such as follow-up emails. More generally however, the disadvantages of making use of an online self-administered survey is that there is a very low response rate and there is a need for a low-distraction environment for survey completion which is a variable that cannot be controlled (Cooper & Schindler, 2014:225).

- **Phase 2:**

Phase 2 was undertaken to improve the 2.7% response rate that phase 1 had realised. On 10 July 2018 a call centre was contracted to call individual firms and fill out the questionnaire over the phone with participants. Data collection from phonecalls ran from 10 July 2018 to 10 September 2018.

3.5.2 Survey error

There are two forms of survey errors that were likely to affect this study; namely, extremity bias and auspices bias (University of Pretoria, 2015d:1-2).

Extremity bias is a form of response bias where respondents answer questions on the questionnaire by only selecting the extreme points on the scale (University of Pretoria, 2015d:2). This can be intensified if respondents deliberately falsify information regarding the company to create a false impression of the company or owners' state. Extremity bias can affect the study because owners of the enterprises are busy, and they might answer the questions hastily and not verify certain facts when answering the questions. This study made efforts to reduce this error by giving firm owners and/or managers the surveys well in advance and reminded the respondents of the importance of honesty for the success of the study in the email and the cover letter of the questionnaire.

Auspices bias is a form of response bias that occurs when the respondents alter their responses based on their knowledge of the identity of the organisation sponsoring the study (University of Pretoria, 2015d:2). The University of Pretoria is a renowned institution; as a

result, respondents may be persuaded to adjust their responses. This study made efforts to reduce this bias by stressing the importance of honesty for a successful study to all the respondents by means of email and the cover letter of the questionnaire.

3.5.3 Questionnaire design

Forsman (2011) developed an instrument to measure the innovation capacity of manufacturing and service firms. This instrument was adapted to measure the innovation capacity of South African engineering firms. The questionnaire used in the study is attached as Appendix A (p. 42-50). Table 1 below matches the questions in the questionnaire with the research questions of the study.

Table 1: Research questions and survey questions matrix

Research objective	Question(s) or scale(s) in draft questionnaire
What is the degree of innovation capacity of small, medium and large-sized South African consulting engineering firms?	General objective
Are there significant differences in the innovation capabilities of small, medium and large-sized South African consulting engineering firms?	Question 3 to 8 (capabilities).

3.6 MEASURES

3.6.1 Screening question

A dichotomous scale was used to screen the respondents on whether they met the target requirements of an owner and/or manager of an engineering consulting firm (see Appendix A question 1 on p. 43). If the respondents met the requirement, they were able to proceed and complete the rest of the questionnaire.

3.6.2 Research and development (R&D)

The annual funds that are invested in an enterprise for innovation and the improvement of products were measured with a multiple-choice, single-response scale (see Appendix A

question 2 on p. 43). A high response indicated high investment in innovation, which impacts the overall innovation in an enterprise.

3.6.3 Innovation capabilities

The results of a completed pilot test in 2015 indicated that the data was skewed. Question 3 to question 8 indicated that more than 50% of respondents would lean towards the same answer. This is a form of extremity bias where respondents answer questions on the survey questionnaire by only selecting the extreme points on the scale (University of Pretoria, 2015d:2). To avoid a biased survey, the questionnaire has been changed from a three-point scale based on Forsman's (2011:749) to a five-point Likert scale (see Appendix A on p. 43-46). The five-point scale is labelled as follows: 1 = Very low, 2 = Low, 3 = Average, 4 = High, 5 = Very high; with no items in the questionnaire reverse scored.

Table 2 below shows the results for internal consistency for the innovation capabilities. According The internal consistency was measured with Cronbach alpha's reliability coefficient, giving results above the critical limit of 0.6 (Forsman, 2011:743, Özer & Günlük, 2010:1503).

Table 2: A description of the measurement scale used to measure the seven capabilities

Sub-dimension	Items	Cronbach's alpha
Capabilities for knowledge exploitation	3.1, 3.2 and 3.3	0.810
Entrepreneurial capabilities	4.1, 4.2 and 4.3	0.778
Risk management capabilities	5.1, 5.2 and 5.3	0.625
Networking capabilities	6.1, 6.2 and 6.3	0.811
Development capabilities	7.1, 7.2 and 7.3	0.711
Capabilities for market and customer knowledge	8.2, 8.3 and 8.4	0.696

A composite score was calculated for each of the seven sub-dimensions by averaging respondents' answers across the items in each sub-dimension. The higher a respondent's composite score on a particular sub-dimension, the more they practice the capabilities in their firm. The Cronbach's alpha for the six sub-dimensions indicated acceptable reliability consistency (see Tables 7 to 13 in Appendix B on p. 54 to 57). The "change management

capabilities" only has a single question to measure the respective construct. As a result, Cronbach alpha could not be computed for this scale.

3.6.4 Innovation development through network

The external input into innovation development through networking's impact on the enterprise is measured using a five-point itemised rating scale (see Appendix A, question 9). The scales were labelled as follows: 1 = Very negative impact, 2 = Negative impact, 3 = No impact, 4 = Positive impact, 5 = Very positive impact. A high score on the scale represents the high value that networking has on the enterprise's capabilities

3.6.5 The firmographic profile of engineering consulting firms represented

A mix of multiple-choice, single response and multiple-choice, multiple-response scale questions measuring the characteristics of the enterprise to define firm profiles of small, medium and large respondent firms were asked in the survey. These include the number of employees; number of operating years; annual turnover, field of discipline and geographical areas of operations (see Appendix A, question 12, 13, 14, 15 and 16).

3.6.6 Demographics

The questionnaire contains questions to determine the respondent's gender, age, and education level (see Appendix A, question 17, 18 and 19).

4 CHAPTER 4: RESULTS AND FINDINGS

4.1 UNIVARIATE DESCRIPTIVE STATISTICS

Composite scores were calculated for overall innovation capacity by calculating the average scores of innovation capabilities which are sub-dimensions of innovation capacity. The results indicate that innovation capacity scored a mean of 3.655 on a five-point rating scale of innovation capabilities. This value lies between "average" and "high". Individual composite scores were calculated for individual innovation capabilities. The results further indicate that

innovation capacity scored a mean of 3.499, 3.707 and 3.752 for small medium and large firms respectively. Large firms have the highest innovation capacity whereas small-sized firms have the lowest capacity. Overall, the capability that scored highest among the respondents is networking capabilities (*M* = 3.759, *SD* = 0.658), and the capability that scored the lowest is market and customer knowledge (*M* = 3.560, *SD* = 0.534).

4.1.1 Composite score for innovation capacity

Table 3: Innovation capacity and sub-dimension composite scores

Capability	Size of firm	N	Mean	Std. Deviation
Innovation capacity				
	Total	94	3.655	0.599
	Small	29	3.499	0.638
	Medium	40	3.707	0.536
	Large	25	3.752	0.614
Capabilities for knowledge exploitation				
	Total	94	3.713	0.621
	Small	29	3.575	0.745
	Medium	40	3.767	0.519
	Large	25	3.787	0.615
Entrepreneurial Capabilities				
	Total	94	3.731	0.579
	Small	29	3.540	0.523
	Medium	40	3.808	0.584
	Large	25	3.827	0.602
Risk management capabilities				
	Total	94	3.578	0.579
	Small	29	3.368	0.686
	Medium	40	3.617	0.515
	Large	25	3.760	0.476
Networking capabilities				
	Total	94	3.759	0.658
	Small	29	3.667	0.787
	Medium	40	3.758	0.528
	Large	25	3.867	0.694

Capability	Size of firm	N	Mean	Std. Deviation
Development capabilities				
	Total	94	3.564	0.515
	Small	29	3.471	0.508
	Medium	40	3.617	0.410
	Large	25	3.587	0.662
Change management capabilities				
	Total	94	3.681	0.707
	Small	29	3.552	0.632
	Medium	40	3.750	0.707
	Large	25	3.720	0.792
Market and customer knowledge				
	Total	94	3.560	0.534
	Small	29	3.322	0.587
	Medium	40	3.633	0.488
	Large	25	3.720	0.458

4.1.2 Firmographic profile of respondents' enterprises

A total of 94 responses were collected of which 42.6% of were medium-sized firms by reporting annual turnover of "Less than R35 million, but greater than R11.5 million". The second largest pool of respondents are small firms which reported annual turnover of "Equal to or less than R11.5 million" representing 30.9% of respondents. Large firms represented 26.6% of respondents and reported annual turnover of "Greater than or equal to R35 million" (see Figure 1 in Appendix C on p. 61).

Furthermore, 86.2% of small firms have less than 20 employees where almost 50% of medium-sized firms have 5-19 employees and 60% of large firms have more than 50 employees (see Appendix C, Figure 2 on p. 62). Majority of all small, medium and large enterprises have been in operation for more than 10 years, reporting almost 40%, 45% and 80% respectively (see Appendix C, Figure 3 on p. 62). The respondents indicated that most of their operations is in civil engineering for small, medium and large-sized firms as the respondents reported 51%, 37% and 27% respectively (see Appendix C, Table 15 on p. 63). The results show that small, medium and large sized firms are operating mostly in the

Gauteng province reporting 40%, 43% and 40% respectively. Responses show larger firms across the country, even operating outside of SA; whereas smaller firms were not represented in each province (see Table 16 in Appendix C on p. 63-64).

4.1.3 Demographic profile of respondents

The respondents comprised of 92.5% males and 7.5% females (see Appendix C, Figure 4 on p. 64). The share of 36.6% for respondents aged “up to 45 years” old is the same share of respondents who were between the ages of “46-55”. The rest of the respondents reported being “+56 years” old and represented 26.9% of the responses (see Appendix C, Figure 5 on p. 65). The education levels of respondents indicate that “Post-graduate degrees” (39.8%) have the highest incidence. “Bachelor’s degrees” are second highest with 38.7% and “Up to Diploma” has the lowest incidence among respondents at 21.5% (see Appendix C, Figure 6 on p. 65). The skewed distribution of gender in the sample supports the widely accepted notion that the construction industry in South Africa (including built environment professionals) is a male-dominated industry (English & Hay, 2015:159).

4.2 BIVARIATE DESCRIPTIVE STATISTICS

4.2.1 Chi-Square test of independence for R&D and firm size

The results of the Chi-Square test for independence below show that size of firm is associated with amount of R&D a firm invests into itself, $X^2 = 20.483$; $p = .009$.

Table 4: Chi-Square test for association between external input and size of firm

Investment in R&D	Small firm	Medium firm	Large firm	Total respondents
No R&D	9	8	4	21
Less than R20, 000	8	6	1	15
R20, 001 - R50, 000	7	17	6	30
R50 001 - R100 000	2	6	4	12
R100 001or more	3	3	10	16
Total	29	40	25	94

4.2.2 Spearman correlation between external input, innovation capabilities and R&D investment

A medium strength positive correlation was found between market and customer knowledge capability as well as external input, r = 0.46, p<0.01. The other 6 capabilities showed only a mild correlation with external input.

Table 5: Spearman's correlation coefficient innovation capabilities and external input

Innovation capability		External input
Investment in R&D	Correlation coefficient Sig. (2-tailed) N	0.134 0.198 94
Capabilities for knowledge exploitation	Correlation coefficient Sig. (2-tailed) N	.298** 0.004 94
Entrepreneurial capabilities:	Correlation coefficient Sig. (2-tailed) N	.215* 0.038 94
Risk management capabilities:	Correlation coefficient Sig. (2-tailed) N	.338** 0.001 94
Networking capabilities:	Correlation coefficient Sig. (2-tailed) N	.283** 0.006 94
Development capabilities:	Correlation coefficient Sig. (2-tailed) N	.235* 0.022 94
Change management capabilities:	Correlation coefficient Sig. (2-tailed) N	.386** 0 94
Market and customer knowledge	Correlation coefficient Sig. (2-tailed) N	.406** 0 94
External input through networking	Correlation coefficient Sig. (2-tailed) N	1 . 94

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.3 NON-PARAMETRIC TESTS

Investment in R&D, entrepreneurial capabilities, risk management capabilities and market and customer knowledge were significantly affected by firm size. For these observed variables, Jonckheere's test revealed a significant trend in the data at a significance level of .05%: the larger the size of the firm, the higher the scoring on the specified capabilities.

Table 6: Kruskal Wallis test and Jonckheere Terpstra test for ordered alternatives

	Kruskal-Wallis Test	Jonckheere-Terpstra Test for Ordered Alternatives
Investment in R&D	**Sig**	**Sig**
Investment in R&D	0.004	0.001
Knowledge exploitation	0.177	0.103
Entrepreneurial capabilities	0.046	0.019
Risk management capabilities	0.044	0.012
Networking capabilities	0.609	0.316
Development capabilities	0.383	0.279
Change management capabilities	0.384	0.206
Market and customer knowledge	0.35	0.103
External input through networking	0.103	0.060

Asymptotic significance displayed. The significance level is .05.

5 CHAPTER 5: CONCLUSION

This study investigated the innovation capacity of consulting engineering firms operating in South Africa and compared innovation capabilities across these firms (i.e. small, medium and large-sized consulting engineering firms). Innovation capacity is an overall construct which generates capabilities for knowledge exploitation, entrepreneurial capabilities, risk management capabilities, networking capabilities, development capabilities, change

management capabilities and market and customer knowledge (Forsman, 2011:744; Forsman & Rantanen, 2011:35).

There remains minimal available literature that has explored and measured the innovation capacity and innovation capabilities of South African SMEs yet alone consulting engineering firms operating in South Africa (Forsman, 2011:739-750; Forsman & Rantanen, 2011:27-50; Gemünden & Rohrbeck, 2010:231-243). This study was conducted with the purpose of enhancing the body of knowledge that is available to academics on the topic of innovation development of consulting engineering firms operating in South Africa.

5.1 SUMMARY OF FINDINGS

The results of the study conducted suggest that respondents' engineering consulting firms have an "average" to "high" innovation capacity where medium (M = 3.707, SD = 0.536) and large (M = 3.752, SD = 0.614) sized firms have a similar capacity; however small (M = 3.499, SD = 0.638) firms are lagging. Results further indicate that there exists a significant difference in entrepreneurial capabilities, risk management capabilities, and capabilities for market and customer knowledge where larger firms report to have a higher scoring than smaller firms. In particular, the results for risk management capabilities and capabilities for market and customer knowledge show small firms in the lower range of "average" to "high", medium firms just over the midpoint for "average" to "high" and large firms in the upper range of "average" to "high". The finding regarding risk management is in line with the literature which states that large firms are more likely to engage and implement risk management activities (Zhao *et al.*, 2015:355). Overall, finding that large firms have a higher capacity for innovation was expected given that the literature pointed out that they have access to more resources and capabilities than small firms - including human capital and technology (Ates & Bititci, 2011:5602; Gronum *et al*., 2012:272; Jørgensen & Ulhøi, 2010:397; Park & Ryu, 2015:340).

As mentioned, innovation capacity is the capability of an enterprise to progress its resources and capabilities to discover and take advantage of opportunities to better satisfy customer needs; thus, innovation capacity is driven by resources and different capabilities (Forsman, 2011:740). This study observed internal and external resources of small, medium and large

firms as R&D and external input respectively, to identify opportunities to improve overall innovation capacity. The findings show that the size of the firm is associated with the amount of R&D investment where larger firms invested more financial assets into their R&D efforts. Therefore, the larger the firm the more R&D investment they are likely to invest into the firm. However, there was no significant difference across firm size for external input. In addition, a significant moderate strength positive correlation was found between external input and capabilities for market and customer knowledge. This suggests that there is an opportunity for smaller sized firms to invest in external input and directly improve their capabilities for market and customer knowledge to bridge the gap in capability between itself and larger sized firm.

5.2 MANAGERIAL IMPLICATIONS

The study suggests that there is room for improvement with regards to engineering consulting firms' innovation capacity particularly with small and medium-sized firms. Capability building efforts of entrepreneurs, policy makers and associations or industry groups should prioritise capabilities which are lagging; namely entrepreneurial capabilities, risk management capabilities and capabilities for market and customer knowledge. Special focus should be given to small firms with regards to risk management capabilities and the capabilities for market and customer knowledge. Smith *et al.* (2011:8) offers investments in human and technological capital as an approach to improving innovation capabilities. However, a more practical and seemingly equally effective approach appears to be the former given that small and medium-sized firms are often financially constrained and would therefore be unlikely to make significant strides in technological advancements. Investments in human capital come in the form of training and enhancing skills within the firm (Bernard *et al*., 2014:4). Although the latter should not be completely dismissed, and technological investments should be evaluated on its own merit.

Given that investments in R&D improves innovation capacity, it is suggested that policy makers invest in more financial assistance for small and medium firms which also support innovation (Forsman & Rantanen 2011:41). Small and medium sized firms often have limited financial resources, citing lack of finance as a main reason for failure. If the institutions can provide an environment where SMEs are more likely to be innovative then SMEs will be

more likely to fulfil their developmental role in the economy (Herrington *et al*., 2015:4; Nieman & Pretorius, 2004:3; Olawale & Garwe, 2010:729). Furthermore, because the R&D activities of SMEs are often informal it is of paramount importance that entrepreneurs are mindful of daily business developments and are constantly seeking opportunities to collaborate in their efforts to be a more innovative firm (Forsman, 2011: 740).

Generally, SMEs are encouraged to engage in networking activities to access the market, complementary skills, capabilities, knowledge and resources which are not internally available (Ates & Bititci, 2011:5602; Gronum *et al.*, 2012:272; Jørgensen & Ulhøi, 2010:397; Park & Ryu, 2015:340). In addition, SMEs should leverage customer participation in the ideation and launch stages of product development thereby also helping to make up for the lack of resources relative to larger firms (Chang & Taylor, 2016:60).

5.3 LIMITATIONS

The basis of this study was centred on comparing the performance of sub-groups on the topic of innovation; namely, small, medium and large-sized engineering consulting firms. The paper adopted CESA's definition for small, medium and large sized firms as at 4 September 2017, which stated that:

- A small consulting engineering firm has an annual turnover less than or equal to R11.5 million
- A medium consulting engineering firm's annual turnover is more than R11.5 million but less than R35 million
- A large consulting engineering firm's annual turnover more than or equal to R35 million

According to Campbell (2018) CESA has since changed the definition to be in line with what is typically used in the Construction Sector Codes which were promulgated in December 2017. The Code now defines the size of a firm based on annual turnover as follows:

- A small firm or exempted micro enterprise (EME) is less than or equal to R6 million
- A medium firm is more than R6 million but less than R25 million
- A large firm is greater than or equal to R25 million

The interpretation of results is thus limited to the definition of firm size prior to the promulgation in December 2017 and cannot be extended to the more recent definition that has now been adopted by CESA given potential overlaps.

It is to be further noted that there are other definitions for firm size which are inconsistent with CESA's definition. For example, Section 1(xv) of the National Small Business Act (102/1996) (hereafter referred to as the Act) inter alia, states that firm size is defined by additionally observing number of full-time equivalents of paid employees, and gross asset value (excluding fixed property) (Nieman & Pretorius, 2004:5):

- A small construction business has less than 50 full-time equivalents of paid employees, annual turnover of less than R5 million and gross asset value of less than R1 million
- A medium construction business has less than 200 full-time equivalents of paid employees, annual turnover less than R20 million and gross asset value of less than R4 million
- A large construction firm has more than or equal to 200 full-time equivalents of paid employees, annual turnover of more than or equal to R20 milion and gross asset value of more than or equal to R4 million

The results of this study are founded on CESA's definition of firm size which is based on a single factor, namely annual turnover. Consequently, this may make it difficult to align the results of the study to other literature which may have classified firm size using additional factors or a combination thereof. However, CESA's definition is in line with the latest Construction Sector Codes which addresses built environment professionals (BEPs) directly; thereby suggesting that there may be non-academic grounds for the definition promulgated by policy-makers.

An additional limitation to the study is the reliability test for the change management capability. Given that the change management construct is measured only by one scale item, Cronbach alpha was not appropriate to test reliability. It is advised that in future, a test retest reliability should be built into the pre-testing phase of the study.

5.4 RECOMMENDATIONS FOR FUTURE RESEARCH

This study adopted the precedent of Forsman (2011) and measured the internal, transformative and external inputs of innovation capacity as R&D investment, innovation capabilities and external input. However, given the research objectives of the study which was to measure the innovation capabilities of consulting engineering firms and identify differences in capabilities across firm size, the study did not focus on internal and external input factors to innovation capacity. As such, the literature investigated was constrained primarily to understanding innovation capacity as an overall construct and understanding the innovation capabilities.

The differences that were found in innovation capabilities across firm size, by this study, prompts the need for future research to explore why small consulting engineering firms are lagging in their innovation capabilities, and particularly in their risk management capabilities and their capabilities for market and customer knowledge. One approach might be to explore the effects of gender bias in the construction industry on innovation capacity.

Given that innovation capabilities provide a view on the transformative capabilities of the firms, future research should expand this view to include internal and external inputs to innovation capacity, even in the literature. Perhaps the differences in innovation capabilities across firm size can additionally be explained by the internal and external inputs to innovation capacity; which the GII has alluded to as being critical to the innovation process.

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APPENDIX A

- Final questionnaire and informed consent form -

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

DEPARTMENT OF BUSINESS MANAGEMENT

INNOVATION CAPACITY QUESTIONNAIRE

Dear respondent

You are invited to participate in an academic research study conducted by Mahlatse Mogashoa, a Masters student from the Department of Business Management at the University of Pretoria.

The purpose of the study is to identify the differences in innovation capacity across small and medium-sized consulting engineering firms. “Innovation” is defined as creating, developing and adapting new ideas, processes or even products with the objective of enhancing the competitiveness of the enterprise.

Please note the following:

- This study involves an anonymous survey. Your name will not appear on the questionnaire and the answers you give will be treated as strictly confidential. You cannot be identified in person based on the answers you give.
- Your participation in this study is very important to us. You may, however, choose not to participate and you may also stop participating at any time without any negative consequences.
- The results of the study will be used for academic purposes only and may be published in an academic journal. We will provide you with a summary of our findings on request.
- You are welcome to contact my study leader, Prof. Antonites on tel: (012) 420-13119 or e-mail: Alex.Antonites1@up.ac.za, if you have any questions or comments regarding the study.
- Please answer the 19 questions in the questionnaire as completely and honestly as possible. This should not take more than 15 minutes of your time.
- The questionnaire can be accessed through the link sent in the email, which will direct you to Qualtrics. Remember to submit the questionnaire when completed.

By completing the questionnaire, you will indicate that:

- You have read the information provided above.
- You give your consent to participate in the study on a voluntary basis.

Thank you for your kind assistance.

Sincerely,

Mahlatse Mogashoa

Resp. no. | | | |

- Innovation Capacity Questionnaire -

Please answer <u>all</u> the questions by placing a cross (×) in the appropriate block. There are no right or wrong answers. We are interested in understanding the differences in innovation capabilities across small and medium South African consulting engineering firms.

Q1. Are you an owner or a manager of a South African consulting engineering firm?

Yes	1	➔ **Go to Q2.**
No	2	➔ **Please stop. You unfortunately do not qualify to participate in this study. Thank you for your time.**

Q2. **Research and Development (R&D)**: work directed toward the innovation, introduction, and improvement of products and process.

What amount have you spent on R&D during the last financial year? (Please tick only one option.)

None	1
Less than R20 000	2
R20 001-R50 000	3
R50 001-R100 000	4
R100 001-R500 000	5
R500 001 or more	6

Q3. **Capabilities for knowledge exploitation**: the ability of using new knowledge that you have gained to benefit your business. A number of statements describing the <u>capabilities for knowledge exploitation</u> of your business in terms of innovation are listed below. Please read each statement carefully and rate the extent to which the statement describes the innovation capabilities of your business.

		Very low	Low	Average	High	Very high
3.1	Capabilities to recognise relevant external knowledge.	1	2	3	4	5

		Very low	Low	Average	High	Very high
3.2	Capabilities to internalise new external knowledge.	1	2	3	4	5
3.3	Capabilities to exploit new knowledge for innovation.	1	2	3	4	5

Q4. **Entrepreneurial capabilities:** the ability to sense and seize opportunities and mitigate threats in order to remain competitive. A number of statements describing the entrepreneurial capabilities of your business in terms of innovation are listed below. Please read each statement carefully and rate the extent to which the statement describes the innovation capabilities of your business.

		Very low	Low	Average	High	Very high
4.1	Capabilities to recognise new opportunities	1	2	3	4	5
4.2	Capabilities to seize new opportunities for developing new solutions.	1	2	3	4	5
4.3	Capabilities to exploit opportunities for generating new profitable business.	1	2	3	4	5

Q5. **Risk management capabilities**: the ability to take risks and assess which risks to take. A number of statements describing the risk management capabilities of your business in terms of innovation are listed below. Please read each statement carefully and rate the extent to which the statement describes the innovation capabilities of your business.

		Very low	Low	Average	High	Very high
5.1	Capabilities for risk assessment	1	2	3	4	5
5.2	Willingness to take risks.	1	2	3	4	5
5.3	Abilities to take risks.	1	2	3	4	5

Q6. **Networking capabilities**: the ability to work with people and businesses outside of yours and use them to improve your business. A number of statements describing the networking capabilities of your business in terms of innovation are listed below. Please read each statement carefully and rate the extent to which the statement describes the innovation capabilities of your business.

		Very low	Low	Average	High	Very high
6.1	I always follow a networking orientation.	1	2	3	4	5
6.2	Capabilities to create collaborative relationships.	1	2	3	4	5
6.3	Capabilities to exploit networks in business.	1	2	3	4	5

Q7. **Development capabilities**: the ability to create new innovations that are different from what the competition is offering customers, being able to improve on existing products and services offered by the enterprise and being able to exploit the innovations that have been developed by others. A number of statements describing the development capabilities of your business in terms of innovation are listed below. Please read each statement carefully and rate the extent to which the statement describes the innovation capabilities of your business.

		Very low	Low	Average	High	Very high
7.1	Capabilities to generate new innovations which differ from competitors' offerings.	1	2	3	4	5
7.2	Capabilities to improve existing products and services.	1	2	3	4	5
7.3	Capabilities to exploit innovations developed by others.	1	2	3	4	5

Q8. **Change management capabilities**: the ability to change the business according to the market and customer needs. A number of statements describing the change management capabilities of your business venture in terms of innovation are listed below. Please read each statement carefully and rate the extent to which the statement describes the innovation capabilities of your business.

		Very low	Low	Average	High	Very high
8.1	Capabilities to quickly implement change based on market and customer knowledge.	1	2	3	4	5
8.2	Capabilities to acquire new customers.	1	2	3	4	5
8.3	Capabilities to expand to new markets.	1	2	3	4	5
8.4	Capabilities to increase sales to existing customers.	1	2	3	4	5

Q9. **External input** is the input from outside sources into the innovation process. A number of statements describing the external input into innovation development through networking are listed below. Please indicate what impact networking has had on your business.

		Very negative impact	Negative impact	No impact	Positive impact	Very positive impact
9.1	Knowledge creation.	1	2	3	4	5
9.2	Resource acquisition.	1	2	3	4	5
9.3	Development activities of your business	1	2	3	4	5

Q10. **Radical innovation** is new and different from what the competitors are doing. What type(s) of radical innovation has developed in your business during the past four years?

None	1
Products (visible to external stakeholders)	2
Services (visible to external stakeholders)	3

Business processes (includes all tasks, schedules, activities and routines)	4
Production methods (the way in which you make or build products and/or services	5
Mode of action (single actions that have led to innovations of entire managerial or organisational practices and procedures	6

Q11. **Incremental innovation** is an improvement that is different from the existing offerings in the market in terms of some of its features. What type(s) of incremental innovation has developed in your business during the past four years?

None	1
Products (visible to external stakeholders)	2
Services (visible to external stakeholders)	3
Processes (includes all tasks, schedules, activities and routines)	4
Production Methods (the way in which you make or build products and/or services)	5
Mode of action(single actions that have led to innovations of entire managerial or organisational practices and procedures	6

Q12. How many permanent employees are employed in your company? (Please tick only one option.)

1-4 employees	1
5-19 employees	2
20-49 employees	3
50-199 employees	4
200 or more employees	5

Q13. How long has your business been operating? (Please tick only one option.)

Less than a year	1
1-2 years	2
3-5 years	3
6-10 years	4
More than 10 years	5

Q14. What has been your business' annual turnover rate over the last financial year? (Please tick only one option.)

Equal to or less than R11.5 million	1
Less than R35 million, but greater than R11.5 million	2
Greater than or equal to R35 million	3

Q15. In what industry do you operate (core business)?

Acoustics	1
Agricultural	2
Architecture	3
Building Services	4
Chemical	5
Civil	6
Development	7
Dispute Resolution	8
Electrical	9
Electronic	
Environmental	
Expert witness/Insurance claim	
Facilities/Maintenance Management	
Geographic Information System (GIS)	
Geotechnical	
Industrial	

Information systems/Technology	
Marine	
Mechanical	
Mining	
Process Engineering	
Project Management	
Quality Management System (QMS)	
Quantity Surveying	
Rural Development	
Structural	
Town Planning	
Transportation	

Q16. In what geographical area/s is your business operating in (primary location)?

Eastern Cape	1
Free State	2
Gauteng	3
Kwa-Zulu Natal	4
Limpopo	5
Mpumalanga	6
North West	7
Northern Cape	8
Western Cape	9
Outside SA borders	10

Q17. What is your gender?

Male	1
Female	2

Q18. What is your age? (Please tick only one option.)

18-30	1
31-45	2
46-55	3
56-65	4
66 or older	5

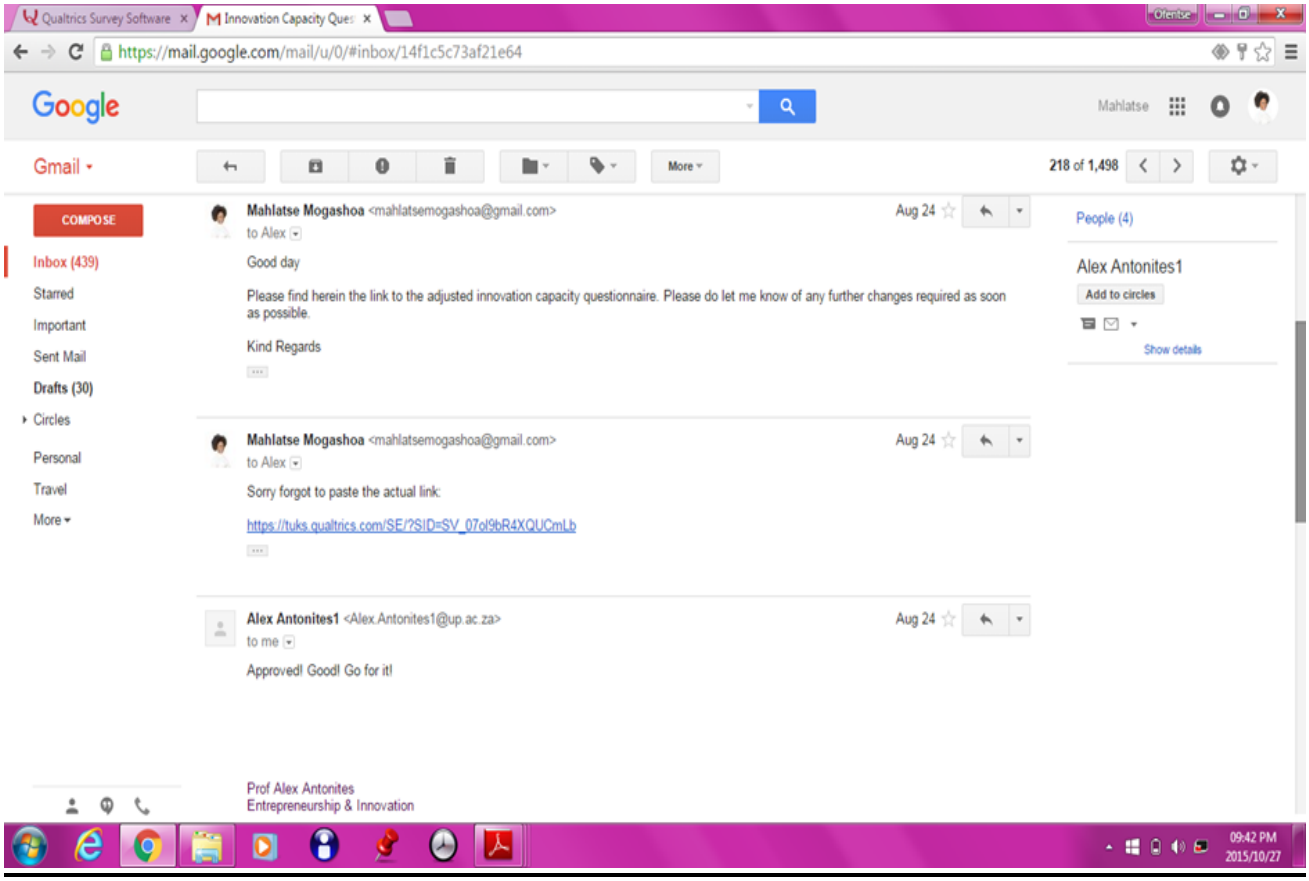
Q19. Indicate your highest qualification (Please tick only one option.)

None	1
Below grade 12	2
Grade 12	3
Certificate (e.g. short learning programme/s)	4
Diploma	5
Bachelor's Degree	6
Post-graduate degree	7

Thank you for completing the survey.

We appreciate your assistance.

Email copy of approval



Approval from UP Research Ethics Committee

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences

RESEARCH ETHICS COMMITTEE

Tel: +27 12 420 3395
E-mail: ronel.rensburg@up.ac.za

8 November 2017

Prof AJ Antonites
Departement of Business Management

Dear Professor Antonites

The application for ethical clearance for the research project described below served before this committee on an ad hoc basis on 7 November 2017.

Protocol No:	EMS041/17
Principal researcher:	**MM Mogashoa**
Research title:	Innovation capacity: a survey of South African consulting engineering firms
Student/Staff No:	12043011
Degree:	MCom (Business Management)
Supervisor/Promoter:	Prof AJ Antonites
Department:	Business Management

The decision by the committee is reflected below:

Decision:	Approved
Conditions (if applicable):	None
Period of approval:	November 2017 – October 2018

The approval is subject to the researcher abiding by the principles and parameters set out in the application and research proposal in the actual execution of the research. The approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Codes of Research Ethics of the University of Pretoria if action is taken beyond the approved proposal. If during the course of the research it becomes apparent that the nature and/or extent of the research deviates significantly from the original proposal, a new application for ethics clearance must be submitted for review.

Please convey this information to the researcher. We wish you success with the project.

Sincerely

pp PROF RS RENSBURG
CHAIR: COMMITTEE FOR RESEARCH ETHICS

cc: Student Administration

APPENDIX B

- Results of reliability analyses -

Reliability tests

This study focussed on measuring the degree of innovation of South African engineering consulting firms and identifying significant differences in innovation capabilities across firm size. The internal consistency reliability tests were measured for all the sub-dimensions of innovation capacity and of external input. All results were found to be above the critical limit of 0.6 (Forsman, 2011:743, Özer & Günlük, 2010:1503).

Table 7 below indicates item-total statistics for the “knowledge exploitation” sub-dimension.

Table 7: Item-total statistics for knowledge exploitation

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Recognising external knowledge	7.28	1.557	.666	.738
Internalising external knowledge	7.49	1.715	.723	.681
Exploiting new knowledge	7.51	1.801	.601	.799

Cronbach’s alpha for the sub-dimension “knowledge exploitation” was calculated at 0.810 across three of its item scales. A total of 94 respondents contributed to the Cronbach’s alpha calculated, where no respondents were excluded. The Cronbach’s alpha was found to be satisfactory as the value is greater than the recommended cut-off of 0.6. In addition, the item-to-total correlations were all above 0.4 and found to be of similar size.

Table 8 below indicates item-total statistics for the “entrepreneurial capabilities” sub-dimension.

Table 8: Item-total statistics for entrepreneurial capabilities

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Recognising opportunities	7.30	1.561	.601	.716
Seizing opportunities	7.53	1.382	.688	.617
Exploiting opportunities	7.58	1.550	.561	.760

The sub-dimension “entrepreneurial capabilities” had a Cronbach’s alpha of 0.778 across all three of its item scales. A total of 93 respondents contributed to the Cronbach’s alpha calculated, where one respondent was excluded due to no response on this particular sub-dimension. The Cronbach’s alpha was found to be satisfactory as the value is >0.6. In addition, the item-to-total correlations were all above 0.4 and found to be similar, as a result no deletions were made.

Table 9 below indicates item-total statistics for the “risk management capabilities” sub-dimension.

Table 9: Item-total statistics for risk management capabilities

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Risk assessment capabilities	6.91	1.862	.323	.669
Willingness to take risks	7.29	1.404	.521	.394
Ability to take risk	7.24	1.530	.469	.476

A Cronbach’s alpha for “risk management capabilities” was calculated at 0.625 across three of its item scales. A total of 93 respondents contributed to the Cronbach’s alpha calculated, where one respondent was excluded due to no response on one of the sub-items. Cronbach’s alpha was found to be satisfactory as the value is >0.6. The item-to-total correlations were not all above 0.4. The “risk assessment capabilities” was found to be lower than 0.4 and not of similar size the other sub-items. In fact, its deletion would improve the Cronbach alpha coefficient. No deletions have been made as the instrument used to measure innovation capacity is a globally standardised questionnaire developed by Dr. H. Forsman.

Table 10 below indicates item-total statistics for the “networking capabilities” sub-dimension.

Table 10: Item-total statistics for networking capabilities

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
Networking orientation	7.53	1.822	.663	.741
Collaborative relationships	7.44	2.055	.663	.745
Exploits networks	7.59	1.815	.665	.739

Cronbach's alpha for "networking capabilities" was calculated at 0.811 across three of its item scales. A total of 94 respondents contributed to the Cronbach's alpha calculated where no respondents were excluded. Cronbach's alpha for "networking capabilities" was found to be satisfactory as the value was found to be well above the cut-off point of >0.6. The item-to-total correlations were all above 0.4 and found to be similar, hence no item scale deletions were made.

Table 11 below indicates item-total statistics for the "development capabilities" sub-dimension.

Table 11: Item-total statistics for development capabilities

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Generation of new innovation	7.15	1.031	.585	.552
Improving existing offerings	7.06	1.329	.497	.661
Exploits others' innovations	7.17	1.283	.518	.637

Cronbach's alpha for "development capabilities" was calculated at 0.711 across three of its item scales. A total of 94 respondents contributed to the Cronbach's alpha calculated where one respondent was excluded. The Cronbach's alpha for "development capabilities" was found to be satisfactory as the value was found to be larger than 0.6. The item-to-total correlations were not all above 0.4 and found to be more or less the same size.

Table 12 below indicates item-total statistics for the "capabilities for market and customer knowledge" sub-dimension.

Table 12: Item-total statistics for market and customer knowledge

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Acquires new customers	7.11	1.408	.479	.644
Expands to new markets	7.22	1.165	.605	.479
Increase sales to existing customers	7.03	1.365	.459	.671

A total of 94 respondents contributed to the Cronbach's alpha calculated where no respondents were excluded. Cronbach's alpha for "capabilities for market and customer knowledge" was found to be satisfactory as the value was found to be larger than the cut-off of 0.6 at 0.696. The item-to-total correlations were all above 0.4 and found to be similar.

Table 13 below indicates item-total statistics for the "external input" sub-dimension.

Table 13: Item-total statistics for external input through networking

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Knowledge creation	7.47	1.295	.681	.772
Resource acquisition	7.63	1.147	.699	.754
Development activities	7.49	1.231	.686	.765

Cronbach's alpha for "external input" was calculated at 0.829 across three of its item scales. A total of 93 respondents contributed to the Cronbach's alpha calculated where one respondent was excluded due to no response on the scale. Cronbach's alpha coefficient for "external input" was found to be satisfactory as the value was found to be much greater that the cut-off of 0.6. The item-to-total correlations were all above 0.4 and found to be similar, hence no item scale deletions were made.

APPENDIX C

- Descriptive statistics -

Descriptive statistics for nominal and ordinal data

Table 14 below provides univariate descriptive statistics for individual innovation capabilities that are sub-dimensions of innovation capacity.

Table 14: Innovation capability profile of respondents

Innovation capability variables	N	Mean	Std Deviation
Capabilities for knowledge exploitation:			
Recognising external knowledge	94	3.860	0.784
Internalising external knowledge	94	3.650	0.683
Exploiting new knowledge	94	3.630	0.718
Entrepreneurial capabilities:			
Recognising opportunities	94	3.910	0.682
Seizing opportunities	94	3.680	0.707
Exploiting opportunities	94	3.600	0.752
Risk management capabilities:			
Risk assessment capabilities	94	3.810	0.723
Willingness to take risks	94	3.440	0.797
Ability to take risk	93	3.480	0.775
Networking capabilities:			
Networking orientation	94	3.740	0.802
Collaborative relationships	94	3.840	0.708
Exploits networks	94	3.690	0.804
Development capabilities:			
Generation of new innovation	94	3.540	0.713
Improving existing offerings	94	3.630	0.604
Exploits others' innovations	94	3.520	0.617
Change management capabilities:			
Change implementation	94	3.681	0.707
Market and customer knowledge			
Acquires new customers	94	3.570	0.647
Expands to new markets	94	3.460	0.698
Increases sales to existing customers	94	3.650	0.683

The highest form of knowledge exploitation is the “capabilities to recognise relevant external knowledge” (M = 3.860, SD = 0.784), and the lowest form is the “capabilities to exploit new knowledge for innovation” (M = 3.630, SD = 0.718). This concludes that respondents have the capabilities to recognise knowledge; however, the capabilities to use the gained knowledge for innovation are lower in comparison.

The entrepreneurial capabilities of respondents scored highest with regards to “capabilities to recognise new opportunities” in terms of innovation (*M* = 3.910, *SD* = 0.682), and lowest on “capabilities to exploit opportunities for generating new profitable business” (*M* = 3.600, *SD* = 0.752. Respondents are more capable at recognising new opportunities but are least capable at transforming the opportunity into a profitable tangible business.

The respondent’s “capability to assess risks” (*M* = 3.810, *SD* = 0.723) is higher in comparison to the “willingness to take risks” (*M* = 3.440, *SD* = 0.797) and “ability to take risks” (*M* = 3.480, *SD* = 0.775).

The networking capabilities of the respondents’ firms scored highest on “capabilities to create collaborative relationships” (M = 3.840, SD = 0.708) and lowest on “capabilities to exploit networks in business” (M = 3.690, SD = 0.804). It seems although respondents don’t always follow a networking orientation; they are able to still form collaborative relationships, however still lagging in the capability of exploiting these relationships.

For the respondent’s development capabilities, the “capabilities to improve existing offerings” (M = 3.630, SD = 0.604) scored the highest and the “capabilities to exploit innovations developed by others” (M = 3.520, SD = 0.617) scored the lowest.

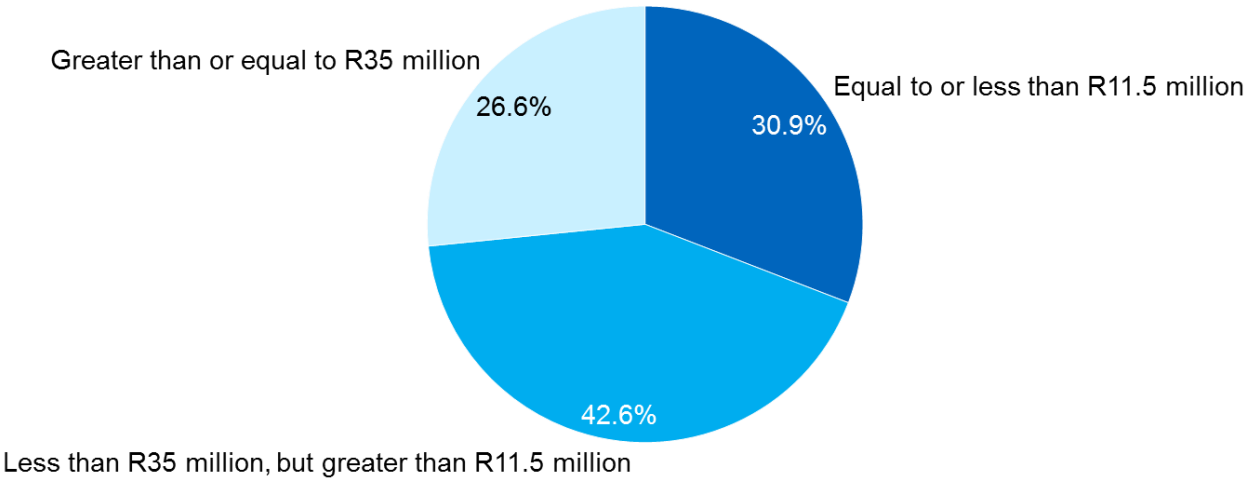
The market and customer knowledge of respondents’ firms in terms of innovation, scored highest on “capabilities to increase sales to existing customers” (M = 3.560, SD = 0.534) and lowest on “capabilities to expand to new markets” (M = 3.460, SD = 0.698). Respondents measured similarly on the “capabilities to quickly implement change based on market and customer knowledge” (M = 3.681, SD = 0.707).

Figure 1 below shows the annual turnover of respondents’ firms. Given that the study adopted CESA’s definition for the size of a consulting engineering firm; these statistics also show the distribution of small, medium and large firms that participated in the study; where:

- A small consulting engineering firm has an annual turnover equal to or less than R11.5 million
- A medium consulting engineering firm’s annual turnover exceeds R11.5 million but not R35 million

- A large consulting engineering firm's annual turnover is greater than or equal to R35 million

Figure 1: Firm's annual turnover



A total of 94 responses were collected of which 42.6% of were medium-sized firms by reporting annual turnover of "Less than R35 million, but greater than R11.5 million". The second largest pool of respondents are small firms which reported annual turnover of "Equal to or less than R11.5 million" representing 30.9% of respondents. Large firms represented 26.6% of respondents and reported annual turnover of "Greater than or equal to R35 million"

Figure 2 below shows the number of permanent employees in a firm; 86.2% of small firms have less than 20 employees where almost 50% of medium-sized firms have 5-19 employees and 60% of large firms have more than 50 employees

Figure 2: Number of permanent employees

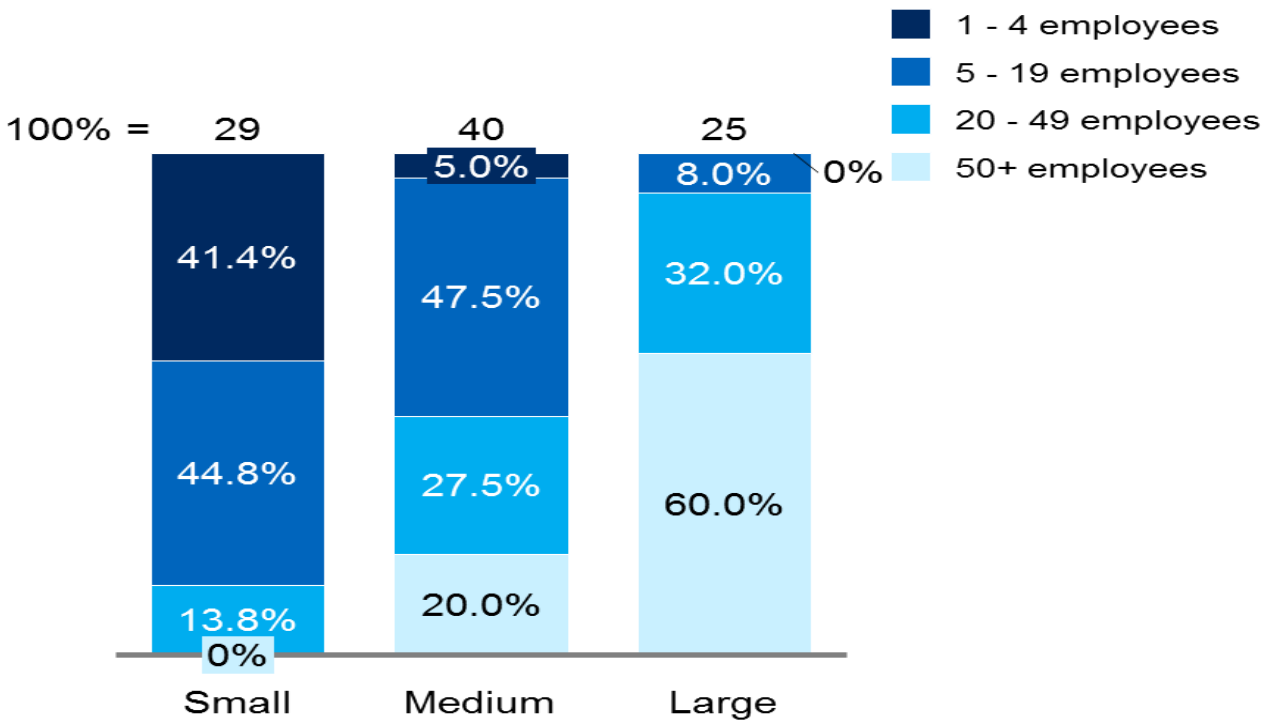
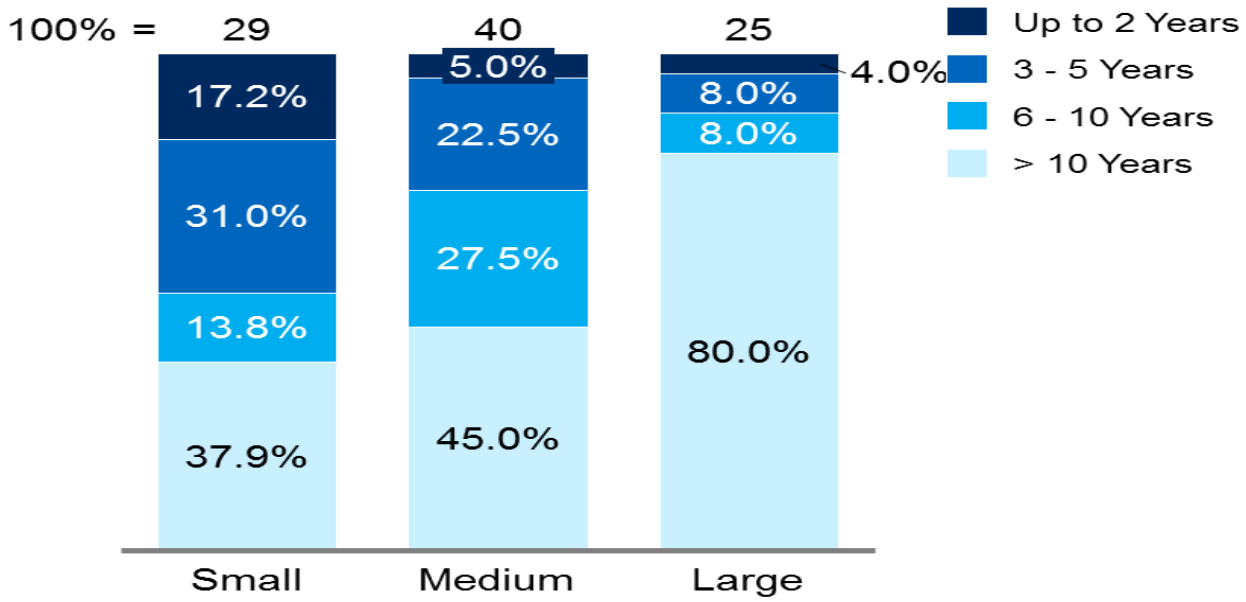


Figure 3 below shows the number of operating years for each firm size

Figure 3: Number of operating years



The results based on the number of operating years of respondents' firms indicate that majority of all small, medium and large enterprises have been in operation for more than 10 years, reporting almost 40%, 45% and 80% respectively.

The table below shows the fields of specialisation that respondents operate in.

Table 15: Field of discipline

Field of discipline	Small firm	Medium firm	Large firm	Total respondents
Civil	51%	37%	27%	37%
Structural	7%	20%	13%	15%
Project Management	12%	13%	18%	14%
Electronic	16%	8%	8%	10%
Building services	5%	3%	8%	5%
Development	0%	4%	6%	4%
Mechanical	5%	3%	5%	4%
Chemical	5%	1%	0%	2%
Environmental	0%	1%	3%	2%
Geo technical	0%	1%	3%	2%
Transportation	0%	3%	0%	1%
Town Planning	0%	3%	0%	1%
Industrial	0%	1%	0%	1%
Process Engineering	0%	1%	2%	1%
Mining	0%	1%	2%	1%
Quantity Surveying	0%	0%	2%	1%
Facilities	0%	0%	2%	1%
Maintenance	0%	0%	2%	1%
GIS	0%	1%	0%	1%

The respondents indicated that most of operations are in civil engineering for small, medium and large-sized firms as the respondents reported 51%, 37% and 27% respectively. It appears that larger firms are more diversified than their smaller counterparts

Table 16 below indicates the geographical area/s respondents' firms are operating

Table 16: Geographical areas

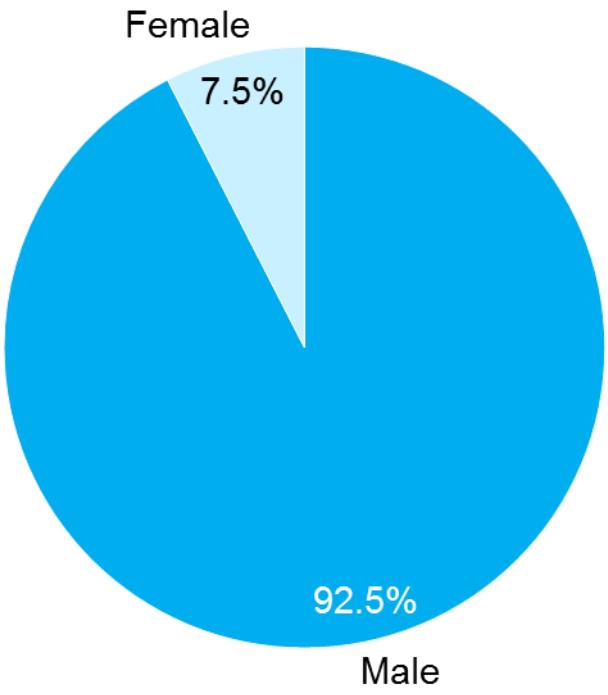
Geographical area	Small firm	Medium firm	Large firm	Total respondents
Gauteng	40%	43%	40%	42%
Western Cape	13%	13%	12%	13%
KwaZulu-Natal	10%	11%	17%	13%
Limpopo	13%	13%	2%	9%
Mpumalanga	7%	7%	7%	7%

Geographical area	Small firm	Medium firm	Large firm	Total respondents
Eastern Cape	3%	4%	10%	6%
Free State	0%	7%	2%	3%
North West	3%	2%	2%	3%
Northern Cape	10%	0%	0%	3%
Outside SA	0%	0%	7%	3%

The results show that small, medium and large sized firms are operating mostly in the Gauteng province reporting 40%, 43% and 40% respectively. Responses show larger firms across the country, even operating outside of SA; whereas smaller firms were not represented in each province.

Figure 4 below illustrates the ratio of male and female respondents.

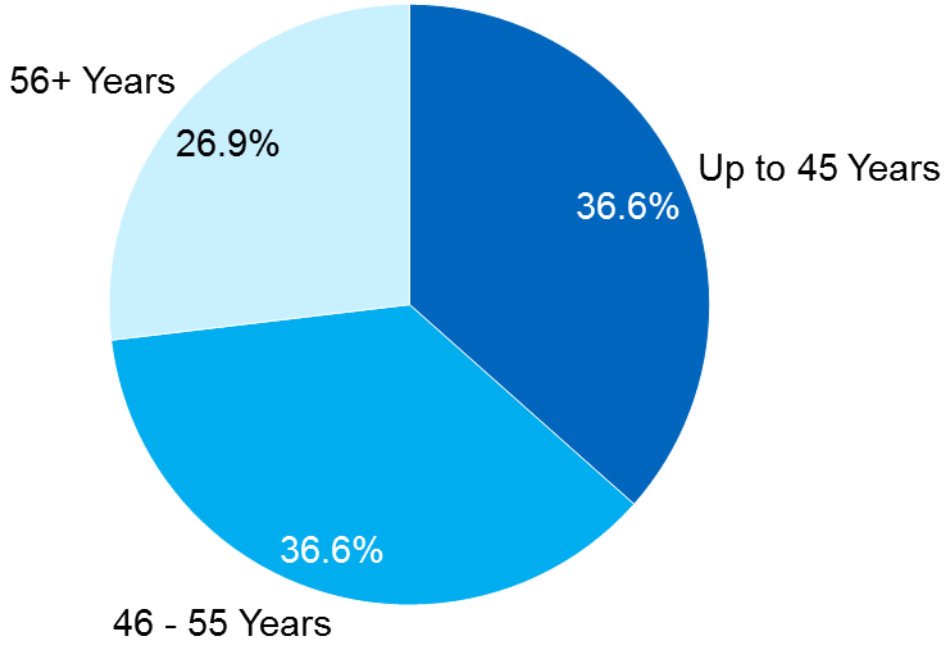
Figure 4: Gender ratios of respondents



The respondents comprised of 85% more males (92.5%) than females (7.5%).

Figure 5 below illustrates the ages of respondents.

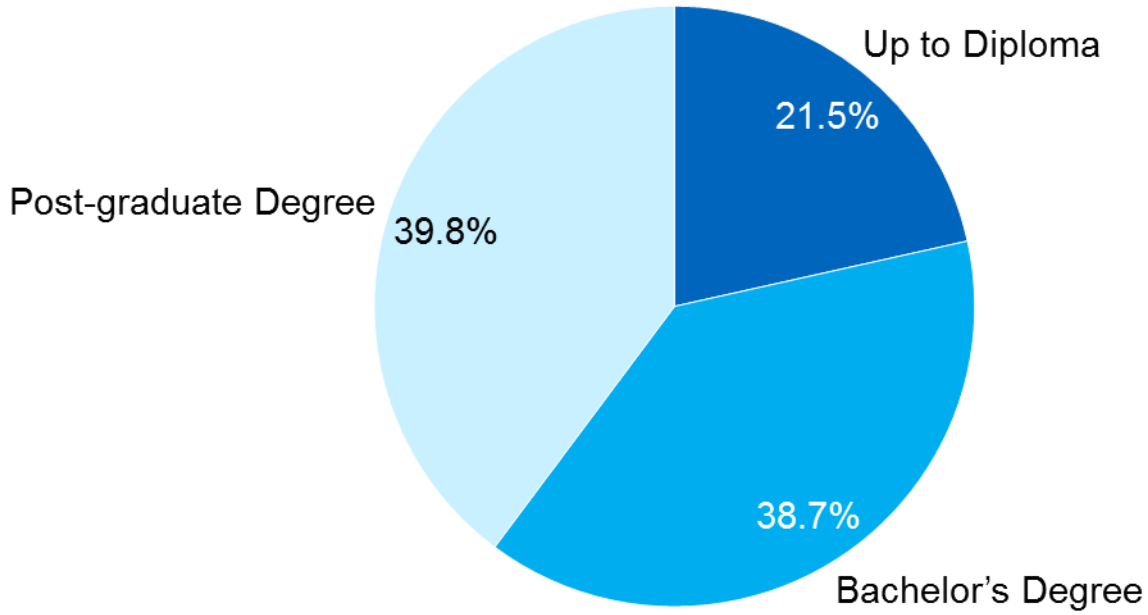
Figure 5: Age distribution of respondents



The figure above shows that the share of 36.6% for respondents aged “up to 45 years” old is the same share of respondents who were between the ages of “46-55”. The rest of the respondents reported being “+56 years” old and represented 26.9% of the responses.

Figure 6 below illustrates the ages of respondents.

Figure 6: Highest level of respondents’ education



The education levels of respondents indicate that “Post-graduate degrees” (39.8%) have the highest incidence. “Bachelor’s degrees” are second highest with 38.7% and “Up to Diploma” has the lowest incidence among respondents at 21.5%.

APPENDIX D

- Test results: Statistical assumptions -.

Tests for statistical assumptions

According to Field (2009:133), most parametric tests based on normal distribution have four basic assumptions that must be met for the test to be accurate:

- Data should be normally distributed
- Variances should be the homogenous throughout the data
- Data should be measured at least at the interval level
- Data from the different respondents should be independent

It was found that the innovation capabilities met two of the four assumptions. Firstly, a Likert scale has been used to measure data resulting in the collection of interval level data. Secondly, data collected from respondents were independent given that invitations to participate in the study were sent to representatives of different firms. The behaviour of one respondent did not influence the behaviour of another as there was no contact between the respondents in the collection of data. Therefore, the study tested for the assumptions of normality and homogeneity to identify possible violations to these assumptions of parametric tests.

The table below shows the significance test for normality of data collected for small firms using the Kolmogorov-Smirnova and the Shapiro-Wilk test.

Table 17: K-S and Shapiro-Wilk tests for small firm data normality

Variable	Kolmogorov-Smirnovb[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Investment in R&D	0.204	29	0.003	0.867	29	0.002
Capabilities for knowledge exploitation	0.194	29	0.007	0.921	29	0.033
Entrepreneurial capabilities	0.182	29	0.015	0.912	29	0.019
Risk management capabilities	0.151	29	0.089	0.963	29	0.391
Networking capabilities	0.181	29	0.016	0.929	29	0.052
Development capabilities	0.168	29	0.036	0.933	29	0.068
Change management capabilities	0.313	29	0	0.793	29	0

Variable	Kolmogorov-Smirnovb[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Capabilities for market and customer knowledge	0.204	29	0.003	0.897	29	0.008
External input through networking	0.199	29	0.005	0.925	29	0.04

a. Lilliefors Significance Correction

Investment in R&D D(29) = 0.003, $p < .05$, capabilities for knowledge exploitation D(29) = 0.007, $p < .05$, entrepreneurial capabilities D(29) = 0.015, $p < .05$, networking capabilities D(29) = 0.016, $p < .05$, development capabilities D(29) = 0.036, $p < .05$, change management capabilities, D(29) = 0, $p < .05$, capabilities for market and customer knowledge D(29) = 0.003, $p < .05$, external input through networking D(29) = 0.05, $p = .05$, were all significantly non-normal.

However, risk management capabilities D(29) = 0.089, $p > .05$ was not significantly different from a normal distribution.

The table below shows the significance test for normality of data collected for medium-sized firms using the Kolmogorov-Smirnova and the Shapiro-Wilk test.

Table 18: K-S and Shapiro-Wilk tests for medium firm data normality

Variable	Kolmogorov-Smirnovb[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Investment in R&D	0.235	40	0	0.894	40	0.001
Capabilities for knowledge exploitation	0.249	40	0	0.906	40	0.003
Entrepreneurial capabilities	0.179	40	0.002	0.952	40	0.09
Risk management capabilities	0.239	40	0	0.937	40	0.027
Networking capabilities	0.251	40	0	0.901	40	0.002
Development capabilities	0.2	40	0	0.885	40	0.001
Change management capabilities	0.288	40	0	0.832	40	0
Capabilities for market and customer knowledge	0.174	40	0.004	0.947	40	0.061

Variable	Kolmogorov-Smirnovb[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
External input through networking	0.247	40	0	0.887	40	0.001

a. Lilliefors Significance Correction

Investment in R&D D(40) = 0, $p < .05$, capabilities for knowledge exploitation D(40) = 0, $p < .05$, entrepreneurial capabilities D(40) = 0.002, $p < .05$, risk management capabilities D(40) = 0, $p > .05$, networking capabilities D(40) = 0, $p < .05$, development capabilities D(40) = 0, $p < .05$, change management capabilities, D(40) = 0, $p < .05$, capabilities for market and customer knowledge D(40) = 0.004, $p < .05$, external input through networking D(40) = 0, $p = .05$, were all significantly non-normal.

The table below shows the significance test for normality of data collected for large firms using the Kolmogorov-Smirnova and the Shapiro-Wilk test.

Table 19: K-S and Shapiro-Wilk tests for large firm data normality

Variable	Kolmogorov-Smirnovb[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Investment in R&D	0.185	25	0.027	0.903	25	0.022
Capabilities for knowledge exploitation	0.263	25	0	0.839	25	0.001
Entrepreneurial capabilities	0.223	25	0.002	0.924	25	0.062
Risk management capabilities	0.222	25	0.003	0.889	25	0.011
Networking capabilities	0.224	25	0.002	0.894	25	0.013
Development capabilities	0.228	25	0.002	0.939	25	0.137
Change management capabilities	0.358	25	0	0.735	25	0
Capabilities for market and customer knowledge	0.209	25	0.006	0.936	25	0.117
External input through networking	0.281	25	0	0.839	25	0.001

a. Lilliefors Significance Correction

Investment in R&D D(25) = 0.027, $p < .05$, capabilities for knowledge exploitation D(25) = 0, $p < .05$, entrepreneurial capabilities D(25) = 0.002, $p < .05$, risk management capabilities

D(25) = 0.003, $p > .05$, networking capabilities D(25) = 0.002, $p < .05$, development capabilities D(25) = 0.002, $p < .05$, change management capabilities, D(25) = 0, $p < .05$, capabilities for market and customer knowledge D(25) = 0.006, $p < .05$, external input through networking D(25) = 0, $p = .05$, were all significantly non-normal.

The table below shows the significance test for variance on the data collected for South African engineering firms conducted using Levenes test.

Table 20: Test of homogeneity of variance

Variable		Levene statistic	df1	df2	Sig.
Investment in R&D	Based on Mean	2.382	2	91	0.098
	Based on Median	2.048	2	91	0.135
	Based on Median and with adjusted df	2.048	2	89.144	0.135
	Based on trimmed mean	2.211	2	91	0.115
Capabilities for knowledge exploitation	Based on Mean	2.231	2	91	0.113
	Based on Median	1.992	2	91	0.142
	Based on Median and with adjusted df	1.992	2	87.408	0.143
	Based on trimmed mean	2.259	2	91	0.11
Entrepreneurial capabilities	Based on Mean	0.235	2	91	0.791
	Based on Median	0.19	2	91	0.828
	Based on Median and with adjusted df	0.19	2	88.848	0.828
	Based on trimmed mean	0.264	2	91	0.768

Variable		Levene statistic	df1	df2	Sig.
Risk management capabilities	Based on Mean	2.147	2	91	0.123
	Based on Median	2.313	2	91	0.105
	Based on Median and with adjusted df	2.313	2	87.665	0.105
	Based on trimmed mean	2.161	2	91	0.121
Networking capabilities	Based on Mean	1.599	2	91	0.208
	Based on Median	1.366	2	91	0.26
	Based on Median and with adjusted df	1.366	2	84.255	0.261
	Based on trimmed mean	1.609	2	91	0.206
Development capabilities	Based on Mean	1.647	2	91	0.198
	Based on Median	1.056	2	91	0.352
	Based on Median and with adjusted df	1.056	2	66.31	0.354
	Based on trimmed mean	1.513	2	91	0.226
Change management capabilities	Based on Mean	0.009	2	91	0.991
	Based on Median	0.12	2	91	0.887
	Based on Median and with adjusted df	0.12	2	86.461	0.887
	Based on trimmed mean	0.06	2	91	0.941
	Based on Mean	0.97	2	91	0.383

Variable		Levene statistic	df1	df2	Sig.
Capabilities for market and customer knowledge	Based on Median	0.933	2	91	0.397
	Based on Median and with adjusted df	0.933	2	87.585	0.397
	Based on trimmed mean	0.914	2	91	0.405
External input through networking	Based on Mean	1.077	2	91	0.345
	Based on Median	0.915	2	91	0.404
	Based on Median and with adjusted df	0.915	2	89.144	0.404
	Based on trimmed mean	0.972	2	91	0.382

Across all firm sizes of engineering firms, variances were equal for the investment in R&D F(2, 91) = 2.382, *ns*, capabilities for knowledge exploitation F(2, 91) = 2.231,*ns*, entrepreneurial capabilities F(2, 91) = 0.235, *ns*, risk management capabilities F(2, 91) = 2.147, *ns*, networking capabilities F(2, 91) = 1.599, *ns*, development capabilities F(2, 91) = 0.09, *ns*, change management capabilities F(2, 91) = 0.09, *ns*, capabilities for market and customer knowledge F(2, 91) = 0.970, *ns*, external input through networking F(2, 91) = 1.077, *ns*.

The results from the Kolmogorov-Smirnova, the Shapiro-Wilk test and Levenes test show that although the data met the parametric assumption for homogeneity; the test for normal distribution of data was violated. As a result, the study has used non-parametric tests (instead of parametric tests) to analyse the results of the study.