Emerging technology innovation in South Africa in the context of the 4th industrial revolution

Mphedziseni Munzhelele

1483664

A research article submitted in partial fulfilment

of the requirements for the degree of

Master of Business Administration

Faculty of Commerce, Law and Management

University of the Witwatersrand

Johannesburg

2018

Protocol number: WBS/BA1483664/774

(Version October 2018)

DECLARATION

I, Mphedziseni Munzhelele, declare that this research article is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

…….
Mphedziseni Munzhelele

Signed at ……..…Secunda……

On the …29th……. day of ……..…October…… 2018……...

SUPPLEMENTARY INFORMATION

Nominated journal:	The South African Journal of Entrepreneurship and Small Business Management (SAJESBM)
Supervisor / Co-author:	Anton Christopher
Word count †:	11813
Supplementary files:	Research instrument Survey report Statistical analysis

† *Including abstract, references, etc.*

ABSTRACT

Background: In 2008 South Africa launched a ten-year innovation plan to transform the country's economy from a resource-based to a knowledge-based economy that is powered by emerging technological innovations. Years have gone by and the country has not achieved its goal. Instead, the country's economy has continued shedding jobs, with poverty and inequality increasing while economic growth declines.

Aim: To understand the determinants for emerging technological innovation in South Africa by identifying the relationship that innovation funding, the National System of Innovation (NSI), human capital and innovation policies have with the emerging technology innovation performance of South Africa as a country.

Setting: The study was conducted on institutions that form part of the NSI in Gauteng province. The range of institutions covered included the Innovation Hub, private sector companies, public research organisations and higher education institutions. A wide spectrum of professionals from the stated institutions was invited to participate in the study.

Methods: We examined how independent variables related to innovation funding, the NSI, human capital and innovation policies relate to emerging technologies innovation performance. The Kruskal-Wallis test and Spearman's correlation analysis were used to detect associations or relationships between these independent variables and innovation performance.

Results: The results indicated that the country's emerging technologies innovation performance cannot be determined by a single factor but is the outcome of a combination of factors which, when working together, produce a certain innovation performance in the country. The results also confirmed a strong correlation between collaboration and investment in innovation activities or infrastructure. In addition, collaboration also emerged as the highest benefit that innovation policy provides. This confirms findings of previous studies which showed that failure to connect to the right networks has a negative effect on accessing finance and other forms of support for innovation activities and that the

interactions between actors in the NSI allow the flow of funds and knowledge between actors as influenced and governed by various policies and instruments put in place by the government

Conclusion: It is concluded that innovation funding, the NSI, human capital or innovation policies alone do not determine the innovation performance of the country, but certain combinations of these factors do. Future research should determine the sets of combinations that are required for a country to achieve elevated levels of innovation performance.

Keywords: Innovation Funding, National System of Innovation, Human Capital, Innovation Policies, Innovation Performance, Emerging Technology Innovation, Collaboration, and Networking

---

INTRODUCTION

South Africa, just like other emerging economies, lags behind developed economies regarding income levels and living standards, and turning this situation around will require countries in the emerging economies to increase their knowledge output and R&D expenditures (Urban-Econ Development Economists, 2017; Department of Science and Technology, 2007).

In the quest for transforming its resource-based economy to being knowledge-based, South Africa launched a ten-year innovation plan in 2008 that was aimed at addressing the country's socioeconomic challenges of unemployment, poverty and inequality (Department of Science & Technology, 2007). The ten-year innovation plan was built on the foundation of South Africa's National System of Innovation (NSI), which comprises the government, universities, science councils, the private sector, non-governmental organisations, and international performers and funders, to help the country seize opportunities offered by emerging technological innovation such as biotechnology, nanotechnology and the hydrogen economy in fields such as advanced manufacturing, agriculture, information communication

technology, natural resources, health and energy (Baatjies, 2013; Department of Science and Technology, 2007; Urban-Econ Development Economists, 2017). This is consistent with the opportunities that the future world will provide in areas such as digital technologies, biotechnologies, advanced manufacturing, and energy and environmental technologies (OECD, 2016).

The future world in the fourth industrial revolution will change the way people live and work, putting some of the high-skills jobs at risk of extinction due to artificial intelligence, robotics, nanotechnology and other socio-economic factors replacing humans in the workplace (Schwab, 2016; Adao, 2016; World Economic Forum [WEF], 2017). South Africa's failure to transform its economy from resource-based to knowledge-based may worsen its unemployment, poverty and inequality.

Despite having such an impressive ten-year innovation plan, South Africa continues shedding jobs, with poverty and inequality increasing and economic growth declining (Industrial Development Corporation [IDC], 2017).

The failure of the ten-year innovation plan to transform the economy from a resource-based to a knowledge-based economy that is driven by emerging technological innovation has prompted the need to understand the determinants for emerging technological innovation in South Africa.

Therefore, the problem statement for the research is to identify the main determinants for emerging technological innovation in South Africa.

To address the research problem, the study will have to identify the following:

- The impact that Innovation Funding has on emerging technological innovation performance in South Africa
- The relationship that the NSI has with emerging technological innovation performance in South Africa
- The relationship that Human capital has with emerging technological innovation performance in South Africa, and

- The influence that Innovation Policies have on emerging technological innovation performance in South Africa.

The study will seek to understand the determinants for emerging technological innovation in South Africa by identifying the relationship that innovation funding, the National System of Innovation (NSI), human capital and innovation policies have with the emerging technology innovation performance of South Africa as a country.

Literature review and propositions

In the knowledge-based economies, innovation is proving to be much more important than the conventional primary factors of production such as land, physical capital, or labour in creating national economic growth and development (Tseng, 2009).

A country failing to innovate may not be able to withstand competition in the market place. Innovation is needed to help the country to overcome barriers to entry and maintain competitiveness. It is for this reason this research examines determinants for emerging technological innovation in South Africa.

Therefore, the literature review for this research will cover the theoretical base on innovation funding, NSI, innovation Human Capital and innovation policy which are the four constructs applicable for addressing the research problem statement.

Innovation funding

Finance and corporate governance systems form part of the key elements in the NSI and the characteristics of the shareholders and financiers influence the relative and absolute innovation levels in the country (Tylecote, 2007). The protectionism and risk aversion behaviours of the funders inhibit innovation as funders avoid uncertainty and high expenses associated with disruptive innovations by channelling their financial support to safer incremental innovations that do not disrupt the status quo (Chalmers, 2013).

A mixed funding model consisting of government and private sector funders is therefore needed to counteract the bias against disruptive innovation by private

funders. Government funding of disruptive innovation can help in reducing uncertainty and the high cost associated with disruptive innovation activities, making development and implementation of such innovation affordable to the private sector (Reiljan & Paltser, 2015).

Governments and private sector innovation funders tend to be protectionists and risk averse during periods of economic downturn and respond by reducing spending on R&D and innovation activities because innovation is known to increase expenditure with little or no return in the short term (Schmitt, 2005). A paradigm shift is required that will view investing in innovation activities such as intellectual or knowledge infrastructure as a viable option for getting out of periods of economic downturn (Etzkowitz & Etzkowitz, 2017). Such thinking can assist in transforming the country's economy from a resource or manufacturing-based to a knowledge-based economy (Etzkowitz & Etzkowitz, 2017).

Countries that are leading in science and technology R&D, such as Japan, respond to economic downturn by increasing their investment in R&D and restructuring their science and technology policy and institutions (Yoshida, 2001).

In periods of economic downturn when tax revenues and the cost of borrowing are low, governments can use debt instruments, such as selling of bonds, to fund R&D and other innovation activities (Etzkowitz & Etzkowitz, 2017).

There are direct and indirect instruments that governments use to fund innovations in the private sector. Direct instruments such as subsidies have a positive impact on innovation performance and indirect instruments such as tax benefits have been found to provide a stronger stimulus for innovation activities than direct subsidies, even though they do not motivate enterprises to initiate new R&D projects (Reiljan & Paltser, 2015). State funding agencies are good channels used by government to provide seed money for funding high-risk projects with potential to attract new venture capital in the future (McCann et al., 2011).

The South African government, in particular, has established a number of agencies that support innovation activities in the country with funding, such as the Technology and Human Resources for Industry Programme (THRIP), the

Innovation Fund, and Innovation Funding and Pre-commercialisation Support (IFPCS) (Letseka, 2005; Urban-Econ Development Economists, 2017).

It is important to have the right and healthy networks for sourcing investments for innovation activities. According to Lettice and Parekh (2010), as cited in Chalmers (2013), failure to connect to the right networks has a negative effect on accessing both finance and other forms of support for innovation activities. The failure to adequately engage funders results in low investment in innovations (Tylecote, 2007).

There are other creative ways of funding innovations, such as letting users pay additional premiums for products or services now to fund technological innovations aimed at providing them with benefits in the future (Schmitt, 2005). Innovation firms operating in countries where there is less support and structure to enable innovations have a competitive disadvantage compared to those in countries where there are resources, personnel and funding for innovation (Simon et al., 2002 as cited in Griffiths & Kickul, 2008), and countries that are leading in innovation invest significantly on R&D (Griffiths & Kickul, 2008).

Therefore, based on the findings of the literature review about innovation funding, the following propositions can be made:

Proposition 1

The character of the funders affects the relative and absolute innovation levels of the country.

Proposition 2

The level of R&D funding is an important determinant of the innovation performance and, consequently, the emerging technological innovation performance in the country.

National System of Innovation

The National System of Innovation (NSI) is often made up of institutions such as government, universities, public research organisations and the private sector. Innovation systems help to understand and manage the innovation process

(Jenson, Leith, Doyle, West, & Miles, 2016a). They consist of elements and relationships that interact in the production, diffusion and use of new economically useful knowledge (Lundvall, 1992 as cited in Godin, 2009). The performance of innovation systems is dependent on the relationship between actors in the systems (Godin, 2009).

In an era where innovation can no longer be viewed as an outcome of isolated entrepreneurial genius, but is a systematic and complex social process involving people in different roles (Arocena & Sutz, 2000 as cited in Lucio-Arias, 2006) and as a result of collective endeavours and complex systematic interactions (Landabaso, 2014), the creation and strengthening of multiple and reciprocal linkages among the various actors in the innovation process is important (Etzkowitz & Leydesdorff, 1997 as cited in Lucio-Arias, 2006). Success in innovation requires the organisation to use external resources, internal resources and internal capabilities (Mas-Verdu, Ortiz-Miranda, & García-Álvarez-Coque, 2016), and organisations that have established relationships with other organisations have been found to be more innovative (Ahuja, 2000; Powell et al., 1996 as cited in Poorkavoos, Duan, Edwards, & Ramanathan, 2016). Enriching and expanding internal and external networks helps in increasing and broadening the organisation's knowledge base and commercial potential, but organisations without internal capabilities for innovation are unable to benefit from the superior network position (O'Connor, 2009).

Networking relationships can be formal relationships that are based on contractual agreements or informal ones such as engagement among employees of different organisations which can be very difficult to capture (Poorkavoos et al., 2016). Interactions between institutions in the NSI allow the flow of funds and knowledge between institutions as influenced and governed by various policies and instruments put in place by the government (Kahn & Blankley, 2005).

Innovation is frequently seen as the result of an extensive network collaboration of actors with their external agents such as suppliers, partners and customers (Chesbrough, 2003 as cited in Mas-Verdu et al., 2016). Although previous studies indicated that there is no linear relationship between the intensity of cooperation and innovation outcomes, there are particular advantages of collaboration such as

market diversification, cross-fertilisation of knowledge, access to new external sources of information and savings derived from shared costs on various innovation activities (Mas-Verdu et al., 2016).

University–Industry collaborations produce innovation success that gives rise to product radicalness and enhanced organisational competitiveness (Gassmann & Enkel, 2004 as cited in Moon, Mariadoss, & Johnson, 2017). In some instances it is necessary to create intermediate institutions between universities and industries to improve relationships and interactions, which can help to provide feedback mechanisms for communicating the needs of business to the universities (Lucio-Arias, 2006). Blau (2010) indicated that successful innovation does not depend on government and universities alone, but also on the strength of the internal structures and processes in the organisation, which include a team of independent thinkers with time to experiment, formal processes for testing and approving ideas, and collaboration with suppliers, customers and other outsiders.

Innovation clusters create a dynamic environment that connects innovation thinkers with resources and venture capitalists. They also allow small firms with the ability to generate ideas to intermingle with larger firms that have access to capital and the ability to scale up and grow ideas. Physical proximity created through clusters catalyses innovation by allowing dynamic thinkers and entrepreneurs to collaborate (Holden, 2011).

In developing countries, most of the cooperation in innovation happens through non-research and development innovation activities such as engineering and design, training, technical assistance, and information and product testing. Such cooperation relationships are formed with partners in the vertical and horizontal axis, with vertical axis partners representing suppliers and clients and horizontal axis partners representing competitors, universities, laboratories and other public organisations of science and technology (Fernández Sastre, Vera, & Eduardo, 2017).

Several lenses can be used to analyse and understand innovation systems. Jenson, Leith, Doyle, West, and Miles (2016b) suggest the use of structural theory with its five conditions that affect innovation performance – infrastructure,

interactions, capability of actors, and market factors – and functional theory with its seven conditions that affect innovation performance – entrepreneurial experimentation, knowledge development, knowledge dissemination, direction of research, market formation, provision of resources, and gaining of technology acceptance.

Siyanbola, Olaopa and Hassan (2013) suggest the use of institutional and process lenses to analyse innovation systems, where universities are seen as more than just teaching and basic research institutions but as being involved in innovative applied research that can lead to wealth creation and entrepreneurial activities; where government is seen as providers of an enabling environment for successful innovation through regulations, tax incentives and other support mechanism; and where industry is seen as exploiters of government opportunities and research results from knowledge-based institutions to produce innovation. In analysing innovation systems as a process, the performance and maturity of the NSI can be measured by studying input indicators such as number of R&D personnel and/or output indicators such as the number of co-publications or patents (Seidel, Müller, Köcker, & Filho, 2013), but these performance indicators are not sufficient to measure the performance of the NSI. There is a need for measures that can reflect the efficiency and effectiveness of the NSI in producing, diffusing and using economically useful knowledge (Lundvall, 1992 as cited in Godin, 2009).

In their study, Jenson et al. (2016b) concluded that innovation failures that are not random in nature can be addressed through policy and managerial interventions because failure of structural parameters normally requires policy interventions and failure in functional conditions often requires managerial action.

In 2005 the South African NSI consisted of a large private sector inclusive of wholly and partially state-owned enterprises, the government sector inclusive of eight major science councils, and 36 higher education institutions (HEIs) (Kahn & Blankley, 2005).

Based on the reviewed literature on NSI, the following propositions can be made:

Proposition 3

Strong networks and collaborations among actors in the NSI have a positive effect on the innovation output of the country if the country has strong internal innovation capabilities.

Proposition 4

The success of the country in innovation depends on the internal capabilities of that country to use both its internal and external resources.

Human capital

As national economies move from being resource to being innovation driven, countries will have to embark on more sophisticated human resource development (HRD) strategies that will put human capital development (HCD) and people at the centre of strategic capital investment to support the new economic trajectories of the 21st century (Osman-Gani, 2004).

Innovation depends on the knowledge, expertise, and commitment of the human capital involved in the innovation process (Chen & Huang, 2009), but capitalism by its nature accelerates the process of obsolescence of products, knowledge and expertise (Pineda, 2003 as cited in Lucio-Arias, 2006), leading to continuous demand for new products, new knowledge and new expertise. Thus to support the sustainability of the NSI, the education of young people, the feedstock for innovation human capital, should be addressed according to the demand of the economy (Lucio-Arias, 2006). The ways in which innovation human capital is generated, developed or acquired and utilised must respond to the evolving global circumstances and conditions (Turpin, Woolley, & Marceau, 2010).

“The knowledge embedded in the human capital is an enabler for the enhancement of distinctive competitiveness and the discovery of innovation opportunities” (Hansen, 1999; Grant, 1996; Wright et al., 2001 as cited in Chen & Huang, 2009, p. 106). A high level of human capital involvement and participation is required in the innovation process since the production of creative ideas and enhancement of innovation performance depends on the ability and motivation of

the human capital (Damanpour, 1991; Hurley and Hult, 1998 as cited in Chen & Huang, 2009).

The innovation process has both uncertainty and variability. It therefore requires creative human capital with flexibility, a high appetite for risk, and tolerance for uncertainty and ambiguity (Madsen & Ulhoi, 2005 as cited in Chen & Huang, 2009).

Human resource assets have three components: competence, attitude and intellectual agility, and human resource competence can further be divided into skills and knowledge (Roos, Roos, Dragonetti, & Edvinsson, 1997 as cited in O'Connor, Roos, & Vickers-Willis, 2007). The two key components of human capital assets, knowledge and skills, are acquired through general education and training respectively (Huo, 2009). Competence in innovation covers a range of skills such as creativity, opportunity recognition, and specific skills in some technical disciplines. Attitudes, in the context of innovation, include negative behaviours that can create barriers to innovation such as conservatism, conformity and risk-avoidance (Neely & Hii, 1998 as cited in O'Connor et al., 2007). Lastly, intellectual agility refers to the "ability to use the knowledge and skills, build on it, apply it in a practical context and increase it through further learning" (Roos *et al.*, 1997, p. 39 as cited in O'Connor et al., 2007, p. 539).

Breakthrough innovation requires deep customer insight to ensure that new products, services, or business models address the unmet needs of the customers in a way that cannot be done through traditional approaches (Weigel & Goffin, 2015). This requires that the organisations build capabilities to generate customer insights, convert those insights into innovative solutions, and initiate projects based on those solutions (Weigel & Goffin, 2015). Success in innovation requires a shift from a knowledge-push approach in which scientists and engineers come up with ideas and push them to the market, to a demand-pull system where industry and users play an active role in the development of market-oriented innovation (Blau, 2008).

Three distinct competencies are necessary for breakthrough innovation to occur: discovery, incubation and acceleration (O'Connor, 2009), with discovery focusing

on creation and identification of opportunities that may have major impact in the marketplace, incubation focusing on experimentation with the technology and business concepts or models to get to a demonstrated model of a new business that brings breakthrough value to the market and the organisation, and lastly, with acceleration, which can be defined as the competency of being able to develop critical mass.

Human capital is important to enhance organisational absorptive capacity for knowledge and to facilitate technology and knowledge transfer as part of the innovation process (Frenz & Oughton, 2006 as cited in Beynon, Jones & Pickernell, 2016). Hence, the knowledge and skills embedded in human capital are often seen as a precondition for achieving high innovation performance in the country (De Jong & Vermeulen, 2006). Therefore, formal education and/or training program for developing human capital to keep up their knowledge and skill levels is important for achieving high innovation performance (Romijn & Albaladejo, 2002 as cited in De Jong & Vermeulen, 2006). According to Parziale and Scotti (2016, p. 2), “a good level of education among the population is a precondition for the constitution of the human capital in the country”. This further emphasises the need for education in HCD to enhance innovation performance. Scholars largely share the common understanding that the education level promotes innovation and this can contribute to economic development (Parziale & Scotti, 2016). Other scholars argue that regions with low levels of tertiary education can still achieve high innovation outcomes provided that they have high levels of collaboration among small and medium enterprises and public investment in R&D (Mas-Verdu et al., 2016). Having said that, it should be remembered that collaboration alone does not lead to high innovation outcomes, but only creates an enabling environment for high innovation outcomes to be achieved.

The national HCD strategy should be integrated with the economic and national strategies of the country. Some of the features of a good HCD policy are that it should be based on tripartite cooperation of employers, unions and government. In addition, it should have a multidepartment approach encompassing all relevant government departments (Osman-Gani, 2004). The success of such a policy is dependent on the commitment from tripartite parties and a network of government

departments, and leadership farsightedness is important in directing the human capital development policy (Osman-Gani, 2004).

In the current era, where the flow of migrants between countries is linked to the transfer of skills, talent and knowledge, the NSI needs to find ways to optimise the gains on innovation human capital derived from the mobility of the highly-skilled personnel in the global skills pool (Turpin et al., 2010). It is in this era where mobility rather than migration provides the most important conduit for the flow of skills and knowledge. It has therefore become essential for small economies to better manage the inward and outward flows of science and technology human capital to build a sustainable NSI. In today's boundaryless operating environment, the notion of the NSI is rapidly losing its meaning because both skilled resources and knowledge can move anywhere around the world without any boundaries. There is a need for local players to connect globally to global talents, companies and research organisations (Blau, 2008).

The human resource functions must fully participate in the development of training programs and career paths to support the innovation culture in organisations (Gobble, 2016). There must be a shift to managing human capital in a manner that supports long-term business goals. Science, technology and innovation human capital capacity building is no longer only about retaining or gaining scientific personnel but is also about accessing their networks as they move in and out of countries throughout their careers (Turpin et al., 2010). Thus, innovation policy instruments should go beyond emphasising education and immigration as the primary means for expanding the national skills base and start exploiting the long-term mobility of scientific and technical specialists to build the national innovation human capacity.

"The most successful corporate innovation strategies are those that mainly focus on people and human capital" (Gobble, 2016, p. 1).

It is important to build the human capital capability and capacity because the country's innovation output is dependent on the number of researchers in the targeted field of innovation and the critical mass of high-tech workers in an economy (Griffiths & Kickul, 2008). Greater effort should be placed on finding,

engaging and incentivising key innovation talent by promoting and rewarding entrepreneurship and risk taking (Gobble, 2016).

Both the innovation capacity and capability of the country are necessary to achieve its desired innovation objectives. The innovation capability of the country is a function of how best it utilises its resource and transformation assets to achieve desired innovation objectives. According to Calantone, Cavusgil and Zhao (2002) and Ngo and O'Cass (2013) as cited in Wang and Dass (2017, p. 127), innovation capability can be defined as the "ability to generate, accept and implement new ideas, processes, products, or services" for the attainment of the desired innovation objectives such as economic success. Figure 1 shows a conceptual framework to illustrate the relationship between the innovation capacity and innovation capability of the country.

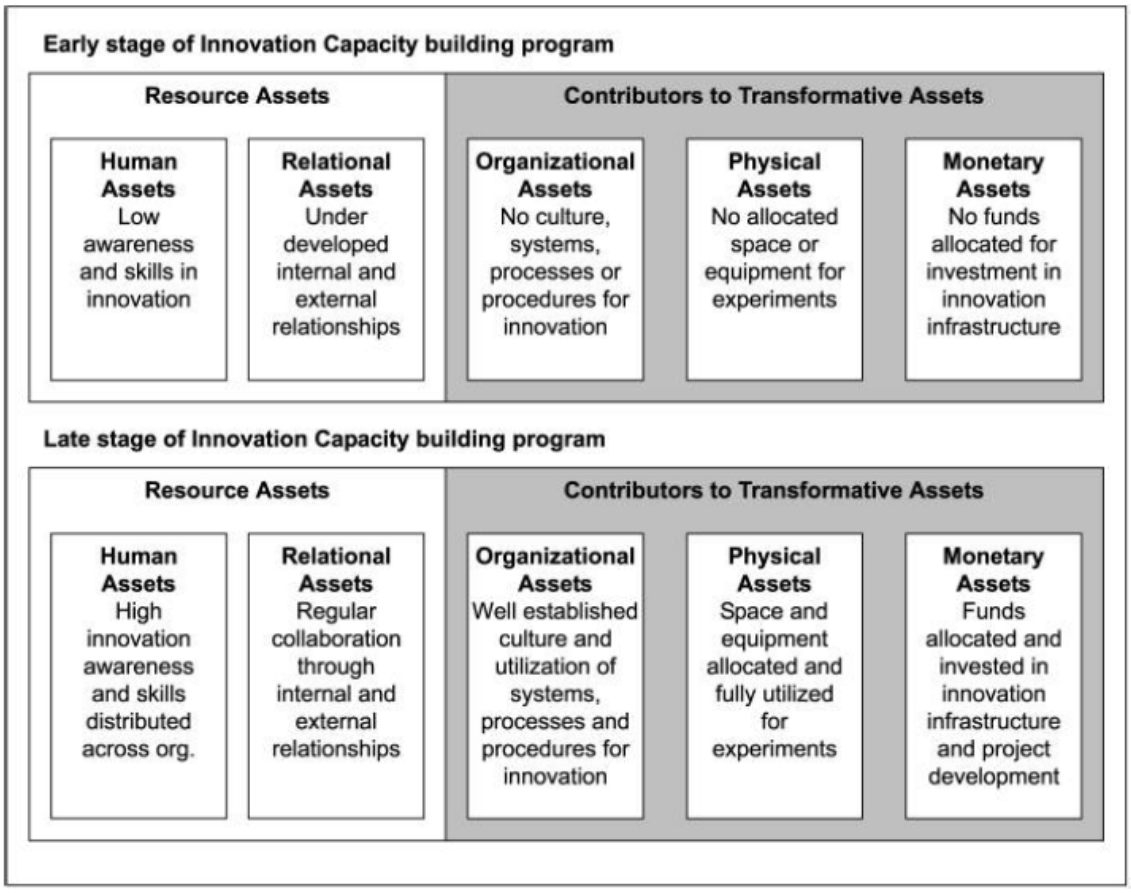

Figure 1: Asset characteristics and growth in innovation capacity

Source: O'Connor, Roos, & Vickers-Willis, 2007.

The innovation potential of any organisation depends on the internal resources of that organisation and the ability of the organisation to combine internal capacities with the resources found in the external environment (Mas-Verdu et al., 2016). The national innovation capacity produces and commercialises products, services and processes innovations which are determined by the country's infrastructure, NSI, and the existing interconnectivity (Furman et al., 2002 as cited in Beynon et al., 2016).

> According to research, there are various ways of developing innovation capabilities, including: investing in R&D, obtaining knowledge from multiple stakeholders, developing a market/learning-oriented culture, and encouraging knowledge sharing among various stakeholders (Wang & Dass, 2017, p. 127).

Leadership, as part of the human assets, does have an influence on innovation performance. According to Curado, Muñoz-Pascual and Galende (2018), leaders with higher training levels are better able to take risks, analyse the environment, or make changes towards enhancing innovation performance. Leaders' training levels reduce the risk of their resistance to new systems, and are seen as a possible moderator with limited influence on the relations between the antecedents of innovation performance and innovation performance (Curado et al., 2018).

Leadership innovativeness and relative orientation – exploration or exploitation – influence the type of innovation outcome that can be achieved (Wang & Dass, 2017). Leaders with exploration orientation are likely to foster the search for new ideas and technologies, encourage risk taking, and discover new opportunities (Wang & Dass, 2017). Exploitation-orientated leaders, on the other hand, focus more on discovering opportunities using the available resources and the innovation implementation process (Wang & Dass, 2017). Leadership innovativeness refers to the extent to which leaders have favourable attitudes toward innovation and are willing to take risks by investing resources in innovation activities (Wang & Dass, 2017). Leadership innovativeness has a positive effect on the innovation and financial performance of organisations, and leadership relative to exploration-orientation plays a mediating role in the relationship between leadership innovativeness and innovation performance (Wang & Dass, 2017).

Proposition 5

Innovation human capital competence, attitude, intellectual agility and leadership innovativeness have a positive relationship with the innovation performance of the country.

Innovation policies

Policy, in general, can be regarded as an intention, a pronouncement or a general plan of action adopted by a particular institution to solve a certain problem, counter a threat or pursue certain objectives (Akindele & Olaopa, 1997; Agagu, 2001; Agagu, 2010 as cited in Siyanbola et al., 2013). Innovation policy can be defined as a set of actions intended to raise the quantity and efficiency of innovative activities (Rodriguez & Montalvo, 2007). Innovation policy should extend beyond stimulating key industrial activities to being a mechanism for addressing pressing societal challenges through social entrepreneurship (Pages, 2010).

Innovation policies are more generic than science, technology and research policies, and may include non-technological aspects such as organisational learning and commercialisation (Rodriguez & Montalvo, 2007). Political ideologies and economic circumstances have an influence on innovation policies and they cannot be ignored, but should rather be managed in a way that will encourage innovation in the country (Pages, 2010).

The key political and general aims of innovation policies are to drive structural economic change and develop the innovation capability of the economy (Isaksen, Normann, & Spilling, 2017).

Innovation policies are multidimensional and can be framed to cover supranational, national, regional, sectorial and technological aspects in their scope. They can also be multifaceted and wide ranging, covering initiatives in areas such as science, education, research, technology development, and industrial modernisation, and also overlap with industrial, environmental, labour, and social sectors (Rodriguez & Montalvo, 2007).

There are two types of innovation policy framework, general and specific policy frameworks, which can be applied to create an innovation-friendly environment.

The latter is a place-based innovation policy focusing on developing industries and regions based on their specific capabilities and characteristics. The specific policy framework is developed or adopted based on the informed assessment of regional needs and opportunities because regions differ significantly in size and structure (Isaksen et al., 2017).

The general innovation policy framework is a place-neutral type of innovation policy. This type of policy framework is regarded as simplistic and tangible because it includes instruments such as the provision of physical infrastructure, grants for universities and research institutions, talent exchange program, spinoffs, start-ups, entrepreneurial support, networking support, and various types of tax deduction schemes for R&D (Isaksen et al., 2017). This type of policy framework does not adapt to differences in local industrial structures, innovation capability and innovations. Hence, they are incapable of making the most of the variation in potential across places (Isaksen et al., 2017).

Innovation policy should be an outcome of interactions and collaborations among the institutional players within the NSI rather than being a prescription from either government or industry (Siyanbola et al., 2013).

Regional policies need to focus on fostering local entrepreneurship and innovation, and they must be realistic, taking into account the nature of the regional institution, and appropriate for the regional context. Hence, to create an efficient NSI, sound regional or place-based innovation policies that are developed using a bottom-up approach rather than a one-size-fits-all or top-down national sectorial approach will be required (Landabaso, 2014).

Innovation policy must ensure the consistent and harmonious functioning of the NSI by formally and informally mediating the linkages between enterprises, organisations and institutions involved in innovations (Reiljan & Paltser, 2015). The quality of the innovation policy is measured by its ability to encourage institutions forming part of the NSI to collaborate and network effectively, and exploit in full the opportunities for wealth and job creation through R&D and innovation (Siyanbola et al., 2013). These effective networks, collaboration and cooperation among the private sector, public research organisations and HEIs

create channels for the scientific knowledge to find its way to the market where economic value is created (Martin, Pahor, & Jaklič, 2015). The free circulation of scientific knowledge, ideas and human capital uplifts the scientific and innovation competitiveness of the country (Blau, 2010).

The research generated by universities and public research organisations should be connected to the industry in order to generate solutions for the economic, technological and social problems in society by creating new companies, adopting and marketing new technologies, generating technology-based exports and improving productivity in the country (Martin et al., 2015). Therefore, innovation policy should enhance innovation in the country by focusing on both expanding innovation in the identified technology areas, also referred to as "smart specialisation" areas, and building identified critical network connections.

Effective innovation policies target the real economy and focus on creating sustainable jobs by developing and maintaining a healthy and productive balance between competition and cooperation in an interconnected society faced with complex challenges of climate and resource constraints in a global world (Sachs, 2012 as cited in Landabaso, 2014). Such policies improve the relevance and uptake of public research by the private sector.

The paradigm in which firms both compete and cooperate in the innovation process within the same market is only possible if their actions lead to higher quality, technology and value added in the products, services or processes that can result in individual firms' economic success. It is less feasible in cases where firms have competitive advantages that are based on marginal or opportunity costs driven mainly by low labour costs (Landabaso, 2014).

During innovation policy formulation, special consideration should be given to analysing and understanding the trade flows of the region or country to discover opportunities for interregional, intercontinental or international cooperation and complementation. This helps in ensuring that the innovation policy fully exploits the opportunities presented by understanding the centrality and connectivity of the regions (Landabaso, 2014).

One of the pitfalls for developing countries is their over-reliance on multinational corporations rather than on locally-owned firms to deliver new ideas and technological innovations (Blau, 2010). This puts the developing countries at risk because multinational corporations can relocate at any time as they continue to search for lower-cost markets. Often the research networks for these multinational corporations are linked to their parent companies, making exchange of knowledge and experience with various actors in host countries exceedingly rare. Therefore, to be successful, developing countries need the right mix of policies and investments for research and innovation. These countries need to take deliberate and organised action to support their top scientists and to create scientific centres of excellence (Blau, 2010).

Innovation policy should integrate innovation-related components found in several other fields of policy into one coherent and comprehensive whole (Reiljan & Paltser, 2015). This should help to effectively manage the innovation activities of the country. If the innovation policy is not in congruence with other policies in the country, the innovation system can be negatively impacted because implementation of innovation activities could be hindered and the desired outcome of economic growth, increased productivity or competitiveness might not be achieved (Reiljan & Paltser, 2015).

Good governance, underpinned by transparency, responsibility, accountability, stakeholder participation and responsiveness to the social needs of the country plays a central role in the establishment and successful implementation of a good policy (Siyanbola et al., 2013). More transparency, accountability and inclusiveness is required to maximise mobilisation, engagement and participation of relevant stakeholders, within the innovation system, during effective innovation policy formulation (Landabaso, 2014).

Proposition 6

Innovation policy affects innovation output of the country positively by encouraging high levels of collaboration in the NSI and investment in R&D and other innovation activities in the country.

Literature review conclusion

Innovation funding, the NSI, human capital and innovation policies do influence the innovation performance of the country. Although the country's innovation performance is not dependent on individual factors acting in isolation, it is a product of a combination of factors coming together in a coordinated manner. To elaborate on this point, we customised and used the framework of asset characteristics and growth in innovation capacity by O'Connor et al. (2007) shown in Figure 2 for our application.

The country's innovation performance is dependent on its internal resources (resource assets and transformation assets) and its ability to combine its internal resources with the resources found in the external environment. The primary function of the NSI, in this context, is to establish healthy linkages, networks and relationships, so that there can be a smooth flow of knowledge, funds, technology and other resources to support the innovation process; there are interactions among innovation actors, institutions and infrastructure; and there can be healthy collaboration and cooperation among stakeholders. Therefore, the NSI alone cannot determine the innovation performance of the country; however, it can create an enabling environment for high innovation performance to be achieved. It is when the NSI is combined with other factors such as strong human, organisational, physical and monetary assets that high innovation output can be achieved.

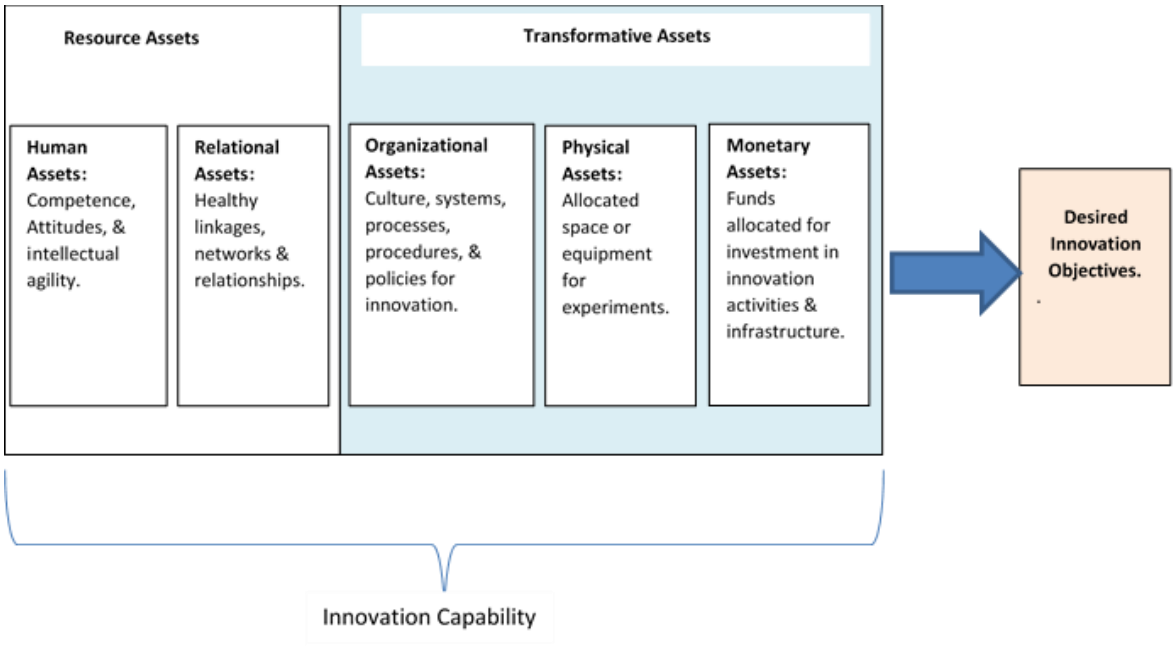

Figure 2: Innovation capacity and capability relationship

Source: O'Connor et al., 2007.

Innovation policy can be defined as a set of actions intended to raise the quantity and efficiency of innovative activities (Rodriguez & Montalvo, 2007) in the country. It therefore is obvious that a good innovation policy would create a set of actions required to address any weaknesses diagnosed in the innovation capacity and capabilities of the country while encouraging exploitation of internal strength and opportunities in the market place. The quality of the innovation policy is measured by its ability to encourage institutions forming part of the NSI to collaborate and network effectively, and exploit in full the opportunities for wealth and job creation through R&D and innovation (Siyanbola et al., 2013). Innovation policy creates structure, order and some level of certainty, and it is this structured coordination in the innovation eco-system that creates an enabling environment for long-term investment in innovation. Innovation policy, just like the NSI, cannot determine the innovation performance of the country; it can only create an enabling environment for innovation performance by encouraging collaboration and investment in R&D and innovation. Innovation policy helps to align and coordinate innovation efforts throughout the assets (i.e. resource and transformative assets).

It is the internal strength of the country regarding its human, relational, organisational, physical and monetary assets that makes it appealing to external

investors. Private funders are often protectionists and risk averse and would do all they can to remove uncertainty and expenses associated with disruptive innovations by channelling their financial support to safer incremental innovations (Chalmers, 2013).

To prevent this investor bias on innovation funding, a mixed funding model encompassing both government and private sector is needed. Government support is needed to decrease the uncertainty in the private sector associated with funding of disruptive innovation activities, so that the private sector can afford the cost of developing and implementing such innovations (Reiljan & Paltser, 2015).

The character of the funders for innovation activities affects the relative and absolute innovation output in the country (Tylecote, 2007).

The innovation process demands knowledge, expertise, and commitment from the country's human capital. It requires creative individuals who are flexible, have high appetite for risk and are tolerant of uncertainty and ambiguity (Chen & Huang, 2009).

Human capital is a key enabler for enhancing distinctive competitiveness and creating innovation opportunities (Chen & Huang, 2009). Both knowledge and skills are embedded in the human assets of the country. The country can compensate for low levels of tertiary education in its human assets by creating high levels of collaboration among small and medium enterprises and public investment in R&D (Mas-Verdu et al., 2016).

It has been asserted that although South Africa has made great strides in developing policies, legislations, institutions, and other support measures to develop skilled human resources in science, engineering and technology; to increase collaboration in research and technology development among HEIs, industry and government; to promote and support the NSI; and to support the development of small, medium-sized and micro-scale enterprises, the country needs to address the lack of seed investment in new technologies to establish technology-based companies; incubation support for young entrepreneurs and new technology-based businesses; and venture capital investment and company-building skills (Van der Walt & Blankley, 1999). In short, South Africa needs to

address the shortage of entrepreneurs and venture capitalists with the expertise to build companies.

In conclusion, from the literature search it is clear that the country's innovation performance cannot be determined by a single factor but is the outcome of a combination of factors working together to produce a certain innovation performance in the country. The question that may need to be answered in future studies is: what is the combination of factors that will produce optimal innovation performance for South Africa?

RESEARCH METHODS, DESIGN, DELIMITATIONS AND ASSUMPTIONS

This study used a non-experimental research method where existing circumstances, without attempting to manipulate controlled variables, were used to describe any existing relations (Page & Meyer, 2005). This was expected to assist in determining the relationship between innovation and the independent variables related to the four constructs being studied: innovation funding, the NSI, human capital, and innovation policies.

In non-experimental research, it is important to understand the variables being studied and the best statistical method to use in explaining the relationships among those variables to be able to generate acceptable conclusions (Welman, Kruger, & Mitchell, 2005). Hence so much time and effort were invested in the literature review to gain better understanding of the study variables. Descriptive statistics were used to analyse the quantitative data collected in the study. Descriptive measures are particularly useful for comparing the response pattern for different groups or different questions (Page & Meyer, 2005).

Although we had initially thought that the study would use both qualitative and quantitative approaches to enhance the depth and the breadth of our findings, economic and time constraint limitations made it impractical, resulting in a quantitative approach only, which was cheaper yet still time consuming.

The quantitative approach provides the hard facts and numbers required for analysing the relations among variables within the scope of the research (Page &

Meyer, 2005). The qualitative approach would have been used to qualify the meaning of the hard facts and numbers acquired through the quantitative approach. This was important, because in this research we wanted to show whether there is any association between innovation performance and the independent variables related to the four identified study constructs and also understand the nature of such relationships.

Although the study was ultimately aimed at identifying determinants for emerging technology innovations in South Africa, it will be difficult, if not impossible, to define a complete sampling frame for such a complex population. Actors in emerging technology innovations are spread all over the country, with some being private individuals, making it very difficult to define the total population in the country with certainty. According Kahn and Blankley (2005), most of the innovations activities in South Africa were concentrated inland in the province of Gauteng, with smaller regional clusters in the Western Cape and KwaZulu-Natal. It has been assumed that due to the complex nature of emerging technology innovations, such activities will require the involvement of formal institutions that are part of the NSI; hence the decision to confine the study within the province of Gauteng and focus on institutions that form part of the NSI in Gauteng.

Therefore, the research sample consists of institutions that are part of the NSI in Gauteng province, including institutions such as the Innovation Hub, private sector companies from the Innovation Hub database, public research institutions, higher education institutions and other Gauteng private sector companies involved in emerging technology innovations.

The disadvantage of the selected research population is that it does not include all innovation actors located in Gauteng and this makes the sampling frame invalid. This clearly shows how difficult it is to practically define a sampling frame that will include the entire population of Gauteng innovation actors. Without a properly defined complete sampling frame, it would be impossible to use probability samples in our research and hence our research findings would not be generalisable to the entire population of innovation actors in Gauteng.

Although the topic of our research looks at emerging technology innovation at country level, the findings of this research may not be generalised to the entire country (target population) where the research hypothesis applies because statistical model only permits generalisation to the experimentally accessible population from which a random sample has actually been obtained. The experimentally accessible population for this research only covered selected institutions based in Gauteng province. Efforts were made to randomly sample respondents within the selected institutions so that the research findings can be generalised to all those selected institutions.

In general, the conclusions reached through non-experimental studies have less internal validity as compared to those reached through experimental and quasi-experimental research (Welman et al., 2005). To improve internal validity of this research, efforts were made to ensure that measurement instruments are clearly worded and easy to understand without ambiguity and experimenter effect was avoided by using an online survey which helped in preventing influence of respondents by the researcher.

Total reliability is achieved when instruments used in the research provides identical repeated results related to some constant factor every time when the same test is repeated on the same sample (Page & Meyer, 2005). To enhance the reliability of this research, the research instrument used was designed with certain questions that checked consistency in the responses.

According to Page and Meyer (2005), the best data-collection method is the one that can ensure that the data collected is capable of answering the research questions efficiently and accurately. Effort was put at ensuring that questions on the survey questionnaire are clear and relevant to the research questions, and are not ambiguous.

If the appropriate research variables have been defined from the research questions and these research variables are translated appropriately to relate directly to the questions that are framed in the survey tool for the research participants, then the chosen research methodological approach should be appropriate for the study.

The advantage with the chosen approach is that it allows the relationships between the identified variables to be examined within the limited available time for the study and in a cost-effective manner. The disadvantage is that we would not be able to establish any causal relationship between variables.

An online survey questionnaire, which is a non-interactive method of collecting the data, was used to collect the data for this study.

Although innovation infrastructure plays a foundation role in supporting emerging technology innovation in a country, for this study we assumed innovation infrastructure to be a fixed variable because South Africa as compared to other developing nations in Africa, especially in urban areas, has a world class innovation infrastructure. Therefore, infrastructure support for emerging technology innovation has been treated as a given.

The study will be confined to Gauteng province which is regarded as the innovation hub for the country and we assume that respondents in this province will reflect the national perspectives and experiences.

RESULTS

The sample for this study was made up of 40 respondents from various fields and occupations. All respondents were from organisations that form part of the emerging technology innovation eco-system within Gauteng. Table 1 gives a summary of the sample characteristics.

	Frequency	Percent
Engineer	15	37.5
Scientist	4	10.0
CEO	2	5.0
Bio-entrepreneur	1	2.5
Business person	1	2.5
Commercialisation Manager in research environment	1	2.5
Director	1	2.5
Executive	1	2.5
Incubation Manager for Wits University	1	2.5
Innovation Manager	1	2.5
IT	1	2.5
IT Management Consultant	1	2.5
Management Consultant	1	2.5

	Frequency	Percent
Marketing Director	1	2.5
Programme Manager	1	2.5
R&D Manager	1	2.5
Research Manager	1	2.5
Sales Area Manager	1	2.5
Senior Marketer	1	2.5
Technopreneur	1	2.5

Table 1: Sample characteristics

Various organisations that are based in Gauteng were represented in the sample, including institutions from the private sector, higher education, public research organisations, and private research organisations. Figure 3 is a chart showing the types of organisation represented in the study sample.

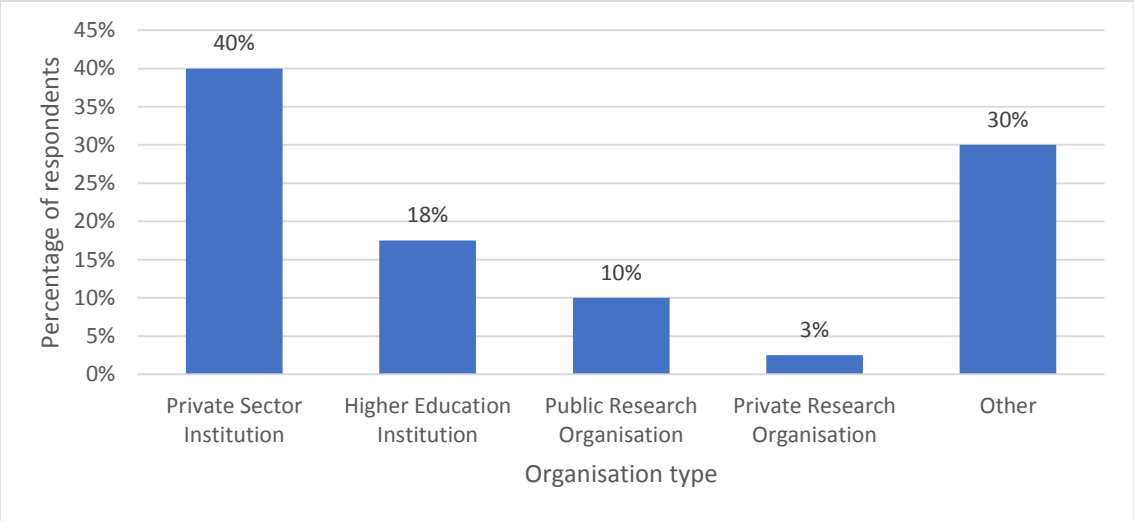

Figure 3: Types of organisation

Most of the respondents in the sample were from the digital technologies innovation space. Figure 4 shows a chart with the fields of emerging technology innovations represented in the sample.

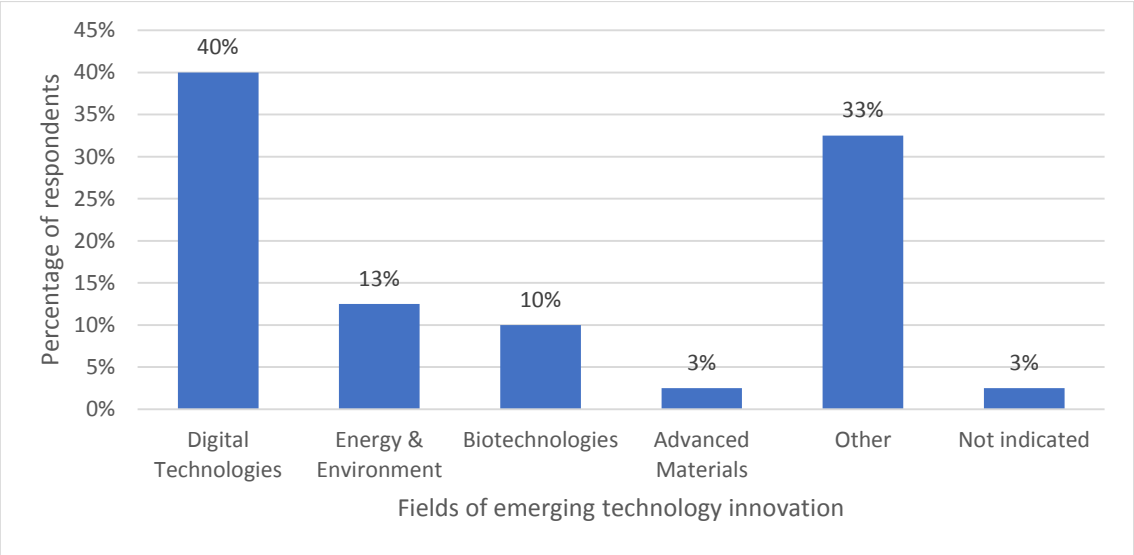

Figure 4: Fields of emerging technology innovation

In this study, the number of registered patents (Poorkavoos et al., 2016; Seidel et al., 2013) and commercialised technologies (Moon et al., 2017) were used as an output measure of innovation performance. Innovation performance was therefore computed by adding the number of patents registered and number of innovation projects commercialised in the last ten years. Table 2 shows the total number of patents registered and innovation projects commercialised in the last ten years.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Number of patents registered or assisted to be register in the last 10 years	35	0	150	10	29.993
Number of products, services or process innovation projects commercialised or assisted to commercialise in the last 10 years	35	0	200	18	37.821
Innovation performance	35	.00	200.00	28	52.431

Table 2: Innovation performance

According to the study results the average number of patents registered in the last ten years for the sample was ten and the average innovation projects commercialised in the last ten years for the sample was 18. This resulted in a total average innovation performance output of 28 for the sample. The study tested the

relationship between innovation performance, regarded as the dependent variable, and independent variables listed in Table 3.

Variable	Option	Frequency	Percent
Which of the following characteristics best describe the character of your funders?	They are risk averse	19	47.5%
	They are risk takers	9	22.5%
	They are protectionists	3	7.5%
	They are adventurous	7	17.5%
	Not indicated	2	5.0%
What percentage of the overall sales revenue or total income is invested into R&D activities in your organisation?	0%	7	17.5%
	0% - 5%	9	22.5%
	5% - 10%	4	10.0%
	10% - 20%	4	10.0%
	Above 20%	15	37.5%
	Not indicated	1	2.5%
What is the innovation funding structure of your organisation?	100 % privately funded	15	37.5%
	Mixed funding model	20	50.0%
	100 % government funded	5	12.5%
Which of the government funding mechanisms has had the most impact on innovation activities in your organisation?	Government subsidies	5	12.5%
	Government grants	15	37.5%
	None	18	45.0%
	Government tender contracts	1	2.5%
	Varied in my unit	1	2.5%
How often does your organisation collaborate with Higher Education Institutions?	None	9	22.5%
	Seldom	2	5.0%
	Sometimes	6	15.0%
	Often	6	15.0%
	Very often	16	40.0%
	Not indicated	1	2.5%
How often does your organisation collaborate with Public Research Organisations?	None	10	25.0%
	Seldom	4	10.0%
	Sometimes	11	27.5%
	Often	6	15.0%
	Very often	8	20.0%
	Not indicated	1	2.5%
How often does your organisation collaborate with Private Research Organisations?	None	15	37.5%
	Seldom	8	20.0%
	Sometimes	4	10.0%
	Often	9	22.5%
	Very often	3	7.5%
	Not indicated	1	2.5%
How often does your organisation collaborate with Private Sector	None	7	17.5%
	Seldom	5	12.5%

Variable	Option	Frequency	Percent
Institutions?	Sometimes	9	22.5%
	Often	14	35.0%
	Very often	5	12.5%
How often does your organisation use patents developed by others to innovate?	Not at all	20	50.0%
	Seldom	7	17.5%
	Sometimes	7	17.5%
	Often	4	10.0%
	Very often	2	5.0%
How often does your organisation share information, knowledge and technology with other players in the industry?	Not at all	4	10.0%
	Seldom	8	20.0%
	Sometimes	9	22.5%
	Often	10	25.0%
	Very often	9	22.5%
What is the average level of qualification for employees in your organisation?	Matric	4	10.0%
	Diploma	9	22.5%
	Degree	12	30.0%
	Postgraduate degree	15	37.5%
What is the average qualification level for leaders in your organisation?	Matric	1	2.5%
	Diploma	4	10.0%
	Degree	10	25.0%
	Postgraduate degree	25	62.5%
Which of the following characteristics best describe the character of the majority of the employees in your organisation?	They are risk averse	11	27.5%
	They are risk takers	9	22.5%
	They are protectionists	6	15.0%
	They are adventurous	14	35.0%
How much of their knowledge and skills do employees apply to support innovation in your organisation?	A great deal	14	35.0%
	A lot	15	37.5%
	A moderate amount	9	22.5%
	A little	2	5.0%
Which of the following characteristics best represents the character of the leadership	They are risk averse	8	20.0%
	They are risk takers	11	27.5%
	They are protectionists	3	7.5%
	They are adventurous	17	42.5%
	Not Indicated	1	2.5%
What benefits has your organisation derived from the country's innovation policies?	Improved networking and collaboration	17	42.5%
	Improved investment on R&D	7	17.5%
	Improved investment on innovation activities and/or infrastructure	8	20.0%
	Reduced uncertainty and risk	4	10.0%
	No benefits at all	17	42.5%

Table 3: Other variables

Prior to analysing the results, tests for measurement scale validity and reliability were conducted. Exploratory factor analysis was used to assess the validity of the collaboration construct which had four items measured using a five-point Likert scale. The results showed that factor analysis was feasible, with a Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value of 0.625, which is higher than the minimum acceptable value of 0.5, confirming that the sample was good enough to run factor analysis. The Bartlett's Test of Sphericity was significant, which indicates that the items within the scale were correlated and thus factor analysis was feasible.

The factor analysis results indicated that the collaboration construct retained one factor which explained the 54.283% of variation in the original four items. All four items loaded highly onto the retained factor with the minimum factor loading being 0.630, which is higher than the minimum acceptable value of 0.4. Thus, the collaboration construct is valid.

Reliability tests were done on the collaboration construct using the Cronbach's Alpha and the tests gave a Cronbach's Alpha of 0.710, which is slightly higher than the minimum acceptable value of 0.7. Although is on the borderline, the results mean that the four items on the collaboration scale can be grouped together to form a summated scale. The summated scale was computed using the average ratings of collaboration with the various institutions.

A normality test was conducted using Kolmogorov-Smirnov and Shapiro-Wilk tests to assess whether the dependent variable, innovation performance, is normally distributed. Both the Kolmogorov-Smirnov test and the Shapiro-Wilk test gave p-values (sig) of less than 0.05, indicating that innovation performance is not normally distributed. Hence, hypothesis/proposition testing was done using non-parametric tests.

Proposition 1

The character of the funders affects the relative and absolute innovation levels of the country.

The Kruskal-Wallis test was conducted to assess whether the characteristics that best describe the character of the funder have an impact on the innovation performance.

The results show a chi-square value of 3.733 and a p-value of 0.292. Since the p-value is greater than 0.05, it means that there is no relationship between the characteristics that best describe the character of the funder and innovation performance.

The Kruskal-Wallis test was also conducted to assess whether the innovation funding structure of an organisation has an impact on the innovation performance.

The results gave a chi-square value of 0.042 and a p-value of 0.979. Since the p-value is greater than 0.05, it means that there is no relationship between the innovation funding structure of an organisation and innovation performance.

The Kruskal-Wallis test was also conducted to assess whether the government funding mechanism has an impact on the innovation performance.

The results show a chi-square value of 0.794 and a p-value of 0.373. Since the p-value is greater than 0.05, it means that there is no relationship between the government funding mechanism and innovation performance.

Therefore, based on the three sub-propositions, it can be concluded that there is no relationship between the character of the funders and the relative and absolute innovation levels in the country.

Proposition 2

The level of R&D funding is an important determinant of the innovation performance and consequently the emerging technology innovation performance in the country.

The Kruskal-Wallis test was conducted to assess whether the level of R&D funding is an important determinant of the innovation performance and consequently the emerging technology innovation performance in the country. The results gave a p-

value of 0.106 (p-value > 0.05). This shows that the level of R&D funding is not an important determinant of the innovation performance.

Proposition 3

Strong networks and collaborations among actors in the NSI have a positive effect on the innovation output of the country if the country has strong internal innovation capabilities.

Spearman's correlation analysis was conducted to assess whether strong networks and collaborations among actors in the NSI have a positive effect on the innovation output of the country. The analysis results reveal that there is no relationship between innovation performance and collaboration (r= - 0.021, p-value > 0.05) since the p-value is greater than 0.05.

Proposition 4

The success of the country in innovation depends on the internal capabilities of that country to use both its internal and external resources.

Spearman's correlation analysis was conducted to assess whether the success of the country in innovation depends on the internal capabilities of that country to use both its internal and external resources.

The results show that innovation performance does not depend on frequency of sharing information, knowledge and technology with other players in the industry since the p-value is greater than 0.05 (r = 0.077, p-value > 0.05).

The Kruskal-Wallis Test was conducted to assess whether the innovation performance is dependent on the average qualification level of employees in an organisation.

The results show that innovation performance does not depend on the average qualification level of employees in an organisation since the p-value (0,144)>0.05.

Proposition 5: *Innovation human capital competence, attitude, intellectual agility and leadership innovativeness have a positive relationship with the innovation performance of the country.*

The Kruskal-Wallis Tests were conducted to assess whether innovation human capital competence, attitude, intellectual agility and leadership innovativeness have a positive relationship with the innovation performance of the country.

The tests reveal that there is no significant difference in innovation performance by average level of qualification for leaders in the organisation since the results show a p-value > 0.05 (p-value = 0.256).

The results of the Kruskal-Wallis Tests show that there is no significant difference in innovation performance based on characteristics that best describe the majority of the employees in the organisation since p-value>0.05 (p-value = 0.736).

The results of the Kruskal-Wallis Tests show that there is no significant difference in innovation performance based on knowledge and skills employees apply to support innovation since the p-value>0.05 (p-value=0.129).

The Kruskal-Wallis Tests Results reveal that there is no significant difference in innovation performance based on the character of the leadership in the organisation since the p-value>0.05 (p-value = 0.120). Therefore, the test results indicate that the innovation performance does not depend on the innovation human capital competence, attitude, intellectual agility and leadership innovativeness in the organisation.

Proposition 6

Innovation policy affects innovation output of the country positively by encouraging high levels of collaboration in the NSI and investment in R&D and other innovation activities in the country.

Each variable was coded as 1 if the benefit was selected and 0 if the benefit was not selected in the survey questionnaire. Four innovation policy benefits were

tested in the survey. Spearman's correlation was conducted between benefits of innovation policy and innovation performance.

The analysis results indicate that there is no correlation between innovation performance and each of the innovation policy benefits tested during the study: improved networking and collaboration (r=0.189, p-value>0.05), improved investment on R&D (r=0.142, p-value>0.05), improved investment on innovation activities and/or infrastructure (r=0.106, p-value>0.05), and reduced uncertainty and risk (r=0.15, p-value>0.05) since the p-values are greater than 0.05.

We further conducted Spearman's correlation between benefits of innovation policy and collaboration. Each variable was coded as 1 if the benefit was selected and 0 if the benefit was not selected.

The results show that there is a positive and significant correlation between collaboration and improved investment on innovation activities and/or infrastructure (r = 0.451, p-value = 0.01) since the p-value was less than 0.05.

However, there was no correlation between collaboration and each of the following: improved networking and collaboration (r = 0.002, p-value > 0.05), improved investment on R&D (r = 0.275, p-value > 0.05), and reduced uncertainty and risk (r = 0.225, p-value > 0.05) since the p-values are greater than 0.05.

Most respondents indicated that innovation policy has improved networking and collaboration. The analysis above also shows that there is a positive and significant correlation between collaboration and improved investment on innovation activities and/or infrastructure. This is an important finding because it implies that although there is no correlation between innovation policy and innovation performance, innovation policy can help boost investment in innovation activities and/or infrastructure by creating an environment where there is more collaboration within the innovation eco-system.

DISCUSSION

The study showed that neither the character of the funders, innovation funding structure nor government funding mechanisms have a relationship with the

innovation performance of the country. It further showed that the level of R&D funding is not an important determinant of innovation performance.

No significant relationship was found between innovation performance and collaboration. No relationship was identified between sharing of information, knowledge and technology with other players and innovation performance. Hence no confirmation was found to prove that innovation performance is dependent on the internal capability of the country to use its internal and external resources.

The results confirmed that there was no significant difference in innovation performance that could be associated with qualification levels of employees and leaders in the organisation, the character of employees and leaders in the organisation, or the use of knowledge and skills by the employees in the organisation. No proof was found to suggest that innovation performance is dependent on innovation human capital competence, attitude, and intellectual agility or leadership innovativeness. Results showed no evidence that strong networks, collaboration and strong internal innovation capabilities lead to innovation performance.

No significant relationship was found between innovation policy benefits and innovation performance, hence there is no proof to suggest any association between innovation policy and innovation performance in the country.

The study failed to prove the existence of any association between innovation performance and the independent variables that were studied. The results showed that none of the four constructs covered in this study – innovation funding, the NSI, innovation human capital, and innovation policy – has strong correlation with innovation performance. A country can lack any of the four constructs and still perform well in innovations.

The research results confirmed a strong correlation between collaboration and investment in innovation activities or infrastructure. Collaboration also emerged as the highest benefit that innovation policy provides. This finding supports the findings of previous studies which showed that failure to connect to the right networks has a negative effect on accessing finance and other forms of support for innovation activities and that the interactions between actors in the NSI allow the

flows of funds and knowledge between actors as influenced and governed by various policies and instruments put in place by the government (Chalmers, 2013; Kahn & Blankley, 2005).

CONCLUSION

The research findings confirmed the existence of a strong correlation between collaboration and investment in innovation activities or infrastructure. The results also showed collaboration as the highest benefit that innovation policy provides. Therefore, based on these results, innovation policy instruments can be used to influence innovation funding by increasing levels of collaboration. Strong collaboration is a reflection of healthy levels of interactions among actors in the NSI. This finding highlight the influence that innovation policy instruments have on NSI and innovation funding. Although there is no proof to suggest any association between innovation policy and innovation performance in the country, innovation policy instruments can be used to improve collaboration which will, as a consequence, have a positive influence on investment in innovation activities or infrastructure in the country.

The research findings could be an indication that the country's innovation performance cannot be determined by a single factor, but is the outcome of a combination of factors which, when working together, produce a certain innovation performance in the country. We therefore suggest that further study be done with a bigger sample to confirm our results and that a fuzzy set qualitative comparative analysis be used to identify possible multiple sets of combinations of the study constructs – innovation funding, the NSI, innovation human capital, and innovation policy – that may causally relate to the innovation performance of the country (South Africa).

ACKNOWLEDGEMENTS

First and foremost I would like to take this opportunity and thank God Almighty for giving me the opportunity, ability and strength to complete this project. I also want to thank my wife and our four kids for sacrificing their time and giving me support throughout this journey.

I would like to acknowledge and thank my supervisor, Anton Christopher, for his guidance and support on this project. Thank you also Honest Muchabai for assisting me with data analysis in this project. To all of you who provided me with moral support, I say thank you.

I appreciate the professionalism and the quality of service of technical editor Ronèl Gallie and language editor Leonie Viljoen, who helped to make my article read and look professional.

REFERENCES

Adao, V. (2016). *How the fourth industrial revolution will impact jobs*. Retrieved from https://www.moneyweb.co.za/news/tech/fourth-industrial-revolution-will-impact-jobs/

Baatjies, W. (2013). *South Africa's National Innovation System: Policy and institutional landscape*. Paper presented at the ESASTAP Workshop, East London. Retrieved from www.esastap.org.za/download/present01_innov_session_may2013.pdf

Beynon, M., Jones, P., & Pickernell, D. (2016). Country-level investigation of innovation investment in manufacturing: Paired fsQCA of two models. *Journal of Business Research, 69*(11), 5401-5407.

Blau, J. (2010). East Europe innovation still far behind West. *Research Technology Management, 53*(2), 8.

Blau, J. (2008). Finland to implement new innovation strategy. *Research Technology Management, 51*(6), 2-4.

Chalmers, D. (2013). Social innovation: An exploration of the barriers faced by innovating organizations in the social economy. *Local Economy, 28*(1), 17-34.

Chen, C.-J., & Huang, J.-W. (2009). Strategic human resource practices and innovation performance—The mediating role of knowledge management capacity. *Journal of Business Research, 62*(1), 104-114.

Curado, C., Muñoz-Pascual, L., & Galende, J. (2018). Antecedents to innovation performance in SMEs: A mixed methods approach. *Journal of Business Research, 89,* August, 206-215.

De Jong, J. P., & Vermeulen, P. A. (2006). Determinants of product innovation in small firms: A comparison across industries. *International Small Business Journal, 24*(6), 587-609.

Department of Science & Technology. (2007). *Innovation towards a knowledge-based economy: Ten-year plan for South Africa (2008-2018).* Pretoria: Department of Science and Technology.

Etzkowitz, A., & Etzkowitz, H. (2017). Counter-cyclical public venture capital: Debt-funding as an anti-austerity innovation strategy. *Social Science Information, 56*(3), 477-495.

Fernández Sastre, J., Vera, V., & Eduardo, C. (2017). Cooperation for innovation in developing countries and its effects: evidence from Ecuador. *Journal of Technology Management & Innovation, 12*(3), 48-57.

Gobble, M. A. M. (2016). Human Resources as an engine of innovation. *Research-Technology Management*, *59*(3), 68-70.

Godin, B. (2009). National innovation system: The system approach in historical perspective. *Science, Technology, & Human Values, 34*(4), 476-501.

Griffiths, M. D., & Kickul, J. (2008). The socioeconomic determinants of innovation: An empirical examination. *The International Journal of Entrepreneurship and Innovation, 9*(4), 231-240.

Holden, G. (2011). Innovation clusters: Creating jobs, retaining talent. *Research-Technology Management, 54*(5), 5.

Huo, J. (2009). The role of interfirm networks in technological innovation and education. *Comparative Political Studies, 42*(5), 587-610.

Industrial Development Corporation (IDC). (2017). *Economic trends: Key trends in the South African economy.* Retrieved from https://www.idc.co.za/images/2017/IDC_RI_publication_Key-trends-in-SA-economy_31-March-2017.pdf

Isaksen, A., Normann, R. H., & Spilling, O. R. (2017). Do general innovation policy tools fit all? Analysis of the regional impact of the Norwegian Skattefunn scheme. *Journal of Innovation and Entrepreneurship, 6*(1), 6. Retrieved from https://doi.org/10.1186/s13731-017-0068-x

Jenson, I., Leith, P., Doyle, R., West, J., & Miles, M. P. (2016a). Innovation system problems: Causal configurations of innovation failure. *Journal of Business Research, 69*(11), 5408-5412.

Jenson, I., Leith, P., Doyle, R., West, J., & Miles, M. P. (2016b). Testing innovation systems theory using qualitative comparative analysis. *Journal of Business Research, 69*(4), 1283-1287.

Kahn, M., & Blankley, W. (2005). The changing face of South Africa's national system of innovation, 1991–2001. *Industry and Higher Education, 19*(2), 121-130.

Landabaso, M. (2014). Guest editorial on research and innovation strategies for smart specialisation in Europe: Theory and practice of new innovation

policy approaches. *European Journal of Innovation Management, 17*(4), 378-389.

Letseka, M. (2005). Government incentivization of partnerships in South Africa: An audit of THRIP and the innovation fund. *Industry and Higher Education, 19*(2), 161-168.

Lucio-Arias, D. (2006). Fuelling a national innovation system in Colombia. *Industry and Higher Education, 20*(4), 237-241.

Martin, S., Pahor, M., & Jaklič, M. (2015). The structure of policy-induced innovation networks in Slovenia. *European Journal of Innovation Management, 18*(4), 428-450.

Mas-Verdu, F., Ortiz-Miranda, D., & García-Álvarez-Coque, J. M. (2016). Examining organizational innovations in different regional settings. *Journal of Business Research, 69*(11), 5324-5329.

McCann, J. J., Hills, E. B., Zauszniewski, J. A., Smith, C. E., Farran, C. J., & Wilkie, D. J. (2011). Creative partnerships for funding nursing research. *Western Journal of Nursing Research, 33*(1), 79-105.

Moon, H., Mariadoss, B. J., & Johnson, J. L. (2017). Collaboration with higher education institutions for successful firm innovation. *Journal of Business Research* [in press].

O'Connor, A., Roos, G., & Vickers-Willis, T. (2007). Evaluating an Australian public policy organization's innovation capacity. *European Journal of Innovation Management, 10*(4), 532-558.

O'Connor, G. C. (2009). Sustaining breakthrough innovation. *Research-Technology Management, 52*(3), 12-14.

OECD. (2016). *OECD Science, technology and innovation outlook 2016*. Retrieved from http://dx.doi.org/10.1787/sti_in_outlook-2016-en

Osman-Gani, A. M. (2004). Human capital development in Singapore: An analysis of national policy perspectives. *Advances in Developing Human Resources, 6*(3), 276-287.

Page, C., & Meyer, D. (2005). *Applied research design for business and management.* Australia: The McGraw-Hill Companies, Inc. (Pty) Ltd.

Pages, E. R. (2010). Obama's innovation policy: Can the new directions hold? *Local Economy, 25*(8), 678-684.

Parziale, F., & Scotti, I. (2016). Education as a resource of social innovation. *SAGE Journals*, July-Sptember, 1-9. Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/2158244016662691

Poorkavoos, M., Duan, Y., Edwards, J. S., & Ramanathan, R. (2016). Identifying the configurational paths to innovation in SMEs: A fuzzy-set qualitative comparative analysis. *Journal of Business Research, 69*(12), 5843-5854.

Reiljan, J., & Paltser, I. (2015). The influence of research and development policy: the case of Estonia in the EU. *European Journal of Innovation Management, 18*(3), 307-329.

Rodriguez, V., & Montalvo, C. (2007). Innovation policies from the European Union: Methods for classification. *Bulletin of Science, Technology & Society, 27*(6), 467-481.

Schmitt, J. M. (2005). Financing innovation in the German healthcare system. *Journal of Medical Marketing, 5*(2), 126-129.

Schwab, K. (2016). *The fourth industrial revolution: What it means, how to respond.* Retrieved from https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

Seidel, U., Müller, L., Köcker, G. M. Z., & Filho, G. D. A. (2013). A new approach for analysing national innovation systems in emerging and developing countries. *Industry and Higher Education, 27*(4), 279-285.

Siyanbola, W., Olaopa, O., & Hassan, O. (2013). Designing and implementing a science, technology and innovation policy in a developing country: Recent experience from Nigeria. *Industry and Higher Education, 27*(4), 323-331.

Turpin, T., Woolley, R., & Marceau, J. (2010). Scientists across the boundaries: National and global dimensions of scientific and technical human capital (STHC) and policy implications for Australia. *Asian and Pacific Migration Journal, 19*(1), 65-86.

Tylecote, A. (2007). The role of finance and corporate governance in national systems of innovation. *Organization Studies, 28*(10), 1461-1481.

Urban-Econ Development Economists. (2017). *Technological Innovation Agency economic impact assessment*. Retrieved from https://www.tia.org.za/files/2017/12/201617-TIA-Economic-Impact-Assessment-Report.pdf

Van der Walt, T., & Blankley, W. (1999). South African strategies for promotion of research and technology innovation – Towards effective collaboration and new business development. *Industry and Higher Education, 13*(1), 4-8.

Wang, X., & Dass, M. (2017). Building innovation capability: The role of top management innovativeness and relative-exploration orientation. *Journal of business research, 76*(1), 127-135.

Weigel, T., & Goffin, K. (2015). Creating innovation capabilities. *Research Technology Management*, *58*(4), 28-35.

Welman, C., Kruger, F., & Mitchell, B. (2005). *Research methodology*. Cape Town, South Africa: Oxford University Press South Africa (Pty) Ltd.

World Economic Forum (WEF). (2017). *The jobs of the future – and two skills you need to get them*. Retrieved from https://www.weforum.org/agenda/2016/09/jobs-of-future-and-skills-you-need/

Yoshida, P. G. (2001). Asian economies striving to enhance innovation capabilities. *Research Technology Management, 44*(1), 2-6.