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Modelling the Innovation Value Chain: Evidence from Manufacturing Sector SMMEs in South Africa

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A dissertation submitted to the Wits Business School in the University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in the field of Innovation Studies

Johannesburg, 2018

ABSTRACT

The development of Small, Medium and Micro-sized Enterprises, or SMME firms, is at the centre of the South African government's policy and strategic priorities. The attention on SMMEs is not misplaced; they make up the largest share of private businesses in South Africa, employing over 61% of the nation's workforce and contribute to up to 60% of South Africa's gross domestic product (GDP). However, despite this attention, innovation research is still largely transfixed on large firms. As a consequence, it is not surprising that the inner-workings of innovation activities in SMMEs are relatively not a well-understood phenomenon globally, and more so, in South Africa in particular.

Two aims were pursued in this report using evidence from a firm level dataset drawn from the 2013 South African Business Innovation Survey. Firstly, it sought to characterise the influence of knowledge sources on the development of innovations in SMMEs through the innovation value chain framework. Secondly, the study investigates and identifies the determinants of innovations in manufacturing sector SMMEs.

The research is quantitative in nature and consists of three empirical investigations making use of several established econometric tools. The findings make practical contributions in the area of inter-organizational learning and management of innovation in SMME. In particular, the influences of knowledge linkages on firm performance were identified and the extent to which some of the determinants of small firm innovation were interrogated. While the findings permit the research to drawn various implications and contributions from this work. It is comforting to note that in as far as the information–innovation–performance nexus goes – it matters greatly for the SMME's performance if the firm succeeds in introducing significantly improved or new products and processes.

KEYWORDS: South Africa, Small medium and micro enterprises (SMMEs), Dynamics of innovation, Innovation value chain, Manufacturing

DECLARATION

I, Ronald Machaka, declare that this dissertation is my own unaided work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Innovation Studies at the Wits Business School in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other University.



_____

Ronald Machaka, PhD

20th of August 2018

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The earliest draft of this report benefited from the revisions courtesy of my brother Nicholas Nhepera – *Shaya Jnr.!*

The moral and financial support from I received from my family and the unconditional patience of my daughter Anopa and loving wife, Sibu cannot go unnoticed. Thank you.

To my late sister Lindiwe J. Machaka, BA; thank you for the random visits to my WBS classes… it was really great while it lasted. On the anniversary of your untimely passing, I dedicate my efforts to your memory, my dear.

“

FOR THE THINGS WE HAVE TO LEARN BEFORE WE CAN DO THEM, WE LEARN BY DOING THEM.

” The Nicomachean Ethics, Book II

Aristotle (350 B.C.)

DEDICATED TO THE MEMORY OF MY DEPARTED SISTER

JANNET LINDIWE MACHAKA
(18 Dec. 1989 – 20 Aug. 2017)

LIST OF ABBREVIATIONS & ACRONYMS

ABBREVIATIONS	DESCRIPTION
CeSTII	Centre for Science, Technology and Innovation Indicators
CIS	Community Innovation Survey
CDM	Crépon, Duguet and Mairesse or Crépon-Duguest-Mairesse
DTI	Department of Trade and Industry
DSBD	Department of Small Business Development
Eurostat	Statistical Office of the European Commission
GDP	Gross Domestic Product
HSRC	Human Sciences Research Council
IPAP	Industrial Policy Action Plan
IVC	Innovation Value Chain
MVP	Multi-variate Probit (regression approach)
NDP	National Development Plan
OECD	Organisation for Economic Co-operation & Development
R&D, RDI	Research and Development, Research, Development & Innovation
SA, RSA	South Africa, Republic of South Africa
SABIS	South African Business Innovation Survey, South African Innovation Survey
SARS	South African Revenue Services
SEDA	Small Enterprise Development Agency
SME	Small and Medium Enterprise
SMME	Small, Medium and Micro Enterprise
Variables and symbols	* See Appendix B

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CHAPTER 1.
INTRODUCTION

1.1 PURPOSE OF THE STUDY

There is a growing body of literature on various aspects of the Small, Medium and Micro-sized Enterprises (SMMEs) (Abor & Quartey, 2010; Beck, Demirguc-Kunt, & Levine, 2005; Bell, Crick, & Young, 2004; Booyens, 2011). The interest is backed by studies suggesting that SMMEs currently have a large share of new jobs and job creation opportunities and employs the highest proportion of the workforce, even after controlling for the age of the firm (Tidd & Bessant, 2013). The interest is also informed by the seminal 1912 Schumpeterian 'creative destruction' arguments (Schumpeter, 1912) that it is the SMMEs that challenge large established firms by introducing new innovation (OECD, 2010, p. 27).

In more recent research reports, such as (Malone, Mazzarol, & Reboud, 2014; Roper & Hewitt-Dundas, 2017; Smit, 2015), the importance of such small businesses, as seedbeds of new-to-the-market innovation is still undoubted, see also (Abor & Quartey, 2010; Booyens, 2011; Tidd & Bessant, 2013). In more recent South African studies; (Booyens, 2011; Muringani, 2014; Phiri, Molotja, Makelane, Kupamupindi, & Ndinda, 2016; SEDA, 2012) and the 2008 Innovation Survey (Moses, Sithole, Labadarios, & Blankley, 2011) researchers concluded that SMMEs may be more innovative than large enterprises in the South African economic environment.

SMMEs have been an object of fascination for researchers, policymakers and governments alike (Beck et al., 2005; Berry et al., 2002; Malone et al., 2014; Roper & Hewitt-Dundas, 2017). For example, to support and promote the growth of SMMEs in South Africa, the Government established a Ministry under the National Small Business Amendment Act 26 of 2003 (2004).

Despite this, much of the research attention on innovation has been focused on larger firms (Roper & Hewitt-Dundas, 2017). It is thus not surprising that the inner-workings of innovation activities in small firms is relatively an under-researched

phenomenon globally, and more so, in South Africa in particular (Abor & Quartey, 2010; Beck et al., 2005; Bell et al., 2004; Berry et al., 2002; Booyens, 2011; Tidd & Bessant, 2013).

The study seeks to explore the innovation strategies of manufacturing SMMEs in the South Africa context. Specifically, the study intends to assess the influence of knowledge linkages (sources) on business performance through the innovation value chain framework.

Findings from this study will offer:

- Researchers and innovation practitioners, an aggregated view of the SA SMME innovation efforts; giving a more end-to-end treatment to innovation, focusing on knowledge sourcing and the impact of the sourced knowledge to the entire innovation value chain.
- SMME managers, owners, and interested stakeholders a breakdown of their innovation efforts into three dimensions to take advantage of the combined effect between firms' internal and external sources of knowledge and overcome the great stagnation plaguing South Africa's manufacturing sector in general as pointed out by SEDA (2012, pp. ii, 50), DED (2011) and DTI (2016).
- Policymakers and related agencies recommendations to institutions on what can be done to facilitate innovation in small firms in order to enable them to realise their full potential.

1.2 CONTEXT OF THE STUDY

The National Development Plan adopted by the South African government in 2014 (Commission, 2012) outlines its long-term strategic plan. The plan spells out comprehensive goals to be achieved by 2030. These include:

> *"Building consensus on the key obstacles to us achieving these goals and what needs to be done to overcome those obstacles.*
>
> *Providing a shared long-term strategic framework within which more detailed planning can take place in order to advance the long-term goals set out in the NDP.*
>
> *Creating a basis for making choices about how best to use limited resources" (Morris, 2013).*

The NDP, among other key national strategic initiatives, recognises the importance of SMMEs in South Africa as potential sources of economic growth, as key drivers of prosperity, and a possible solution to many socio-economic problems such as high unemployment according to the NPC (2013) and Muringani (2014).

This focus is not misplaced. In fact, SMMEs makeup over 91% of the private businesses in South Africa, employs over 61% of the nation's workforce and contribute up to between 52 and 57% to South Africa's GDP (Abor & Quartey, 2010). Booyens (2011). More recently Muringani (2014) largely concurs with Abor & Quartey and Booyens in suggesting that SMMEs may be more innovative than large enterprises in the South African context. Furthermore, these statistics are not unique to South Africa; even in the industrialised, other industrialising countries, and non-industrialised economies, SMMEs are the largest employer of workers rather than large businesses (Bell et al., 2004; Malone et al., 2014; Page & Söderbom, 2015).

Scholars around the world, and especially in the Global North, have produced a vast body of research on the processes of innovation in larger firms. However, as Muringani (2014) decorously points out, the literature shows that research into the processes of innovation in SMMEs per se largely remains ignored (Booyens, 2011; Malone et al., 2014; Mazzarol & Reboud, 2011; Tidd & Bessant, 2013). Focus and efforts remain largely transfixed on their larger-sized firms for a possible number of reasons:

- Schumpeter's Mark II arguments (Roper & Hewitt-Dundas, 2017; Schumpeter, 1942).
- SMMEs are a heterogeneous group of enterprises; ranging from lone survivalists, operating in the poorest stratum of the population (informal micro-enterprises), all the way to established formal businesses employing a few hundred people (medium-sized enterprises) (Berry et al., 2002).
- A widespread lack of information on innovation in small firms because small firms are sometimes closed and secretive (Muringani, 2014; Tidd & Bessant, 2013). Furthermore, Roper and Hewitt-Dundas (2017) argue that the innovation processes tends to be observed as after-effects rather than current phenomena.
- (Booyens, 2011; Moses, Sithole, Blankley, et al., 2012; Moses et al., 2011; Roper & Hewitt-Dundas, 2017), for example, established that innovation surveys

traditionally put emphasis on measures and actions in larger firms and may have contributed towards the systematic neglect of innovation in smaller firms.

- The perception that small firms are seen as transitory, bound to eventually grow into large firms (Tidd & Bessant, 2013).
- Innovation processes are not obviously observed in small firms, due to the "dynamic nature and potential rapidity" of the processes (Roper, Du, & Love, 2008; Roper & Hewitt-Dundas, 2017).

1.3 PROBLEM STATEMENT

The local manufacturing industry has been identified as one of the six core pillars of growth to drive the South African economy, see DED (2011) and DTI (2016). The role of the manufacturing sector SMMEs in South Africa has been emphasized in a wide range of national strategies and plans. The development of SMMEs is at the centre of the South African government's policy and strategic priorities (SEDA, 2012). Together they are an important element of the national government's long-term strategy which seeks to stimulate the economy, enhancing South Africa's competitiveness on both a regional and global levels, create decent jobs and ensure a better life for all its citizens (DED, 2011; DTI, 2016).

The first problem that this study seeks to address is the lack of sufficient reliable data points on innovation in small firms in general, often touted as a hindrance to econometric analysis.

Further, based on the context and background presented thus far, the second problem that this study seeks to address is that innovation activities in these manufacturing sector SMME firms in South Africa are an under-researched phenomena specifically in South Africa.

In attempting to address these problems, this study builds upon a few prior studies formulated using evidence and data derived from the South African innovation surveys (Booyens, 2011; Moses, Sithole, Blankley, et al., 2012; Mustapha & Mendi, 2015; Oerlemans & Pretorius, 2006) and many others that have made use of the innovation survey microdata to quantitatively study activities in firms.

1.4 RESEARCH AIMS AND OBJECTIVES

Two aims were pursued in this report using evidence from a firm level dataset drawn from the 2013 South African Business Innovation Survey. Firstly, it sought to characterise the influence of knowledge sources on the development of innovations in SMMEs through the innovation value chain framework. Secondly, the study investigates and identifies the determinants of innovations in manufacturing sector SMMEs.

On a more specific note, the objectives of this research are:

1. To identify those factors that significantly influence an SMME's decision to undertake innovative activities.
2. To identify the impact of different knowledge sources on business performance through the different links in the innovation value chain. This involves a more end-to-end treatment of innovation activities, taking into consideration knowledge sourcing, how that knowledge is transformed into new or significantly improved processes and products, and the eventual exploitation of innovation for value creation in the firm.
3. To examine the determinants of innovative ability in small firms.

1.5 SIGNIFICANCE OF THE STUDY

In order stimulate growth in the South Africa's economy and improve the quality of life for all, the manufacturing industry has been identified as 'one of the six core pillars or growth' and the development of SMMEs is at the heart of the South African government's policy and strategic priorities see DED (2011), (SEDA, 2012), and DTI (2016).

Clearly, together the SMMEs and the manufacturing sector together are important elements in the South African government's long-term plans which are aimed at stimulating the economy, enhancing South Africa's competitiveness on both regional and global levels, and creating decent job opportunities and a better life its citizens (DED, 2011; DTI, 2016).

In 2012, the Small Enterprise Development Agency (SEDA), an agency of the Department of Trade and Industries (DTI), published a research report entitled "*Analysis of the Needs, State and Performance of Small and Medium Businesses*

in the Agriculture, Manufacturing, ICT and Tourism Sectors in South Africa" (SEDA, 2012). The report identified the lack of innovation and creativity, lack of access to appropriate equipment and technology, shortage of technical skills, among others (SEDA, 2012, pp. ii, 50) as the general challenges that SMMEs in South Africa face.

> According to Hansen and Birkinshaw (2007) and Singh Panesar and Markeset (2008), innovation involves the creation and sourcing of new ideas from internal and external environment (consumers, competitors, universities, investors, suppliers, scientists and independent entrepreneurs – SMMEs in the South African manufacturing sector need not to suffer from their lack of 'innovation and creativity', lack of access to proper equipment and cutting-edge technology, and shortage of technical skills if they are not isolated (SEDA, 2012).

Therefore, it would be significant to consider the problem of the innovation strategies adopted by SMMEs in the manufacturing sector to understand the determinant factors that drive their innovation strategy and efforts.

The dissertation seeks to contribute to the existing theories, existing literature and to different stakeholders in a number of ways.

- First as foremost, from a scholarly perspective, small firms are a relatively under-researched phenomenon in South Africa (Abor & Quartey, 2010; Berry et al., 2002). However, even fewer studies have examined the, in particular, the inner-workings of innovation activities (Booyens, 2011; Muringani, 2014; SEDA, 2012). This work seeks to contribute towards enhancing the understanding and impact of different knowledge sources on the innovation processes.
- From a **policy-making perspective** according to Booyens (2011), the South African National Innovation Surveys and the related R&D surveys have not been 'rigorously' analysed by researchers. As such, she implies that policy-makers have very little insights to inform their SMME innovation policies upon. This work seeks to contribute towards further analysing the South African National Innovation Surveys and the related R&D surveys in this work from a fresh perspective.

- From a **management point of view**, the application and outcomes of the IVC modelling proposed for analysing SMMEs data from the South African National Innovation 2013 Survey will reveal detailed information that will help (the management of SMMEs in South Africa) identify strength and barrier factors aiding or frustrating each step in their innovation process, thereby emphasizing actionable strategic and policy priorities (Hansen & Birkinshaw, 2007; Neely & Hii, 1998).
- The IVC modelling approach adopted for this study will also demonstrate to **innovation practitioners, policymakers, SMME management, and other stakeholders** several innovation systems linkages (Ganotakis & Love, 2012) in the entire innovation value chain of SMMEs and how SMMEs are benefiting therefrom, or not.
- Invested stakeholders, including **policymakers, government agencies and venture capitalists** etc., will be able to propose and implement interventions and support programmes that are relevant, coherent and aligned to the needs of small firms in South Africa.
- Finally, very few researchers have interrogated how knowledge exchanges at the SMME level can augment the firm's innovative efforts (Ganotakis & Love, 2012; Spithoven, Frantzen, & Clarysse, 2010; Taghizadeh, Jayaraman, Ismail, & Rahman, 2014). This study aims at taking an in-depth perspective of how SMMEs in the manufacturing sector in South Africa innovate.

1.6 DELIMITATIONS OF THE STUDY

Delimitations are the boundaries a researcher sets in a study. Some of the delimitations that apply to this report are for instance;

i. This report provides a sense of the profile of the innovation patterns in the South African manufacturing sector, using data drawn from the 2013 South African Business Innovation Survey (SABIS2013). It is based on 138 SMMEs in the manufacturing sector in South Africa that responded to the survey questionnaire.

ii. In addition to (i), the study is based on microdata data; the current researcher had no control over the design of the original SABIS2013 survey in the 2010-2012 period when the survey was conducted.

iii. The study is therefore limited to the secondary cross-sectional SABIS2013 data. The cross-sectional nature of the research is a limitation, as it relates to the longitudinal perspective, especially given that no lags were built into the

econometric methods used. Therefore, changes in the SMME activities over time are not considered.

iv. Focusing on knowledge sourcing and the impact of the sourced knowledge the entire innovation value chain. Other determinants and such factors as those hampering innovation activities that are not linked to the innovation value chain and were therefore analysed separately.

v. Yet another limitation of the study relates to the heterogeneous nature of SMMEs as a group of firms; they can be inclusive of anything from the lone survivalist to established formal businesses employing a few hundred people (medium-sized enterprises) (Berry et al., 2002). In addition, the widespread lack of adequate information on innovation in small firms because such small firms are sometimes closed and secretive (Birch, 1987; Tidd & Bessant; 2009; Muringani, 2014).

1.7 ASSUMPTIONS

The research is based on secondary data drawn from the SABIS2013. It is based on 138 manufacturing sector SMMEs in South Africa that responded to the survey questionnaire. It is assumed that:

i. The sample study's or participating firms are as representative of the population of SMMEs in the manufacturing sector in South Africa the researcher wishes to make inferences on.
ii. The management of the participating SMMEs voluntarily decided to contribute to the study at the time the SABIS2013 was conducted.
iii. The SMME firms that participated in the SABIS2013 responded to the survey honestly and factually. Furthermore, the study assumes that the participants' responses to the survey's questions are relevant, informative, and insightful – that these responses will give insights into their experiences otherwise not obtainable without their participation.
iv. The analysis of the SABIS2013 data is considered to be well-intentioned and secure enough, so as to preserve anonymity and confidentiality of the firms that participated in the initial study.
v. Since the IVC framework and modelling tool are being applied to the South African context for the first time, the study assumes that the analysis tool and its models will give reliable outcomes.

1.8 DEFINITION OF KEY TERMS

The following key terms and concepts are defined as they are intended to be applied in this study:

Innovation: While innovation invokes different impressions to different individuals, especially in unrelated circumstances. For the purposes of this work, after Barrett and Sexton (2006), the following thinking is adopted "*innovation is a problem-solving process of generating, acquiring and/ or applying new knowledge for economically and socially beneficial purposes through efficient unfolding of various learning processes involving trial and error under conditions of uncertainty and complexity*" quoted as also by Muringani (2014).

Innovative firm: An innovative firm is "*one that has implemented an innovation during the period under review*" (OECD, 2005a, p. 152).

Innovation capacity: Innovation capacity is "*the ability of a firm to recognise the value of new external information, assimilate it and apply it to commercial ends is critical to its innovative capabilities*", according to Cohen and Levinthal (1990) or "the potential of a firm, a region or a nation to generate innovative outputs" depending on the connexions between firm's resource base, internal learning processes, and its external environment, according to Neely and Hii (1998) and Hii and Neely (2000).

Innovation process: The innovation process or sometimes "innovation management", is the conscious execution and control of activities such as knowledge sourcing (searching and researching), selection and implementation of ideas and capturing value through the transformation of these ideas into innovation (Hansen & Birkinshaw, 2007; Muringani, 2014; Roper & Hewitt-Dundas, 2017).

Innovation strategies: Innovation strategy is an organizational philosophy and approach relating to the conscious decisions it takes (on wide-ranging internal and external activities; including idea sourcing, collaborations and partnerships choices, resource allocation decisions, investment decisions, and adopted courses of action) as they carry out their innovation activities in order to enhance their innovative capacity and to meet their goals (Lendel & Varmus, 2013; Muringani, 2014).

Innovation value chain (IVC): Also known as the Hansen and Birkinshaw's IVC after the authors of the work in the Harvard Business Review in 2007 (Hansen & Birkinshaw). The IVC is both a framework and modelling tool. The IVC breaks down the innovation processes into three interrelated activities, beginning with a firm seeking knowledge from different sources for its innovation activities, then transforming the sought knowledge into outputs (such as new goods, services or processes), and finally the exploitation of the innovative firm' innovations into gains (Hansen & Birkinshaw, 2007; Neely & Hii, 1998; Roper & Hewitt-Dundas, 2017).

Small businesses: The National Small Business Act classifies firms as either survivalist, micro, very small, small, or medium enterprises according to their level of annual turnover and/or the number of employees within the firm (Abor & Quartey, 2010; Berry et al., 2002; Booyens, 2011; National Small Business Amendment Act 26 of 2003, 2004; SEDA, 2012), as shown in Table 1, below.

Table 1: Schedule of the SMMEs by size and annual turnover.

Enterprise Size	Number of Employees	Annual Turnover (in South African rands)	Gross Assets, Excluding Fixed Property
Medium	Fewer than 100 to 200. Industry dependent.	Less than R4 million to R50 million. Industry dependent.	Less than R2 million to R18 million. Industry dependent.
Small	Fewer than 50.	Less than R2 million to R25 million. Industry dependent.	Less than R2 million to R4.5 million. Industry dependent.
Very Small	Fewer than 10 to 20. Industry dependent.	Less than R200 000 to R500 000. Industry dependent.	Less than R150 000 to R500 000. Industry dependent.
Micro	Fewer than 5.	Less than R150 000.	Less than R100 000.

Source: National Small Business Amendment Act 26 of 2003 (2004)

SMMEs: SMMEs abbreviates small-, micro- and medium-sized enterprises (SMMEs). The firms are sometimes referred to as small-, and medium-sized enterprises (SMEs), or simply as small firms.

South African Innovation Survey, the: also known as the South African Business Innovation Survey (SABIS). The survey questionnaire is directly comparable Eurostat/OECD's Round 4 of the core questionnaire for the Community Innovation Survey (CIS 4) with customization, particularly a few questions tailored for the South African setting (Moses, Sithole, Makelane, Mudavanhu, & Kupamupindi,

2013). See also the SABIS2013 methodology Moses et al. (2011, p. 59); Moses et al. (2013, pp. 14-17).

1.9 CONCEPTUAL FRAMEWORK

The IVC framework selected for this work breaks down the firms' innovation process dimensions; (a) beginning with sourcing the knowledge necessary for innovation, (b) selecting and transforming of that knowledge into innovation outputs (such as new goods, services or processes), and finally (c) the exploitation of firms' innovations (Ganotakis & Love, 2012; Hansen & Birkinshaw, 2007; Neely & Hii, 1998; Roper et al., 2008).

Knowledge sourcing activities represent the commencement of a process of value creation through innovation (Ganotakis & Love, 2012; Hansen & Birkinshaw, 2007; Neely & Hii, 1998; Roper et al., 2008). Knowledge and ideas may originate from: the firms' internal sources such as 'in-house' R&D activities, or externally - through (a) collaborations with external partners or competitors, (b) linkages to customers or suppliers, or (c) linkages to research institutions or public knowledge sources such as universities.

Knowledge transformation activities constitute the subsequent step in the IVC (Ganotakis & Love, 2012; Hansen & Birkinshaw, 2007; Hseih, Love, & Ganotakis, 2011). This entails the process through which the knowledge is intentionally turned into tangible outputs (products or processes, in the context of this work) with the aid of the firm's resources and its adaptive capacity according to Ganotakis and Love (2012) and Cohen and Levinthal (1990), respectively.

Knowledge exploitation activities represent new market offerings as firms' try to capture the full market value from their innovations (Ganotakis & Love, 2012; Hansen & Birkinshaw, 2007; Neely & Hii, 1998; Roper et al., 2008; Singh Panesar & Markeset, 2008). The exploitation is typically operationalised into the firm's bottom-line performance (productivity, sales growth, or employment).

The overall conceptual framework depicted in Figure 1 underpins this study, it is based on studies conducted by Ganotakis and Love (2012). The contribution that this work adds to the knowledge base is the inclusion of

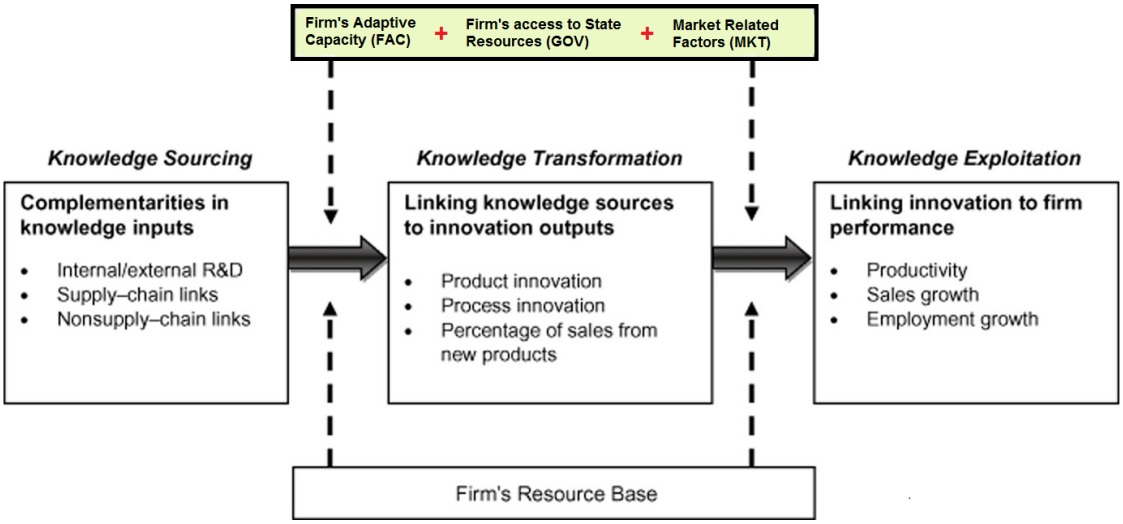


Figure 1: The overall conceptual IVC model showing its dimensions and key variables (the shaded element is the new contribution).

Source: Author's modification of Ganotakis and Love (2012)

1.10 RESEARCH QUESTIONS

Cognisant of the aims and objectives of this dissertation, the following research questions are pursued:

RQ1	Which factors are significantly influential in the SMME's decision to undertake new to the firm/market innovations?
RQ2	Which knowledge sourcing activities and strategies do SMMEs adopt in their innovation pursuits?
RQ3	What effect does knowledge sourcing activities have on the innovative activity of the SMMEs in the production of new products and processes?
RQ4	Do SA SMME firms profit from the development of significantly improved or new products and processes;
RQ5	What are the determinants of innovations in the manufacturing sector SMMEs in South Africa?

1.11 STRUCTURE OF THE REPORT

Six chapters make up this dissertation

This introductory chapter outlined the purpose and context of the work as well as the problem statement, research questions, assumptions and delimitations of the study. In addition, key terms were defined and the conceptual framework underpinning the study was sketched.

Chapter 2 outlines the literature appropriate and relevant to the research at hand, the thesis context, and the development of the theoretical framework and hypotheses. Chapter 3 is based on the developed theoretical framework, a description of the research methodology and a research method are outlined. The data used for this work and the empirical techniques employed.

In Chapter 4 the findings from investigations into the innovation decision-making and attempts to model the innovation value chain for South African SMMEs in the manufacturing sector are presented and discussed. Findings from investigations into the determinants for innovation activities in the South African SMMEs in the manufacturing sector are presented and discussed in Chapter 5.

Chapter 6 briefly concludes the work by way of presenting the significant findings and drawing the possible implications for policymaking and contributions to the literature.

CHAPTER 2.
LITERATURE REVIEW

2.1 INTRODUCTION

The current chapter presents the theoretical background and a review of the literature on matters related to the current study. This chapter also reviews the definitions of innovation, the theories of innovation in the firm, and related arguments, innovation in SMMEs, the innovation value chain concept, and lays out the work's theoretical framework. In addition, the hypotheses of this study are proposed.

2.2 SELECTED THEORIES ON THE GROWTH OF THE FIRM

2.2.1 Schumpeterian hypotheses

The Schumpeterian Mark I hypothesis (1912) is sometimes considered "an early view of innovation" (Fontana, Nuvolari, Shimizu, & Vezzulli, 2012). It hypothesizes that new, and often small entrant, entrepreneurial firms are at the centre of the innovation as they are better positioned to introduce new to the market (radical) innovations at the detriment of incumbent firms ("creative destruction").

The Mark II hypothesis sometimes considered "a later view of innovation" was also proposed by Schumpeter (1942, p. 106). Contrary to the earlier view, Schumpeter's Mark II hypothesis places the large-scale establishments at the centre of the innovation pursuits in what is termed "the most powerful engine of progress". Other theories relating firm size and innovation have followed Schumpeter's hypotheses. For example, starting with the view that development and innovation activities are costly and risky in nature, Galbraith (1957, p. 86) argues that large firms are better positioned to mitigate that risk and minimise the costs by taking on a diversity of projects thus increasing the likelihood of benefits to be gained (Hadhri, Arvanitis, & M'Henni, 2016). Van Dijk, Den Hertog, Menkveld, and Thurik (1997), using data for a different economy offered evidence that innovation offers large firms monopoly profits they need to finance further R&D and

growth. In his paper entitled *Innovation in Large and Small Firms*, Nobel Prize-winning economist Kenneth Arrow sarcastically sums up his arguments as follows:

> *"While anecdotes are no substitute for good statistical analysis, a striking number of innovations have been produced by giant corporations on the basis of ideas (and perhaps some production) from small firms" (Arrow, 1993, p. 124).*

Against the Mark II Schumpeterian views, however, small firms continue to be objects of increasing fascination for researchers, industry, policymakers and governments alike (Beck et al., 2005; Berry et al., 2002; Malone et al., 2014; Roper & Hewitt-Dundas, 2017). In South Africa, to support the growth and development of SMMEs, the National Small Business Amendment Act (2004) was passed, agencies such as Small Enterprise Development Agency (SEDA) through the Act 29 of 2004, and a dedicated Department of Small Business Development (DSBD) was established in 2014.

More and more research reports (Abor & Quartey, 2010; Ayyagari, Beck, & Demirguc-Kunt, 2007; Barrett & Sexton, 2006; Beck et al., 2005; Berry et al., 2002; Booyens, 2011; Moses et al., 2011; Muringani, 2014; Page & Söderbom, 2015; Rogerson, 1998, 2001; Roper & Hewitt-Dundas, 2017) continue to highlight the significant role of the small firms as sources of disruptive innovations, contrary to the Mark II argument.

2.2.2 Penrosian resource-based view argument

Of great interest to the current study is Penrose's contribution to the theories of firm and innovation (Penrose, 1959, 2009). Although largely ignored by her contemporaries in her time (Nair, Trendowski, & Judge, p. 1026), Penrose challenged the neo-classical economics view of innovation and its preoccupation with the firm's size. Like Schumpeter, Galbraith and Arrow, Penrose also acknowledged that large firms invested significantly in R&D, but she regarded their resource-base and capabilities as the main drivers of their growth rather than their size alone (Buckley & Casson, 2010).

Among other things, by formulating a resource-based view theory, Penrose shifted the focal point of the debate from the relationship between the size of the firm and

its propensity to innovate to the resource determinants of innovation. The ‘resources’ are the “*physical things a firm buys, leases or produces for its own use and the people hired on terms that make them effectively part of the firm*” (Penrose, 1959, p. 67) or a 'bundle of resources’ according to Buckley and Casson (2010, p. 153).

It is, therefore, one of the objectives of this study to explore the determinants of innovative ability in small firms or the said 'bundle of resources’ according to Buckley and Casson (*ibid.*), but without demanding an in-depth review of the resource-based view theoretical framework *per se* (Barney, Wright, & Ketchen Jr, 2001).

2.2.3 New growth theory argument

The new growth theory is the more recent of the theories on the growth of the firm. It is often accredited to Paul Romer and his contemporaries (Cortright, 2001; Curado, 2006; Romer, 1994). The central new growth theory argument is that knowledge is a key driver of growth in the firm. According to Cortright (2001), the new growth theory introduces a shift from a Penrosian resource-based view of the enterprise to a more knowledge-based view of the firm – where knowledge becomes the most determinant strategic resource of the firm (Curado, 2006, p. 5).

Following these knowledge-based view arguments based on new growth theory (Romer, 1994) intramural R&D activities are expected to lead to product and process innovation and sustain growth as suggested in Abazi-Alili (2014). In fact, this is the premise of DST’s national plan on innovation through a knowledge-based economy (Blankley & Booyens, 2010).

2.3 INNOVATION IN SMMEs

Defining an SMME and innovation both have profound implications for this work. Adopting the Oslo Manual (OECD, 2005, pp. 46-47) definitions of innovation and how it can be measured, for example, allow the researcher to use and interpreted data derived from the South African national innovation survey (the survey’s strategies for gathering and the collecting the data is based on the Oslo Manual guidelines).

2.3.1 Small Firms or SMMEs

Defining SMMEs in South Africa

SMMEs abbreviates small-, micro- and medium-sized enterprises. At times they are referred to as small- and medium-sized enterprises (SMEs) or just small firms.

The schedule of classification of what constitutes small-, micro- or medium-sized firms is contentious. Others researchers prefer to define SMMEs in term of the number of the firm's employees while others define SMMEs in terms of monetary turnover (Abor & Quartey, 2010; Berry et al., 2002; Booyens, 2011; Mazzarol & Reboud, 2011).

In South Africa, the classification schedule differs from industry to industry. The National Small Business Amendment Act 26 of 2003 (2004) classifies firms as either survivalist, micro, very small, small, or medium enterprises according to their level of annual turnover and/or the firm's number of employees within, as below.

The definitions for the SMMEs subsequent categories are given as follows, but only for completeness:

i. Survivalist enterprises: their level of annual turnover is less than the minimum income standard or the national poverty datum line. The category is typically pre-entrepreneurial (consisting hawkers, vendors and subsistence farmers) (Abor & Quartey, 2010; Berry et al., 2002).
ii. Microenterprises: their level of annual turnover is less than the value added tax registration limit (R150 000/year). These firms are ordinarily informal (typically consisting of household industries such as the '*spaza shops*' and minibus taxis). These characteristically employ about five people at most (Marnewick, 2014; National Small Business Amendment Act 26 of 2003, 2004).
iii. Very small enterprises: are enterprises formally operating, employing up to between 10 employees to 20 employees, with an annual turnover of up to R200,000 to R5000,000/year but not operating in the mining, electricity, manufacturing and construction sectors (Booyens, 2011; National Small Business Amendment Act 26 of 2003, 2004).
iv. Small enterprises: are generally more established enterprises, formal operating and exhibit more complex business practices, they employ up to 50 employees and have an annual turnover of up to R2 million to R25 million/year (Booyens,

2011; Marnewick, 2014; National Small Business Amendment Act 26 of 2003, 2004).

v. Medium enterprises: are well-established enterprises, formal operating and exhibit more complex practices, they employ as many as 200 employees and have an annual turnover is of up to R4 million to R50 million/year. These enterprises are often characterised by a delegation of power to an additional management layer (Bell et al., 2004; Berry et al., 2002; Marnewick, 2014; National Small Business Amendment Act 26 of 2003, 2004).

In a South African context, the characteristics of SMMEs, their development trajectories and constraints – especially issues relating to their financing and policy environment and the potential for SMMEs to address socio-economic plagues such as poverty and unemployment have been studied, and are well reported (Booyens, 2011; Moses, Sithole, Blankley, et al., 2012; Muringani, 2014; Rogerson, 2001). The need to promote economic development and growth through an SMME-driven economy towards global marketplace competitiveness has also been debated. Empirical research on innovation in South Africa has largely neglected SMMEs, in general, and the manufacturing sector specifically. As also indicated by Avermaete et al. (2004), beyond anecdotal and common sense evidence, innovation patterns in small manufacturing firms remain unnoticed.

A segment of particular interest to this work is the manufacturing SMMEs. In a cross-cutting report prepared for SEDA an agency of the DTI, entitled "*Analysis of the Needs, State and Performance of Small and Medium Businesses in the Agriculture, Manufacturing, ICT and Tourism Sectors in South Africa*" (National Small Business Amendment Act 26 of 2003, 2004), South African SMMEs face numerous challenges identified for each of the industrial sectors. South African manufacturing sector SMMEs normally encounter challenges associated to barriers to entry, challenges associated to constraints related to a general lack of innovation and creativity, challenges associated with lack of access to suitable equipment and technology, and challenges associated with the shortage of specialised technical skills, among others (SEDA, 2012, pp. ii, 50).

2.3.2 Innovation in SA SMMEs

Rogerson (1998, 2001), like Pedersen and McCormick (1999), argues that "*for many African countries 'industrialisation is seen as a key to development'*" in a comprehensive review on the growth of manufacturing SMME in the Gauteng province in South Africa. As one of his findings, Rogerson advocates for 'technological innovation' in the manufacturing sector to meet the challenge of the international competition.

Whilst it is known that a firm's competitive edge can come from its size or resource base, a more recent exploratory study, (Booyens, 2011) suggests that SMMEs may be more innovative than large enterprises in the South African context. This observation can also be collaborated by looking at the innovation activities across firm size classes in the period 2005 – 2007 as reported in the South African 2008 Innovation Survey as depicted in Figure 3 (Moses et al., 2011).

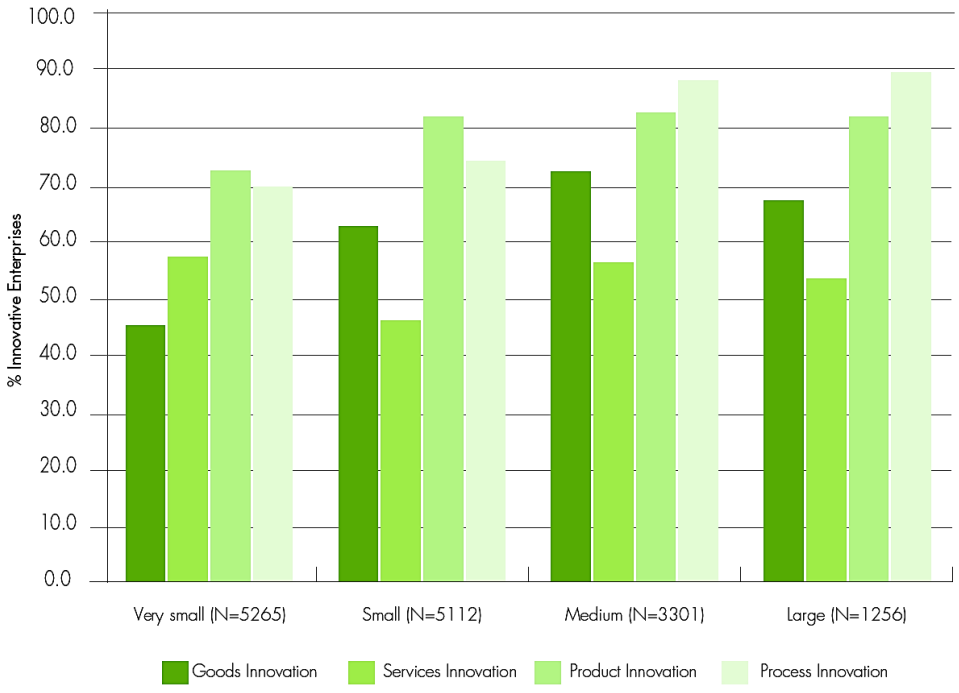


Figure 2: Innovation activities according to size class, 2005 – 2007.

Source: South African 2008 Innovation Survey (C Moses et al., 2011)

In addition to this descriptive depiction, scholars around the world, and especially in the Global North, have produced a vast body of academic and research on the processes of innovation in larger firms.

Yet the focus and efforts remain transfixed principally on their larger-sized firms, as Muringani (2014) correctly points out that the literature shows that research into the processes of innovation in SMMEs remains neglected (Mazzarol & Reboud, 2011; Muringani, 2014; Tidd & Bessant, 2013). It is thus not surprising that the inner-workings of innovation activities in small firms is relatively an under-researched phenomenon globally, and more so in South Africa in particular (Abor & Quartey, 2010; Beck et al., 2005; Bell et al., 2004; Berry et al., 2002; Booyens, 2011; Tidd & Bessant, 2013) and (Ndlovu, 2016) more recently.

2.3.3 The Concept of Firm Innovation

Defining firm innovation

Innovation is today "one of the most bandied about terms in global business" that is used widely and so dubiously to the point of lacking a precise and shared meaning (Adams, Bessant, & Phelps, 2006, p. 22; Mercier-Laurent & Mercier-Laurent, 2015, p. 54). As such, the distinction between invention from innovation (Schumpeter, 1912, 1942) cited in (Christopher Freeman & Soete, 1997, p. 6) and the definition of innovation has been an object of interest both for researchers and for policymakers, culminating in the OECD Oslo Manual (2005b, pp. 46-47). Perhaps Bonnyai (2013, pp. 18-27) presents one of the most expansive discussions on the definition of innovation; this discussion, along with some of the seminal contributions in innovation literature are summarised and tabulated below in Table 2.

The now-established OECD definition of innovation categorically puts emphasis on the implementation aspect, that is:

> *"…the implementation [or commercialisation] of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer... the implementation [or adoption] of new or significantly improved production or delivery methods... involv[ing] changes in*

equipment, human resources, working methods or a combination of these" (OECD, 2005b, pp. 46-47).

The OECD definition pronounces three important emphases:

- that of implementation [or commercialisation],
- broad range of innovation types: product (original or significantly upgraded goods/services), process (modifications in product production/delivery ways), organizational (reforms in work-place or business practices or their firm's external connections), and/or marketing (changes in packaging, product design, etc.) (*ibid*.),
- clarification on the dimensions across the economic spectrum (Booyens, 2011, p. 75; Garcia & Calantone, 2002; Oerlemans, Buys, & Pretorius, 2001) from 'radical innovations' to 'incremental innovations' at different life-cycle stages of the product.

Table 2: Some of the highest and most widely cited definitions of innovation

Reference	Contributions to innovation literature definitions
Schumpeter (1912,1942)	Posits that innovation is the main driver of economic change and the description of innovation as the creation and implementation of 'new combinations'.
Rogers (1983, pp. 11-12)	The objective valuation and perception of *newness aspects* of an idea, products, and practices "*by an individual or another unit [s] of adoption*". While Rogers (1983) places emphasis on the individual unit adoption, others such as van de Ven (1986) subscribe to the concept of adoption at an institutional level.
C. Freeman (1982)	Defines an innovation in the economic sense and emphasises the commercial aspect involving the new product, process, system or device. Freeman also highlights the ambiguity of the word when it's also used to describe the entire development and commercialization process.
Lundvall (1992)	Posits that 'economically speaking' since incremental innovations are most likely compared to radical innovations; incremental innovations may be more significant than the radical innovations. (Fagerberg, 2005).
	Broadens the discussion on the definitions of innovation by including public institutions and households.
1st Ed. Oslo Manual (OECD, 1992)	First attempt to standardise the innovation definition for measurement purposes and set strategies for gathering and interpreting the collected data.
2nd Ed. Oslo Manual (OECD, 1997, pp. 31-39)	Updated the 1st Oslo Manual but retained a focus on Technological product and process (TPP) innovations; where products innovation means either goods or services innovations.

3rd Ed. Oslo Manual (OECD, 2005b, pp. 46-47).	The Oslo Manual in three iterations sought to harmonise the definitions of innovation by shifting away from a predominantly 'technological' preoccupation and encompassing non-technological innovations, providing guidance on measuring innovation and core Community Innovation Survey (CIS) methodology, and an Annex to interpret the manual for use in the Global South economies.
Oerlemans et al. (2001)	Sketches some definitions of innovation for the first South African Innovation Survey.

Source: Author's work based on reviews of the literature

The Oslo Manual (OECD, 2005b, pp. 46-47) as also indicated by Bastias (2014, pp. 28-29), further submits the characteristic features of innovations to reinforce the said definitions conceivably after Schumpeter (1942), and further offers definitions differentiation between product, process, marketing and organisational innovations (OECD, 2005b, pp. 46-47). The definition of innovation from the Oslo Manual is adopted for the purposes of this dissertation.

Determinants of innovation

In addition to the IVC enquiry as proposed, the researcher further seeks to investigate the determinants of innovation, as discussed in the literature, specifically for SMMEs in the South African manufacturing sector.

While most economists and innovation practitioners generally agree that innovation has an enormous impact on any firm's growth propensity, *ceteris paribus*; no consensus seems to exists however in as far as the specific factors influencing a firm's innovation activities (Alpkan, 2015; Avermaete et al., 2004; Barasa, Knoben, Vermeulen, Kimuyu, & Kinyanjui, 2017; Booyens, 2011; Hadhri et al., 2016; Van Dijk et al., 1997; Zemplinerová & Hromádková, 2012). A wide-ranging review of small firm innovation literature shows clearly that there are numerous studies that have shown that there are plenty of factors that can influence innovation activities in enterprises (Alpkan, 2015; Avermaete et al., 2004; Ayyagari et al., 2007; Booyens, 2011; De Jong & Vermeulen, 2006; Jang, 2017; Pretorius & Oerlemans, 2006; Van Dijk et al., 1997).

Perhaps Kilic and Hamarat and co-workers have attempted the development of 'a comprehensive model of determinants listing numerous characteristics grouped

into four main categories (Alpkan, 2015; Gunday, Ulusoy, Kilic, & Alpkan, 2011; Kilic & Hamarat, 2010, p. 766, Fig. 1), i.e.:

- General firm characteristics (including factors such as the firm's size, age, ownership structure and foreign capital status);
- Organizational structure (including factors such as the intellectual, human, social capital as well as the organizational culture of the firm - degree of human capital or skilled labour qualifications etc.);
- Firm strategies (including factors such as the innovation expenditure, orientation on quality and foreign markets, level of market competition, knowledge sourcing strategies and inter- or intra-organisational collaborations),;
- Sectoral conditions and relations (including factors such as the barriers to finance innovation, the economic situation of a country or region, and, government grants and R&D subsidies).

While firm size is perhaps the most studied and contested determinant following the Schumpeterian hypotheses (see earlier discussion, see Section 2.2 on p.15), an equal number of reports arguing for and against the directionality of firm size as a determinant exists (see Table 4). The researcher will weigh in and contribute to this determinants discourse using South African data and more factors than before.

As also pointed out in the following works (Barasa et al., 2017; El Elj & Abassi, 2014; Oerlemans & Pretorius, 2006), the researcher noticed that most studies on the determinants of innovation are reported from the context of advanced economies. However, as El Elj and Abassi (2014) duly points out that "*[u]nderstanding the major incentives behind a firm's decision to innovate is just as important in developing countries as in developed countries"*. Fewer studies on the determinants of innovation are reported from the context of the South African firm, and even fewer in the context of South African SMME, (Booyens, 2011; Ndlovu, 2016; Pretorius & Oerlemans, 2006) and (Mustapha & Mendi, 2015).

2.4 THE SOUTH AFRICAN NATIONAL INNOVATION SURVEY

The five waves of the SA innovation survey

The first South African National Innovation Survey wave was conducted by the University of Cape Town. Its aim was to measure innovation undertakings in the

manufacturing sector firms in the period 1992-1994. It was reported in 1997 according to Moses, Sithole, Blankley, et al. (2012).

Table 3: A summary of the contemporary literature on the determinants of innovation in a South African context and Sub-Saharan Africa in general.

Determinants	General Direction	South African or Sub-Saharan Africa Context (references)
In-house R&D	+	(Abdu & Jibir, 2017; Barasa et al., 2017; Booyens, 2011; Ndlovu, 2016)
Linkages to clients, suppliers, consultants, competitors, joint ventures, or to public research facilities	+	(Booyens, 2011; Ndlovu, 2016)
Firm size	-/+	(Abdu & Jibir, 2017; Barasa et al., 2017; Booyens, 2011; Ndlovu, 2016; Pretorius & Oerlemans, 2006)
Firm age	+	(Barasa et al., 2017; Ndlovu, 2016)
Legal status	+	(Barasa et al., 2017)
Number of employees	+	(Booyens, 2011)
Export orientation	-	(Abdu & Jibir, 2017)
Turnover	-/+	(Booyens, 2011)
R&D intensity	+	(Booyens, 2011; Oerlemans & Pretorius, 2006)
Part of group	ø	
Foreign ownership	+	(Oerlemans & Pretorius, 2006)
Skilled workforce	+	(Barasa et al., 2017; Booyens, 2011; Oerlemans & Pretorius, 2006)
Degreed workforce	+	(Abdu & Jibir, 2017; Barasa et al., 2017)
Gov. support	+	(Booyens, 2011; Oerlemans & Pretorius, 2006)
Province or region	-	(Barasa et al., 2017)
Managerial experience	+	(Barasa et al., 2017)
Manufacturing sector	ø	
Training	+	(Abdu & Jibir, 2017; El Elj & Abassi, 2014)
Market structure	ø	
Training	+	(Abdu & Jibir, 2017; El Elj & Abassi, 2014)

NOTES:
+ means a positive effect was generally observed
- means a negative effect was generally observed
+/- means mixed effects were observed (by different researchers)
ø: no available information;

Source: Author's interpretation

The second wave of the South African National Innovation Survey, covering the years 1998-2000), covered services in addition to the manufacturing sector firms. It was conducted by the University of Pretoria in partnership with Eindhoven University and reported in 2001 (Oerlemans et al., 2001).

CeSTII has conducted the third wave (covering the years 2002-2004), fourth wave (covering the years 2005-2007), and fifth wave (covering the years 2010-2012) South African National Innovation Surveys (Blankley & Moses, 2009, 2013; Moses, Sithole, Blankley, et al., 2012; Moses et al., 2011; Moses et al., 2013). CeSTII is currently conducting the sixth (covering the years 2014-2016) South African Innovation Survey.

The fifth wave of the South African Innovation Surveys is the object of this study.

Over the period 01 January 2010 to 01 December 2012, HSRC through CeSTII, gathered information on how firms in South Africa sourced their knowledge and co-operated in their innovation activities, their core innovation activities, as well as the firms' performance and specific characteristics.

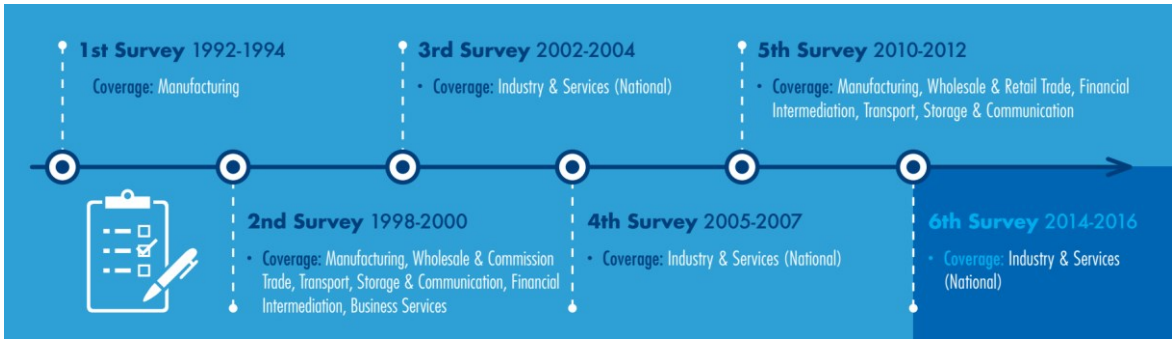


Figure 3: The six waves of the SA innovation survey.

Source: CeSTII (Moses et al., 2013)

Figure 3 visually illustrates the chronology and coverage of the six waves of the SA innovation survey.

The South African Innovation Survey is also known as the South African Business Innovation Survey, SABIS. The survey questionnaire is directly comparable OECD's Round 4 of the core questionnaire for the Community Innovation Survey (CIS 4) with customization, particularly a few questions tailored for the South

African setting (Moses et al., 2013). See also the SABIS2013 methodology Moses et al. (2011, p. 59); Moses et al. (2013, pp. 14-17).

Following the standard OECD-Eurostat guidelines and methodology allows the SABIS survey's outcomes to be practically comparable to the outcomes from other countries. Bonnyai also in his PhD thesis, delivers arguably one of the most comprehensive reviews of CIS microdata in the available literature. He discusses aspects such as the strengths and limitations of the CIS, typical sampling and weighting techniques, missing responses and applied data cleaning procedures, and changes in the survey design over time and geographies (2013, pp. 31-112).

The SABIS2013 full questionnaire (See Appendix A on p. II), and related methodological insight into survey processes, and subsequent statistical analysis, are all publicly available and covered in detail elsewhere, see (Moses et al., 2011; Moses et al., 2013). The researcher did not participate in the primary surveying work; it briefly summarises the SABIS2013 sample selection criteria, sampling frame and sampling technique but only for completeness's sake.

According to CeSTII (Moses et al., 2011; Moses et al., 2013), the modes of data collection included email survey, face-to-face interviews, postal survey, self-completion, and telephonic interview.

The sampling frame used by the SABIS2013 was businesses from the Business Register database of Statistics South Africa (C Moses et al., 2011). The Business Register is the business equivalent of the country's population registers; comprising incorporated and unincorporated businesses in South Africa. It provides statistical information (contact details, firm size, industry, geography etc.) and indicators (life status, turnover, standard sectoral classifications required by each department, and etc.). Using tax data from the South African Revenue Agency (SARS) and the Business Register, the SABIS2013 was based on a random stratified sample of 6 000 firms.

After data cleaning, the remaining valid enterprises in the database totalled 5850. The stratified random sampling technique was implemented using geography and size of enterprise (See also the SABIS2013 methodology (C Moses et al., 2011, p. 58). Thereafter, the sample was are extrapolated to the original population. After two rounds of postal surveys and (telephonic and e-mail) reminders and follow-

ups, the survey achieved a final response of 746 completed questionnaires which is a response rate of 16.0%.

2.5 THE INNOVATION VALUE CHAIN

IVC is a relatively new innovation framework although it has roots in prior models (Smit, 2015). The framework is usually viewed and used as: (a) a strategic approach tool in the assessment of the strength and weakness in the innovation activities (Hseih et al., 2011; Martowidjojo & Alamsjah, 2011); (b) brings together a more end-to-end treatment to innovation, taking into consideration its knowledge sourcing, its transformation, and eventual exploitation of innovation for value creation (Hseih et al., 2011; Roper & Arvanitis, 2012; Roper et al., 2008); and (c) ensure that the innovation process will be analysed and measured in a quantitative study which often is needed for policy-making purposes (Guan & Chen, 2010).

According to Hseih et al. (2011), the IVC introduced by Roper et al. (2008) in 2008 incorporated econometric functions to the original IVC introduced by Hansen and Birkinshaw (2007).

An alternative form of the IVC exists as the innovative production process which is *"an operational sum of a series of functional innovation events and implemented by stages, which is clearly characterized by a consecutive process consisting of multiple divisional and relational sub-processes" according to Guan and Chen (2010, p. 348).*

However, the focus of this work is the IVC as a tool to (a) assess the strengths and weaknesses of the innovation process

2.5.1 Decision to Innovate

The nature of the innovation is such that it cannot be exploited until it has been introduced. Equally, both Roper et al. (2008) and Doran and O'Leary (2011) concede that a firm's decision to embark on innovative activities precedes the innovation endeavour itself. According to Du, Love, and Roper (2007, p. 766), most studies casually make the assumption but rarely test it - this study will, therefore in addition to the focus of this work is the IVC, attempt to examine the factors and influences behind the innovation decisions.

The quantitative methods opted for as well as the well-accepted secondary data sources are designed to ensure objectivity, generalizability and reliability (Leung, 2015) and to improve the reliability and validity of the outcomes of this study.

The IVC framework is also not as useful if the firm decides not to partake in any innovative activities. Therefore, following Doran and O'Leary (2011), the empirical analysis of the decision precedes the modelling of the three IVC links; the overall empirical strategy is a hybrid four-equation framework (see §3.5 on page 51). This hybrid approach has its foundations in the work of Crépon, Duguet and Mairesse (Crépon, Duguet, & Mairessec, 1998; Lööf, Mairesse, & Mohnen, 2017).

Figure 4 depicts the innovation-decision as a stage in the innovation process and the two discrete choices (decision tree) models that can be used to model it.

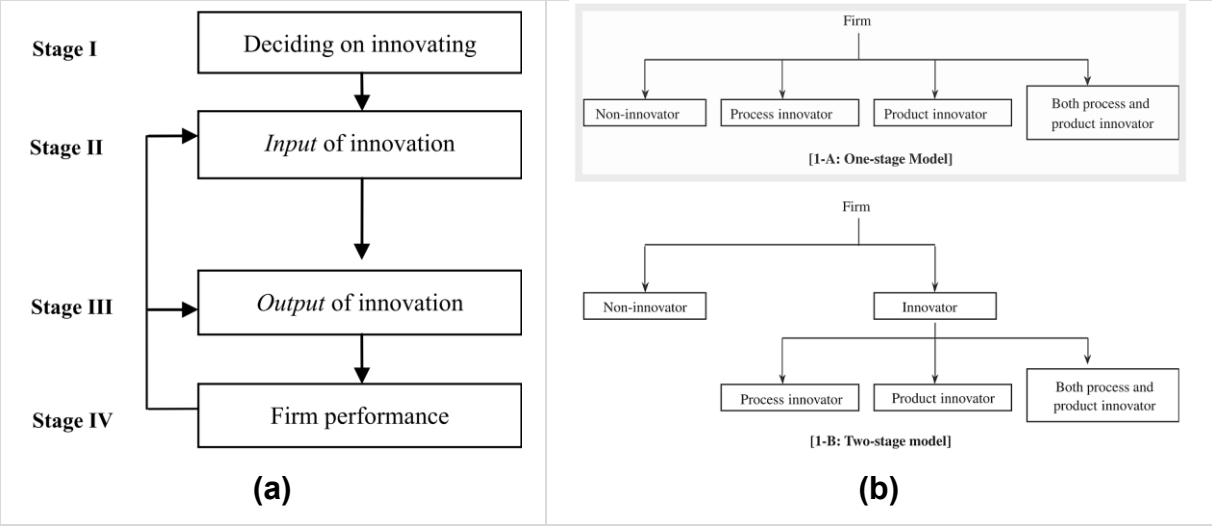


Figure 4: Innovation decision (a) as a stage in the innovation process and (b) the firms' decision tree models.

Source: (a) Braga and Braga (2013, p. 333) and (b) Du et al. (2007, p. 767)

The literature review demonstrates that numerous studies on the decision of firms to innovate; the decision equation typically takes a set of 'traditional' determinants of innovation, see for example (Bocquet & Musso, 2010, p. 8; Crépon et al., 1998; Eickelpasch, 2014; Kemp, Folkeringa, De Jong, & Wubben; Loi & Khan, 2012; Lööf et al., 2017; Pellegrino, 2014; Zemplinerová & Hromádková, 2012) and the Oslo Manual (OECD, 2005b). More comprehensive lists of explanatory variables and their expected signs of effects or the relations between the explanatory variables

and the propensity to innovate can be found elsewhere, see Kemp et al. (p. 43, Table 14), Hadhri et al. (2016, Table 1 on p. 83) and Du et al. (2007, p. 769).

In this context, the dependent variable is the propensity of the firms to innovate, the control variables are the firm's size, age, legal status, region, sector, etc. after Barasa et al. (2017); Loi and Khan (2012, pp. 15-17) and the explanatory variables are drawn from the five main clusters identified in the prior discussion on the Determinants of innovation† (p. 23) above.

In the implementation of the decision to innovate equation, following Du et al. (2007) and Hadhri et al. (2016). The study assumes that a firm has decided to innovate (i.e. $DECISION_i = TRUE$) if it has indicated it undertook some activities implied in the established OECD definition of innovation (OECD, 2005b, pp. 46-47) in addition to any other on-going/aborted innovation activities Hadhri et al. (2016, p. 494).

2.5.2 Knowledge sourcing

Knowledge (or ideas) is the currency of any innovative endeavour (Dale, 2007) and the most impelling indicator of the likelihood of innovation (Farace & Mazzotta, 2011).

Knowledge sourcing activities constitute the foremost link in the IVC framework (Hansen & Birkinshaw, 2007; Roper et al., 2008). Knowledge can possibly originate from a number of sources; in this case (a) the firms' intramural R&D or other internal R&D activities, (b) external sources through collaboration relations (c) external sources such as forward linkages to consumers, (d) external sources such as backward linkages consultants and suppliers or (e) non supply-chain external source linkages such as research institutions or public research entities such as institutions of higher education.

The IVC framework makes use of five knowledge sources (Ganotakis & Love, 2012; Roper et al., 2008) or up to seven knowledge sources (Hseih et al., 2011; Martowidjojo & Alamsjah, 2011) in order to break down the innovation processes into three interrelated activities and characterise how the sought knowledge is

† See also Kemp et al. (2003, Table 14 on p. 43)

transformed into outputs (such as new goods, services or processes), and finally exploited into gains.

2.5.3 Knowledge transformation

Knowledge transformation activities constitute the second IVC link (Hansen & Birkinshaw, 2007; Roper et al., 2008). This entails the process through which the sourced knowledge is intentionally turned into tangible outputs (products or processes, in the context of this work). The success of a firm in its knowledge transformation endeavours into innovation production is a known reflection of a firm's determinants of innovation such as characteristics, firm's resource-base (including the quality of human resource, managerial and organisational qualities as well as internal capabilities) (Doran & O'Leary, 2011; Ganotakis & Love, 2012; Neely & Hii, 1998; Roper et al., 2008).

2.5.4 Knowledge exploitation

Knowledge exploitation activities complete the IVC (Hansen & Birkinshaw, 2007). This activity represents new market offerings as firms' try to capture the full market value from their innovations. Although the knowledge exploitation linkage depends on firms' initial knowledge sourcing activities, at the exploitation stage, the prior sourced knowledge is exploited in the form of the firm's commercial product/process innovations (Ganotakis & Love, 2012; Hansen & Birkinshaw, 2007; Hseih et al., 2011; Neely & Hii, 1998; Roper et al., 2008; Singh Panesar & Markeset, 2008). Knowledge exploitation is typically operationalised into the firm's bottom-line performance to probe the relationship between firms' propensity to innovate and their performance.

The adoption of this particular framework follows an approach based on recent results from Ganotakis and Love (2012) as well as some projects reported in the European countries (Lendel & Varmus, 2013; Roper et al., 2008; Woerter & Roper, 2010).

2.6 THEORETICAL FRAMEWORK

In theory, Roper et al. (2008) combined the Crépon-Duguet-Mairesse inspired CDM empirical models to the original Hansen and Birkinshaw (2007) IVC

framework. The theoretical framework adopted for this current study is based on the Roper et al. (2008)'s IVC. The modified IVC conception is schematically illustrated in Figure 5 below, after Roper et al. (2008)‡. The merits of the concept were discussed earlier in detail within §2.5 on page 28 and in §3.5 on page 51.

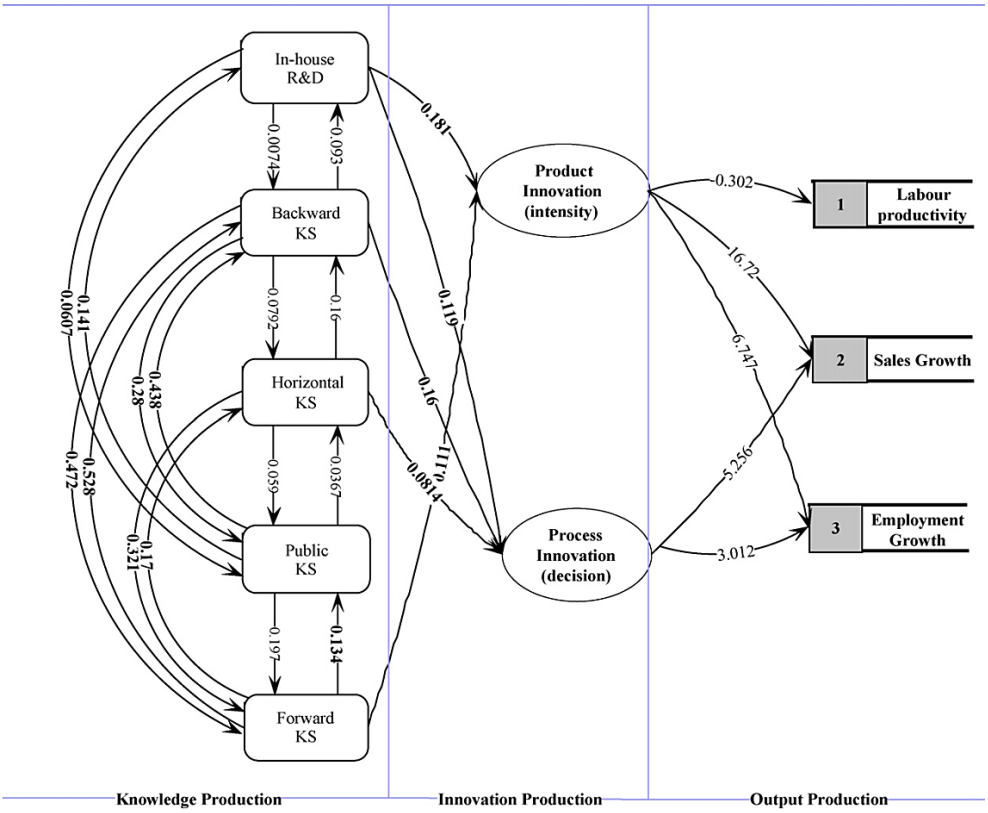


Figure 5: A visualization and interpretation of the IVC

Source: Roper et al., (2008, Fig. 3)

Three activities make-up the innovation value chain; the knowledge sourcing activities (originating either from the firms' internal, backward, horizontal, public or forward or a combination of these linkages), innovation production activities (product or process innovation or a combination of these activities), and the output

‡ Internal knowledge sourcing activities mentioned is in-house sourced knowledge tacit to the firm or from its R&D activities. The backward sourced knowledge is through the firm's linkages to either its suppliers or consultants. The horizontal associations mentioned refer to knowledge sourced through the firm's linkages to its competitors. The public associations mentioned refer to knowledge sourced through the firm's linkages to either institutions of higher education or other public research facilities.

production activities (as measured using the proxies by labour productivity, sales growth or employment growth).

2.7 HYPOTHESES OR PROPOSITIONS

Drawing on the comprehensive review of the literature presented in this chapter and the research questions presented on p. 13, the following hypotheses are formulated:

On the decision, the researcher hypothesises that:

H1a	Firm characteristics can positively influence the firm's decision to participate in innovation activities, in general.
H1b	Factors that are obstacles to innovation can equally influence the firm's decision to undertake new to the firm and new to the market innovations

On the knowledge sourcing activity:

H2	SMME firms in South Africa make use of a number of knowledge sources in conducting their innovation activity.
H3	A complementary relationship exists between internal knowledge sources and all other knowledge sources when manufacturing sector SMME firms in South Africa undertake innovation pursuits

On the knowledge transformation activity:

H4	Internal R&D knowledge sourcing activities can lead to the successful implementation of new or improved products and/or processes,
H5	Non-supply–chain linkage knowledge sources can lead to the successful implementation of new or improved products and/or processes.
H6	Supply-chain linkage knowledge sources can lead to the successful implementation of new or improved products and/or processes.
H7	Public universities and research laboratories linkage knowledge sources can lead to the successful implementation of new or improved products and/or processes.

On the knowledge exploitation activities from the IVC:

H8	Development of new or significantly improved products should increase the performance of the firm.
H9	Development of new or significantly improved processes should increase the performance of the firm.

On the determinants of innovation:

H10	The firm's resource base factors, its adaptive capacity related factors, factors associated with firm's access to public support, market or industry-specific characteristics, factors associated with the firm's knowledge sourcing activities, and innovation hampering factors are all equally dominant driver.
H11	Process innovations and product innovation equally have the same dominant drivers the innovations.
H12	The determinants of process innovations and product innovation have the same impact.

2.8 SUMMARY

In this chapter, the theoretical background and a review of the literature on matters related to the current study were discussed. In particular, the definitions of innovation, the theories of innovation in the firm, and related arguments, innovation in SMMEs were reviewed. The innovation value chain concept and framework as an analysis tool was introduced and laid out the work's theoretical framework. The author summarizes this chapter by using the research questions to formulate the research's hypotheses.

CHAPTER 3.
RESEARCH DESIGN AND METHODOLOGY

The structure of this chapter is as follows: Section 3.1 outlines the research strategy and design. The selection of participants, i.e. the target population, the selected sample and the selection criteria are described in Sections 3.2 and 3.3. Section 3.4 outlines the SAIS secondary dataset, as well as the SAIS instrument, data collection, for completeness. The empirical analysis strategies adopted for the study are explained in Section 3.5. Before concluding the chapter, the limitations of the study, the ethical and the reliability and validity considerations will be discussed in Sections 3.6 - 3.8.

3.1 INTRODUCTION

This study attempts to adapt a quantitative research methodology as demonstrated by Doran and O'Leary (2011), Hseih et al. (2011) and (Roper et al., 2008).

In the following few sections, the researcher makes use of Wilson's Honeycomb of Research Methodology framework to schematically and progressively guides the choices in formulating the "*most the appropriate methodology*" Wilson (2014, p. 8). Each of the blocks in the illustration of the Honeycomb approach encompasses six elements that principally informs the *'what'* and the *'how'* within the overall enquiry (see Figure 6 below). This approach is not unique; it is analogous to 'the research onion' advanced by Saunders, Lewis, and Thornhill (2009, pp. 100-102).

This study seeks to explore the innovation strategies of manufacturing SMMEs in South Africa; i.e.

i. To investigate decision making in the South African manufacturing sector SMMEs on innovation activities;
ii. Identify the complementary/substitutionary relationships between the knowledge sources and their impact on business performance through, and
iii. Identify the determinants of innovation.

3.2 RESEARCH PARADIGM AND PHILOSOPHICAL POSITION:

3.2.1 Philosophical position

Research paradigm and philosophy refers to ways of explaining the basic set of world-view beliefs that is assumed by the researcher. According to Saunders et al. (2009), Wilson (2014), and O'Leary (2013), a paradigm defines the *epistemology*, *ontology* and *axiology* constructs of the research and the assumptions that govern the study. O'Leary (2013, p. 5) defines ontology as "*the study of what exists, and how things are understood and categorised"* while suggesting that the epistemology accounts for *"how we come to have legitimate knowledge of the world; rules for knowing*". Saunders et al. (2009) define axiology as those constructs of the research dealing with judgements about the value and the "*the guiding reason of all human action*".



Figure 6: An illustration of the Honeycomb approach to developing a research methodology

Source: Wilson (2014, p. 8)

There are three formative research philosophies; the positivist, interpretivist and the pragmativist research philosophies (Creswell & Clark, 2007; Creswell, Klassen, Plano Clark, & Smith, 2011; Johnson, Onwuegbuzie, & Turner, 2007; Teddlie & Yu, 2007). Throughout the past decades, scholars have robustly advocated for, or contested, this philosophy chasm with no noticeable agreement; these 'paradigm wars' as they are sometimes branded, are well documented (Creswell et al., 2011; Guba & Lincoln, 1994; Johnson et al., 2007; Onwuegbuzie & Leech, 2005).

Barring the 'paradigm wars', some of the assumptions underpinning the study include the following:

i. The researcher was not part of the primary SABIS2013 survey process. Hence, the subjective interests, 'feelings and values' of the researcher could not have possibly influenced the formulation of the survey questions;
ii. The researcher considers himself as being independent of the firms that participated in the initial SABIS2013 research (the DST, the HSRC, or any of the surveyed firms) and could not possibly have affected or been affected by its outcomes (Remenyi, Williams, Money, & Swartz, 1998, p. 33); and
iii. Like all other CIS surveys, the SABIS2013 survey outcomes are quantifiable and enumerated observations that easily lend themselves to 'scientific' enquiry as demonstrated by Doran and O'Leary (2011), Hseih et al. (2011), and Roper et al. (2008).

Positivism the view that "*all true knowledge is scientific and is best pursued by scientific method*" (O'Leary, 2004, p. 10). In the context of the current study, the positivist approach has the following advantages:

i. The innovation activities and phenomena or desired quantities can be described or measured based on a numerical system following the Oslo Manual guidelines.
ii. Other researchers, notably (Doran & O'Leary, 2011; Hansen & Birkinshaw, 2007; Lööf et al., 2017; Oerlemans & Pretorius, 2006; Roper et al., 2008; Zemplinerová & Hromádková, 2012), have applied established principles and methods innate in natural science to explore various firm innovation characteristics, and
iii. The standardisation enables an easier gathered codified data.

As a result, the study adopts a positivist epistemology assumption towards reality. The ontological assumption along with an objectivism ontology stance in explaining relationships between phenomena and a value-free judgment axiology.

3.2.2 Research approach

Research approaches are the actions and schemes of the research study (Crowther & Lancaster, 2009) as cited in Saunders et al. (2009, p. 127). There are two main approaches that a research can take – a deductive approach or an inductive approach. The choice of a research philosophy, in true 'onion peel away' style, directly influences the research approach Saunders et al. (2009, pp. 100-102). Table 5 below highlights the compares the characteristic differences between deductive and inductive approaches.

Table 4: Comparing the inductive and deductive research approaches

DEDUCTIVE APPROACH	INDUCTIVE APPROACH
Explains casual relationships between variables	Understanding the research context closely
Uses quantitative data	Uses qualitative data
From data to theory	Human attach to events
Large sample for generalization	Less concern about generalizations
Scientific principles	Gaining an understanding of the meaning
Researcher independent from the study	The researcher is involved in the study
The approach is highly structured	Flexible structure for changes
Applying controls for validity need	

Source: Saunders et al. (2009, p. 127)

The choice to use either the deductive or inductive approach is not trivial; in the logical progression of the honeycomb model, the choice of the research approach the researcher adopts is dictated by the prior research paradigm philosophy choices.

Under quantitative studies, the researcher attempts to confirm causal relationships between the evolution of phenomena or quantities with respect to variables based on thorough empirical models testing using quantitative data (Creswell, 2012). According to Hussey and Hussey (1997, p. 51) as quoted in (Obeng, 2007, p. 165), a deductive research approach, as adopted for this study, ensures that:

*"… the logical reasoning is applied to the research so that precision, objectivity and rigour **replaces** [author's emphasis] hunches, experience and intuition as the means of investigating research problems".*

Since the current study has assumed a quantitative research paradigm and seeks to test the existing innovation value chain model and determinant theories using an empirical nation-wide observation, the deductive approach appears to be the most appropriate research approach.

While the deductive research approach deals with testing existing theories and development of theory and hypotheses by designing research strategies to test the hypotheses (Hussey & Hussey, 1997; Saunders et al., 2009).

As a result, the deductive approach is adopted for the current study.

3.2.3 Research strategy and design

Using the secondary SABIS2013 dataset, this study attempts to explain the measurable evidence, cause-and-effect relations and construction of statistical models fosters the possibility of replication and generalization to a population (Creswell & Clark, 2007; Creswell et al., 2011; Leung, 2015). Quantitative research methods are therefore influenced by the positivism paradigm – they borrow approaches from the scientific methods. They rely on the collection of numerical or enumerable data (Creswell, 2012) using the associated methodologies such as surveys, questionnaires, randomized controlled trials, and time-series designs etc. (Creswell et al., 2011).

In the logical progression of the honeycomb model depicted in Figure 4, this study attempts to use quantitative research strategy following methodologies demonstrated by Hseih et al. (2011) and Roper et al. (2008) that this study seeks to replicate.

Quantitative methods are designed to ensure objectivity, generalizability and reliability (Leung, 2015). Where qualitative methods produce a depth of experiences, the quantitative methods can provide insight into the breadth of experiences (Creswell & Clark, 2007; Creswell et al., 2011; Johnson et al., 2007; Teddlie & Yu, 2007).

3.2.4 Research design and data collection

This study attempts to makes use of data from the latest South African Innovation Survey (SABIS2013) gathered during the 2010 to 2012 period in time. The study, therefore, is utilizing data initially gathered by another primary researcher or "*reanalysing data that have already been collected for some other purpose*" (Johnston, 2017; Saunders et al., 2009, pp. 256, 600).

The survey-based nature of SABIS2013 in addition to its '*snapshot time horizon*' renders the current study a cross-sectional secondary study (Mairesse & Mohnen, 2010; Neely & Hii, 1998).

In summary, this cross-sectional study research design and the data collection choices are respectively informed by

- By choosing to make use of the latest South African national innovation survey cross-sectional survey-based secondary data, the study takes advantage of the largest and most comprehensive firm-level secondary dataset which is based on the same guidelines as the OECD/Eurostat CIS surveys. The researcher takes advantage of a dataset which contains a wide-ranging set of firm-level innovation indicators to provide the most appropriate and reliable information for providing the answers to the research questions. This also takes advantage of a dataset which is a result of a survey designed to measure and provide information on the extent of innovativeness in the industry and service sectors.
- Although the SA innovation survey is currently in the fifth wave, the dataset guardians (CeSTII of the HSRC on behalf of the DST) demand anonymization of the dataset as a 'non-negotiable' access condition. This is done to safeguard the anonymity and confidentiality of the voluntary participating firms and for them to adhere to the survey's consent agreement with the firms, as also highlighted by Johnston (2017, p. 625) in an unrelated study. This anonymization inevitably prevents the panel-linking of the same enterprise from survey wave to wave through time. This imposes an obvious limitation on the time or longitudinal dimension across waves (Damijan, Kostevc, & Rojec, 2017).
- Thirdly, prior reported studies have reported on the empirical analysis and modelling of the innovation value chain based on national innovation findings in Ireland (Doran & O'Leary, 2011; Roper & Arvanitis, 2012), in the United Kingdom (Ganotakis & Love, 2011, 2012), in China (Guan & Chen, 2010), in Ireland and

Switzerland (Roper & Arvanitis, 2012), in Indonesia (Martowidjojo & Alamsjah, 2011), Malaysia (Taghizadeh et al., 2014) and in Taiwan (Hseih et al., 2011).

3.3 DATASET, POPULATION, AND SAMPLE

This section describes the target population and the sampling strategy adopted.

3.3.1 The SABIS2013 dataset

The study is based on the SABIS2013 secondary data. The questionnaire-based survey was gathered during the 2010 to 2012 period by HSRC's CeSTII research unit on behalf of the DST. The SABIS2013 questionnaire (included in Appendix A on page II, for completeness) was developed and implemented in accordance with the methodological specifications and guidelines as the OECD/Eurostat CIS surveys. The associated methodological insights into survey processes and subsequent statistical analysis are all available but covered in detail in the survey documentation (Moses et al., 2013).

It is most likely the largest and most comprehensive official firm-level secondary dataset based on the OECD/Eurostat CIS surveys core guidelines in South Africa.

3.3.2 Unit of analysis

In accordance with the focus of this research, the unit of analysis identified for this study is the group of manufacturing sector SMMEs in the SABIS2013 dataset.

Three reasons inform this choice. Firstly, the literature review indicates that innovation activities in manufacturing SMME firms is an under-researched phenomenon in general and specifically in South Africa. Secondly, by choosing a single sector, the insights that such a selection ensures a more accurate representation of a specific context as observed by Slater (1995). Finally, the choice also seeks to advance the national government's re-industrialization strategy and building competitive capabilities in the sector.

3.3.3 The population

In line with guidance from Saunders et al. (2009, p. 158) and Saumure and Given (2008) on the population identification, it refers to every individual (or member of the group) that fits the unit of analysis criteria set-out by the researcher (in §3.3.2).

Although the SABIS2013 population was drawn from the Statistics South Africa's Business Register database comprising all incorporated and unincorporated businesses in South Africa, not all manufacturing sector SMMEs therein are part of the population – some are considered survivalist firms (too small to be considered as illustrated in Figure 7).

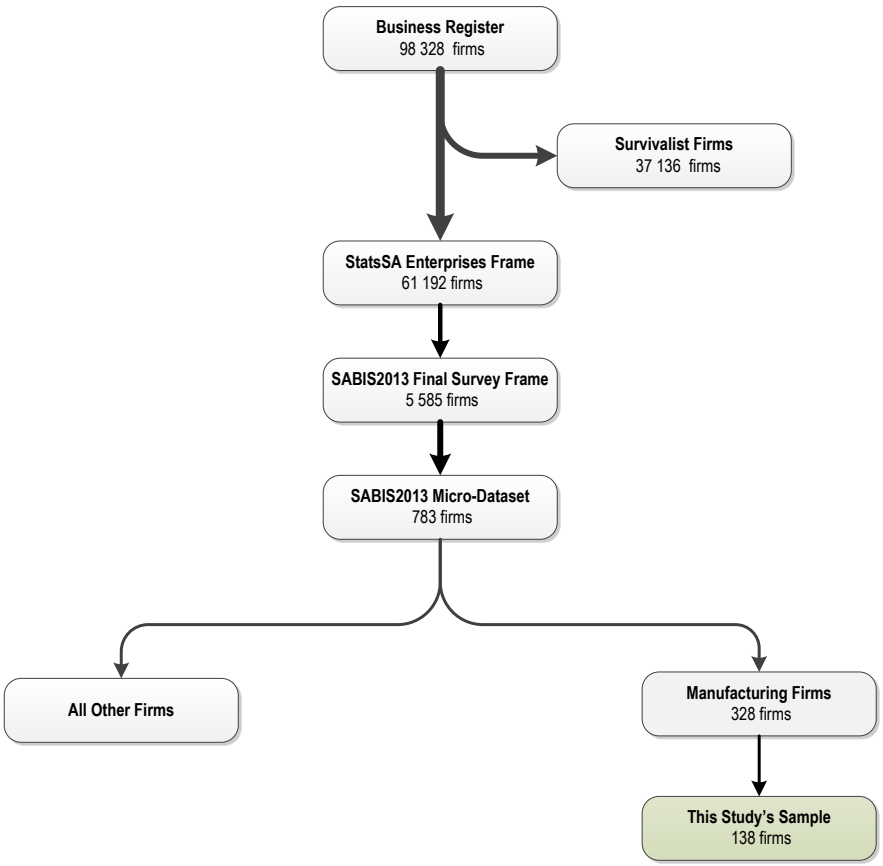


Figure 7: The sample and the selection criteria

Sources: Author's presentation based on details from Moses et al. (2013) and the style adapted from Official Statistics of Finland (2004).

Therefore, this study identifies manufacturing SMME firms operating in/from South Africa that are not survivalist firms as its population according to the firm size classification as set out in the National Small Business Amendment Act 26 of 2003.

3.3.4 The sampling frame, selection criteria, and sample

In order to assist CeSTII conduct the SABIS2013 survey, Statistics South Africa created a sampling frame comprising 61 192 firms as depicted in Figure 7. A random stratified sample of 5 585 firms, based on the size of the firms by turnover and industry sector, received the SABIS2013 survey questionnaire. The survey questionnaire is directly comparable Eurostat/OECD's Round 4 of the CIS 4 core questionnaire for national innovation surveys (Moses et al., 2013).

A total of 783 firms responded to the SABIS2013 survey with completed survey questionnaires, 328 of which are manufacturing sector firms.

The breakdown of some of the demographic data of the 328 manufacturing sector firms in the SABIS2013 dataset with respect to the class size of the firm is shown in Table 6. The majority of businesses making up the sample are medium-sized firms (with 68% of them reporting some innovation activities), while the micro-sized firms display the lowest share (36%) of some innovation activities.

Table 5: Demographic data of the SABIS2013 manufacturing dataset

			Size Category of the Firms			
	Total (number)	Total (%)	Large (%)	Medium (%)	Small (%)	Micro (%)
Total number of enterprises	*328*	100.0	100.0	100.0	100.0	100.0
Enterprises with innovation activities	*223*	68.0	78.5	67.7	48.0	36.2
Number of employees	*124 166*	100.0	100.0	100.0	100.0	100.0
Number of employees in enterprises with innovation activities	*108 554*	87.4	89.6	69.0	58.6	20.3
Turnover (R billion)	*979*	100.0	100.0	100.0	100.0	100.0
Turnover (R billion) of enterprises with innovation activities	961	98.2	98.0	99.3	62.1	40.2

Source: Author's interpretation based on SABIS2013 data (Moses et al., 2013)

After applying the relevant sampling frame/filter (i.e. manufacturing sector SMMEs that responded and completed the SABIS2013 survey) only 138 firms of those 328 manufacturing sector firms in the SABIS2013 dataset are SMMEs.

The sample

Given the low survey response rates, especially from SMME firms, of those 328 manufacturing sector firms, only 138 firms are SMMEs. Therefore, a non-random purposive sampling technique was employed for the maximization of the available information. The resulting selected sample includes the entire group of 138 manufacturing SMME firms in South Africa that responded to the SABIS2013 survey with completed survey questionnaires.

The deductive research approach adopted for this study necessitates that the researcher employs criteria for selecting the largest possible sample of the valid units of study so that the results can be generalized statistically and to draw the most reliable evidence from the study (Saunders et al., 2009, p. 212). Therefore:

- The supposition is that the study's selected sample of 138 SMME firms is as representative enough to reflect the target population of SMMEs in the manufacturing sector that would have been otherwise been considered as valid enterprises according to the SABIS2013 methodology.

A visual depiction of the SABIS2013 sample selection is depicted in Figure 7.

3.4 DATA PREPARATION AND SUMMARY

The researcher data used in this study were received from the custodian of the dataset in the tabular raw data in ASCII format.

This section outlines how the data pre-processing (prior to description and analysis) and post-processing (data presentation, and further descriptive statistics analysis) were conducted. The main variables are defined.

3.4.1 Data preparation

According to Mairesse and Mohnen (2010, p. 1148), access to individual firm raw CIS data to external users is a challenge for both the researcher and more so for the custodian of the dataset - "*at stake is the dilemma between the confidentiality*

of the firm individual information disclosed in the survey". The compromise is often secure remote access "*micro-aggregated or otherwise noise-contaminated data that hide the*" in order to conceal the identity of the surveyed firms (*ibid*.).

Table 6: Description of the variables

Variable	Type	Description of the variable
KSA.INTERNAL	Dummy	In-house Research and Development activities (R&D) (0/1)
KSA.CLIENTS	Dummy	Forward knowledge linkages to clients or customers (0/1)
KSA.SUPPL	Dummy	Backward knowledge linkages to suppliers (0/1)
KSA.COMPET	Dummy	Horizontal knowledge linkages to competitors / joint ventures (0/1)
KSA.CONSULT	Dummy	Knowledge linkages to consultants (0/1)
KSA.UNIV	Dummy	Knowledge linkages to institutions of higher education (0/1)
KSA.PUB	Dummy	Public knowledge linkages to universities, industry operated labs or public labs (0/1)
RIB.SIZE	Categorical	Firm size classes as prescribed in the National Small Business Amendment Act
RIB.EMPL	Number	Firm's size by the number of employees
RIB.AGE	Number	Firm's age (in years)
RIB.MNC	Dummy	The firm is part of a larger group (0/1)
RIB.PLNT.BCH	Dummy	Type of production in plant (0/1) (one-offs = 0, large batches = 1)
RIB.SA.BASED	Dummy	Head office country is based in SA (0/1)
FAC.RND	Dummy	Formal R&D department in the plant (0/1)
FAC.HCD	Dummy	Management training/training on process development/best practice (0/1)
FAC.DEG	Ratio	Number of Employees with Degrees/Diplomas (%)
FAC.INNO.TEAM	Number	Number of employees involved in innovation activities
FAC.INNO.ORG	Dummy	
FAC.GRP.RND	Dummy	Relevant R&D being conducted in the group (0/1)
GOV.INNO	Dummy	Public support for product/process innovations (0/1)
GOV.CAP	Dummy	Public support for capital (plant/machinery) (0/1)
GOV.HCD	Dummy	Public support for human capital development (0/1)
MKT.NAT	Dummy	Established markets in some or all SA provinces (0/1)
MKT.EXP	Dummy	Established markets in outside SA (1\0)
d.EMPL	Ratio	Employment growth from 2010 to 2013 (%)
RND.INT	Ratio	R&D intensity
EQUIP.INT	Ratio	Capital intensity (acquisition of machinery, equipment and software)
INNOV.INT	Ratio	R&D intensity
PROC.INNOV	Dummy	The firm introduced new/significantly improved methods of manufacturing or producing goods and services (0/1)
PROD.INNOV	Dummy	The firm introduced new/significantly improved products (0/1)
BOTH.INNOV	Dummy	The firm introduced both new/significantly improved products & processes (0/1)
NON.INNOV	Dummy	The firm introduced no innovative products or processes (0/1)
HAMPER.INNOV.COSTLY	Score	Innovation constraints: shortages of finance (score)
HAMPER.LACK.INFO	Score	Innovation constraints: lack of necessary information (score)
HAMPER.LACK.COMPETN	Score	Innovation constraints: lack of competition (score)
HAMPER.PRIOR.INNOV	Score	Innovation constraints: prior innovations (score)
SECTOR	Categorical	Manufacturing sub-sectoral categories (Moses et al., 2013, p. 19)

Source: Author's work based on the SABIS2013 dataset and (Roper et al., 2008

As a result, prior to generating a descriptive statistics or any fancy econometric analysis, data pre-processing involving pain-stacking checking and data quality assessment for cleaning up and transforming to a usable format (Huynh, 2017). After a thorough data checking (for missing responses, misspellings and other related inconstancies (for example, sa, SA, S A, S.A., S. A., South Africa, and south africa, South africa), recoding (such as N/Y to 0/1), and cleaning processes a number of samples were created for different purposes, the largest with a total of 113 firms and the smallest with 69 firms were left in the sample (depending on the set of variables selected).

OpenRefine v2.8, an open-source application for cleaning up and transforming to a usable format (Huynh, 2017), was used for this task. The variables included in this study were re-coded to types and levels given in. Tables 7.

3.4.2 Description of the variables

Description of the variables

The SABIS2013 micro-dataset capture numerous variables assumed to have influence on firm innovation (Moses, Sithole, Makelane, Mudavanhu, & Kupamupindi, 2012) - the full long list of the SABIS2013 variables is given elsewhere (CeSTII, 2017). However, the nature of the Confidentiality Agreement entered into, a few but key variables such as innovation expenditures and share of sales due to new products are censored by the guardian and excluded from this study for a number of reasons (Mairesse & Mohnen, 2010); Tables 7 gives a definition of variables included in this study. The coding and the levels of the variables are also given therein.

Dependent variables

Unique dependent variables required in order (i) to investigate prospect that a firm will partake in innovative activities, (ii) to model the three IVC links, and (iii) to study the determinants of firm innovative behaviour. In order to investigate the prospect that a firm will partake in innovative activities, the dependent variable is a dummy variable capturing whether the firm is innovation-active.

In order to model the IVC, three dependent variables are used. For the first IVC link, it’s a latent variable associated with the firm's knowledge sourcing

endeavours, KS_{ji}^{*}. For the second IVC link, it's a set of innovation output measures describing output types (product and process innovation), $INNO_i$. For the third IVC link, it's $BPERF_i$ is an output indicator of a firm's performance in the form of labour productivity (Ganotakis & Love, 2012; Roper et al., 2008).

In order to study the determinants of firm innovative behaviour, the dependent variables are four dummy dependent variables indicating the nature of firm's innovation activities (innovation inactive, product-only innovator, process-only innovator, product and process innovator).

Independent variables

With the foresight of the IVC inquiry ahead, the researcher intends to maximise the use of the dataset and harmonise the empirical exercise. Therefore, the researcher has elected to cluster the determinant factors into five main categories after Roper *et al.* (2008). The decision to undertake an enquiry into the determinants of the innovative behaviour of manufacturing SMME firms in SA was an afterthought, encouraged by the availability of near appropriate firm-level data through the South African CIS-based innovation surveys.

The five main categories are shown in Table 3 and briefly discussed below,

- KSA: factors associated with the firm's knowledge sourcing endeavours; from in-house R&D activities, external linkages to clients, customers, suppliers or consultants, collaborators and/or linkages to institutions of higher education or other industry-operated or public research facilities.
- RIB: factors associated with the firm's resource base, these include the age of the firm, it's size by total employment (or otherwise), it's research and capital intensities, whether the firm is part or a division in a group of companies and whether the firm's R&D activities are being conducted within the group, the firm's investments in infrastructure/fixed assets/licences, type of production in the firm's plant - one-offs or batch production, the factors hampering a firm's innovation drive: e.g. shortages of finance or of technical skills, and lack of access to appropriate machinery and the up-to-date technology, etc.
- FAC: factors associated with the firm's knowledge adaptive capacity; including the percentage of the firm's workforce that has higher education qualifications or specialised training, fraction of workforce involved in the firm's in-house R&D

projects, and the percentage of the firm's experienced management, and whether the firm has access to or has a formal in-house R&D department, etc.

- GOV: factors associated with firm's access to state assistance for innovation and capital upgrading; including state-directed R&D and innovation, government-sponsored assistance on product/process innovation activities (e.g. state procurement), government support on high capital expenditure goods (plant/machinery/ industrial buildings), and government assistance on training (on management/best practice/human capital development), etc.
- MKT: factors associated with the structure of the market or "the buoyancy of local markets" (Roper *et al.*, 2008); including the province the firm is based in, and the legislative/regulatory requirements. Van Dijk et al. (1997) has observed that the effect of the market structure factors can be weak.

In an endogenous system of equations, it is permissible for the dependent variable of one equation to be an independent variable of another equation in the same system. Similarly, the control and explanatory variables classification are not perilous; according to Imai, King, and Lau (2008, pp. 8, 9), it is also not forbidden for control and explanatory variables to have some common variables.

For these reasons, and to avert the possibility of fostering misperceptions, the dissertation will have two results chapters and in each chapter, some variables will be redefined without fear of repetition.

3.4.3 Descriptive statistics

The third step in generating descriptive statistics involved statistical computation. An open-source software in R, an environment for statistical computing and graphics (R Core Team, 2013), was used. The computed summary of the study's sample reveals the basic attributes of the data used in the study. Tables 7 and 8 summarise the demographic composition of the sample and the descriptive statistics for the main variables considered in this study.

After the data preparation procedure, Table 7 shows the demographic composition of the usable sample by the sizes of those firms (micro-, small-, and medium-sized firms) against their propensities to abstain from innovation activities, to undertake

product-only innovations, process-only innovations, or undertake both product and process innovations.

Table 7: Composition of the sample by innovation activities and distribution of firms by their size.

Dependent variables	Medium	Small	Micro
Non-Innovative enterprises = 1 (%)	20 (36.4)	10 (52.6)	26 (65.0)
Product Innovative enterprises = 1 (%)	31 (56.4)	7 (36.8)	13 (32.5)
Process Innovative enterprises = 1 (%)	28 (50.9)	7 (36.8)	10 (25.0)
Product & Process Innovative enterprises = 1 (%)	24 (43.6)	5 (26.3)	9 (22.5)
Number of firms, n	55	19	40

Source: Author's work based on the SABIS2013 data

In addition, a breakdown of the demographic data of the 328 manufacturing sector firms in the SABIS2013 dataset with respect to the class size of the firm is shown prior in Table 5 on page 43 shows that majority of businesses making up the sample are medium-sized firms.

The correlational results to expose the possible pair-wise relationships within the set of basic variables used in this study are presented in Figure 8. The data were analysed and visualised using the ***Hmisc*** package in R.

The dummy variables the size of the firm by annual turnover (RIB.SIZE) and the size of the firm by a number of employees (RIB.EMPL) show a high but negative correlation. The dummy variables the size of the firm's innovation team (FAC.INNO.TEAM) is also correlated with both the size of the firm by a number of employees (RIB.EMPL) and the innovation intensity (INNO.INT). The correlations between The other main variables are relatively low.

A more expansive correlation matrix (without the significance levels) for the set of variables in Table 8 is offered in Table A2 in Appendix C.

Table 8: Descriptive of Statistics for SA firms

	Mean	SD	Median	Min	Max
KSA.INTERNAL	3.278	0.995	4	1	4
KSA.CLIENTS	2.478	1.292	2	1	4
KSA.SUPPL	2.444	1.291	2	1	4
KSA.COMPET	2.944	1.095	3	1	4
KSA.CONSULT	3.433	0.835	4	1	4
KSA.UNIV	3.678	0.577	4	1	4
KSA.PUB	3.678	0.651	4	1	4
RIB.SIZE	NA	NA	2		
RIB.EMPL	78.389	88.28	39	2	365
RIB.AGE	21.578	14.078	18	1	67
RIB.MNC	0.188	0.394	0	0	1
RIB.PLNT.BCH	0.2667	0.4445	0	0	1
RIB.SA.BASED	0.800	0.402	1	0	1
FAC.RND	0.511	0.503	1	0	1
FAC.HCD	0.544	0.501	1	0	1
FAC.DEG	8.811	14.76	3	0	70
FAC.INNO.TEAM	3.300	5.897	0	0	34
FAC.INNO.ORG	0.144	0.354	0	0	1
FAC.GRP.RND	0.600	0.493	1	0	1
GOV.INNO	0.122	0.329	0	0	1
GOV.CAP	0.033	0.181	0	0	1
GOV.HCD	0.511	0.503	1	0	1
MKT.NAT	0.822	0.385	1	0	1
MKT.EXP	0.544	0.501	1	0	1
d.EMPL	0.354	0.102	0.34	0	0.69
RND.INT	0.739	2.604	0	0	20.9
CAP.INT	0.133	1.022	0	0	9.64
EQUIP.INT	1.206	3.563	0	0	22.4
INNOV.INT	2.120	4.749	0	0	25.6
PROC.INNOV	0.488	0.503	0	0	1
PROD.INNOV	0.555	0.500	1	0	1
BOTH.INNOV	0.411	0.495	0	0	1
NON.INNOV	0.367	0.485	0	0	1
HAMPER.INNOV.COSTLY	2.600	1.216	3	1	4
HAMPER.LACK.INFO	2.822	0.967	3	1	4
HAMPER.LACK.COMPETN	2.622	1.157	3	1	4
HAMPER.PRIOR.INNOV	3.244	0.839	3	1	4

Source: Author's work based on the SABIS2013 dataset

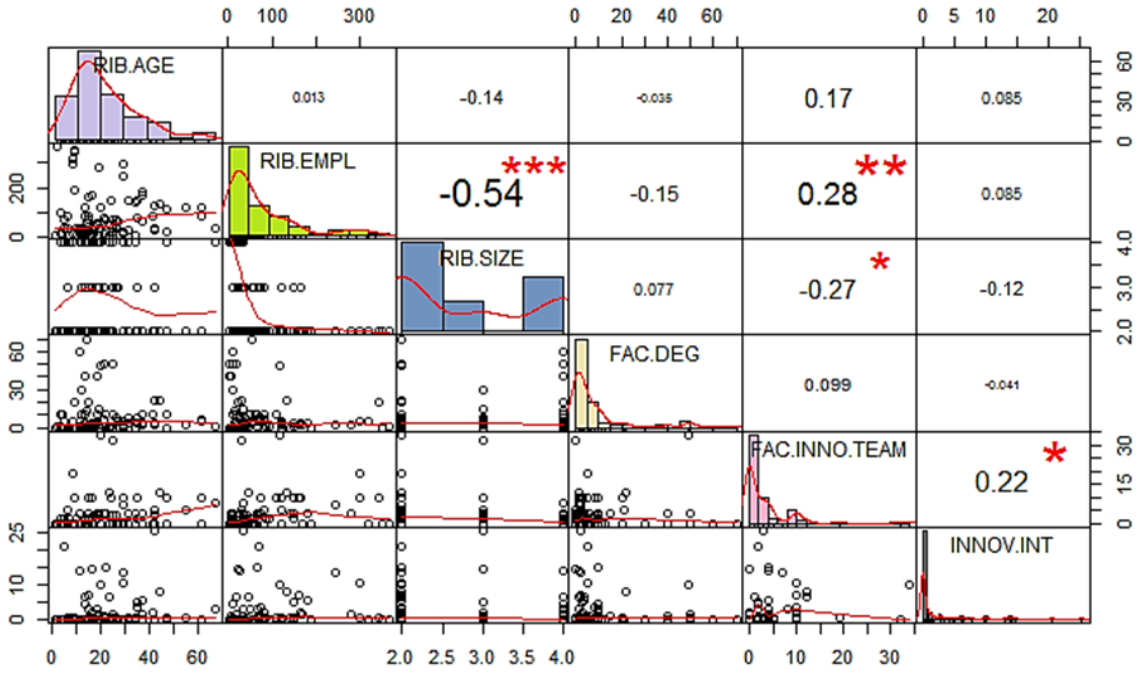


Figure 8: The Pearson correlation matrix of basic variables used

Source: Author's work based on the SABIS2013 dataset

3.5. ECONOMETRIC METHODOLOGY AND STRATEGIES

The estimation strategy adopted for this study involves a combination of quantitative analysis techniques taking direction from literature.

3.5.1 The decision to innovate: estimation strategy

First, in the implementation of the decision to innovate equation, the study assumes that a firm has decided to innovate (i.e. $DECISION_i = TRUE$) if it has indicated it undertook some activities implied in the established OECD definition of innovation (2005b, pp. 46-47) in addition to any other on-going/aborted innovation activities Hadhri et al. (2016, p. 494).

To model the firm's decision-making on innovation, the study considers four different econometric approaches; one used by Hadhri et al. (2016), another by Doran and O'Leary (2011), and the two other approaches proposed by Du et al. (2007). The researcher elected instead to conduct empirical analysis based on Du et al.'s *One-Stage Model* which involves a one-off choice between four discrete alternatives (a choice to engage in product innovation, process innovation, to

engage in both process and product innovation, and to abstain from any innovation activity at all).

The prospect that a firm will partake in innovative activities can be estimated using the decision equation (Eq. 3.1), a latent variable model as shown below after Doran and O'Leary (2011):

$$D2I^*_i = \beta_0 + \beta_1 \cdot \mathbf{X}_i + \beta_2 \cdot \mathbf{Z}_i + \xi_i > 0$$
$$Pr(DECISION_i = TRUE \mid \mathbf{X}_i, \mathbf{Z}_i) = \Phi(\alpha \cdot \mathbf{X}_i + \beta \cdot \mathbf{Z}_i + \xi_i) \quad \text{(Eq. 3.1)}$$
if $D2I^*_i > 0$ then $DECISION_i = TRUE$; otherwise $DECISION_i = FALSE$

where $Pr(DECISION_i = TRUE \mid \mathbf{X}_i, \mathbf{Z}_i)$ represents the conditional probability that firm i decides to engage in innovative undertakings ($DECISION_i = TRUE$) given observable explanatory characteristics $\mathbf{Z}_i$ and some firm control variables $\mathbf{X}_i$ (Eickelpasch, 2014, p. 10; Loi & Khan, 2012, p. 17), $D2I^*_i$ is a dichotomous unobserved latent variable but observed only if the firm has innovated or if $DECISION_i$, the dummy variable capturing whether the firm has undertaken some innovation activity, is observed to be TRUE. $\Phi(\bullet)$ is the standard normal cumulative distribution function (typical for the probit model) – it takes a value of 1 if $DECISION_i = TRUE$ (Pellegrino, 2014), the βs are unknown parameters being estimated, and the error term has a multivariate normal distribution, $\xi_i \sim N(0,\sigma^2)$.

To empirically estimate the decision of manufacturing sector SMMEs to take part in innovation activities (Eq. 3.1), the Du et al. (2007)'s *One-Stage Model*, which is conceptually the simplest of the two multiple discrete selection problems is considered. The *One-Stage Model* was estimated using a multinomial probit model (MNP), using the ***MNP*** package in R (Imai & Van Dyk, 2005).

The *Two-Stage Model* approach was statistically more reliable – but it is computationally challenging. The choice to embrace the *One-Stage Model* approach was also encouraged by the fact that the Du and co-workers clustered their explanatory variables into five main categories as Roper et al. (2008) does for the IVC. This maximises the use of the dataset and harmonises the empirical exercise.

3.5.2 Modelling the IVC: estimation strategy

Roper *et al.*'s IVC framework (2008) allows the researcher to break down the firms' innovation process and empirically model the in three stages (Ganotakis & Love, 2012; Hansen & Birkinshaw, 2007; Neely & Hii, 1998; Roper et al., 2008).

The empirical analysis framework is based on the work of Roper et al. (2008) and Doran and O'Leary (2011) based on microdata from the Irish innovation survey; Ganotakis and Love (2012), from the U.K. innovation survey and Hseih et al. (2011) on the Taiwanese innovation survey. The researcher's decision to conduct the empirical analysis based on the work of Doran and O'Leary (2011) is motivated by one main constraint: the anonymization demands of the chosen dataset inhibit the panel linking of the same firm through time, Doran and O'Leary's empirical analysis demonstrates that cross-sectional data can be used (2011).

The first IVC link

In the first step of modelling the IVC, (Eq. 3.2), the investigation closely follow the approach reported by both Roper et al. (2008) and Doran and O'Leary (2011) which allows for a detailed analysis and subsequent interpretation of the impact of various knowledge sources; Eq. (3.2) is estimated using a series of probit models, performing one empirical estimation for each knowledge source activity at a time.

The tendency of the ith firm to participate in any one of the k knowledge sourcing activities is represented by a latent variable, KS_{ji}^{*} and KS_{ji} represents its corresponding dichotomous variable. The probability is estimated using the knowledge production equation, Eq. (3.2) shown below:

$$KS_{ji}^{*} = \beta \cdot KSA_{ki} + \gamma_0 \cdot RIB_{ji} + \gamma_1 \cdot FAC_{ji} + \gamma_2 \cdot GOV_{ji} + \gamma_3 \cdot MKT_{ji} + \varepsilon_{ji} \quad \text{Eq. (3.2)}$$

$$\text{if } KSA_{ji}^{*} = 1 \text{ then } KSA_{ji} = 1\text{; otherwise } KSA_{ji} = 0$$

where KSA_{ki} is a collection of variables associated with the firm's knowledge sourcing activities, RIB_{ji} with the firm's resource base, FAC_{ji} a collection of variables associated with the firm's absorptive capacity, GOV_{ji} a collection of variables associated with firm's access to public funding for innovation and capital expenditure (through the national, provincial and/or local governments, municipalities, cities, state entities, etc.) while MKT_{ji} represent is a set of variables

associated with the structure of the market or "the buoyancy of local markets" (Roper *et al.*, 2008). The set of coefficients, γ_0, γ_1 and γ_2 are unknown coefficients associated with the independent variables, The error term ε_{ji} is expected to have a multivariate normal distribution where $\varepsilon_{ji} \sim N(0,\sigma^2)$. The variables were also defined explicitly prior to this in Table 6 on p. 45.

The second IVC link

The probability that a firm will embark on activities to transform knowledge into innovations is estimated using the innovation production function. The innovation production equation is shown as Eq. (3.3) below:

$$INNO_i = \phi_0 \cdot KSA_i + \phi_1 \cdot RIB_i + \phi_2 \cdot FAC_i + \phi_3 \cdot GOV_i + \phi_4 \cdot MKT_i + \mu_i \qquad \text{Eq. (3.3)}$$

where $INNO_i$ is an innovation output dependent variable, the ϕs are unknown coefficients, μ_i is an error term having a multivariate normal distribution, the sets of variables KSA_{ji}, RIB_{ji}, FAC_{ji}, GOV_{ji} and MKT_{ji} are also defined as in Eq. (3.2) before.

The third IVC link

To model this knowledge exploitation effect, if a firm has participated in innovative activities, Eq. (3.4) below then expresses the influence of innovation output on the firm's performance/productivity. The output production Eq. (3.4), for all intents and purposes, is a modified production function from the Crépon-Duguest-Mairesse model (CDM) framework (Crépon et al., 1998; Doran & O'Leary, 2011).

$$BPERF_i = \lambda_0 + \lambda_1 INNO_i + \lambda_2 X_i + \lambda_3 MKT_i + \tau_i \qquad \text{Eq. (3.4)}$$

where $BPERF_i$ is an indicator of innovation output measures or firm's performance (Ganotakis & Love, 2012; Roper et al., 2008), $INNO_i$ representing a set of variables describing product and process innovation output measures, X_i represents a set of firm-specific variables assumed to be determinants of firm performance, λ_i is a set of unknown coefficients, while τ_i, is an error term having a multivariate normal distribution. As in Eq. (3.2) – Eq. (3.4) before, the variables are explicitly defined also in Table 6 on p. 45.

Doran and O'Leary (2011), like Crépon et al. (1998) and Lööf et al. (2017) before them, advise that the innovation production equation (Eq. 3.3) and the outputs production equation (Eq. 3.4) are codetermined; some of the innovation output

measures are dependent variables in Eq. (3.3) and also explanatory variables in the Eq. (3.4). Biased estimates of Eq. (3.3)'s and Eq. (3.4)'s respective coefficients may result if the single equation estimation approach is applied on each of the production equations separately. Eq. (3.3) and Eq. (3.4) are therefore estimated simultaneously, due to this endogeneity problem (Doran & O'Leary, 2011).

In the second and third steps of modelling the IVC (using Eq.s 3.2 and 3.3), the investigation also considered the approaches reported in the literature (Doran & O'Leary, 2011; Ganotakis & Love, 2012; Hseih et al., 2011; W. L. Hsieh, Ganotakis, Kafouros, & Wang; Roper et al., 2008) (Doran & O'Leary, 2011; Ganotakis & Love, 2012; Hseih et al., 2011; W.-L. Hsieh, 2013; Roper et al., 2008); in the end, the two were estimated using the three-stage least squares (3SLS) procedure in R.

3.5.3 Determinants of innovation: estimation strategy

The study also attempts to determine the factors that influence South African SMMEs to undertake innovation activities. The empirical model used for the purposes of the work is shown as Eq. (3.5) in its general form. The dependent binary variable is the tendency of a firm to undertake innovative activities; it is a latent variable denoted y_i^* in Eq. (3.5b). The observed dependent variable (y_i), proxy to the latent variable, assumes a value of 1 if the firm is innovating, otherwise it equals zero as indicated in Eq. (3.5a).

$$y_i = \begin{cases} 1, & y_i^* = \beta_i x_i + \mu_i > 0 \\ 0, & Otherwise\ (Non\ Innovators) \end{cases} \quad (3.5a)$$

$$y_i^* = P(y_i = 1|x) = \beta_i x_i + \mu_i \quad (3.5b)$$

$$Pr(y_i = 1|x) = \Phi(\beta_0 + \beta_1 \boldsymbol{RIB}_i + \beta_1 \boldsymbol{FAC}_i + \beta_1 \boldsymbol{GOV}_i + \beta_1 \boldsymbol{MKT}_i + \beta_1 \boldsymbol{KSA}_i + \mu_i) \quad (3.5c)$$

where $Pr(y_i = 1|x)$ is the propensity of firm i to innovate, $\Phi(\bullet)$ denotes the standard normal cumulative distribution function, β_i is a vector of the unknown coefficients associated with the explanatory variables, x_i. The random error term μ_i is known to follow a normal distribution. In Eq. (5c), the study follows Abdu and Jibir (2017) in identifying and grouping variables: RIB_i as those firm-specific factors, FAC_i as those factors associated with the firm's adaptive capacity, GOV_i as factors associated with firm's access to public support for innovation and innovative activities, MKT_i as those market- or industry-specific characteristics or "*the*

buoyancy of local markets" (Roper et al., 2008, p. 963) while KSA_i are those factors associated with the firm's knowledge sourcing activities.

The strategy is to use a bivariate probit model analysis with instrumental variables (Sector, South African based, and being part of a larger group of companies) after Hadhri et al. (2016). Also after Hadhri *et al.* (*ibid*.), in order to assess the probability of a firm to engage in different innovation activities, the study employs a number of different econometric models starting with a baseline model as specified in Eq. (5.2) and, then build successive models by carefully introducing other sets of factors. This approach is common in the econometrics literature see for example (Barasa et al., 2017; Bogliacino & Pianta, 2012; Guarascio, Pianta, & Bogliacino, 2017)

The data were analysed and visualised using the ***probitmfx*** procedure in R in the R environment for statistical computing.

3.6 FEASIBILITY OF THE STUDY

In more recent times, innovation indicators have become widely used as more superior indicators of innovation activities compared to the conventional patent data R&D expenditures and/or patent R&D surveys, see Aerts and Czarnitzki (2004) and Ndlovu (2016), for example.

Using evidence from innovation survey, various researchers have investigated the relationship between firms' characteristics (e.g. export status, ownership structure, and size) and their different sorts of innovation activities (Ganotakis & Love, 2012; Hseih et al., 2011; Lööf et al., 2017; Mustapha & Mendi, 2015; Roper et al., 2008; Taghizadeh et al., 2014), productivity and innovation at the firm-level, the decision to innovate and the propensity of innovation (Abdu & Jibir, 2017; Bocquet & Musso, 2010; Bogliacino & Pianta, 2012; Guarascio et al., 2017; Jang, 2017).

The innovation value chain framework and tool describes a process with three intertwined stages, from sourcing knowledge for research and development (R&D) to transforming this sourced knowledge into innovation output and for performance gains. Prior studies have reported on the empirical analysis and modelling of the innovation value chain based on national innovation findings in Ireland (Doran & O'Leary, 2011; Roper & Arvanitis, 2012), in the United Kingdom (Ganotakis &

Love, 2011, 2012), in China (Guan & Chen, 2010), in Ireland and Switzerland (Roper & Arvanitis, 2012), in Indonesia (Martowidjojo & Alamsjah, 2011), Malaysia (Taghizadeh et al., 2014) and in Taiwan (Hseih et al., 2011). Stunningly, altogether a diverse set of countries have been studied using this tool, none of the countries studied is from Africa and specifically the Sub Saharan region.

The methodology of the SABIS2013 recognises four types of innovation, (namely product, process, marketing and organisational innovations) – but focuses on product, process, and partly on organisational innovations (Moses, Sithole, Makelane, et al., 2012). The survey-based secondary data also collected information on the knowledge sources and co-operation for innovation activities and effects of innovation. These data are useful for the modelling of the innovation value chain.

3.7 ASSUMPTIONS

The research will be based on inputs from interviews with the management of SMMEs in the manufacturing sector in South Africa. It is assumed that:

i. The participating SMMEs responded to the survey or interview questions honestly and factually.
ii. The study sample is as representative enough as the population of SMMEs in the manufacturing sector in South Africa we wish to make inferences on.
iii. The interview process is assumed to be secure as to preserve anonymity and confidentiality. In addition, it is assumed to create a trusting environment in which the relevant information about innovation in small firms in South Africa can be obtained without exposing the identities of the participants. Furthermore, it is assumed that participants' responses to the questions are relevant, informative, and insightful – that their answers will give insights into their experiences otherwise not obtainable.
iv. The IVC framework and modelling tool have never been applied in the South African context, in particular. It is assumed therefore that the tool will give reliable outcomes.

3.8 RESEARCH QUALITY

A few reliability and validity issues were raised in the report.

According to the principal researchers of the SABIS2013 survey caution that the survey's response rate was less than the necessary target required in order to produce national aggregates of overall innovation indicators as National Innovation Survey (Moses et al., 2013, p. 13).

The SABIS2013 survey design was based on the Oslo Manual (OECD, 1997, 2005); the survey questionnaire is directly comparable OECD's CIS 4 core questionnaire (Moses et al., 2013). While the CIS 4 methodology recommends basing the size of the business enterprise employee numbers, the SABIS2013 survey bases the size classes in accordance with the National Small Business Amendment Act – thus on the turnovers of enterprises rather than the number of employees. According to the principal researchers of the SABIS2013 survey, see Moses et al. (2013, pp. 13-14), any comparisons with countries that strictly follow the CIS 4 methodology must take note of these deviancies.

However, the quantitative methods opted for as well as the well-accepted secondary data sources are designed to ensure a degree of objectivity, generalizability and reliability (Leung, 2015). To further improve the reliability and validity of the study, the analysis conducted for this work is intentionally in replication of seminal works such as (Doran & O'Leary, 2011; Du et al., 2007; Ganotakis & Love, 2012; Roper et al., 2008).

3.9 LIMITATIONS OF THE RESEARCH METHODOLOGY

This methodology identified the following limitations:

- Due to ethical considerations and in the interest of safeguarding anonymity and confidentiality of the voluntarily participating firms, the guardian of the SABIS2013 dataset demands anonymization as a concomitant access condition. This prevents the panel linking of the same enterprise from survey wave to wave through time. This imposes an unusual limitation on the dynamic effects (time-series) or longitudinal dimension in the innovation status of firms. According to Damijan et al. (2017) "one can only rely on the cross-sectional dimension of the data".
- The research approach adopted for this study seeks to statistically analyse large volumes of secondary survey enumerated data in order to generate reliable insights and breadth of experiences. Although the methodology allows for

generalisations of the outcomes because the survey instrument captured structured responses, the research methodology fails to generate depth-of-experiences descriptions such as human perception and beliefs (Creswell & Clark, 2007; Creswell et al., 2011; Johnson et al., 2007; Teddlie & Yu, 2007). As such, the failure to provide more detailed information to explain complex issues is a glaring limitation of the adopted research methodology. Enumerating every other variable might lead to a situation where empirical solutions fail to provide satisfactorily practicable information to guide innovation practitioners (as well as firms, innovation agencies and industry sectors) on what they should do in terms of actions/response.

- Innovation survey quantitative research characteristically involves large sample sizes which necessitate a budget that makes this kind of research (a dissertation such as mine) unjustified. Therefore, the researcher had no control over the sampling techniques, selection of participating firms, as well as how the environments in which the participants were immersed (Baxter 2008). The researcher is aware therefore that the participants' responses often depend on the particular time and conditions prevailing during that particular time frame.
- While on the quantitative research nature of typically requiring large sample sizes, a limitation of the adopted research methodology arises with the SABIS2013 particularly owing to the low response rate. The survey's 16% response rate is less than the acceptable target required in order to produce national aggregates of overall innovation indicators as initially intended in the survey.
- According to Roper et al. (2008), the nature of the IVC's suggests that innovation cannot be implemented unless it has been introduced; the tool is not useful if innovation has not been exploited.
- Since the definition of firm size class is subjective, if not contentious, a limitation of the adopted research methodology might arises where the size classes as prescribed in the National Small Business Amendment Act in the case of the SABIS2013 which is biased towards representing the extent of the turnovers of enterprises differ from those used in the EU which is biased towards representing the number of employees. Any comparisons with countries that base their size classes on employee numbers, as recommended by CIS 4 methodology, should be viewed in the light of these differences.

3.10 ETHICAL CONSIDERATIONS

The research involved the gathering and using data collected from people (human participants). In formulating this study, the researcher undertook to fully submit to the Guidelines for Human Research Ethics Clearance Application (Non-Medical) set-out by the University of the Witwatersrand (2013) and the CeSTII, HSRC's data access conditions (HSRC, 2017).

The researcher made an application to the University of Witwatersrand Ethical Committee for ethical clearance before the research work commenced.

The researcher considered five major ethical issues that arise when one conducts social research, as identified by McNamara (1994), are concerns that deal with:

i. the issue of informed consent,
ii. the issue of voluntary participation,
iii. the issue of respect for privacy,
iv. the issue of safeguarding anonymity and confidentiality, and
v. the issue of accuracy of report and result.

While issues (i and ii) are not directly under the control of the researcher due to the nature of the survey-based secondary data approach taken. The researcher understands that participation in the CIS surveys was voluntary. Further, CeSTII survey methodologies give assurances that issues (i) and (ii) were considered when the surveys are conducted (Moses et al., 2011, pp. 96-101).

In addition, the researcher together with CeSTII considered issues (iii) and (iv) of respect for privacy, safeguarding anonymity and confidentiality.

i. The CIS data characteristically considers confidentiality sacrosanct. As the first layer of protection, access to CeSTII data is strictly controlled.
ii. However, in addition to the safeguards, yet another feature of CIS data is that is has been anonymised so as to ensure any individual persons or businesses who voluntarily participated in the survey cannot be identified
iii. Before being granted access to the anonymised data, the researcher signed a confidentiality agreement guaranteeing "the physical security of the data, including prevention and taking action in case of violation of confidentiality", specifying the agreed purposes and terms of use of the data.

iv. In addition to removing firm identifying data indices, other variables that could otherwise serve as identifier were removed prior to access. Industries with a small number of firms surveyed were also not included in the sample in order to safeguard their privacy and right to anonymity.
v. Delete any original files received from CeSTII when the research comes to an end.

By accessing and using the HSRC's dataset, the researcher gave assurance that:

i. The requested original files received from CeSTII would be used only for research purposes after which redundant data files would be destroyed. Any additional purposes would require further consultations from the CeSTII Data Committee.
ii. There would be no unauthorised duplication and redistribution (including selling) of the data without prior approval from the CeSTII Data Committee.
iii. That the HSRC will be duly acknowledged and informed of any unpublished and published produced from the received data set. This includes "books, articles, conference papers, theses, dissertations, reports or other publications based in whole or in part on the data and documentation".
iv. That all electronic copies of any of the unpublished and published works, resulting from work on the received data set, would be proffered to the HSRC for archiving and bibliographic purposes.

3.11 SUMMARY

The conceptual framework highlights that innovation activities are a complex tandem process involving equally complex constructs (Volberda *et al.*, 2013) and involving fragmented internal and external agents and many moving parts (Hansen & Birkinshaw, 2007) (determinants). This is suitable for this study since innovation is a multidimensional and complex subject characterised by multiple knowledge sources (Barrett & Sexton, 2006; Creswell & Clark, 2007).

Some significant characteristics of SABIS2013, the sample selection criteria and empirical strategies and methodological aspects are summarised in Table 9 and. Figure 9 below.

Table 9: Summary of sample methodological aspects

Geographical area	South Africa
Units of analysis	Manufacturing sector SMME in the SABIS2013 dataset
Population	Manufacturing SMME firms operating in/from South Africa that are not survivalist firms
Data collection	Secondary data 2013 South African Business Innovation Survey
Duration of data collection	01 January 2011 to 01 December 2012
Survey details	The survey was conducted by CeSTII of the HSRC on behalf of the DST, in accordance with the OECD/Eurostat CIS survey methodological specifications and guidelines.
Sample selection	Size (by the firm's annual total turnover) Purposive judgement sampling technique Schematically presented in Figure 7
Sampling frame	Manufacturing sector SMMEs that responded and completed the SABIS2013 survey
Sample used	138 manufacturing sector SMMEs
Software statistic	OpenRefine (version 2.8) – for cleaning up or transforming messy tabular data to usable formats (Huynh, 2017). R, an environment for statistical computing and graphics (R Core Team, 2013) and numerous R packages
Data analysis	Exploratory descriptive statistics Econometric data modelling and analysis

Source: Athour

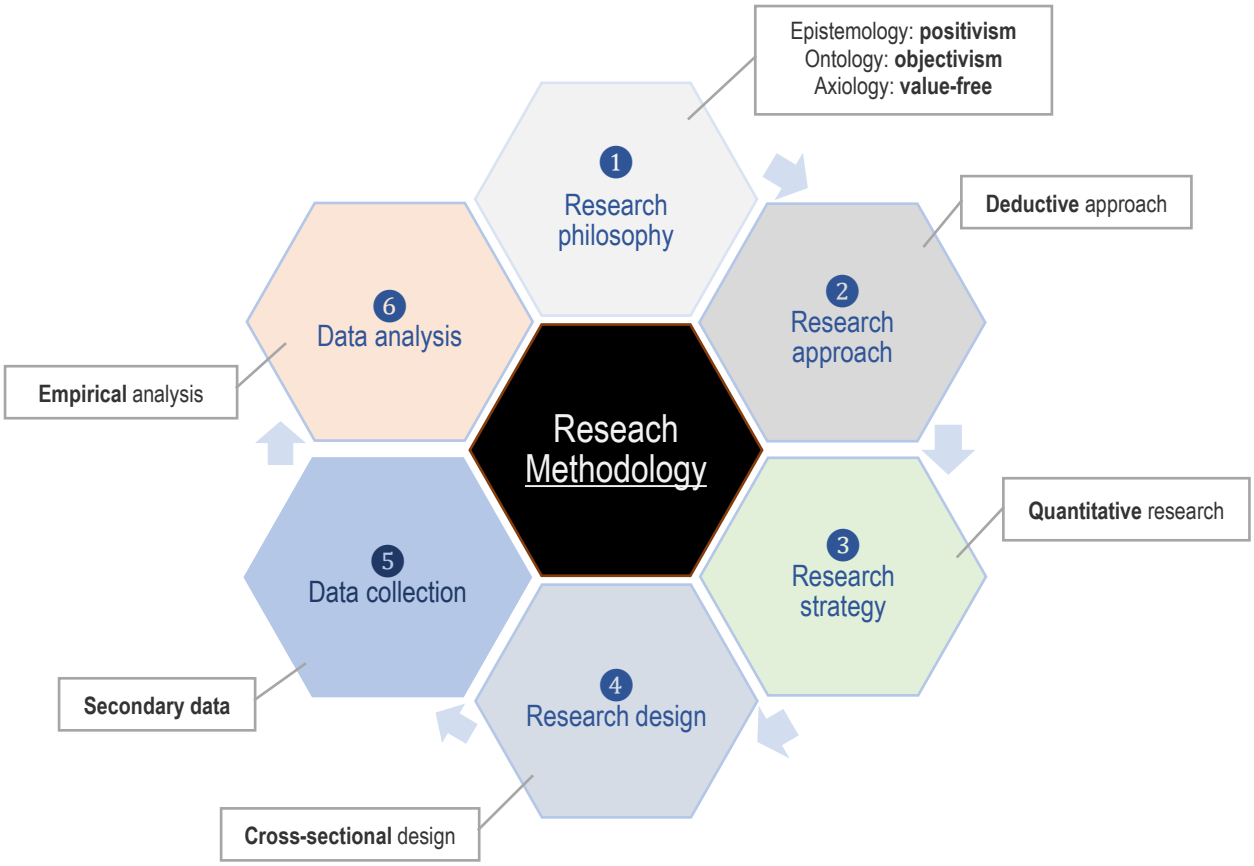


Figure 9: The strategy informing the development of the research methodology.

Source: after Wilson (2014)

CHAPTER 4.
MODELLING THE INNOVATION VALUE CHAIN

4.1 BRIEF BACKGROUND

The innovation value chain (IVC) is a relatively new innovation framework although the framework has roots in prior models (Hansen & Birkinshaw, 2007; Smit, 2015). The IVC framework allows the researcher to break down the firms' innovation process and empirically model the in three stages (Ganotakis & Love, 2012; Hansen & Birkinshaw, 2007; Neely & Hii, 1998; Roper et al., 2008).

The framework is usually viewed and used as: (a) a strategic approach tool in the assessment of the strength and weakness in the innovation process (Hseih et al., 2011; Martowidjojo & Alamsjah, 2011); (b) a tool for bringing together a more end-to-end treatment to innovation, taking into consideration its knowledge sourcing, its transformation, and eventual exploitation of innovation for value creation (Hseih et al., 2011; Roper & Arvanitis, 2012; Roper et al., 2008); and (c) ensure that the innovation process will be analysed and measured in a quantitative study which often is needed for policy-making purposes (Guan & Chen, 2010).

While seeking to model the IVC, the researcher appreciates the fact that the decision to undertake innovative activities at a firm level precedes the endeavour itself. According to Du et al. (2007, p. 766) most studies casually make the assumption however, investigations into how the decisions to innovate remains are made and what influences them to remain largely unreported in the emerging markets; to the best of the author's knowledge, no prior report on the investigations into the innovation decision-making in the south African context is available in the literature.

Recent works by Doran and O'Leary (2011), Braga and Braga (2013), Bourke and Jordan (2015), Sdiri and Ayadi (2016), and Lopez-Fernandez, Serrano-Bedia, and Gómez-López (2016) have reported the way by which firms make their innovate decisions using two econometric models proposed by Du et al. (2007).

In this chapter, the study attempts to investigate innovation decision-making in South African SMMEs in the manufacturing sector by estimating the effects of

various factors on the firms' innovation decision – using an approach proposed by (Du et al., 2007). An attempt is made to model the IVC for the manufacturing sector SMMEs in South Africa in order to highlight the determinants of innovation, productivity and growth in these firms. The research uses evidence from the responses contained in the 2013 national innovation survey.

4.2 DATA AND SAMPLE

The Sample

A summary of the composition of the sample by innovation activities and distribution of firms by their size based on the SABIS2013 dataset is shown in Table 7. Some significant aspects of the sample used in this chapter are summarised in Table 9.

4.3 THE MODELS AND ESTIMATION STRATEGY

4.3.1 Decision-making model

The study assumes that a firm has decided to innovate (i.e. $DECISION_i = TRUE$) if it has indicated it undertook some activities implied in the established OECD definition of innovation (2005b, pp. 46-47) in addition to any other on-going/aborted innovation activities Hadhri et al. (2016, p. 494).

Model specification

The prospect that a firm will partake in innovative activities can be estimated using the decision equation, a latent variable model as shown below, (Eq. 4.1) (Doran & O'Leary, 2011):

$$D2I^*_i = \beta_0 + \beta_1 \cdot \mathbf{X}_i + \beta_2 \cdot \mathbf{Z}_i + \xi_i > 0$$
$$Pr(DECISION_i = TRUE \mid \mathbf{X}_i, \mathbf{Z}_i) = \Phi(\alpha \cdot \mathbf{X}_i + \beta \cdot \mathbf{Z}_i + \xi_i) \quad \text{(Eq. 4.1)}$$

if $D2I^*_i > 0$ then $DECISION_i = TRUE$; otherwise $DECISION_i = FALSE$

where the terms in the equation were defined in Eq. (3.1).

The estimation strategy

The estimation strategy follows the *One-Stage Model* procedure as suggested by Du et al. (2007). In this work makes use of the multinomial probit model (MNP) ***MNP*** package (Imai & Van Dyk, 2005) in R, a statistical computing and graphics environment (R Core Team, 2013), to estimate Eq. (4.1).

4.3.2 Modelling the IVC

Model specifications

Panel data analysis was initially intended for this study, based on the work of Roper *et al.* (2008). However, the anonymization demands of the chosen dataset inhibit the panel linking of the same firm through time, Doran and O'Leary's empirical analysis demonstrates that cross-sectional data can be used (2011). The researcher opted then to conduct the empirical analysis based on the work of Doran and O'Leary (2011) instead.

The likelihood that an SMME will participate in the knowledge sourcing undertakings is given by Eq. (4.2) while Eq.s (4.3) and (4.4) presents the second and third IVC links. The complete IVC model is given by the following equations

$$\boldsymbol{KSA^*_{ji}} = \beta_{ji}\boldsymbol{KSA}_{ki} + \gamma_0\boldsymbol{RIB}_{ji} + \gamma_1\boldsymbol{FAC}_{ji} + \gamma_2\boldsymbol{GOV}_{ji} + \gamma_3\boldsymbol{MKT}_{ji} + \varepsilon_{ji} \quad \text{Eq. (4.2)}$$

$$\text{if } KS^*_{ji} > 0 \text{ then } KS_{ji} = 1\text{; otherwise } KS_{ji} = 0$$

$$INNO_i = \phi_0 \cdot KSA_i + \phi_1 \cdot RIB_i + \phi_2 \cdot KUC_i + \phi_3 \cdot GOV_i + \phi_4 \cdot MKT_i + \mu_i \quad \text{Eq. (4.3)}$$

$$BPERF_i = \lambda_0 + \lambda_1 INNO_i + \lambda_2 X_i + \lambda_3 MKT_i + \tau_i \quad \text{Eq. (4.4)}$$

where the terms were prior defined as in Eq.s (3.2 -3.4) in Chapter 3.

The estimation strategy

To estimate the Eq. (4.2), while "*the most efficient approach from an econometric point of view*" is the multinomial probit regression approach (Ganotakis & Love, 2012; Roper et al., 2008) the researcher's trials and experience with the 'efficient' multinomial probit approach is that achieving convergence is not easy. Therefore, following Ganotakis and Love (2012); Roper et al. (2008) and Doran and O'Leary

(2011), instead of pursuing the multinomial probit estimator for efficiency, several single-equation probit models were used, one for each knowledge source.

This approach, of using several single-equation probit models, does sacrifice some statistical efficiency but for the ability to calculate marginal effects that are easier to conceptualise as opposed to the probit regression coefficients.

Doran and O'Leary (2011), like Crépon et al. (1998) and Lööf et al. (2017) before them, advise that the innovation production equation (Eq. 4.3) and the outputs production equation Eq. (4.4) are codetermined; since some of the innovation, output measures are dependent variables in Eq. (4.3) and also explanatory variables in the Eq. (4.4). Biased estimates of Eq. (4.3)'s and Eq. (4.4)'s respective coefficients may result if the single equation estimation approach is applied on each of the production equations separately. Eq. (4.3) and Eq. (4.4) are therefore estimated simultaneously, due to this endogeneity problem (Doran & O'Leary, 2011).

4.4 RESULTS AND DISCUSSIONS

The results of the analysis are reported in this section. Unless otherwise stated, the regression results tables presented in this section report average marginal effects instead of the common model coefficients.

4.4.1 The empirical results: The innovation-decision

If the firms' innovation decision is treated as a multiple choice problem according to the one-stage innovation decision-making model adopted, Tables 10 below reports on the marginal effects of the econometric estimation derived from Eq. (4.1).

Regarding the influence of the firm's characteristic:

- Intramural R&D endeavours can significantly and positively influence the likelihood of the SMMEs to undertake both the new to the firm and the new to market innovations.
- Marginal effects, although positive, suggests that the SMMEs' age or a number of employees makes no difference to their decision to undertake both new to new to the firm and new to market innovations. These observations show that

SA SMMEs are less likely to decide to participate in new-to-firm innovations than foreign-based firms. The expectation that foreign-owned or foreign-based firms are exposed to additional sources of knowledge when compared to the locally based or owned firms was also advanced by Abazi-Alili (2014, p. 13).

Table 10: Probit model estimates of the decision to innovate

	Dependent variable	
Variable	NEW2FIRM (1)	NEW2MKT (2)
RIB.EMPL	0.001 (0.004)	0.0001 (0.002)
SA.BASED	**-0.896***** (0.794)	0.316 (0.439)
RIB.AGE	0.030 (0.022)	0.003 (0.013)
INHSE.RnD	**0.222**$^{.}$ (0.053)	**0.941***** (0.380)
FCT.LACK.FUNDS	-0.693 (0.534)	0.233 (0.358)
FCT.LACK.FIN	-0.532 (0.454)	**-0.207*** (0.101)
FCT.INNOV.COSTLY	-0.576 (0.474)	-0.060 (0.250)
FCT.SKILLS.SHORT	0.528 (0.459)	0.024 (0.296)
FCT.NO.INFO.TECH	**-0.847**** (0.748)	**-0.01**$^{.}$ (0.004)
FCT.NO.KS.PARTNERS	-0.698 (0.463)	0.089 (0.267)
FCT.MKT.MONOP	**0.947*** (0.505)	-0.101 (0.222)
FCT.MKT.UNCERT	-0.398 (0.487)	-0.029 (0.257)
FCT.BCOZ.PRIOR.IP	0.926 (0.621)	-0.354 (0.352)
FCT.BCOZ.NO.DMND	**0.905*** (0.521)	0.303 (0.344)
PREV.INNOV	**0.410*** (0.213)	**-0.705*** (0.371)
Observations	70	70
Log Likelihood	-21.828	-41.153
Akaike Inf. Crit.	75.656	114.307

Notes: Coefficients are marginal effects and the standard errors are in parentheses; the Signif. Codes are as follows: *** p < .001, ** p < .05, * p < .1.

Source: Author's work based on the SABIS2013 dataset

Regarding the influence of those other factors that can hinder the decision to engage innovation activities, the effects are mixed, as in Doran and O'Leary (2011):

- SMMEs that identified prior innovations (PREV.INNOV) as reasons not to innovate were surprisingly more likely to decide to undertake new-to-firm and less likely to decide to undertake new to the market innovations. The former is consistent observations made by Doran and O'Leary (2011) and a case for the firms' learning capabilities and the prospects pursuing secondary innovation activities (Wu, Ma, Shi, & Rong, 2009).
- However most notably, SMMEs that identified market uncertainties (FCT.MKT.UNCERT), lack of enough information (FCT.NO.INFO.TECH), and lack of adequate finance (FCT.LACK.FIN) as important factors in hindering their innovation activities or projects were generally less likely to decide to undertake both new-to-firm and new to the market innovations.
- SMMEs that identified no demand for innovations (FCT.BCOZ.NO.DMND) and lack of skilled personnel (FCT.SKILLS.SHORT) as reasons not to innovate were surprisingly more likely to decide to undertake both new-to-market and new to the firm innovations. The possible explanations for these as well as the other mixed effects are not immediately clear from this study alone.
- Based on these observations, the hypothesis H1 is not supported.

The influences of those factors that have been identified as hindrances to the decision to engage innovation activities need not to appear counter-intuitive; for it is those innovation-active firms that are more likely to encounter, identify these factors, and want to solve them (Doran & O'Leary, 2011).

The researcher recognises that the *One-Stage* estimation procedure adopted for this work is simpler but statistically inferior against the *Two-Stage* estimation procedure with respect to predictive power. However, the margin of the inferiority, 61% vs 66% according to Sdiri and Ayadi (2016), can be shown to be thin and inconsequential. Subsequently, the results obtained for this study are largely consistent with those reported by Du et al. (2007, p. 769) and Roper et al. (2008, p. 969).

4.4.2 The empirical analysis: IVC knowledge sourcing

Just over 75% of the firms have sought information for innovation activities from various sources. The average number of firms engaging a knowledge sourcing activity used by each of the survey firms is presented in Figure 10 below.

SA manufacturing SMME firms are about two-thirds most likely to engage with institutions of higher education and rival firms (competitors) than other knowledge sources. It is clear most of the firms make use of external knowledge sources, thus the hypothesis H2 is confirmed.

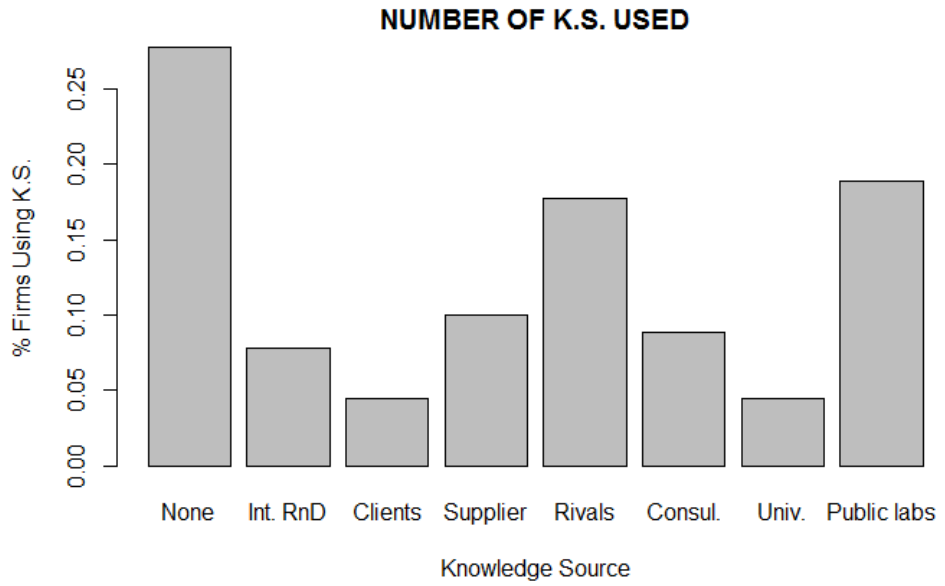


Figure 10: Frequency of knowledge sources by types of external sources

Source: Author's work based on the SABIS2013 dataset

Table 11: Marginal effects estimates of the knowledge sourcing for innovation activities.

	In-House R&D	Forward Knowledge Sourcing	Backward Knowledge Sourcing	Horizontal Knowledge Sourcing	Public Knowledge Sourcing
	dF/dx (Std. Err.)	dF/dx (Std. Err.)	dF/dx (Std. Err.)	dF/dx (Std. Err.)	dF/dx (Std. Err.)
Knowledge Sourcing Variables					
KSA.INT	∅	7.90E-02· (3.97E-02)	0.2667*** (< 2.2e-16)	-6.67E-02*** (2.49E-05)	2.87E-01*** (7.92E-02)
KSA.FWD	2.63E-02 (1.49E-01)	∅	0.1333*** (< 2.2e-16)	2.56E-01*** (4.30E-05)	8.93E-03 (1.42E-01)
KSA.BWD	4.95E-01*** (1.13E-01)	7.28E-02 (1.16E-01)	∅	6.78E-01*** (1.61E-04)	3.57E-01*** (6.38E-02)
KSA.HZL	1.62E-01· (1.49E-01)	5.91E-01*** (1.21E-01)	0.2778*** (< 2.2e-16)	∅	1.01E-01 (1.36E-01)
KSA.PUB	3.38E-01*** (8.18E-02)	1.47E-01 (1.46E-01)	0.2667*** (< 2.2e-16)	1.78E-01*** (3.34E-05)	∅
Resource Base Variables					
RIB.EMPL	2.43E-04· (4.30E-05)	-5.57E-06 (1.54E-03)	0 (NA)	-3.80E-07 (6.12E-05)	1.25E-03 (1.59E-03)
RIB.AGE	4.81E-03 (8.90E-03)	5.12E-03 (9.46E-03)	0 (NA)	3.46E-06 (5.68E-04)	-5.25E-03 (8.47E-03)
RIB.AGE (Squared)	-5.75E-05 (1.45E-04)	-4.00E-05 (1.61E-04)	0 (NA)	6.40E-08 (1.03E-05)	7.14E-05 (1.27E-04)
RIB.SA.BASED	7.60E-02 (1.10E-01)	1.67E-01* (8.37E-02)	0 (NA)	-1.28E-04 (2.04E-02)	-2.68E-01** (9.24E-02)
Knowledge Utilisation Variables					
FAC.GRP.RND	-9.85E-02 (1.33E-01)	-3.86E-02 (8.59E-02)	0 (NA)		-2.52E-01* (1.23E-01)
FAC.DEG	6.88E-04 (3.15E-03)	-5.11E-04 (2.31E-03)	0 (NA)	-1.23E-07 (2.62E-05)	-9.03E-04 (3.01E-03)
FAC.INNO.TEAM	-6.10E-03 (5.71E-03)	-1.21E-02 (8.24E-03)	0 (NA)	-7.37E-06 (1.19E-03)	6.65E-03· (5.86E-03)
FAC.RND	6.28E-02 (1.12E-01)	2.36E-01 (1.77E-01)	0.100*** (< 2.2e-16)	-8.14E-02 (3.34E+01)	1.15E-01 (1.03E-01)
RND.INT	7.05E-04 (1.24E-02)	6.70E-02· (3.93E-02)	0 (NA)	1.00E-03 (1.61E-01)	-2.10E-02 (2.15E-02)
FAC.INNO.ORG	-3.27E-03 (9.55E-02)	-1.44E-01* (6.95E-02)	0.033*** (< 2.2e-16)	1.41E-01 (1.68E+00)	
Innovation Constraints					
HAMPER.LACK.FUNDS	-1.39E-02 (3.63E-02)	7.19E-02· (3.82E-02)	0 (NA)	3.90E-05 (6.27E-03)	3.90E-02 (3.35E-02)
HAMPER.LACK.SPECIAL.SKILLD.	-3.22E-02 (6.10E-02)	-2.05E-02 (2.80E-02)	0 (NA)	-1.27E-04 (2.04E-02)	1.30E-02 (5.94E-02)
HAMPER.LACK.INFO	7.78E-02 (6.23E-02)	-3.83E-02 (2.78E-02)	0 (NA)	2.38E-04 (3.84E-02)	-5.15E-02 (5.84E-02)
Observations	106	106	106	106	106
Akaike Inf. Crit.	109.45	85.237	56.951	114.20	69.099
Wald test, P(> X2)	35.1	25.9	9.4	27.6	11.4
Wald test, P(> X^2)	0.00012	0.0039	0.092	0.0024	0.044

Notes: Signif. Codes: *** p < .001, ** p < .05, * p < .1. All coefficients are marginal effects & standard errors in parentheses.

Source: Author's work based on the SABIS2013 dataset

The knowledge sources include internal R&D sources and external sources such as competitors, customers, suppliers and consultants, or universities and government research institutes. And 'knowledge', in this case, assumes many different forms such as codified and tacit knowledge, scarce skills, competence, talents, etc.

It is important to note here, that knowledge sourcing activities as discussed hereon implies or is an operationalization of inter-organizational learning.

The first link in the IVC framework models how firms procure information from numerous knowledge sources for the purposes of innovation. The associations between firms' knowledge sourcing activities were estimated using bivariate probit models (a model for each of the five information sourcing activities considered).

Table 11 reports the estimates of the different knowledge sourcing equation Eq. (4.2) in terms of marginal effects. Also following Doran and O'Leary (2011); Ganotakis and Love (2012); Roper et al. (2008), knowledge sourcing activities are either complementary (if the marginal effects, $\beta_{ji} > 0$) or substitutional (if $\beta_{ji} < 0$).

The question the study seeks to address here relates to the tendencies that manufacturing sector SMMEs in South Africa exhibit in their knowledge sourcing endeavours?

Regarding the knowledge sources;

- The estimated knowledge sourcing activities marginal effects are generally positive and statistically significant. In essence, the South African manufacturing sector SMMEs most likely tend to engage most of their knowledge sources in a complementary way. This observation is broadly in agreement with the findings from the U.K. (Ganotakis & Love, 2012), Ireland (Doran & O'Leary, 2011; Roper et al., 2008) and Switzerland (Roper & Arvanitis, 2012).
- Firms that seek to source their information internally through R&D activities tend to be associated with interaction with forward, backward and public knowledge sourcing while less so for horizontal (competition) knowledge sourcing.
- The mere feasibility of horizontal linkages is enigmatic – competitors sharing knowledge feedstocks for innovation purposes, yet evidence from manufacturing sector SMMEs in South Africa demonstrates the linkage is strong and statistically significant across the other sources. Roper et al. (2008) provide a compelling

explanation in that this linkage is possibly a cost sharing and risk mitigation strategy.

- Firms which tend to seek their information from the group R&D source, on the other hand, tend to engage most of their knowledge sources in a complementary way to the detriment of internally R&D activities. This is not surprising considering that group R&D activities represent a multiplicity of sources of knowledge, some possibly bringing in foreign and new-to-market influences (Doran & O'Leary, 2011, p. 212).

The general weakness of the firm's internal resources and adaptive capacity variables is well documented, see also (Doran & O'Leary, 2011; W.-L. Hsieh, 2013; Roper et al., 2008).

The marginal effects of firms' characteristic variables resources are positive and generally weak, and particularly in relation to the internal knowledge sources.

- As a result, it is evident that the firm's size by a number of employees, for example, can significantly influence the probability of a firm to engage in these knowledge sources and most likely internal R&D departments and institutions of higher learning and public laboratories. In addition, older SMMEs, while not significant appears to be more likely to rely on internal R&D and multiple linkages (forward, backward, horizontal linkages) but not public knowledge sources.

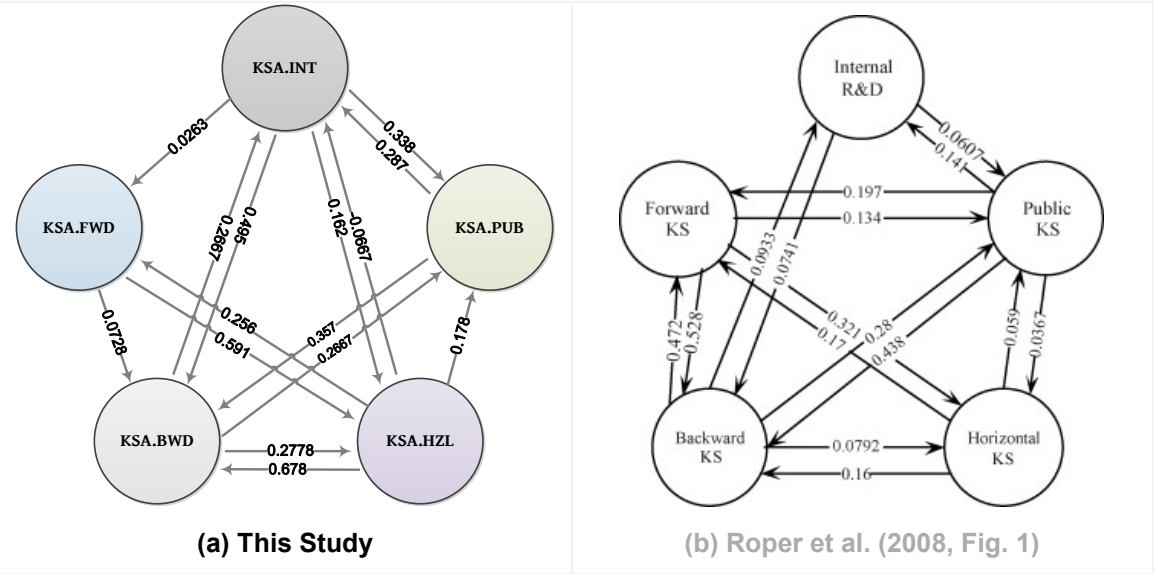
The effects of firms' adaptive capacity variables are surprisingly generally not statistically significant but telling.

- As expected, an increase in the proportion of highly qualified labour is expected to positively influence the probability of a firm to most likely rely on internal R&D department as a knowledge source of choice as opposed to the others. While SA-based in general firms are more likely to exploit forward linkages and internal R&D facilities in their knowledge sourcing activities – Doran and O'Leary (2011) observed that Irish-owned firms were most likely to exploit backward and public linkages.
- R&D intensity and formal R&D laboratory in the plant all generally positive but weak relationships with other knowledge sources. It is not inconceivable however that a formal R&D laboratory in the plant will negatively influence the probability of a firm to engage horizontal knowledge sources; while increased R&D intensity will adversely affect linkages to public knowledge sourcing activities.

The effects of the innovation hampering factors are also generally not statistically significant.

In the light of the importance knowledge-based economy and related national policies (DST, 2008), there estimated marginal effects associated with public knowledge sourcing (universities and private and publicly funded research facilities) deserves an additional word or two. Firms which source knowledge from public knowledge source agents tend to engage with other sources of knowledge in a complementary way – increasing the probability of in-house R&D activities and likelihood for collaborations with customers/suppliers and universities. According to Roper et al. (2008), the firms' drive to pursue public linkages is a cost-cutting measure.

In summary, Figure 11 aids in the visualization of the complementary links between the different knowledge sourcing activities. The arrows represent a significant relationship while the numbers (in the arrows) are marginal probabilities estimates as reported in Table 11 above.



(a) This Study (b) Roper et al. (2008, Fig. 1)

Figure 11: Complementarities between knowledge sourcing activities

Notes: Numbers in (a) are estimated marginal probabilities (reported in Table 11 above). Substitutional relationships are omitted.

Source: Based on (a) author's empirical work and (b) Roper et al. (2008, Fig. 1)

Figure 11(b) demonstrate generally strong complementarities relationships between the firms' knowledge sources. Other factors such as the firms' characteristics and knowledge utilisation capacity and factors hindering innovation were generally less significant than expected. These findings are generally in agreement with those of Roper et al. (2008), see also Figure 11(b).

4.4.3 The IVC model analysis: Innovation and output production

Tables 12 and 13 present the results of the estimation of Eq.s (4.3 and 4.4) for product and process innovations using different methods.

Innovation production

In this section, it is important for the reader to take note that the researcher does not seek or attempt to forecast whether or not a firm will innovate. Rather, like Cabagnols and Le Bas (2002) before, it only seeks to discover which innovation types have been developed and how knowledge sourcing activities could have impacted on that choice. Needless to say, little is known on the subject for African and South African innovating firms, if the literature is anything to by.

Doran and O'Leary (2011), like Crépon et al. (1998) and Lööf et al. (2017) before them, suggest that the innovation production equation (Eq. 4.3) and the outputs production equation Eq. (4.4) must be codetermined since some of the innovation output measures are dependent variables in Eq. (4.3) and vice versa. Biased estimates of Eq. (4.3) and Eq. (4.4)'s respective coefficients may result if the single equation estimation approach is applied on each of the production equations separately.

However, against that advice, the researcher reckons that since the structure of Eq. (4.3) is similar to that of Eq. (4.2), for that reason, the researcher follows W.-L. Hsieh (2013); Roper et al. (2008) in applying a binary probit procedure to model Eq. (4.3). To model Eq. (4.4) again the researcher follows W.-L. Hsieh (2013); Roper et al. (2008) in using the Tobit model (as initially proposed. In addition, an ordinary least squares (OLS) regression estimator in a replication of a more recent publication by W. L. Hsieh et al. (2017) was used - ironically Doran and O'Leary (2011) also used the OLS estimator in their work as well.

Table 12: Marginal effects estimates of the innovation production equation, Eq. 4.3

	Non-Innovators		Product Innov. Only		Process Innov. Only		Both Process & Product Innov.	
	dF/dx	Std. Err.	dF/dx	Std. Err.	dF/dx	Std. Err.	dF/dx	Std. Err.
KSA.INT	-0.1191	0.1354	**0.2837***	0.1372	**0.2047***	(0.0871)	**0.2684***	(0.1071)
KSA.FWD	-0.1893	(0.1888	0.1007	0.1498	-0.0207	(0.1103)	-0.0436	(0.1173)
KSA.BWD	-0.2422	0.1938	**0.3858***	0.1789	0.1329	(0.1544)	0.1656	(0.1506)
KSA.HZL	0.0316	0.1293	-0.1008	0.1225	0.0641	(0.1371)	0.0489	(0.1387)
KSA.PUB	0.1410	0.0962	**-0.2202***	0.0878	0.0292	(0.0962)	-0.0391	(0.0981)
FAC.RND	-0.0793	0.1409	0.3096*	0.1368	0.0000	(0.1321)	**0.2572·**	(0.1346)
INNOV.INT	0.0124	0.0082	**-0.0327****	0.0106	-0.0008	(0.0073)	**-0.0228****	(0.0087)
FAC.GRP.RND	**-0.3468·**	0.2131	0.0752	0.1483	**0.4556****	(0.1579)	0.2164	(0.1549)
FAC.INNO.TEAM	-0.0012	0.0066	0.0155	0.0096	-0.0050	(0.0054)	0.0017	(0.0061)
FAC.DEG	0.0026	0.0025	**-0.0056·**	0.0032	-0.0043	(0.0028)	-0.0047	(0.0032)
RIB.EMPL	0.0003	0.0005	0.0003	0.0005	0.0001	(0.0005)	0.0007	(0.0005)
RIB.AGE	-0.0113	0.0074	**0.0169·**	0.0087	0.0089	(0.0092)	0.0146	(0.0101)
I(RIB.AGE^2)	**0.0002·**	0.0001	**-0.0002·**	0.0001	-0.0001	(0.0001)	-0.0002	(0.0002)
RIB.SIZE	-0.0054	0.0496	0.0467	0.0520	-0.0306	(0.0532)	0.0313	(0.0551)
HAMPER.INNOV.COSTLY	**0.0794***	0.0347	**-0.0757***	0.0365	**-0.1332*****	(0.0374)	**-0.0744***	(0.0384)
HAMPER.LACK.INFO	**-0.0567·**	0.0468	0.0005	0.0519	**-0.1075***	(0.0479)	-0.0243	(0.0586)
HAMPER.PRIOR.INNOV	0.0226	0.0507	0.0056	0.0517	0.0273	(0.0524)	0.0492	(0.0549)
HAMPER.LACK.SPECIAL.SKILLD.	Ø		**0.1465****	0.0556	**0.2025*****	(0.0517)	**0.1288***	(0.0622)
Observations	90		90		90		90	
Akaike Inf. Crit.	83.141		93.555		85.631		88.791	
Wald χ2 test	5.9		7.4		6.8		8.9	
Pr.(> χ2)	0.12		0.061		0.08		0.031	

Notes: Signif. Codes: *** p < .001, ** p < .05, * p < .1. All coefficients are probit model marginal effects.

Source: Author's work based on the SABIS2013 data

Therefore, in relation to knowledge stock (information) and the sourcing activities, evidence from manufacturing sector SMMEs in South Africa suggests that it has a profound impact on innovation where it is statistically significant. In general:

- The results suggest that firms tapping into their internal R&D activities for knowledge stocks for innovation activities are 28% and 20% more likely to develop a new or significantly improved product or processes, respectively. It is apparent that access to in-house and group R&D knowledge sources (KSA.INTERNAL and FAC.GRP.RND) increases the firm's prospects of being innovative via the 'absorptive capacity' effect according to Cohen and Levinthal (1990). Having an R&D department in the plant (FAC.RND) has the same effect.
- Results show, as suggested in the literature (Du et al., 2007; Roper et al., 2008), forward linkages (KSA.FWD) linkages tend to promote product innovation at the expense of process or concurrent innovations. Kärkkäinen, Piippo, and Tuominen (2001) as cited in Roper et al. (2008, p. 970) refers to this effect as 'customer-led innovation on product rather than process change'. The marginal effects are however not statistically significant.
- Evidence from manufacturing sector SMMEs in South Africa suggests that the backward knowledge linkages (KSA.BWD), involving consultants and suppliers, significantly stimulates the likelihood of a firm to perform product-only and process-only innovations as well as product and process innovations simultaneously. The finding is in agreement with the "*interesting fashion not picked up by the previous literature*" suggested by Du et al. (2007, p. 770) – the joint development of product and process innovation while discouraging the development of product or process innovation individually. The researcher's suspicions that this collaboration linkage will ultimately discourage the introduction of new innovative products on market were confirmed by (W.-L. Hsieh, 2013, p. 72).
- These findings also show that horizontal knowledge sourcing linkages (KSA.HZL) overall promote the process innovation types over product innovations. Although not statistically significant, this observation is interesting in one way; it is consistent with Du et al. (2007) while at the same time in contradiction of Cabagnols and Le Bas (2002)'s observation.
- Involving public knowledge sourcing linkages (KSA.PUB) tends to decrease the probability of product innovation by a significant 22%, yet positively (but not significantly) increasing the probability of introducing new processes by mere

3%. It is tempting to concur with Roper et al. (2008) that this knowledge linkage has no direct influence on the probability of process innovation.

Like with knowledge sources in §4.4.3 and decision to innovate before it in §4.4.2, the impact of the firm characteristics and absorptive capacity on knowledge sourcing activities is generally weaker than expected as observed also by W.-L. Hsieh (2013, p. 73) and Roper et al. (2008, p. 968).

- The age of the firm is positively but weakly associated with product innovation and to process innovation but with no significant effect on the latter. A unit increase in the age of the firm increases the firm's propensity to introduce a new product innovation by just 1.7%. The firm size, in this case by a number of employees, has a positive, statistically insignificant, and yet even weaker impact on product and process innovation alike.
- A dedicated team working on intramural R&D activities (FAC.INNO.TEAM) increases the probabilities of its performing product types of innovation by a measly 1.6%. But most interestingly, Evidence from manufacturing sector SMMEs in South Africa suggests that a high proportion of graduates has a negative effect on all types of innovation. However interesting, this observation is in contradiction with the new growth theory expectation; that the availability of capable human capital inside the plant with an appropriate level of skills and knowledge in R&D activities is considered as the essential internal resources that enable the firm to innovate. but consistent with some prior studies Sdiri, Ayadi, and Elj (2010) and Abdu and Jibir (2017).

In relation to factors hampering innovation activities, the following observations were made:

- Firms recognising the high cost associated with undertaking innovation activities (HAMPER.INNOV.COSTLY) are less likely to decide to innovate across the innovation types of innovators.
- Firms recognising the lack of skilled personnel (HAMPER.LACK.PECIAL.SKILLD.) as a factor hindering innovation activities are more likely to make the innovation-decision. The variable has positive and statistically significant effects. Similarly, firms recognising the lack of information on markets or technology (HAMPER.LACK.INFO) are also more likely to make the innovation-decision although the effects are not statistically significant. These observations are in line with the innovation theories and other findings

notably Doran and O'Leary (2011, p. 208). Interestingly, the lack of information on markets or technology encourages product-only and process-only innovations alike while less-likely to make a decision to undertake combined product and process innovations.

- Firms recognising prior innovations as a factor hindering innovation activities hinders product innovation but makes process innovation more likely.

Table 13: Estimates of the output production equation, Eq. 4.3 with employment growth as a measure of business growth/performance

	EMPLOYMENT GROWTH			
	OLS estimator		*Tobit estimator*	
Variables	**Coefficients**	**Std. Error**	**Coefficients**	**Std. Error**
(Intercept):1	27.0800***	3.4610	27.080***	3.0960
(Intercept):2	NA	NA	2.114***	0.0746
KSA.INT	1.3930	3.0140	1.3930	2.6960
KSA.FWD	-1.0060	3.7890	-1.0060	3.3890
KSA.BWD	-10.0700*	4.0230	-10.070**	3.5990
KSA.HZL	6.8600	4.3250	6.8600·	3.8680
KSA.PUB	-0.6392	3.0950	-0.6392	2.7680
PROD.INNOV	2.2310	2.9730	2.2310	2.6590
PROC.INNOV	3.4400·	2.7810	3.4400*	2.4870
RIB.EMPL	0.1153*	0.0443	0.1153**	0.0397
I(RIB.EMPL^2)	-0.0004**	0.0001	-0.0004**	0.0001
RIB.AGE	0.3458	0.2554	0.3458	0.2285
I(RIB.AGE^2)	-0.0073·	0.0040	-0.0073*	0.0036
RIB.MNC	4.9080·	2.9430	4.9080·	2.6320
FAC.RND	0.3385	2.8180	0.3385	2.5210
FAC.DEG	-0.0342	0.0729	-0.0342	0.0652
FAC.INNO.TEAM	-0.1047	0.2007	-0.1047	0.1795
INNOV.INT	-0.1528	0.2593	-0.1528	0.2320
MKT.EXP	3.5720·	2.0840	3.5720·	1.8640

Notes: Signif. Codes: *** p < .001, ** p < .05, * p < .1. Coefficients are not marginal effects

Source: Author's work based on the SABIS2013 dataset

Output production

Table 13 report the Tobit estimates of the outcomes production function for the business growth indicators (proxy by employment growth variables). The Tobit approach is here deemed crucial in order to deal with what is known as 'censoring'

where the data is characterised by the significant abundance of zeros). The extent to which product and process innovation indicators impact on business growth is the main focus of interest in the innovation value chain link.

While previous researchers (Doran & O'Leary, 2011; Ganotakis & Love, 2012; Roper et al., 2008) have used productivity in terms of value added per employee, the sales growth, and the growth in employment as proxies for firm performance - the dataset available for this work allows only for the use of growth in employment.

The first and most striking impression in the output production models is that the OLS and truncated Tobit regression estimated coefficients are similar. In relation to knowledge stock (information) and the sourcing activities, evidence from the manufacturing sector SMMEs in South Africa suggests that it has a profound impact on innovation where it is statistically significant. In general:

- The results suggest that when firms tap into their internal R&D activities for knowledge stocks for innovation activities they increase their chances of increasing the number of employees or performing well (assuming that growth in employment is a good measure or proxy for firm performance). It is also clear that access to the horizontal linkages and sources has the same effect. This finding is not surprising; it is consistent with the argument that Roper et al. (2008) has put forward that in-house R&D and R&D collaborations with rival firms is a risk mitigation and cost-cutting measure.
- Results show, linkages to public universities and research facilities, forward and backward sources, in increasing order, tend to have an adverse effect on the growth in employment. Noteworthy; the effect of the backward linkage is significant at a 95% significance level. While the low contextual knowledge distance theory peddled by Un and Asakawa (2015, pp. 142-144) can help explain why public universities and research facilities and forward linkages can have negative effects on firm performance, the negative effect for the backward linkage unexpected.

Unlike the knowledge sources above, the impact of the firm characteristics on the firm performance is generally statistically significant.

- The age of the firm and the firm size, in this case by the number of employees, both has a positive effect on growth in employment. It is possible that the longevity of a firm is an indication that its performance is not hopelessly poor.
- As observed before multi-national and exporting firms are expected to perform significantly better than SA-based firms. The findings in Table reflect this expectation. Again, it is possible that through foreign ownership or foreign-based markets firms can be exposed to additional sources of knowledge compared to the locally based or owned firms (Abazi-Alili, 2014, p. 13). Oerlemans and Pretorius (2006, p. 591) and Mustapha and Mendi (2015, p. 136) both observe that foreign-owned enterprises are more likely to produce innovation outcomes compared to locally-owned or -based firms on the 2001 and 2008 South African Innovation Survey's findings, respectively.
- Evidence from manufacturing sector SMMEs in South Africa also suggests that a high proportion of graduates or skilled workforce (with degrees or diplomas), a dedicated team working on intramural R&D activities and increases in the innovation intensity all have a negative impact on the performance of the firm. This observation is a sharp contradiction with existing plans seeking to create a knowledge-based economy or demands for free higher education.

In relation to product and process innovation activities, the following observations were made:

- In agreement with the most basic premise of growth theory of the firm, the results presented here show that if manufacturing sector SMMEs in South Africa succeeded in introducing either significantly improved or new products, the firm is expected to increase the number of employees. The growth theories of the firm were succinctly reviewed in §2.2 and §2.3.2 on p. 15 and p. 21, respectively.

The IVC model developed from the responses of the manufacturing sector SMMEs contained in the SABIS2013 dataset is summarised in Figure 12.

4.5 CONCLUDING REMARKS

In this chapter, findings from the investigations into the decision to innovate and the impact of different knowledge sources in the innovation value chain (from engaging knowledge sources to the firm performance). The findings lead to several conclusions that will be discussed here in line with the research questions and hypothesis presented on p. 13 and p. 33, respectively.

On the innovation-decision research question:

- Firm's characteristics generally have a positive influence on the firms' decision to undertake innovation activities, with the exception of SA-based firms in the case of new to the firm innovations; this largely supports the H1a hypothesis.
- In relation to those factors that constraint innovation activities, there is evidence that they generally increase the likelihood of firms to decide to undertake new to the firm innovations while lessening the prospect of pursuing new to the market innovations. Based on these observations, the researcher fails to support the H1b hypothesis

On the IVC knowledge sourcing link:

- In a demonstration of managerial sophistication in most manufacturing sector SMMEs in South Africa, the SMMEs typically appear to be making use of a multiplicity of knowledge sources in undertaking their innovation activities; this supports the H2 hypothesis.
- While the influence of the knowledge sources is not all equally significant; the results demonstrate that overwhelmingly affirmative and complementary relationships exist between internal R&D and the other knowledge sources as expected. The strength of the complementarity between knowledge sourcing activities demonstrates that there generally exist high intensity of knowledge sharing within the manufacturing sector in South Africa. On the strength of evidence, hypothesis H3 is supported.

On the innovation production

SA manufacturing SMME firms engaged in internal R&D activities and those pursuing backward knowledge sourcing activities were generally more likely to introduce significantly improved or new products and processes.

On the output production;

- The effects of the knowledge sourcing activities are mixed but the strength of enterprises' in-house R&D activities is yet again significant with respect to the firm's performance. In addition, the firm characteristics exhibited mostly positive and significant impact on the firm performance so as the firm's exporting orientation.

- The firms that succeeded in introducing product and process innovations have an overwhelmingly positive effect on the performance, with process innovations being statistically significant.

The most significant IVC modelling findings are consolidated in Figure 12(a) and compared to Figure 12(b) from Roper et al. (2008). The figure illustrates the complete IVC; it puts together the knowledge sourcing link (Table 11 and Figure 11), knowledge transformation link (using the innovation production product and process innovation from Table 12) and output production link (using growth in the employment as a firm performance indicator on Table 13).

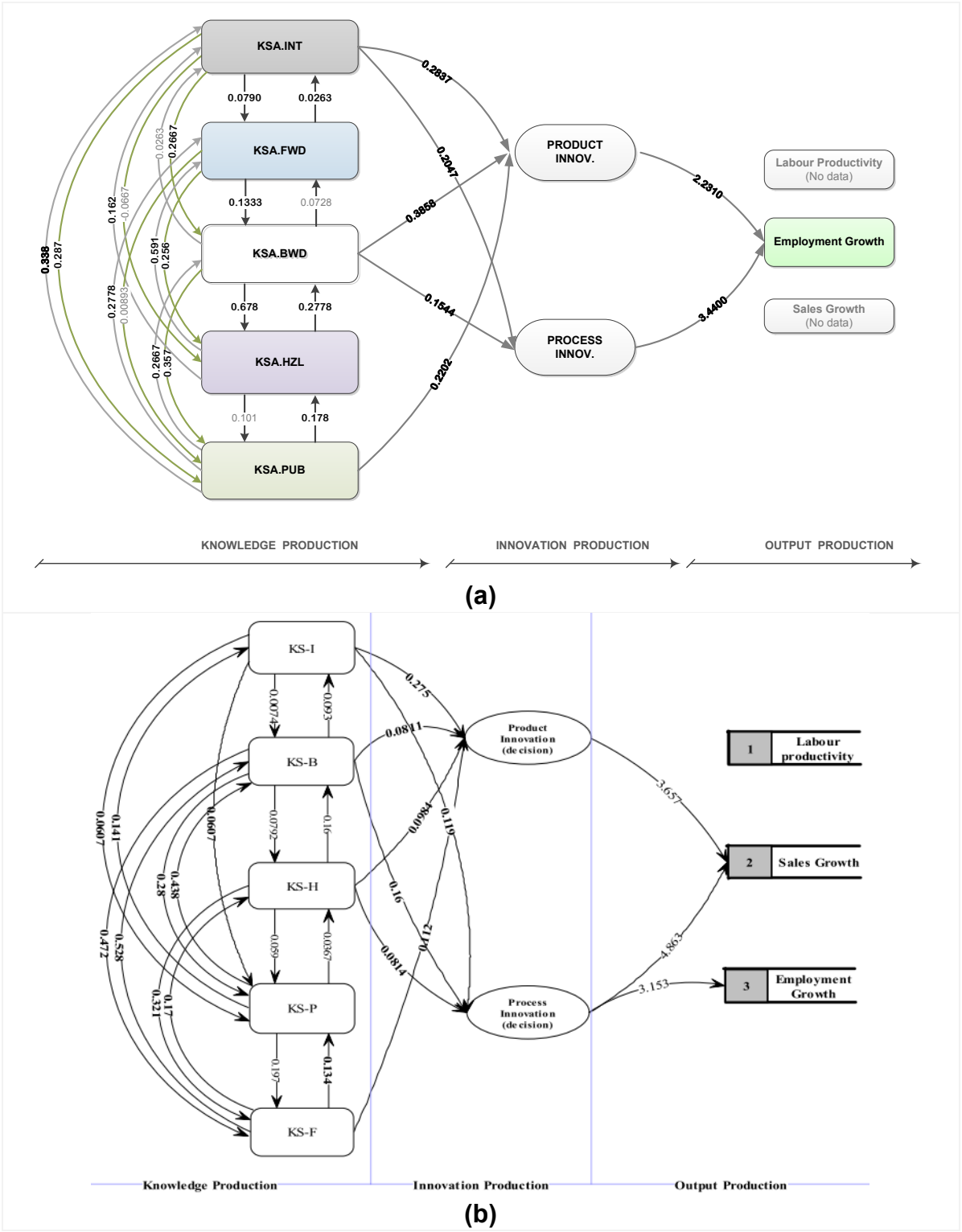


Figure 12: The modelled IVC for SA manufacturing SMME firms in this study (a) and by Roper et al. (2008) in (b)

Source: Author's work based on the SABIS2013 data and (Roper et al., 2008)

CHAPTER 5.
DETERMINANTS OF INNOVATION

5.1 BRIEF BACKGROUND

Chapter 4 examined the decision to participate in innovation activities and innovation value chain across the manufacturing sector SMME firms in SA. More precisely, the stage-wise empirical analysis identifies and factors influencing the main innovation activities and strategies, at the firm level, from the decision to performance.

The author identifies '*the determinants of innovation activities in firms'* as those factors or variables that decisively establish the firm's appetite to innovate or participation in innovation activities in general.

Innovation literature is awash with empirical studies reporting on the factors affecting activities in small firms, see (Avermaete et al., 2004; Ayyagari et al., 2007; Doran & O'Leary, 2011; Zemplinerová & Hromádková, 2012) for example. These reports are mainly in the context of the Global North economies. However, more recently a few reports have come from the emerging economies (Alpkan, 2015; Avermaete et al., 2004; Barasa et al., 2017; Booyens, 2011; Hadhri et al., 2016; Van Dijk et al., 1997; Zemplinerová & Hromádková, 2012). Evidently, no consensus seems to exist on which specific factors decisively influence a firm's innovation activities.

Even fewer studies have been reported from South Africa on the determinants of innovation activities in SMME firms; most notable insights from Ndlovu (2016), Booyens (2011) and Oerlemans and Pretorius (2006) are summarised in Table 14 below.

Although Booyens manages to explore and report the statistical relationship between innovation and its firm-level determinants using two logit regression models for the first time in South Africa – only a few variables (innovation activity, firm size and turnover) are employed and presented (Booyens, 2011, p. 74, Table 4). Other researchers, Abdu and Jibir (2017, p. 6, Table 4) for example, have employed a wider range of variables including sets of a firm's characteristics

variables, resource base variables, adaptive capacity variables, and market- or industry-specific variables.

Table 14: A summary of the contemporary literature on the determinants of innovation (South Africa and Sub-Saharan Africa).

Determinants	General Direction	South African or Sub-Saharan Africa Context (references)
In-house R&D	+	(Abdu & Jibir, 2017; Barasa et al., 2017; Booyens, 2011; Ndlovu, 2016)
Linkages to clients, suppliers, consultants, competitors, joint ventures, or to public research facilities	+	(Booyens, 2011; Ndlovu, 2016)
Firm size	-/+	(Abdu & Jibir, 2017; Barasa et al., 2017; Booyens, 2011; Ndlovu, 2016; Pretorius & Oerlemans, 2006)
Firm age	+	(Barasa et al., 2017; Ndlovu, 2016)
Legal status	+	(Barasa et al., 2017)
Number of employees	+	(Booyens, 2011)
Export orientation	-	(Abdu & Jibir, 2017)
Turnover	-/+	(Booyens, 2011)
R&D intensity	+	(Booyens, 2011; Oerlemans & Pretorius, 2006)
Part of group	ø	
Foreign ownership	+	(Oerlemans & Pretorius, 2006)
Skilled workforce	+	(Barasa et al., 2017; Booyens, 2011; Oerlemans & Pretorius, 2006)
Degreed workforce	+	(Abdu & Jibir, 2017; Barasa et al., 2017)
Gov. support	+	(Booyens, 2011; Oerlemans & Pretorius, 2006)
Province or region	-	(Barasa et al., 2017)
Managerial experience	+	(Barasa et al., 2017)
Manufacturing sector	ø	
Training	+	(Abdu & Jibir, 2017; El Elj & Abassi, 2014)
Market structure	ø	

NOTES:
+ means a positive effect was generally observed
- means a negative effect was generally observed
+/- means mixed effects were observed (by different researchers)
ø: no available information

Source: Author's construction using the herein-cited references

The empirical analysis conducted for this work is grounded on the theoretical underpinnings highlighted in Chapter 3. In this Chapter, like Oerlemans and

Pretorius (2006), Booyens (2011), and Mustapha and Mendi (2015) before, this study attempts to identify the determinants of innovation activities in manufacturing sector SMMEs in South Africa. A broader set of variables, from the SABIS2013 dataset, is employed in this attempt following the few reports from other emerging economies such as South Africa (Abdu & Jibir, 2017; Avermaete et al., 2004; Hadhri et al., 2016; Zemplinerová & Hromádková, 2012).

The main question posed here is:

- Which factors are the dominant drivers the innovations in manufacturing sector SMMEs in South Africa?

The following three hypotheses on firm-level determinants of innovation can be stated as:

- H1: the firm's resource base factors (RIB), its adaptive capacity related factors (FAC), factors associated with firm's access to public support (GOV), market or industry-specific characteristics (MKT), factors associated with the firm's knowledge sourcing activities, and innovation hampering factors (HAMPER) are all equally dominant driver.
- H2: process innovations and product innovation have the same dominant drivers in the innovations.
- H3: The determinants of process innovations and product innovation have the same impact.

5.2 SAMPLE AND DATA DESCRIPTION

The Sample

A summary of the composition of the sample by innovation activities and distribution of firms by their size based on the SABIS2013 dataset is shown in Table 7. Some significant aspects of the sample used in this chapter are summarised in Table 9.

5.3 THE MODELS AND ESTIMATION STRATEGY

In order to determine the factors that influence a South African SMME's to undertake innovation activities, the research piggy-backs on selected aspects of the approaches reported by Hadhri et al. (2016) and Abdu and Jibir (2017).

5.3.1 The Dependent Variables

In the strategy adopted for this work, a firm has four discrete choices: (1) to abstain from innovation activities at all, (2) to participate in product innovation activities only, (3) to participate in process innovation activities only, or (4) to pursue both product and process innovation activities.

Specifically to the estimation strategy, the dependent variables are four dummy dependent variables (1/0). They are an indication of the nature of a firm's innovation activities during the 2010–12 period. These can be defined as proxies for each of the innovative activities.

- If a firm is product-only Innovative enterprise, if it has developed or introduced at least one new or substantially improved product, then the dependent variable assumes a value of 1, else it takes a value of 0.
- If a firm is process-only Innovative enterprises, if it has developed or introduced any new or substantially improved processes, the dependent variable assumes a value of 1, else it takes a value of 0.
- If a firm has developed or introduced any new or substantially improved both products and processes), the dummy dependent variable assumes a value of 1 otherwise, it is zero.

If a firm is a non-innovative enterprise – the dependent variable assumes a value of 1, else it takes a value of 0 (it is innovation active).

5.3.2 The Model Specifications

The empirical model used for the purposes of the work reported in this chapter is shown as Eq. (5.1c) in its general form. The dependent binary variable is the tendency of a firm to undertake innovative activities; it is a latent variable denoted y_i^* in Eq. (5.1b). The observed dependent variable (y_i), proxy to the latent variable, assumes a value of 1 if the firm is innovating, otherwise it equals zero, as indicated in Eq. (5a).

$$y_i = \begin{cases} 1, & y_i^* = \beta_i x_i + \mu_i > 0 \\ 0, & Otherwise\ (Non\ Innovators) \end{cases} \quad (5.1a)$$

$$y_i^* = P(y_i = 1|x) = \beta_i x_i + \mu_i \quad (5.1b)$$

$$Pr(y_i = 1|x) = \Phi(\beta_0 + \beta_1 \boldsymbol{RIB}_i + \beta_1 FAC_i + \beta_1 GOV_i + \beta_1 MKT_i + \beta_1 KSA_i + \mu_i) \quad (5.1c)$$

where $Pr(y_i = 1|x)$ is the propensity of firm i to innovate, $\Phi(\bullet)$ denotes the standard normal cumulative distribution function, β_i is a vector of the unknown coefficients associated with the explanatory variables, x_i. The random error term μ_i is known to follow a normal distribution. In Eq. (5c), the study follows Abdu and Jibir (2017) in identifying and grouping variables: RIB_i as those firm-specific factors, FAC_i as those factors associated with the firm's adaptive capacity, GOV_i as factors associated with firm's access to public support for innovation and innovative activities, MKT_i as those market- or industry-specific characteristics or "*the buoyancy of local markets*" (Roper et al., 2008, p. 963) while KSA_i are those factors associated with the firm's knowledge sourcing activities.

5.3.3 The Econometric Modelling Strategy

The dichotomous nature of the dependent variable in Eq. (5.1c) dictates the application of a multivariate probit regression model or simply a probit model. The binary probit models are generally used to estimate the probability that an explanatory variable is influencing the observed results or the dependent variable (when $y_i = 1$).

Therefore, the analysis strategy is to use a probit model with instrumental variables (Sector, South African based, and being part of a larger group) after Hadhri et al. (2016). Also after (Hadhri et al., 2016), in order to assess the probability of a firm to engage in different innovation activities, the study employs a number of different econometric models starting with a baseline model as specified in Eq. (5.2) and, then build successive models by carefully introducing other sets of factors. This approach is common in econometrics literature see for example (Barasa et al., 2017; Bogliacino & Pianta, 2012; Guarascio et al., 2017).

For simplicity, the interaction effects between factors are intentionally omitted.

5.4 RESULTS AND DISCUSSIONS

The regression analysis results are presented in this section. Unless otherwise stated, the regression results tables presented in this section report average marginal effects instead of the common model coefficients.

5.4.1 The Empirical Results: The Baseline Model

The baseline model

Before turning to the probit model estimation of interest (see Eq. (3.5) on p. **Error! Bookmark not defined.**), the empirical analysis starts with a simplistic (baseline) model that only investigates how innovation in SA manufacturing SMME firms is driven by the firm's in-house research and development activities (and the firm-specific control variables).

The model is in all probability likely to be prone to the endogeneity problem due to missing significant explanatory variables – but that should not be a problem; the model serves only as a comparison standard. It also gives the first intuitions into which factors determine innovation activities in the manufacturing sector SMMEs in South Africa.

The baseline model can be represented as follows,

$$Pr(y_i = 1|x) = \Phi(\beta_0 + \beta_1 RIB_i + \mu_i) \quad \textbf{(5.2)}$$

where the terms and variables are defined as in Eq. (5.1) above.

Probit models estimated coefficients (β_i) are non-linear and not as easily and directly interpretable as the common Ordinary least squares (OLS) regression coefficients (Leeper, 2017). Marginal effects instead are coefficients known to measure the magnitude of the effect of the covariates on the dependent variable (Greene, 1996; Sun, 2015, p. 104); they [marginal effects] are considered practical and more meaningful in the context of probit models (Leeper, 2017).

The marginal effects estimates and predictions

Table 15 below, therefore, reports the marginal effects derived from the probit estimation of Eq. (5.2) for the enterprises in the SABIS2013 that were identified as Product-Only Innovators (Table 13).

The second column in Table 15 reports the results concerning the average marginal effects (dF/dX) associated with the firms' propensity to engage in product-only innovation activities. The marginal effects measure the change in probability for a small change in each independent variable. In this work, they were estimated using the marginal effects for a probit regression '*probitmfx*' procedure in R.

Table 15: Marginal effects estimates of the baseline model for Products-Only Innovators

Marginal Effects: Products-Only Innovators					
	dF/dx	**Std. Err.**	**z**	**P>|z|**	
RIB.SIZE	-0.02963546	0.08132323	0.9325	0.17555	
RIB.EMPL	0.00072329	0.00087086	0.8306	0.40623	
RIB.AGE	0.02866482	0.01447484	1.9803	0.04767	*
I(RIB.AGE^2)	-0.00042316	0.00022927	-1.8457	0.06494	•
RIB.SA.BASED	0.15056868	0.1574554	0.9563	0.33894	
FAC.RND	0.49226671	0.09931136	4.9568	7.17E-07	***
NOTES:					
Signif. codes:	0 '***' 0.001 '**' 0.01 '*' 0.05 '‘' 0.1 ' ' 1			(Std. Err.: Standard)	
AIC:	106.54				
Wald χ^2 test:	$\chi^2 = 5.3$, df = 3, $P(> \chi^2) = 0.15$				
dF/dx:	Marginal effects or discrete change for the variables				

Source: Author's own work based on the SABIS2013 data

The estimates of the baseline model tentatively show that the marginal effects of the firm's age and in-house R&D activities are positive and significant at 10% level for firm's product only innovativeness. This is indicative that, while holding all other factors constant;

i. A unit change in the firm's age is likely to increase its probability to develop a new or significantly improved product by 2.9%.
ii. Likewise, a firm introducing in-house R&D activities, for the first time for example, (a discrete change for the covariate from 0 to 1) is likely to increase its probability to develop a new or significantly improved product by a considerable 49.2%.

The inverted U-shaped response, as in Figure 13(a), is known, it has been reported by others before, see for example (Sdiri & Ayadi, 2016; Sdiri et al., 2010).

The baseline model also shows that the marginal effects of the firm's class size (micro, small or medium) and the firm's size by the number of employees are negative and positive, respectively but both not statistically significant.

For the purposes of visualization, and in addition to the marginal effects estimates (Table 15), average marginal effects predictions from the baseline model were calculated and plotted for selected variables using the **Margins** packages in R (Leeper, 2017).

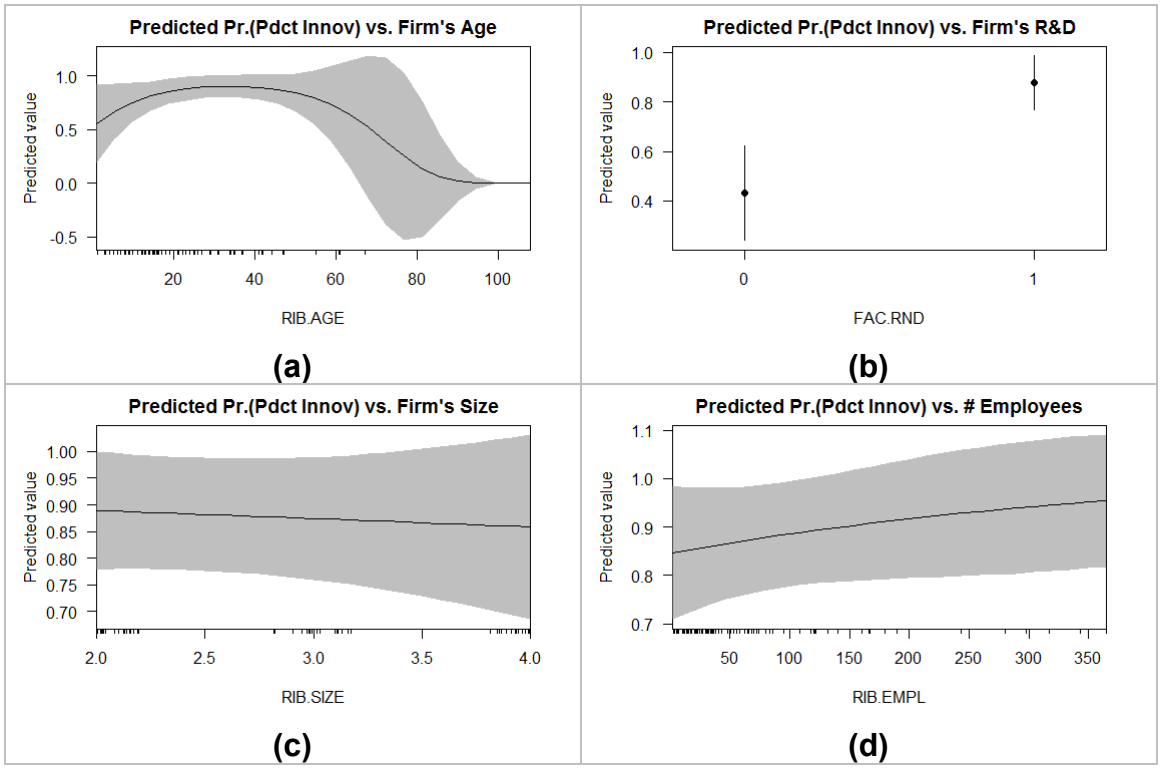


Figure 13: Predicted average margins plot with 95% Confidence Interval for (a) the firm's age, (b) the firm's in-house R&D activities, (c) the firm's size category (2: medium, 3: small, and 4: micro-sized firm), and (d) the firm's size by number of employees.

Source: Author's own work based on the SABIS2013 data

Models robustness tests

The robustness of the model was tested in three ways:

iii. Firstly, the associated p-value estimates for the marginal effects of the model as indicated in the fifth (P > |z|) and sixth (Signif. Codes) columns in Table 14. The generally accepted criterion that p-value estimates less than 0.05 indicate statistically significant predictors was upheld, thus should lead to better prediction (i.e., better model fit).

iv. Secondly, the Wald Chi-Squared test (the Wald test, from here onwards) was also conducted to find out if the model's explanatory variables are significant, and not equal to zero; and

v. Finally, the Akaike Information Criterion (AIC) was calculated mainly for the purpose of comparing different models. Ultimately, the model with the smallest AIC is considered the best.

5.4.2 The empirical results: Probit models 2 – 5

Models 2 – 5[§]

In the second step, also after Hadhri et al. (2016), to the baseline model, those factors associated with the firm's adaptive capacity, research, and capital expenditure are incorporated – thus Model 2. This will hopefully expose strategies and tendencies by SA manufacturing SMME firms to leverage their resource bases and activities towards new product development and learning.

$$Pr(y_i = 1|x) = \Phi(\beta_0 + \beta_1 RIB_i + \beta_1 FAC_i + \mu_i) \quad \textbf{(5.3)}$$

where the terms and variables are defined as in Eq. (5.1) above.

In the third step, to Model 2 additional factors associated with the firm's export activities are incorporated – thus Model 3. In the fourth step, to Model 3 additional factors associated with the firm's knowledge sourcing activities are incorporated – thus Model 4. In the fifth step, to model 4 those variables identified as factors hampering innovation activities are incorporated – the result is Model 5.

$$Pr(y_i = 1|x) = \Phi(\beta_0 + \beta_1 RIB_i + \beta_1 FAC_i + \beta_1 MKT_i + \mu_i) \quad \textbf{(5.4)}$$

$$Pr(y_i = 1|x) = \Phi(\beta_0 + \beta_1 RIB_i + \beta_1 FAC_i + \beta_1 MKT_i + \beta_1 KSA_i + \mu_i) \quad (5.5)$$

$$Pr(y_i = 1|x) = \Phi(\beta_0 + \beta_1 RIB_i + \beta_1 FAC_i + \beta_1 MKT_i + \beta_1 KSA_i + \beta_1 FHI_i + \mu_i) \quad (5.6)$$

where the terms and variables are defined as in Eq. (5.1) above.

[§] The researcher took heed of observations by De Jong and Vermeulen (2006) as cited in Jang (2017, p. 25) that the industries within the manufacturing sector are significant heterogeneous (with respect to sources, paces, and rates of innovation). The Sectors as a variable is not reported here.

Table 16: Marginal effects estimates of the augmented model

Marginal Effects: Products-Only Innovators					
	Dependent variable: PROD.INNOV				
	Eq. (5.2)	Eq. (5.3)	Eq. (5.4)	Eq. (5.5)	Eq. (5.6)
RIB.SIZE	-0.02964	-2.27E-02	-1.25E-03	0.04101	0.08127
	(0.0813)	(0.214)	(8.79E-02)	(0.0832)	(0.07303)
$RIB.AGE^2$	**-0.0004** ·	**-4.70E-04** ·	**-6.07E-04** *	-0.00028	-0.00012
	(0.0002)	(0.001)	(2.61E-04)	(0.0003)	(0.00010)
RIB.EMPL	0.0007	8.83E-05	-9.25E-05	0.00056	0.00049
	(0.0009)	(0.003)	(1.00E-03)	(0.0011)	(0.00087)
RIB.AGE	**0.0287** *	**2.93E-02** *	**3.88E-02** *	0.02051	**0.01301** ·
	(0.0145)	(0.037)	(1.63E-02)	(0.0166)	(0.00917)
RIB.SA.BASED	0.1506	2.04E-01	1.18E-01	**0.40626**	0.42446
	(0.1575)	(0.420)	(1.80E-01)	(0.2246)	(0.26664)
FAC.RND	**0.4923** ***	**4.11E-01** ***	**6.02E-01** ***	**0.72342** ***	**0.70371** ***
	(0.0993)	(0.337)	(1.07E-01)	(0.1217)	(0.14712)
FAC.DEG		-3.47E-03	-7.40E-03	-0.00684	-0.00502
		(4.65E-03)	(5.32E-03)	(0.0056)	(0.00457)
FAC.INNO.TEAM		3.03E-02	**3.34E-02** *	**0.04882** *	**0.04858** *
		(1.94E-02)	(1.93E-02)	(0.0236)	(0.02108)
FAC.INNO.ORG		**3.58E-01** *	N/A	0.16654	0.15013
		(1.40E-01)		0.1568	(0.10315)
FAC.HCD			N/A	0.00823	-0.01686
				(0.1909)	(0.13685)
RND.INT			-3.19E-02	-0.03817	-0.03838
			(3.04E-02)	(0.0262)	(0.03317)
EQUIP.INT			**-5.02E-02** **	**-0.06071** **	**-0.04785** *
			(1.91E-02)	(0.064)	(0.02298)
MKT.EXP1			6.83E-02	-0.04056	-0.02598
			(1.33E-01)	(0.1402)	(0.10550)
KSA.CLIENTS				0.12094	0.08954
				(0.08026)	(0.06197)
KSA.COMPET				**-0.30659** **	**-0.27438** *
				(0.10215)	(0.11191)
KSA.CONSULT				0.14907	0.15553
				(0.11260)	(0.09552)
KSA.UNIV				**0.68054** **	**0.66068** *
				(0.26371)	(0.27818)
KSA.PUB				**-1.00858****	**-0.97530** **
				(0.29734)	(0.38839
HAMPER.LACK.FUNDS					**-0.13089** *
					(0.10317)
HAMPER.INNOV.COSTLY					**-0.13563** *
					(0.09977)
HAMPER.LACK.INFO					**0.13673** ·
					(0.09194)
HAMPER.LACK.COMPETN					-0.16694
					(0.09116)
HAMPER.PRIOR.INNOV					0.13248
					(0.08212)
Observations	91	91	91	91	91
Log Likelihood	-46.269	-42.560	-39.866	-32.264	-26.939
Akaike Inf. Crit.	106.539	105.119	103.732	100.083	98.926
Wald χ^2 test	32.723	40.142	45.52876	69.18084	80.33561
Pr.(> χ^2)	7.16E-06	7.16E-06	3.92E-06	4.75E-07	1.86E-07
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1 ' ' 1			(Standard errors in parentheses)		

Source: Author's work based on the SABIS2013 data

The marginal effects estimates and predictions

The probit regression estimates of the models are presented in Table 16 for those enterprises in the SABIS2013 that were identified as Product-Only Innovators. For comparison purposes, the baseline model is presented in the second column, while the augmented models (Models 2 – 5, or Eq. 5.4 – 5.6) are presented in the subsequent columns.

The marginal effects do not differ mainly in sign, significance or magnitude with the introduction of additional covariates. While not proof for the validity of the models *per se*, diagnostic Wald chi-square tests show that including additional covariates to the baseline model, while ignoring the concomitant interaction effects, is shown to significantly improve the augmented models fitting over the baseline model. The AIC, $\Pr.(>\chi^2)$ and Log Likelihood statistics also demonstrate an improvement in the predictive power of the augmented models.

From Table 16, the probability that business enterprises develop new or significantly improved products in their manufacturing operations is positively associated with: the size of the firm by annual turnover (RIB.SIZE) and number of employees (RIB.EMPL); the firm's age (RIB.AGE) and the South African location based firms (RIB.SA.BASED); firms undertaking other organizational innovative activities such as in marketing and accounting (FAC.INNO.ORG); firms undertaking extramural research and development activities (FAC.RND) and the size of the team undertaking the development activities (FAC.INNO.TEAM); firms indicating to be engaging universities and consultant for knowledge feedstocks (KSA.UNIV and KSA.CONSULT); and firms that acknowledged lack of adequate knowledge feedstocks for innovation as a factor hampering innovation (HAMPER.LACK.INFO).

Notably, the RIB.AGE FAC.RND, and KSA.UNIV are positive and significant associations in line with teachings from the South African and the Global South literature on the determinants of innovation (Bonnyai, 2013; Ndlovu, 2016;

Oerlemans & Pretorius, 2006; Pretorius & Oerlemans, 2006) – a unit increase in the age or discrete change in the firm's extramural R&D activities and university collaborations for product development purposes will increase the probability for product innovation by 1.3%, 70.4%, and 66.1%, respectively while holding other things constant.

The estimates of the complete model also tentatively shows that the firm's prospect to innovate is negatively associated with the following variables; a firm's investment into training employees (FAC.HCD), investments into R&D (RND.INT), and the firm's equipment, machinery, and/or other production or research capital assets (EQUIP.INT); the firm's exporting strategy (MKT.EXP), firms indicating to be engaging competitors and public research institutions for knowledge feedstocks (KSA.COMPET and KSA.PUB); and firms that indicated lack of funds to engage in innovation activities, that innovation activities are costly, or the general lack of competition as a factor hampering innovation (HAMPER.LACK.FUNDS, HAMPER.INNOV.COSTLY, and HAMPER.LACK.COMPETN).

The marginal effects of the production or research capital assets investment (EQUIP.INT); competitors and public research institutions knowledge sources (KSA.COMPET and KSA.PUB); and indicated lack of funds to engage in innovation activities are significant at 10% level for firm's product only innovativeness. Oddly, while holding all other factors constant, the estimates and predictions suggest that engaging in public research institutions completely annihilates any chance that those firms will enterprises develop new or significantly improved products in their manufacturing operations it is not clear to the researcher if this collaboration is substitutional (where public research institutions take on the development on behalf of the firms) or taking on a competitive dimension (where, like KSA.COMPET, public research institutions compete with the firms for the same market) this is consistent with the findings on knowledge sourcing activities as presented in §4.4 on pp. 66-70.

Table 17: Marginal effects estimates for different innovation types

Marginal Effects				
	Dependent Variable			
	None	**Product Only**	**Process Only**	**Both**
RIB.SIZE	9.47E-04	0.08127	-0.02571	0.126626
	3.44E-03	(0.07303)	0.175046	0.106647
RIB.EMPL	-5.89E-05	0.00049	-0.00371	-0.00057
	1.64E-04	(0.00087)	0.003675	0.001202
RIB.AGE	3.74E-05	**0.01301**˙	0.044457	**0.000534**˙
	1.42E-04	(0.00917)	0.034647	0.003894
RIB.SA.BASED	**-4.38E-02**˙	0.42446	0.252961	0.205261
	9.72E-02	(0.26664)	0.31919	0.147886
FAC.RND	**-1.85E-01****	**0.70371*****	**0.94383*****	**0.858186*****
	2.20E-01	(0.14712)	0.075982	0.138805
FAC.DEG	1.04E-04	-0.00502	-0.0149	-0.00965
	3.33E-04	(0.00457)	0.01139	0.006779
FAC.INNO.TEAM	-5.22E-04	**0.04858***	0.003971	**0.056873***
	1.67E-03	(0.02108)	0.041474	0.029278
GOV.ASSIST			**0.705342*****	
			0.161205	
RND.INT	-8.96E-03	-0.03838	-0.04074	**-0.14924***
	2.20E-02	(0.03317)	0.037615	0.073446
EQUIP.INT	**1.55E-0** *	**-0.04785***	-0.03963	**-0.05365•**
	4.15E-03	(0.02298)	0.028986	0.028801
MKT.EXP1	1.65E-04	-0.02598	**0.412097•**	-0.09072
	4.44E-03	(0.10550)	0.247768	0.18851
KSA.CLIENTS	-1.99E-03	0.08954	0.268618	0.111663
	5.79E-03	(0.06197)	0.172942	0.110977
KSA.COMPET	**1.36E-02***	**-0.27438***	**-0.45623***	**-0.34673•**
	3.78E-02	(0.11191)	0.207556	0.180987
KSA.CONSULT	3.74E-03	0.15553	-0.32589	0.05397
	1.10E-02	(0.09552)	0.26489	0.140861
KSA.UNIV	**-3.27E-02****	**0.66068***	**1.222277***	0.636894
	9.08E-02	(0.27818)	0.567427	0.397076
KSA.PUB	**3.92E-02****	**-0.97530***	**-2.11955***	**-1.20411•**
	1.10E-01	(0.38839	0.86225	0.620834
HAMPER.LACK.FUNDS		**-0.13089***		
		(0.10317)		
HAMPER.INNOV.COSTLY	**9.28E-03***	**-0.13563***	**-0.41471***	-0.11655
	2.55E-02	(0.09977)	0.178683	0.079182
HAMPER.LACK.INFO	**-9.47E-05•**	**0.13673**˙	**0.120545**˙	**0.246689•**
	3.55E-02	(0.09194)	0.177503	0.144714
HAMPER.LACK.COMPETN	-2.17E-03	-0.16694	-0.14239	-0.16082
	6.09E-03	(0.09116)	0.215823	0.111832
HAMPER.PRIOR.INNOV	-5.70E-03	0.13248	0.292274	0.134641
	1.54E-02	(0.08212)	0.203959	0.119625
Observations	91	91	91	91
Akaike Inf. Crit.	82.972	98.926	81.849	88.706
Wald χ^2 test	83.30395	80.33561	88.205	80.25184
Pr.(> χ^2)	4.59E-09	1.86E-07	3.2E-10	1.47E-08
Signif. codes	0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		(Standard errors in parentheses)	

Source: Author's work based on the SABIS2013 data

Henceforth with, the discussion on the determinants of innovation, will focus on the results of the complete mode only (Table 17); tables reporting the marginal effects calculated for firms that chose to abstain from innovation activities, to participate in process innovation activities only, and those that chose to pursue both product and process innovation activities are shown in Table 18.

Table 17 reports the marginal effects estimates of the complete probit model (Eq. (5.6)) on the determinants of innovation (for non-innovating firms, product-only innovator firms, process-only innovator forms, and firms conducting both product and process innovators).

The determinants of products-only innovations were discussed earlier in relation to the marginal effects of the complete probit model estimates from Table 16.

Looking first at the baseline control variables after Oerlemans and Pretorius (2006, p. 591); that is the firm-specific variables and those variables associated with the firm's resources base. The following observations were made:

- Across the spectrum of the innovation activities, from the calculated marginal effects, the size of a South African SMME in the manufacturing sector (RIB.SIZE) has a positive association but is not a statistically significant determination of innovation. This is consistent with the findings of Oerlemans and Pretorius (2006, p. 592) on manufacturing sector firms based on the 2001 South African Innovation Survey and also others such as (Zemplinerová & Hromádková, 2012).
- The decision to investigate size as a determinant of innovation is informed by the debates on the Schumpeterian hypothesis discussed prior in §2.2 (on p. 15).
- The results in Table 17 show that the marginal effects associated with the firm's number of employees of a firm (RIB.EMPL) have a mostly negative but not statistically significant determination of innovation. The sign of the effect is consistent with the findings of Booyens (2011) on SMME firms based on the 2002–2004 South African National Innovation Survey data.
- The marginal effects also show that the South African ownership or residence (RIB.SA.BASED) of a firm has a positive but not statistically significant determination of innovation. It shows a negative and statistically significant (at 10% level) marginal effects for non-innovativeness in firms. As a result, An SA-

based SMME is 4.4% not likely to engage in innovative activities. Based on arguments advanced by Abazi-Alili (2014, p. 13), there is an expectation that if a firm is foreign-owned or foreign-based are exposed to additional sources of knowledge compared to the locally based or owned firms. In support of the expectation, Oerlemans and Pretorius (2006, p. 591) and Mustapha and Mendi (2015, p. 136) both observed that foreign-owned SA enterprises are more likely to produce innovation outcomes compared to locally-owned or -based firms on the 2001 and 2008 South African Innovation Survey's findings.

- Although the calculated marginal effects for the firm's age (RIB.AGE) have a positive association across the spectrum of the innovation activities. It is only statistically significant determination of product innovations and the combined product and process innovations. In a review of numerous studies Hadhri et al. (2016, p. 83) show that the firm's age is usually either ignored in the models because previous studies did not particularly indicate that the firm's age is an exogenous determinant on innovation outcomes according to Oerlemans and Pretorius (2006, p. 591).

If the other resource-base and adaptive capacity variables are considered, the following observations were made:

- The results indicate that the effects of having in-house R&D activities (FAC.RND) and the percentage of workers conducting those activities (FAC.INNO.TEAM) are positive and significant at 5% level for firm innovativeness while it is also both negative and significant at 5% level for firm non-innovativeness.
- These observations are in line with the Romer's argument on new growth theory (Romer, 1994) as suggested in Abazi-Alili (2014) - extramural research and development activities are expected to lead to product and process innovation and sustain growth. In fact, this is the premise of DST's national plan on innovation through a knowledge-based economy (Blankley & Booyens, 2010).
- These interpretations are further complemented with the observation that results indicate that the effects of engaging institutions of higher learning to seek knowledge feedstocks (KSA.UNIV) or identifying lack of information as a factor hampering innovation (HAMPER.LACK.INFO) are both mostly positive and significant at 5% level for firm innovativeness while both are also negative and significant at 5% level for firm non-innovativeness.
- Findings show that increasing the proportion of employees with degrees or diplomas of choice both have a negative impact on the firm's innovation

undertakings in the manufacturing sector. Abousenna and Becheikh (2012) observed the same but for the service industry in Egypt. While counter-intuitive, it is perplexing enough to realise that, it is reasonable that the manufacturing sector views graduates as both not well prepared/trained for the tasks, unnecessarily 'costly' – such that the benefits of employing a graduate are not justifiable as reported by Pauw, Oosthuizen, and Westhuizen (2008).

- While the firm's exporting strategy (MKT.EXP), investments into R&D (RND.INT), and the firm's investments equipment, machinery, and/or other production or research capital assets (EQUIP.INT) are expected to lead to product and process innovation and sustains growth, their marginal effects are mostly negative and often not statistically significant in the determination of innovation.
- The researcher is of the opinion that there exists a lagged output effect in relation to investment in R&D activities. This observation for the need of lagged-variables is not unique to this study; for example, while studying the effects of R&D investment on firm performance Usman, Shaique, Khan, Shaikh, and Baig (2017, p. 306) recently noted that "current year R&D investments [has a] negative impact on firm performance. However in relation [to] one year lagged value of R&D investment, such impact became positive".
- While the literature suggests that a measured degree of competitive pressure is healthier for innovation as opposed to either an extreme monopoly or intense competition, see Abazi-Alili (2014) for example. The results in Table 16 also show overwhelmingly that the marginal effects associated with seeking collaborations with competitors or rival firms as knowledge sources (KSA.COMPET) are a negative and statistically significant (at 10% level) for firm innovativeness. Identifying lack of competition as a factor hampering innovation (HAMPER.LACK. COMPETN) although not statistically significant is not positive either. This suggests that for those firms that innovate, engaging a rival firm or competitor decreases the probability of that firm to innovate.
- For non-innovative firms, however not statistically significant, an identifying the lack of competition (and possibly acting upon it) reduces the probability that it remains a non-innovative firm.
- The effects of owning prior developed intellectual property (HAMPER.PRIOR.INNOV) appears to increase the likelihood of firms to innovate.

5.5 SUMMARY

In summary, econometric models were applied to the SABIS2013 micro-data to examine the determinant of innovativeness in manufacturing sector SMMEs in South Africa. The estimations of the augmented model are displayed in Table 18.

Table 18: A summary of the findings against the literature (Table 12).

Determinants	Sub Saharan Africa (Based on Table 12)	Summary of findings RSA (From this work)
In-house R&D	+	+
Linkages to clients, suppliers, consultants, competitors, joint ventures, or to public research facilities	+	-/+
Firm size	-/+	-/+
Firm age	+	+
Legal status (SA based)	+	+
Number of employees	+	+
Export orientation	-	-
Turnover	-/+	Ø
R&D intensity	+	-/+
Part of group	ø	Ø
Foreign ownership	+	+
Skilled workforce	+	+
Degreed workforce	+	-
Gov. support	+	+
Province or region	-	Ø
Managerial experience	+	Ø
Manufacturing sector	ø	Ø
Training	+	Ø
Market structure	ø	Ø

NOTES:
+ means a positive effect was generally observed
- means a negative effect was generally observed
+/- means mixed effects were observed (for different innovation types)
ø: no available information; Red means disagreement.

Source: Author's construction using herein-cited references

The effects of several determinant factors of the firm's innovativeness were tested for firms that indicated they abstained from innovation activities, to participate in process innovation activities only, and those that chose to pursue both product and process innovation activities in the period when the survey was conducted.

A set of stimulating determinants and a set of a set of deterrent determinants were identified. The contributions of the stimulating determinants increase the probability of the firms to innovate. The contributions of the deterrent determinants increase the probability of the firms to innovate or reinforce their non-innovativeness. There is an agreement with the literature as shown in Table 18 summarises the findings.

CHAPTER 6.
CONCLUSION

6.1 BRIEF BACKGROUND

To stimulate growth in the South Africa's economy and improve the quality of life for all, the manufacturing industry has been identified as 'one of the six core pillars or growth' and the development of SMMEs is at the heart of the South African government's policy and strategic priorities see DED (2011), SEDA (2012), and DTI (2016).

This focus on SMMEs, in particular, is not misplaced. They make up the largest share of private businesses in South Africa, employing over 61% of the nation's workforce and contributing up to between 60% to South Africa's GDP. In addition, more recent research, Muringani (2014) for example, has begun suggesting that SMMEs may be more innovative than large enterprises in the South African context. Be that may, these statistics are not unique to South Africa; even in the other developing, developed, and undeveloped economies, the SMMEs are the key economic drivers and the largest employer of workers rather than the large businesses (Bell et al., 2004; Malone et al., 2014; Page & Söderbom, 2015).

Two aims were pursued in this study using evidence on manufacturing sector SMMEs from the 2013 South African Business Innovation Survey. First and foremost, the study sought to explore the innovation strategies of manufacturing SMMEs in the South Africa context. Specifically, the study investigated the influence of linkages to knowledge sources on the development of innovations and business performance through the innovation value chain framework. Secondly, secondarily but not least, the study also sought to investigate and identify the determinants of innovations in manufacturing sector SMMEs in South Africa.

6.2 SUMMARY OF THE MAIN FINDINGS

Cognisant of the aims, this dissertation pursued the following research questions (as also presented on p. 13):

RQ1	Which factors are significantly influential in the SMME's decision to undertake new to the firm/market innovations?
RQ2	Which knowledge sourcing activities and strategies do SMMEs adopt in their innovation pursuits?
RQ3	What effect does knowledge sourcing activities have on the innovative activity of the SMMEs in the production of new products and processes?
RQ4	Do SA SMME firms profit from the development of significantly improved or new products and processes;
RQ5	What are the determinants of innovations in the manufacturing sector SMMEs in South Africa?

To answer these questions, secondary data are drawn from the SABIS2013 Innovation Survey and econometric procedures from previous empirical studies found in the literature were used. Central to these efforts is the IVC. A relatively new innovation framework usually viewed and used as a more end-to-end assessment of the strength and weakness in the innovation process.

The dissertation has two results chapters, Chapters 4 and 5.

Chapters 4 reports on an attempt to investigate innovation decision-making in South African SMMEs in the manufacturing sector by estimating the effects of various factors on the firms' innovation decision – using an approach proposed by (Du et al., 2007). It also reports on an attempt to model the IVC for the manufacturing sector SMMEs in South Africa in order to highlight the determinants of innovation, productivity and growth in these firms. Chapter 4 seeks to address research questions RQ1 to RQ4.

Chapters 5 reports on the attempts to use evidence from the responses contained in the 2013 national innovation survey to investigate the determinants of innovations in the manufacturing sector SMMEs in South Africa. The attempt was opportunistic, inspired by approaches demonstrated by (Abdu & Jibir, 2017; Alpkan, 2015; Avermaete et al., 2004; Booyens, 2011; El Elj & Abassi, 2014; Hadhri et al., 2016; Lopez-Fernandez et al., 2016; Oerlemans & Pretorius, 2006). Findings from Chapter 5 seek to address the research question RQ5.

The main findings from these attempts are summarised here below in terms of the above-stated research questions:

Research question RQ1

In answering research question RQ1, on those factors that can significantly influence in an SMME's decision to undertake either new to the firm or market innovations. The findings show that that the firm's individual characteristics have a generally positive influence. The findings also show that innovation activities restraining factors typically increase the likelihood of firms to decide to undertake new to the firm innovations while lessening the prospect of pursuing new to the market innovations.

Research question RQ2

In answering research question RQ2, on which knowledge sourcing activities and strategies do SMMEs adopt in their innovation pursuits. Findings from this work show that SA manufacturing SMME firms are more likely to engage both internal and external knowledge sources – with institutions of higher education and rival firms (competitors) more frequently.

Furthermore, the nature of the interactions between the firms' knowledge sources is complementary rather than substitutional. According to Roper et al. (2008), the main driver then for pursuing external linkages is as a risk mitigation and cost-cutting measure instead of forgoing to develop their own knowledge. Other factors such as the firms' characteristics and knowledge utilisation capacity and factors hindering innovation were generally less significant than expected.

Research question RQ3

In answering research question RQ3, on the effect of knowledge sourcing activities on the firm's proclivity to develop significantly improved or new products and processes. Findings from this work show that SA manufacturing SMME firms engaged in internal R&D activities and those pursuing backward knowledge sourcing activities were generally more likely to introduce significantly improved or new products and processes. Once again, as with the knowledge production activities, the other factors such as the firms' characteristics and knowledge utilisation capacity and factors hindering innovation were generally less significant than expected.

Research question RQ4

In answering research question RQ4, on whether SA SMME firms perform better, as a result, developing new or significantly improved products. The effects of the knowledge sourcing activities are mixed but the strength of enterprises' in-house R&D activities is yet again significant with respect to the firm's performance. In addition, the firm characteristics exhibited mostly positive and significant impact on the firm performance so as the firm's exporting orientation.

The firms that succeeded in introducing product and process innovations have an overwhelmingly positive effect on the performance, with process innovations being statistically significant.

Research question RQ5

In answering research question RQ5, on the determinants of innovations in the manufacturing sector SMMEs in South Africa. Table 18 summarises the findings on the determinants of innovation activities in the firms. It is immediately clear that there is an overwhelming agreement between these findings, prior finding from South Africa and Africa in general, notably (Mustapha & Mendi, 2015; Oerlemans & Pretorius, 2006), and the findings from the other economies in the Sub-Saharan region (Abdu & Jibir, 2017; Abousenna & Becheikh, 2012; Barasa et al., 2017; El Elj & Abassi, 2014; Sdiri et al., 2010).

A noteworthy finding is that view increasing the proportion of employees with degrees or universities as knowledge sources of choice both have a negative impact on the firm's innovation undertakings in the manufacturing sector. While counter-intuitive, it is plausible that the manufacturing sector views graduates as both not well prepared/trained for the tasks, unnecessarily 'costly' – such that the benefits of employing a graduate are low as reported by Pauw et al. (2008). Interestingly, in concluding their paper Pauw et al. (2008) remarks that it is "*unacceptable that highly skilled individuals suffer unemployment … when the economy so desperately needs their skills" [p. 57].*

6.3 IMPLICATIONS FOR POLICY-MAKERS AND MANAGERS

This study sought to contribute towards developing an enhanced understanding of innovation decisions, activities and their drivers in SA manufacturing SMME firms.

Although the results are based on a sample much smaller than initially intended for the econometric models, they point to several interesting directions to explore when scholars, managers and practitioners embark on developing theories, strategies, and policies, respectively.

The implications of this dissertation for different stakeholders are briefly outlined.

- The South African Business Innovation Survey was 'rigorously' analysed and the main policy implication from this study is a demonstration of several innovation systems linkages work across innovation value chain and how SMMEs benefit or are penalized therefrom. Policy-makers now have some basis and insights to inform their SMME innovation policies.
- The application and outcomes of the IVC modelling and determinants have revealed detailed information that can help the policy-makers and managers of SMMEs in South Africa to identify the strength and barrier factors aiding or frustrate each step in their innovation process, thereby emphasizing actionable strategic and policy priorities (Hansen & Birkinshaw, 2007; Neely & Hii, 1998).
- Invested stakeholders, including policymakers, government agencies and venture capitalists etc., can now propose and implement interventions and support programmes that are informed and relevant, coherent and aligned to the needs of small firms in South Africa based on the findings of the work.
- Yet another main policy implication is that for the development of a vibrant and growing manufacturing sector, those knowledge sources that are 'dead' in as far as influencing product and process innovations in Figure 12 must be stimulated by raising awareness and properly introducing policy incentives of both collaborative and economic relevance to redirect their stimuli towards innovations. The negative influences of graduates (with degrees and diplomas) either or how they are shunned by manufacturing sector SMME firms in South Africa is something that needs to be looked at perhaps at a policy level. Again to quote from paper Pauw et al. (2008) remarks that it is "*unacceptable that highly skilled individuals suffer unemployment … when the economy so desperately needs their skills*" [p. 57].

Finally, very few researchers have interrogated how knowledge exchanges at the SMME level can augment the firm's innovative efforts (Ganotakis & Love, 2012; Spithoven et al., 2010; Taghizadeh et al., 2014). This study aimed at taking an in-

depth perspective of how SMMEs in the manufacturing sector in South Africa innovate.

6.4 CONTRIBUTION TO KNOWLEDGE

In preparing to answer the research questions, the researcher had noticed that indeed innovation activities in South African SMMEs are an under-reported phenomenon. While a few studies on the determinants of innovation have been reported (Booyens, 2011; Mustapha & Mendi, 2015; Ndlovu, 2016; Pretorius & Oerlemans, 2006) none was particularly focused on SMMEs in particular. Furthermore, no reported study has even reported on the knowledge sourcing activities and strategies of firms in South Africa. Now, as El Elj and Abassi (2014) duly points out "*[u]nderstanding the major incentives behind a firm's decision to innovate is just as important in developing countries as in developed countries"*.

The current study has made both theoretical, practical, and methodological contributions.

Firstly, this findings report has made a theoretical contribution in the following way. The research framework proposed for this study, refer to Figure 1, is an adaptation of a conceptual framework initially proposed by Ganotakis and Love (2012). Absent from the initially proposed conceptual framework by Ganotakis and Love (2012) is the inclusion of the firm's adaptive capacity in addition to the firm's.

Secondly, in terms of its practical contribution, the input is threefold. These findings bring confirmation to the prior studies on the determinants of innovation activities in SA manufacturing firms using the innovation survey data – which is advanced further by focussing on the SMME firms. Further, the investigations into the innovation decision-making in South African SMMEs in the manufacturing sector that is reported in Chapter 4 is a first in South Africa. Last, and not least, the investigations related to the impact of the knowledge sourcing activities and strategies in SMMEs in their innovation pursuits is also a first in the South African and African context. In short, this study makes practical contributions to knowledge in the area of innovation in SMME inter-organizational learning and management.

Thirdly, in terms of its methodological contribution, this study has applied the IVC framework and related econometric models methodology, inspired by Roper et al.

(2008) proposed concepts, which is also a first in the South African and African context. As such, this study contributes to the methodology by using a combination of different statistical procedures to conduct an analysis of manufacturing SMME firms using the 2013 South African Business Innovation Survey.

Yet another methodological contribution of this work, according to Booyens (2011) is that the South African National Innovation Surveys and the related R&D surveys have been 'rigorously' analysed by the researcher.

6.5 AGENDA FOR FUTURE RESEARCH

Given that the sample used in the current study had far fewer firms than initially intended. The researcher proposes that future research work on modelling the IVC using South African innovation survey datasets can possibly be based on (a) all the SMMEs in the SABIS2013 dataset or (b) be based on the evidence from the entire dataset. It will also be fruitful to combine link all manufacturing sector firms from all the previous innovation surveys (unbalanced panel) and attempt to model the IVC again for deeper insights.

A puzzling theme derived from the findings from this work is that graduates (with degrees and diplomas) either have a negative impact or are shunned by manufacturing sector SMME firms in South Africa. One can only speculate, although it is not patently obvious, that as the manufacturing sector and the economy are entangled in a vicious yet perfectly-synchronised shrinking cycle. They both can benefit from future enquiries on how to derive stimuli from this special skills pool.

"If we knew what it was we were doing,
it would not be called research,
would it?"

Albert Einstein
14 Mar. 1879 – 18 Apr. 1955

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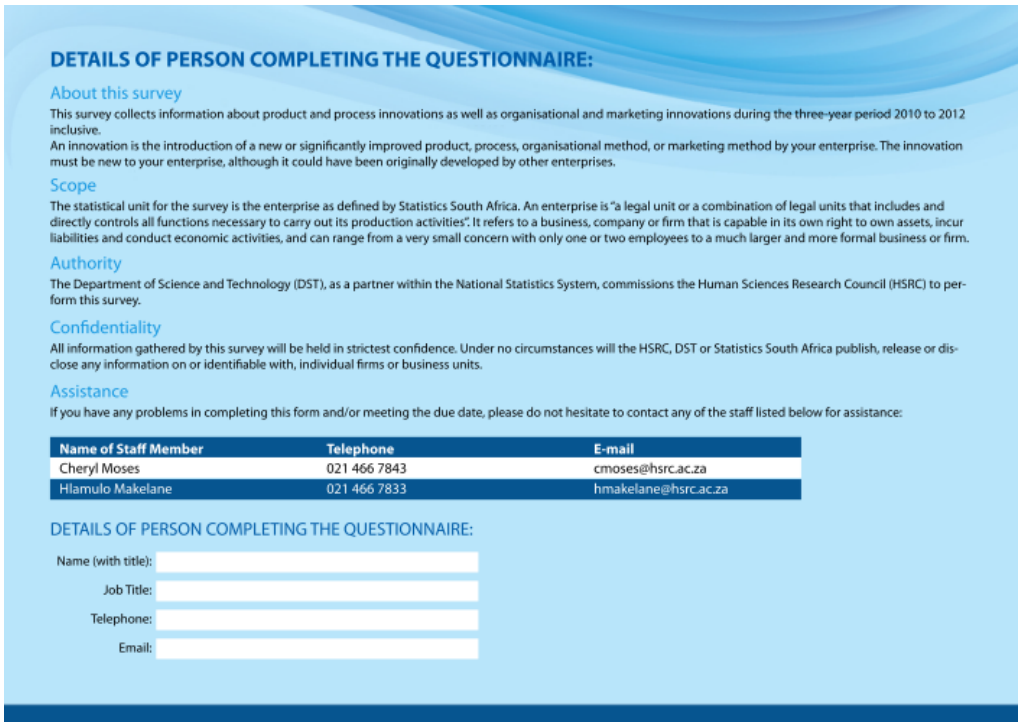
APPENDIX A: SABIS2013 RESEARCH TOOL



Source: CeSTII



Source: CeSTII



1. General information about the enterprise, business, company or firm

1. Please provide a short description of your main business activity or Standard Industrial Classification (SIC) (See SIC codes book attached)

Description:

SIC:

1.1 Is your enterprise part of a larger group?

A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group may serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.

YES NO

In which country is the head office of your group located? Please select from the list provided. PLEASE SELECT

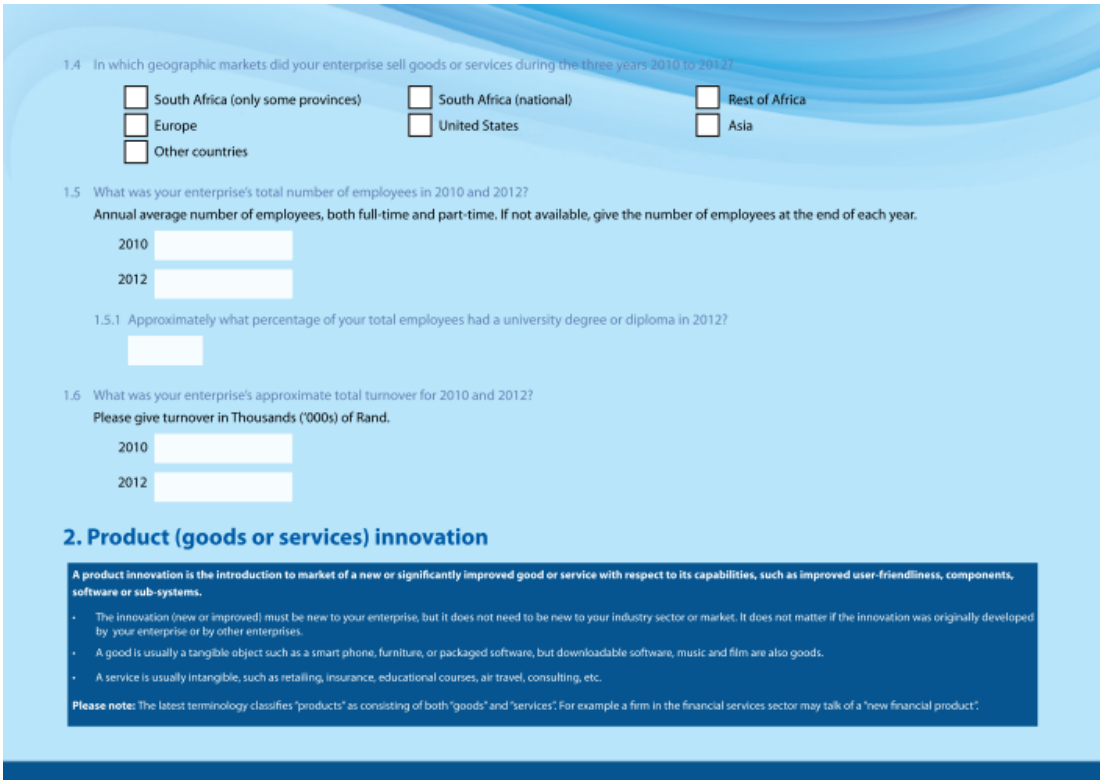
If your enterprise is part of an enterprise group, please answer all further questions only for your enterprise in South Africa. Do not include results for subsidiaries or parent enterprises outside of South Africa.

1.2 Please provide the year in which your enterprise was established.

1.3 During the three years 2010 to 2012, did your enterprise :

	YES	NO
-> Merge with or take over another enterprise	○	○
-> Sell, close or outsource parts of your enterprise	○	○
-> Establish new subsidiaries in other African countries	○	○
-> Establish new subsidiaries outside of Africa	○	○

Source: CeSTII



1.4 In which geographic markets did your enterprise sell goods or services during the three years 2010 to 2012?

☐ South Africa (only some provinces) ☐ South Africa (national) ☐ Rest of Africa
☐ Europe ☐ United States ☐ Asia
☐ Other countries

1.5 What was your enterprise's total number of employees in 2010 and 2012?

Annual average number of employees, both full-time and part-time. If not available, give the number of employees at the end of each year.

2010

2012

1.5.1 Approximately what percentage of your total employees had a university degree or diploma in 2012?

1.6 What was your enterprise's approximate total turnover for 2010 and 2012?

Please give turnover in Thousands ('000s) of Rand.

2010

2012

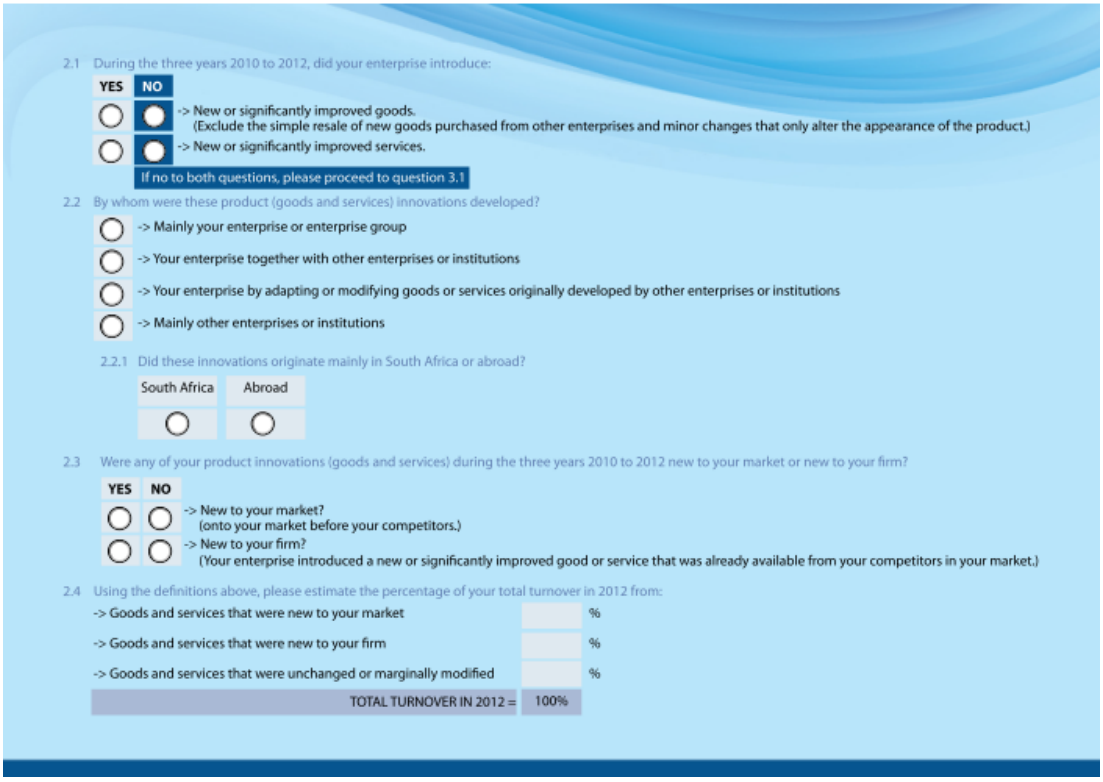
2. Product (goods or services) innovation

A product innovation is the introduction to market of a new or significantly improved good or service with respect to its capabilities, such as improved user-friendliness, components, software or sub-systems.

- The innovation (new or improved) must be new to your enterprise, but it does not need to be new to your industry sector or market. It does not matter if the innovation was originally developed by your enterprise or by other enterprises.
- A good is usually a tangible object such as a smart phone, furniture, or packaged software, but downloadable software, music and film are also goods.
- A service is usually intangible, such as retailing, insurance, educational courses, air travel, consulting, etc.

Please note: The latest terminology classifies "products" as consisting of both "goods" and "services". For example a firm in the financial services sector may talk of a "new financial product".

Source: CeSTII



2.1 During the three years 2010 to 2012, did your enterprise introduce:

YES	NO	
○	○	-> New or significantly improved goods. (Exclude the simple resale of new goods purchased from other enterprises and minor changes that only alter the appearance of the product.)
○	○	-> New or significantly improved services.

If no to both questions, please proceed to question 3.1

2.2 By whom were these product (goods and services) innovations developed?

- ○ -> Mainly your enterprise or enterprise group
- ○ -> Your enterprise together with other enterprises or institutions
- ○ -> Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions
- ○ -> Mainly other enterprises or institutions

2.2.1 Did these innovations originate mainly in South Africa or abroad?

South Africa	Abroad
○	○

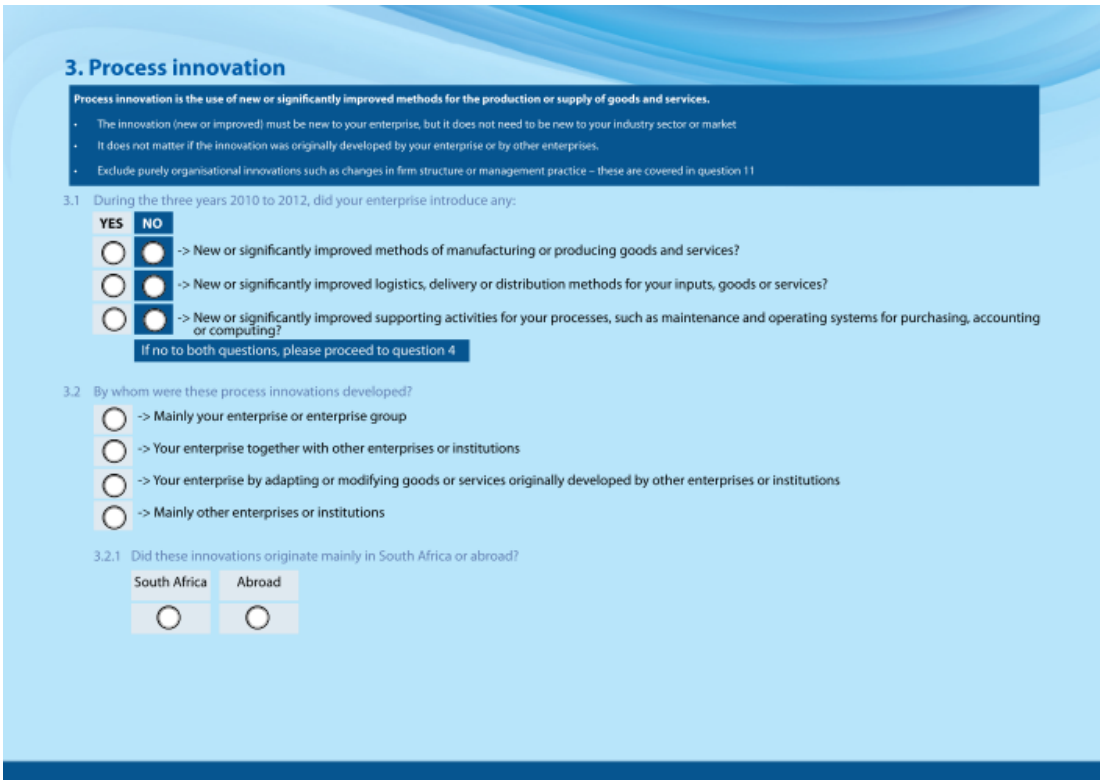
2.3 Were any of your product innovations (goods and services) during the three years 2010 to 2012 new to your market or new to your firm?

YES	NO	
○	○	-> New to your market? (onto your market before your competitors.)
○	○	-> New to your firm? (Your enterprise introduced a new or significantly improved good or service that was already available from your competitors in your market.)

2.4 Using the definitions above, please estimate the percentage of your total turnover in 2012 from:

-> Goods and services that were new to your market		%
-> Goods and services that were new to your firm		%
-> Goods and services that were unchanged or marginally modified		%
TOTAL TURNOVER IN 2012 =	100%	

Source: CeSTII



3. Process innovation

Process innovation is the use of new or significantly improved methods for the production or supply of goods and services.

- The innovation (new or improved) must be new to your enterprise, but it does not need to be new to your industry sector or market
- It does not matter if the innovation was originally developed by your enterprise or by other enterprises.
- Exclude purely organisational innovations such as changes in firm structure or management practice – these are covered in question 11

3.1 During the three years 2010 to 2012, did your enterprise introduce any:

YES	NO	
○	○	-> New or significantly improved methods of manufacturing or producing goods and services?
○	○	-> New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services?
○	○	-> New or significantly improved supporting activities for your processes, such as maintenance and operating systems for purchasing, accounting or computing?

If no to both questions, please proceed to question 4

3.2 By whom were these process innovations developed?

- ○ -> Mainly your enterprise or enterprise group
- ○ -> Your enterprise together with other enterprises or institutions
- ○ -> Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions
- ○ -> Mainly other enterprises or institutions

3.2.1 Did these innovations originate mainly in South Africa or abroad?

South Africa	Abroad
○	○

Source: CeSTII

4. Ongoing or abandoned innovation activities

Innovation activities include the acquisition of machinery, equipment, software, licenses, engineering and development work, training, marketing and research and experimental development (R&D) when they are specifically undertaken to develop and/or implement a product or process innovation

4.1 During the three years 2010 to 2012:

-> Did your enterprise have any innovation activities that did not result in a product or process innovation because the activities were:

PRODUCT INNOVATION			PROCESS INNOVATION		
YES	NO		YES	NO	
◯	◯	-> Abandoned	◯	◯	-> Abandoned
◯	◯	-> Still ongoing at the end of 2012	◯	◯	-> Still ongoing at the end of 2012

If your enterprise also had no product or process innovations or innovation activity during 2010 to 2012 (no to **ALL** options in 2.1, 3.1 and 4.1), please to to question **9.1**. Otherwise, please proceed to question 5.1.

5. Innovation activities and expenditures

5.1 During the three years 2010 to 2012, did your enterprise engage in the following innovation activities?

YES	NO			
◯	◯	A	**Intramural (in-house) Reasearch and Experimental Development (R&D).** Creative work undertaken on a systematic basis within your enterprise to increase the stock of knowledge and its use to devise new and improved products and process.	
			If yes, did your enterprise perform R&D during 2010 to 2012...	**Continuously** ◯ **Occasionally** ◯
◯	◯	B	**Extramural or outsourced R&D.** Same activities as above, but performed by other companies (including other enterprises within your group) or by public or private research organisations and purchased by your enterprise	
◯	◯	C	**Acquisition of machinery, equipment and software** to produce new or significantly improved products or processes.	
◯	◯	D	**Acquisition of other external knowledge.** Purchase or licensing of patents and non-patented innovations, know-how, and other types of knowledge from other enterprises or organisations.	
◯	◯	E	**Training.** Internal or external training for your personnel specifically for the development and/or introduction of new or significantly improved products or processes.	
◯	◯	F	**Market introduction of innovations.** Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising	
◯	◯	G	**Other activities (including design).** Procedures and technical preparations, including design, to implement new or significantly improved products and processes that are not covered elsewhere.	

Source: CeSTII

5.2 Please estimate the amount of expenditure in 2012 only for the first four innovation activities mentioned in 5.1 (A to D).
Include personnel and related costs. Please provide expenditure in thousands of Rands. Example: Five hundred thousand Rand or R500 000 should be entered as 500 in the box provided... 500 000
Please enter 0 in the category box if your enterprise had no expenditure in 2012.

A	Intramural (in-house) R&D		000
B	Purchase/or acquisition of extramural or outsourced R&D		000
C	Acquisition of machinery, equipment and software		000
D	Acquisition of other external knowledge		000
	Total = (A+B+C+D)	R 0.00	000

STRICTLY CONFIDENTIAL
Please report for 2012 only.

5.3 Please provide the approximate numberof employees involved in innovation activities accounted for in 5.2 above

5.4 Are you aware that government offers financial support for innovation? YES ◯ NO ◯

5.4.1 During the 3 years 2010 to 2012, did your enterprise receive any public financial support from the following levels of government?

NATIONAL GOVERNMENT			NATIONAL FUNDING AGENCIES			FOREIGN GOVERNMENT OR OTHER SOURCES:		
YES	NO		YES	NO		YES	NO	
◯	◯	Department of Science and Technology (DST)	◯	◯	National Research Foundation (NRF)	◯	◯	(Example: European Union)
◯	◯	Department of Trade and Industry (DTI)	◯	◯	Medical Research Council (MRC)			
◯	◯	Other: Please specify...	◯	◯	Industrial Development Corporation (IDC)			
			◯	◯	Technology Innovation Agency (TIA)			
			◯	◯	Other: Please specify...			

5.4.2 If you have not accessed government funds for innovation activity, please indicate why:

☐ Process too complicated
☐ Risk of exposure of confidential information
☐ Time constraints
☐ Other: Please specify....

Source: CeSTII

6. Public sector procurement and innovation

*The public sector includes government owned organisations such as local, regional and national administrations and agencies, schools, hospitals, and government providers of services such as security, transport, housing, energy, etc.

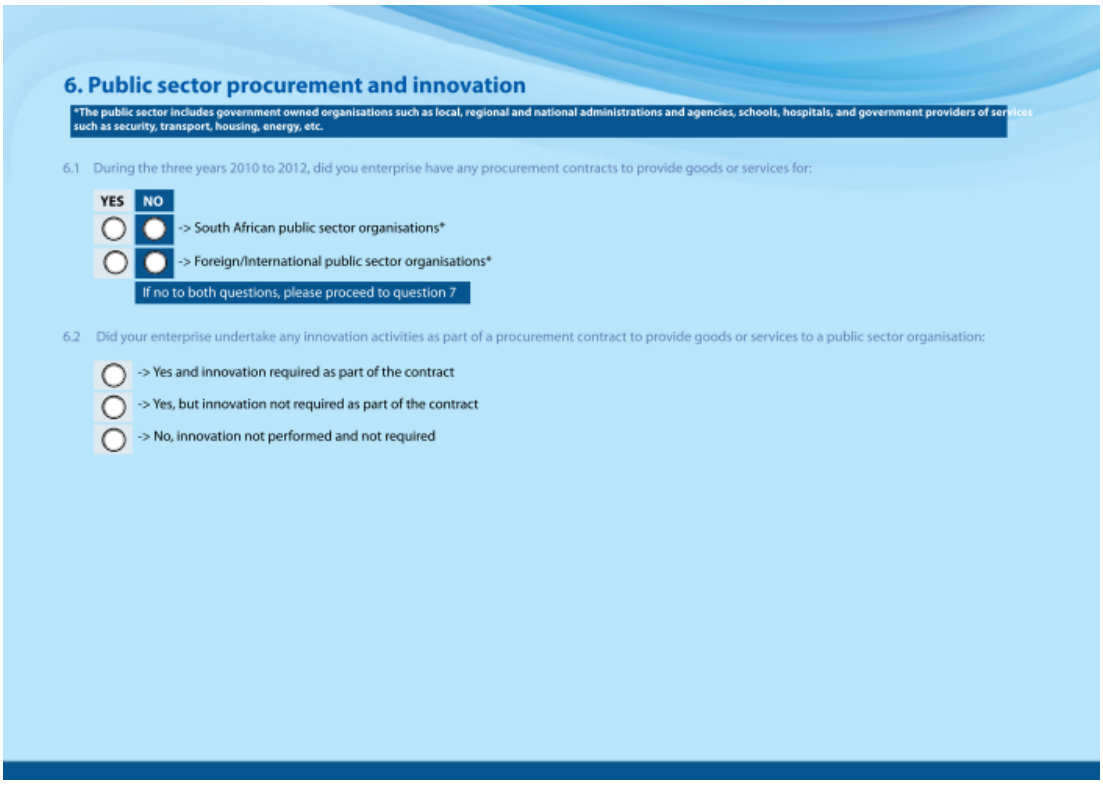
6.1 During the three years 2010 to 2012, did you enterprise have any procurement contracts to provide goods or services for:

YES	NO	
○	○	-> South African public sector organisations*
○	○	-> Foreign/International public sector organisations*

If no to both questions, please proceed to question 7

6.2 Did your enterprise undertake any innovation activities as part of a procurement contract to provide goods or services to a public sector organisation:

- ○ -> Yes and innovation required as part of the contract
- ○ -> Yes, but innovation not required as part of the contract
- ○ -> No, innovation not performed and not required

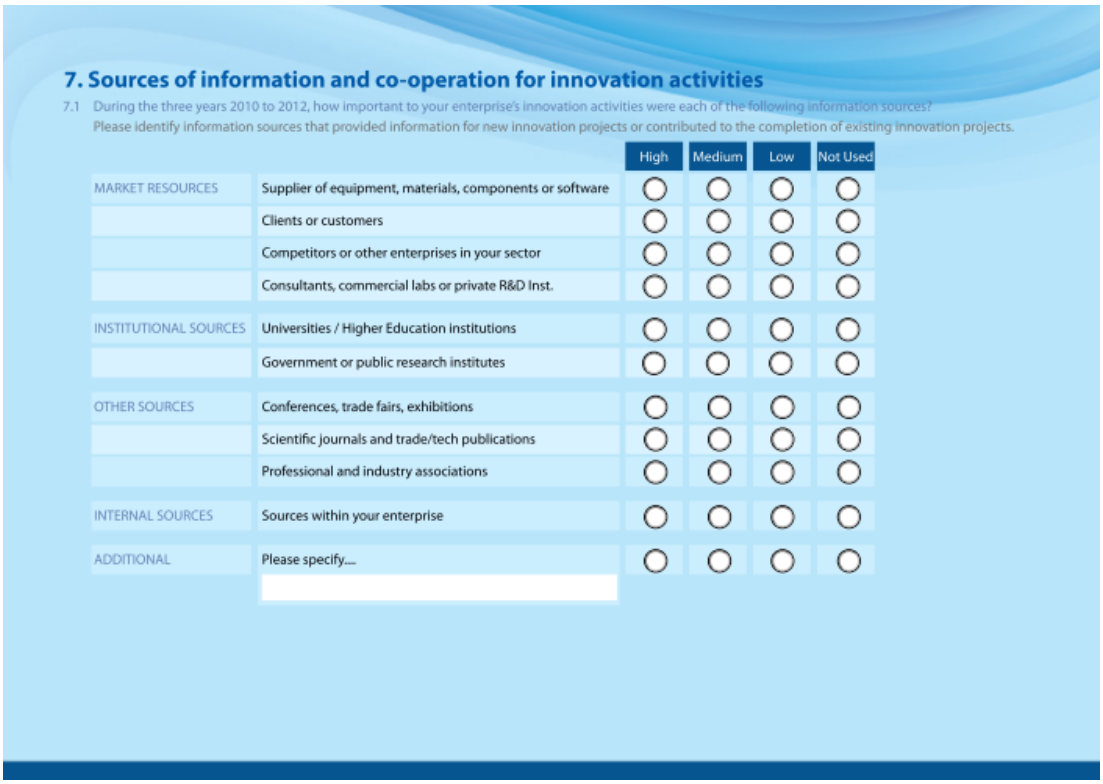


Source: CeSTII

7. Sources of information and co-operation for innovation activities

7.1 During the three years 2010 to 2012, how important to your enterprise's innovation activities were each of the following information sources?
Please identify information sources that provided information for new innovation projects or contributed to the completion of existing innovation projects.

		High	Medium	Low	Not Used
MARKET RESOURCES	Supplier of equipment, materials, components or software	○	○	○	○
	Clients or customers	○	○	○	○
	Competitors or other enterprises in your sector	○	○	○	○
	Consultants, commercial labs or private R&D Inst.	○	○	○	○
INSTITUTIONAL SOURCES	Universities / Higher Education institutions	○	○	○	○
	Government or public research institutes	○	○	○	○
OTHER SOURCES	Conferences, trade fairs, exhibitions	○	○	○	○
	Scientific journals and trade/tech publications	○	○	○	○
	Professional and industry associations	○	○	○	○
INTERNAL SOURCES	Sources within your enterprise	○	○	○	○
ADDITIONAL	Please specify....	○	○	○	○



Source: CeSTII

7.2 During the three years 2010 to 2012, did your enterprise co-operate on any of your innovation activities with other enterprises or institutions?

Innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities.
Both partners do not need to benefit commercially.

YES NO

If no, please proceed to question 8

If yes, please check which of the following reasons were important in determining the involvement of your business unit in co-operative arrangements to develop or commercialize new or significantly improved products (goods and services) and/or processes.

- -> Sharing the cost of developing innovations
- -> Accessing research and development (R&D)
- -> Accessing information
- -> Accessing critical expertise/skills
- -> Prototype development
- -> Scaling up production processes

Commercialisation of Innovation

- -> Accessing new markets
- -> Accessing new distribution channels
- -> Other reasons: Please specify...

Source: CeSTII

7.3 Please indicate the type of co-operation partner and their location.

		SA	AFRICA	EU	USA	ASIA	OTHER
A	Other enterprises within your enterprise group	☐	☐	☐	☐	☐	☐
B	Suppliers of equipment, materials, components or software	☐	☐	☐	☐	☐	☐
C	Clients or customers	☐	☐	☐	☐	☐	☐
D	Competitors or other enterprises in your sector	☐	☐	☐	☐	☐	☐
E	Consultants, commercial labs or Private R&D institutions	☐	☐	☐	☐	☐	☐
F	Universities / Higher education institutions	☐	☐	☐	☐	☐	☐
G	Government or public research institutes	☐	☐	☐	☐	☐	☐

7.4 Which type of co-operation partner was the most valuable?

Please Choose

Source: CeSTII

8. Effects of innovation during 2010 - 2012

8.1 How succesful were each of the following outcomes for your product and process innovation?

		High	Medium	Low	Not Used
PRODUCT OUTCOMES	Increased range of goods or services	○	○	○	○
	Entered new markets or increased market share	○	○	○	○
	Improved quality of goods or services	○	○	○	○
PROCESS OUTCOMES	Improved flexibilty of production or service provision	○	○	○	○
	Increased capacity of production or service provision	○	○	○	○
	Reduced labour costs per unit output	○	○	○	○
	Reduced materials and energy per unit output	○	○	○	○
OTHER OUTCOMES	Reduced enviromental impacts or improved health and safety	○	○	○	○
	Met governmental regulatory requirements	○	○	○	○
ADDITIONAL	Please specify...	○	○	○	○

Source: CeSTII

QUESTIONS 9, 10 and 11 TO BE ANSWERED BY ALL ENTERPRISES:

9. Factors hampering innovation activities

9.1 How important were the following factors in hampering your innovation activities or projects?

		High	Medium	Low	Not Used
COST FACTORS	Lack of funds within your enterprise or group	○	○	○	○
	Lack of finance from sources outside your enterprise	○	○	○	○
	Innovation costs too high	○	○	○	○
KNOWLEDGE FACTORS	Lack of qualified personnel	○	○	○	○
	Lack of information on technology	○	○	○	○
	Lack of information on markets	○	○	○	○
	Difficulty in finding co-operation partners for innovation	○	○	○	○
MARKET FACTORS	Market dominated by established enterprises	○	○	○	○
	Uncertain demand for innovative goods and services	○	○	○	○
REASONS NOT TO INNOVATE	No need due to prior innovations	○	○	○	○
	No need because of no demand for innovations	○	○	○	○
ADDITIONAL	Please specify...	○	○	○	○

Source: CeSTII

10. Intellectual Property rights

10.1 During the three years 2010 to 2012, did your enterprise:

YES	NO	
○	○	-> Secure a patent in South Africa?
○	○	-> Apply for a patent outside of South Africa?
○	○	-> Register an industrial design?
○	○	-> Register a trademark?
○	○	-> Claim copyright?
○	○	-> Grant a licence on any intellectual property rights resulting from innovation?

11. Organisational and Marketing Innovations

An organisational innovation is the implentation of new or significant changes in firm structure or management methods that are intended to improve your firm's use of knowledge, the quality of your goods and services, or the efficiency of work flows.
A marketing innovation is the imlementation of new or significantly improved designs or sales methods to increase the appeal of your goods and services or to enter new markets.

11.1 During the three years 2010 to 2012, did your enterprise introduce:

○	○	ORGANISATIONAL INNOVATIONS
○	○	New or significantly improved knowledge management systems to better use or exchange information, knowledge and skills with your enterprise Exclude routine upgrades
○	○	Major changes to the organisation of work within your enterprise, such as changes in the management structure or integrating different departments or activities
○	○	New or significant changes in your external relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or sub-contracting

YES	NO	MARKETING INNOVATIONS
○	○	Significant changes to the design or packaging of a good or service
○	○	New or significantly changed sales or distribution methods, such as internet sales, franchising, direct sales or distributions licenses.

Source: CeSTII

11.2 If your enterprise introduced an organisational innovation during the three years 2010 to 2012, how important were each of the following results?

	High	Medium	Low	Not Relevant
Improved market share	○	○	○	○
Reduced time to respond to customer or supplier needs	○	○	○	○
Improved quality of your goods or services	○	○	○	○
Reduced costs per unit output	○	○	○	○
Improved employee satisfaction and/or reduced rates of employee turnover	○	○	○	○

12. Specific innovations by your enterprise

12.1 During the three years 2010 to 2012, were any of your new or significantly improved products or processes:

YES	NO	DON'T KNOW	
○	○	○	A first in South Africa?
○	○	○	A world first?
○	○	○	New significant changes in your external relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or sub-contracting.

12.2 Please give a short description of these innovations and an approximate period of time it took to develop these innovations.

12.3 Please list other significant examples of innovations in your enterprise and the approximate period of time it took to develop these.

Source: CeSTII

13. Innovation with environmental benefits

An environmental innovation is a new or significantly improved product (good or service), process, organizational method or marketing method that creates environmental benefits compared to alternatives.

- **The environmental benefits can be the primary objective of the innovation or the result of other innovation objectives.**
- **The environmental benefits of an innovation can occur during the production of a good or service, or during the after sales use of a good or service by the end user.**

13.1 During the three years 2010 to 2012, did your enterprise introduce a product (good or service), process, organisational or marketing innovation with any of the following:

Environmental benefits from the production of goods or services within your enterprise:

YES	NO	
◯	◯	Reduced material use per unit of output
◯	◯	Reduced energy use per unit of output
◯	◯	Reduced CO_2 'footprint' (total CO_2 production) by your enterprise
◯	◯	Replaced materials with less polluting or hazardous substitutes
◯	◯	Reduced soil, water, noise, or air pollution
◯	◯	Recycled waste, water, or materials

Environmental benefits from the after sales use of a good or service by the end user:

YES	NO	
◯	◯	Reduced energy use
◯	◯	Reduced air, water, soil or noise pollution
◯	◯	Improved recycling of product after use

Source: CeSTII

13.2 During 2010 to 2012, did your enterprise introduce an environmental innovation in response to:

Environmental benefits from the production of goods or services within your enterprise:

YES	NO	
◯	◯	Existing environmental regulations or taxes on pollution
◯	◯	Environmental regulations or taxes that you expected to be introduced in the future
◯	◯	Availability of government grants, subsidies or other financial incentives for environmental
◯	◯	Current or expected market demand from your customers for environmental innovations
◯	◯	Voluntary codes or agreements for environmental good practice within your sector

13.3 Does your enterprise have procedures in place to regularly identify and reduce your enterprise's environmental impacts? (For example preparing environmental audits, setting environmental performance goals, ISO 14001 certification, etc).

YES	NO
◯	◯

Thank you for your participation. It is sincerely appreciated.

Please make a copy of this questionnaire for your records and internal use, which may also be referenced if we need to follow-up with any specific issues.

Please submit the completed electronic questionnaire to the HSRC via email.

Website: www.hsrc.ac.za

Source: CeSTII

APPENDIX B: DESCRIPTION OF THE VARIABLES

Table 19: Description of the variables

Variable	Type	Description of the variable
KSA.INTERNAL	Dummy	In-house Research and Development activities (R&D) (0/1)
KSA.CLIENTS	Dummy	Forward knowledge linkages to clients or customers (0/1)
KSA.SUPPL	Dummy	Backward knowledge linkages to suppliers or consultants (0/1)
KSA.COMPET	Dummy	Horizontal knowledge linkages to competitors or joint ventures (0/1)
KSA.CONSULT	Dummy	
KSA.UNIV	Dummy	
KSA.PUB	Dummy	Public knowledge linkages to universities, industry operated labs or public labs (0/1)
RIB.SIZE	Categorical	Firm size classes as prescribed in the National Small Business Amendment Act
RIB.EMPL	Number	Firm's size by the number of employees
RIB.AGE	Number	Firm's age (in years)
RIB.MNC	Dummy	The firm is part of a larger group (0/1)
RIB.PLNT.BCH	Dummy	Type of production in plant (0/1) (one-offs = 0, large batches = 1)
RIB.SA.BASED	Dummy	Head office country is based in SA (0/1)
FAC.RND	Dummy	Formal R&D department in the plant (0/1)
FAC.HCD	Dummy	Management training/training on process development/best practice (0/1)
FAC.DEG	Ratio	Number of Employees with Degrees/Diplomas (%)
FAC.INNO.TEAM	Number	Number of employees involved in innovation activities
FAC.INNO.ORG	Dummy	
FAC.GRP.RND	Dummy	Relevant R&D being conducted in the group (R&D in the group) (0/1)
GOV.INNO	Dummy	Public support for product/process innovations (0/1)
GOV.CAP	Dummy	Public support for capital (plant/machinery) (0/1)
GOV.HCD	Dummy	Public support for human capital development (0/1)
MKT.NAT	Dummy	Established markets in some or all SA provinces (0/1)
MKT.EXP	Dummy	Established markets in outside SA (1\0)
d.EMPL	Ratio	Employment growth from 2010 to 2013 (%)
RND.INT	Ratio	R&D intensity
EQUIP.INT	Ratio	Capital intensity (acquisition of machinery, equipment and software)
INNOV.INT	Ratio	R&D intensity
PROC.INNOV	Dummy	The firm introduced new/significantly improved methods of manufacturing or producing goods and services (0/1)
PROD.INNOV	Dummy	The firm introduced new/significantly improved products (0/1)
BOTH.INNOV	Dummy	The firm introduced both new/significantly improved products & processes (0/1)
NON.INNOV	Dummy	The firm introduced no new/significantly improved products or processes (0/1)
HAMPER.INNOV.COSTLY	Score	Innovation constraints: shortages of finance (score)
HAMPER.LACK.INFO	Score	Innovation constraints: lack of necessary information (score)
HAMPER.LACK.COMPETN	Score	Innovation constraints: lack of competition (score)
HAMPER.PRIOR.INNOV	Score	Innovation constraints: prior innovations (score)
SECTOR	Categorical	Manufacturing sector sub-sectoral categories (Moses et al., 2013, p. 19)

Source: Author's work based on the SABIS2013 dataset and (Roper et al., 2008)

Appendix C: Summary of Statistics

Table 20: Means, standard deviations, and correlations without confidence intervals

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1. DEC.PDC	.44	0.50																												
2. DEC.PRC	0.46	0.50	.66**																											
3. DEC.ALL	0.36	0.48	.86**	.82**																										
4. DEC.NON	0.47	0.50	-.83**	-.86**	-.71**																									
5. INNO.SUCC	13.58	24.91	.62**	.46**	.58**	-.51**																								
6. INNO.PDC	0.42	0.50	.97**	.66**	.85**	-.80**	.64**																							
7. INNO.PRC	0.38	0.49	.67**	.85**	.81**	-.73**	.46**	.67**																						
8. KSA.HSE	0.39	0.49	.66**	.74**	.67**	-.74**	.50**	.65**	.64**																					
9. KSA.FWD	0.13	0.34	.27**	.38**	.29**	-.36**	.12	.19*	.32**	.45**																				
10. KSA.BWD	0.36	0.48	.55**	.76**	.62**	-.71**	.48**	.55**	.66**	.67**	.47**																			
11. KSA.PUB	0.13	0.34	.18*	.42**	.24**	-.36**	.16	.15	.41**	.36**	.42**	.51**																		
12. KSA.HZL	0.39	0.49	.60**	.74**	.64**	-.71**	.38**	.59**	.61**	.72**	.31**	.71**	.31**																	
13. FP.GRWTH.EMP	8.93	29.54	.13	.18*	.23**	-.08	.31**	.15	.25**	.18*	.09	.20*	.08	.12																
14. FP.INNO.INT	1.68	4.28	.08	.40**	.14	-.34**	.05	.09	.33**	.45**	.42**	.48**	.42**	.36**	.04															
15. RIB.SIZE	2.87	0.90	-.30**	-.26**	-.28**	.28**	-.13	-.27**	-.29**	-.30**	-.23**	-.35**	-.11	-.34**	-.15	-.13														
16. RIB.EMPL	71.42	95.21	.15	.17*	.20*	-.13	.12	.14	.16	.16	.11	.30**	.10	.31**	.28**	.09	-.43**													
17. RIB.AGE	211.80	585.56	-.04	-.15	-.09	.10	-.04	-.03	-.10	-.16	-.05	-.14	-.05	-.21*	.02	-.02	-.01	-.16												
18. RIB.MNC	0.18	0.38	-.06	-.00	-.03	.03	.06	-.05	-.00	.03	-.01	.13	.10	-.01	.06	.20*	-.21*	.17*	-.02											
19. RIB.PLNT.BCH	0.20	0.40	.54**	.51**	.59**	-.47**	.58**	.55**	.42**	.64**	.39**	.59**	.29**	.45**	.22*	.19*	-.29**	.26**	-.10	.10										
20. RIB.RI	8.32	12.70	.29*	-.13	.18		.78**	.33*	.04	.15	-.13	.01	-.06	-.25	.24	-.13	.43**	-.23	.21	.06	.19									
21. FAC.DEG	9.21	16.76	-.02	.02	.03	.03	.02	-.01	-.03	.01	-.07	-.03	-.13	-.02	-.01	-.03	.02	-.15	-.06	.23**	.04	.07								
22. FAC.INNO.TEAM	2.48	5.18	.37**	.50**	.43**	-.45**	.17	.37**	.32**	.44**	.13	.50**	.22*	.48**	-.01	.26**	-.26**	.26**	-.09	.14	.35**	-.35*	.04							
23. FAC.INNO.ORG	0.13	0.34	.40**	.42**	.47**	-.36**	.35**	.41**	.50**	.36**	.10	.29**	.23**	.40**	.18*	.16	-.18*	.03	.02	.05	.34**	-.03	-.02	.07						
24. FAC.GRP.RND	0.45	0.50	.70**	.84**	.71**	-.85**	.50**	.68**	.71**	.87**	.43**	.83**	.43**	.84**	.18*	.41**	-.36**	.22**	-.19*	.04	.56**	NA	-.04	.53**	.34**					
25. GOV.INNO	0.09	0.29	.32**	.30**	.32**	-.30**	.29**	.33**	.31**	.15	.17*	.38**	.17*	.36**	.21*	.02	-.23**	.21*	-.11	-.02	.27**	-.19	-.04	.15	.32**	.31**				
26. GOV.CAP	0.03	0.17	.20*	.19*	.23**	-.16	.19*	.20*	.22**	.22*	.32**	.23**	.19*	.22*	.31**	.12	-.17*	.24**	-.06	-.08	.34**	-.05	-.07	.02	.19*	.19*	.39**			
27. GOV.HCD	0.39	0.49	.60**	.74**	.64**	-.71**	.38**	.59**	.61**	.72**	.31**	.71**	.31**	1.00**	.12	.36**	-.34**	.31**	-.21*	-.01	.45**	-.25	-.02	.48**	.40**	.84**	.36**	.22*		
28. MKT.NAT	0.77	0.42	.06	.15	.08	-.12	.05	.04	.14	.11	.16	.19*	.00	.11	-.02	.16	-.02	.12	-.12	.02	.06	-.15	.13	.09	.00	.14	.12	.09	.11	
29. MKT.EXP	0.47	0.50	.19*	.21*	.19*	-.22*	.23**	.16	.22**	.21*	.24**	.19*	.19*	.15	.08	.06	-.22**	.08	-.16	.06	.21*	.08	.06	.13	-.02	.19*	-.01	.01	.15	-.18*

Notes: *M* and *SD* are used to represent the mean and standard deviation, respectively.
The symbol * indicates $p < .05$. ** indicates $p < .01$.

Appendix D: Developed IVC

