Innovation and access to finance in African enterprises

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Declaration

By submitting this thesis I, Mccpowell Sali Fombang, declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

M.S. Fombang March 2017

Dedication

With great gratitude to the Almighty God, I dedicate this work to my parents, my siblings, and family.

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Abstract

Innovation enhances enterprise productivity, and contributes to economic growth (Radas and Bozic, 2009: 438). African firms are lagging behind the rest of the world in terms of innovation (Global Innovation Index, 2015; African Development Bank, 2008). Insufficient capacity to innovate is one of the problems facing African businesses (African Competitive Report, 2013). Moreover, a critical challenge faced by firms in Africa is access to finance and the inability of financially constrained firms to grow (Berger and Udell, 2006; Beck and Demirgüç-Kunt, 2006). Furthermore, studies have examined the role of technology at macro level, but little is known at firm level, and at the same time the few existing studies are skewed towards often publicly traded firms in developed economies (Caineilli, Evangelista and Savona, 2006; Baumol, 2002). With access to firm-level data from emerging African economies provided by the World Bank, this study sought to close that gap and examined whether there was a link between finance and innovation. It further assessed whether the link between finance and innovation was biased towards product innovation or process innovation. This thesis is a collection of essays structured around four topics. Essay one is on access to finance and firm innovation, the second is on the role of finance in product and process innovation in African enterprises, the third essay is on innovation patterns in African enterprises while the fourth essay reviews literature on innovation and finance. Chapter 6 provides a summary and conclusion.

We used firm-level data from the World Bank Enterprise Survey (WBES) for selected countries. We first constructed innovation indices using the multiple correspondent analysis (MCA). We applied instrumental variable techniques to cater for possible endogeneity and selection bias to ensure consistent and robust results.

Findings show that access to finance as depicted through trade credit, asset finance and overdraft facilities enhances aggregate innovation in all five regionally selected countries – South Africa, Kenya, Nigeria, Cameroon and Morocco. Also, asset finance enhances process innovation in South Africa and both product and process innovation in Cameroon, Ghana and Kenya. Overdraft is significantly linked to both product and process innovations in all five countries.

Additional results show that Rwandan enterprises lead in product innovation while Kenya leads in process innovation and aggregate innovation. At the regional level, North Africa leads the continent in process innovation and aggregate innovation while West Africa champions product innovation.

These findings have policy implications for African enterprises and emerging economies. This thesis calls for relevant policies to enhance financial sector development, especially the banking sector, and increased access to finance for enterprises. Furthermore, different financial institutions such as

microfinance institutions that have demonstrated that they have extended credits to more enterprises should be supported to increase credit to enterprises and young entrepreneurs.

Key words:

Innovation, access to finance, enterprises, instrumental variables, multiple correspondence analysis

Table of contents

List of tables

List of figures

List of Appendices

List of acronyms and abbreviations

2SLS	Two stage Least Square
AfDB	African Development Bank
AU	African Union
DRC	Democratic Republic of Congo
GCI	Global Competitive Index
GERD	Gross Expenditure on Research and Development
GII	Global Innovation Index
ICT	Information Communication Technology
IFPRI	International Food Policy Research Institute
IPO	Initial Public Offer
IV	Instrumental Variable
MCA	Multiple Correspondent Analysis
NEPAD	New Partnership for Africa's Development
OECD	Organisation for Economic Cooperation and Development
PCA	Principal Correspondent Analysis
PhD	Doctor of Philosophy
STI	Science Technology and Information
UN	United Nations
USB	University of Stellenbosch Business School
VC	Venture Capital
WBE	World Bank Enterprise
WBES	World Bank Enterprise Survey
WWW	World-wide web or internet

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

According to Schumpeter (1942), innovation is the production of a new product, change in the industrial organization, change in the methods of production and transportation, opening up of a new market. Innovation is an important channel through which firms and enterprises enhance their productivity (Radas and Bozic (2009: 438), which contribute to economic growth and development. However, in this study innovation has been broadly defined to include core innovative activities, such as the introduction of new products and new technologies; but it also includes the imitation of technology, products, and activities that promote networks and knowledge transfers, such as foreign technology license, joint ventures with foreign partners, international quality certification and other actions that impact on the organization of the firm's business activities (Bloch, 2007). Innovation enhances productivity and competitiveness which is essential to spur growth and development. Innovation is also important on a number of levels. It is important for nations and regions for economic growth and development (Mobbs, 2010). Firms that are innovative can survive adverse changes in operating circumstances, reposition their organisation and raise its market profile. They can also open up to new horizons and attract extra funding to raise margins and profitability. These profits can be invested into technological innovation that boosts productivity and contributes to economic growth and development. They stay competitive which is necessary for growth and development while at the same time enjoying profits from improved sales (Mytelta, 1999). Enterprise innovation hinges on a number of factors such as firm size, age, market structure, trade share, research and development intensity and profitability (Bhattacharya and Bloch, 2004). The huge cost involved in innovation made it to be seen as a prerogative of large firms since they were more mature and supposedly had the financial muscle to engage in innovative activities (Schumpeter, 1934).

African firms are mostly small and medium in size without adequate capital to engage in innovation, yet technological advancement and innovation remain key to the continent's economic growth and development (African Union, 2015). Africa needs technology (innovation), and a critical mass of skilled personnel to serve as a catalyst for the economic revival and development of the continent, according to the African Development Bank (2008: 29) while the Forum for Agricultural Research in Africa (FARA) (2012: 7) noted that for African agriculture and agribusinesses to increase productivity they need to innovate. Agribusiness constitutes the major part of most African economies yet over the last 40 years it has declined for a number of reasons, including lack of access to finance and innovation (IFPRI, 2010).

Furthermore, many African enterprises lag behind in innovation compared to their counterparts globally as shown by the drop in the ranking of African countries on the Global Innovation Index. According to the Global Innovation Index (2013) Burundi, Uganda, Morocco and Lesotho dropped 2, 6, 7 and 14 places respectively in ranking between 2012 and 2013. Can access to finance be the panacea needed by African enterprises to improve innovation? Access to finance can be the catalyst needed by African firms to boost innovation. However, Beck and Demirgüç-Kunt (2006) pointed out that access to finance is a huge constraint faced by African firms while Demirgüç-Kunt and Klapper (2012); African Development Bank (2011: 82); and Oyelaran-Oyeyinka, Laditan and Esubiyi (1996) noted that the ability of African firms to innovate is severely constrained by the lack of access to finance. There is a keen and exciting interest to examine the relationship between finance and innovation in African enterprises. Finance is related to economic growth via innovation (King and Levine, 1993a). However, literature has shown that financially constrained firms find it difficult to innovate (Gorodnichenko and Schnitzer, 2013; Acs and Audretsch, 1990). Increased sales and profitability provide enterprises with finance and can greatly influence subsequent innovative activities in industries within a low-technological environment rather than in industries with high-technological environment (Audretsch, 1995: 581). Firms without access to finance are severely constrained in their ability to expand and are hardly able to engage in the innovative pathway (Planes*a,* Bardosa, Sevestreb and Avouyi-Dovib, 2001; Oyelaran-Oyeyinka et al., 1996; Beck and Demirgüç-Kunt, 2012).

These studies and a few others that have studied the relationship between finance and innovation, are skewed toward developed economies (Weis and Moorman, 2015; Goldman and Peress, 2015; Lerner, Sorensen and Strömberg, 2011). This provide a gap in developing economies of Africa that needs to be filled. Furthermore, a number of studies on corporate innovation in Africa (Adeboye, 1997; Adams, 1999; Mahemba and De Bruijn, 2003; Robson and Obeng, 2009) concentrate on growth, manufacturing, network, performance, models of innovation and entrepreneurship. These studies hardly examine the relationship between finance and innovation, resulting in another knowledge gap that this study will attempt to address.

Innovation has been defined to include product and process (Schumpeter, 1942). This is very important as product and process innovation do contribute to productivity and competitiveness but do not impact on growth and development exactly the same way. Equally important but less examined is whether the link between finance and product innovation is different from that between finance and process innovation. The lack of knowledge on these processes of innovation limits our understanding on the ways innovation affects productivity and competitiveness of firms that have direct impact on growth and productivity.

1.2 AN OVERVIEW OF INNOVATION TRENDS IN AFRICA

The New Partnership for Africa's Development (NEPAD) Ministerial Forum on Science and Technology notes that innovation is critical for enterprises and the economic development of the continent (AfDB, 2008: 49). Innovation increases value, enables diversification and improves competition, particularly in emerging economies; more importantly, public expenditures on R&D have significant impacts on productivity and competitiveness (OECD, 2013: 15). Agribusiness constitutes the major part of most African economies yet has declined over the past four decades for several reasons, including lack of access to finance and innovation (IFPRI, 2010).

There has been a recent upsurge in innovative new technology in Africa, especially regarding the use of mobile phone technology and information technology over the past three decades. The impact of the development and adoption of new technological innovations in Africa can be felt in almost every sector of African economies. In finance, the use of mobile phones and credit cards for payments and transfers as well as the adoption of internet technology and Automated Teller Machines in banking has improved the velocity of money in the economy, thus facilitating the development of the financial sector on the continent. For instance, innovation in the use of mobile money technology such as M-Pesa in Kenya, Eco-cash in Zimbabwe and other similar digital payment platforms in Tanzania have facilitated the rapid expansion of access to financial services for the previously unbanked (Jack and Suri, 2011). In agriculture, African farmers are increasingly using innovation to boost agricultural productivity and earn higher incomes. For instance, in rural Niger, a system of agricultural price information has been developed to enable farmers to obtain information about the market price by using mobile phones, thereby reducing market search costs by 50 percent (Aker and Mbiti, 2010). Similarly, innovations in areas of warehouse receipt financing systems in Tanzania, Zambia, Malawi, and Uganda have been developed to collateralise agricultural produce such as grains to enable often-poor rural farmers to have increased access to credit (Coulter, Jonathan and Onumah, 2002). In healthcare innovations, pregnant women now receive antenatal and postnatal healthcare advice via their mobile phones in Tanzania and South Africa, thereby reducing the incidence of infant and maternal mortality (Noordam *et al*., 2011).

However, African economies are still struggling to improve on the innovation input sub-index that is comprised of five pillars and this has a direct impact on the enterprises. These innovation in-put pillars are institutions, human capital and research, infrastructure, market sophistication, and business sophistication, Global Innovation Index (Dutta *et al*., 2015).

Innovation and access to finance remain important in the entire process of enterprise production, with access to finance being critical, according to the African Competitiveness Report (Blanke et al., 2013: 20). Tables 1.1 and 1.2 show how Africa's top 30 countries and last ten nations (according to the Global

Innovation Index) rank far behind in the Global Innovation Index, Global Competitive Index, ease of getting credit, domestic credit to private sector, gross expenditure on research and development, among other factors that enhance innovation and finance.

Table 1.1: Global Competitiveness Index (GCI)

No	country	GCI rank 2013	GCI rank 2012	Change in rank 2013-–2012	GCI rank 2010	GCI rank 2009	Change in rank 2010–2009	Intensity of local competition
1	Mauritius	45	54	9	55	57	2	42
2	South Africa	53	52	-1	54	45	-9	51
3	Rwanda	66	63	-3	80	n/a	n/a	95
4	Botswana	74	79	5	76	66	-10	74
5	Morocco	77	70	-7	75	73	-2	57
6	Tunisia	83	n/a		32	40	8	38
7	Namibia	90	92	2	74	74	0	88
8	Zambia	93	102	9	115	112	-3	61
9	Kenya	96	108	12	106	98	-8	63
10	Algeria	100	110	10	86	83	-3	136
11	Libya	108	113	5	100	88	-12	
12	Gabon	112	99	n/a	n/a	n/a	n/a	128
13	Senegal	113	117		104	92	-12	52
14	Ghana	114	103	-11	114	114	0	53
15	Cameroon	115	112	–3	111	111	0	94
16	Gambia	116	98		90	81	-9	81
17	Egypt	118	107	-11	81	70	-11	118
18	Nigeria	120	115	-5	127	99	-28	89
19	Cape Verde	122	122	0	117	n/a	n/a	119
20	Lesotho	123	137	-14	128	107	-21	115
21	Swaziland	124	135		126	n/a	n/a	109
22	Tanzania	125	120	-5	113	100	-13	107
23	Cote D'Ivoire	126	131		129	116	-13	77
24	Ethiopia	127	121	-6	119	118	-1	133
25	Liberia	128	111	n/a	n/a	n/a	n/a	n/a
26	Uganda	129	123	-6	118	108	-10	76
27	Benin	130	119		103	103	0	90

No	country	GCI rank 2013	GCI rank 2012	Change in rank 2013–— 2012	GCI rank 2010	GCI rank 2009	Change in rank 2010–2009	Intensity of local competition
28	Zimbabwe	131	132					91
29	Madagascar	132	130	-2	124	121	-3	97
30	Mali	135	128		132	130	-2	108
	Bottom 13							
X1	Malawi	136	129		125	119	-6	122
X2	Mozambique	137	138	1	131	129	-2	129
X3	Burkina Faso	140	133	–7	134	128	-6	102
X4	Mauritania	141	134	-7	135	127	-8	n/a
X5	Angola	142	n/a	n/a	138	n/a	n/a	135
X6	Sierra Leone	144	143	-1	n/a	n/a	n/a	n/a
X7	Burundi	146	144	-2	137	133	-4	n/a
X8	Guinea	147	141					113
X9	Chad	148	139		139	131	-8	n/a

Source: World Economic Forum, Global Competitiveness Index (2013)

Innovation also drives productivity. As innovation improves, productivity is likely to improve. According to the Africa Competitiveness Report (Blanke *et al*., 2013: 5) the productivity of sub-Saharan African countries is relatively low compared to other regions of the world and has been dropping since the 1960s. This is reflective of Africa's Global Innovation Index and global competitive index ranking vis-a-vis the rest of the world. From Table 1.1 many countries have dropped from their previous positions in the global competitive index ranking while some in the bottom nine nations have dropped even further between 2009 and 2013. For example, Burundi dropped two places back, Nigeria and Tanzania dropped five places down, Mauritania and Burkina Faso retrograde seven places down while Lesotho regressed by 14 places, global competitive index (2013). Africa nations are ranked far behind regarding gross expenditure on R&D, ease of getting credit and access to finance as shown Table 1.2 (GII, 2013). In addition, most African countries have dropped in ranking on the Global Innovation Index, for example, Botswana having dropped from position 85 to 91, Swaziland from 82 to 104, Cameroon from 121 to 125, Mozambique from 110 to 121, Zimbabwe from 115 to 132, Algeria from 124 to 138, Namibia from 73 to 109 and Madagascar from 126 to 140, as per the Global Innovation Index (GII) (2013).

Table 1.2: Innovation and access to credit in African countries

No	country	GII 2013 rank	GII 2012 rank	difference 2013-2012	Ease of getting credit 2012 ranking	Domestic credit to private sector rank	Gross expenditure on R&D rank	GERD financed by business enterprise rank	ICT access rank
1	Mauritius	53	49	-4	51	37	68	n/a	n/a
2	South Africa	58	54	-4	1	16	36	38	86
3	Tunisia	70	59	-11	93	42	34	64	83
4	Uganda	89	117	28	38	124	67	73	123
5	Botswana	91	85	-6	51	109	57	n/a	93
6	Morocco	92	88	-4	93	48	48	61	71
7	Ghana	94	92	-2	22	130	77	19	120
8	Senegal	96	97	1	110	100	69	74	114
9	Kenya	99	96	-3	12	86	66	66	116
10	Cape Verde	103	n/a	n/a	93	51	n/a	n/a	103
11	Swaziland	104	82	-22		103	n/a	n/a	110
12	Mali	106	119	13	110	117	74	70	118
13	Egypt	108	103	-5	80	97	82	n/a	74
14	Namibia	109	73	-36	n/a	n/a	n/a	n/a	n/a
15	Gabon	111	106	-5	93	139	47	53	97
16	Rwanda	112	102	-10	22	137	n/a	n/a	124
17	Burkina Faso	116	122	6	110	120	84	68	130
18	Zambia	118	107	-11	12	135	70	78	132
19	Malawi	119	120	1	110	119	n/a	n/a	136
20	Nigeria	120	123	3	22	116	80	86	127
21	Mozambique	121	110	-11	110	110	83	n/a	134
20	Gambia	122	130	8	132	128	108	n/a	111
23	Tanzania	123	128	5	110	126	63	n/a	129
24	Lesotho	124	116	-8	129	129	106	76	n/a
25	Cameroon	125	121	-4	93	132	n/a	n/a	131
26	Guinea	126	n/a	n/a	129	140	n/a	n/a	133
27	Benin	127	125	-2	110	108	n/a	n/a	115
28	Ethiopia	129	131	2	93	125	75	69	135
29	Niger	131	140	9	110	134	n/a	n/a	137
30	Zimbabwe	132	115	-14	110	76	n/a	n/a	117
Bottom 10									
1	Angola	135	135	0	110	115	n/a	n/a	128
2	Cote D'Ivoire	136	134	-2	110	122	n/a	n/a	106
3	Algeria	138	124	-14	110	133	100	n/a	n/a

No	country	GII 2013 rank	GII 2012 rank	difference 2013-2012	Ease of getting credit 2012 ranking	Domestic credit to private sector rank	Gross expenditure on R&D rank	GERD financed by business enterprise rank	ICT access rank
4	Togo	139	136	-3	110	99	n/a	n/a	119
5	Madagascar	140	126	-14	141	138	92	n/a	125
6	Sudan	141	141	0	135	136	n/a	n/a	n/a

Source: Global Innovation Index 2013.
GII = Global Innovation Index. GERD = gross expenditure on research and development.
ICT = Information and Communication Technology, Ranked out of 144 Economies/Countries

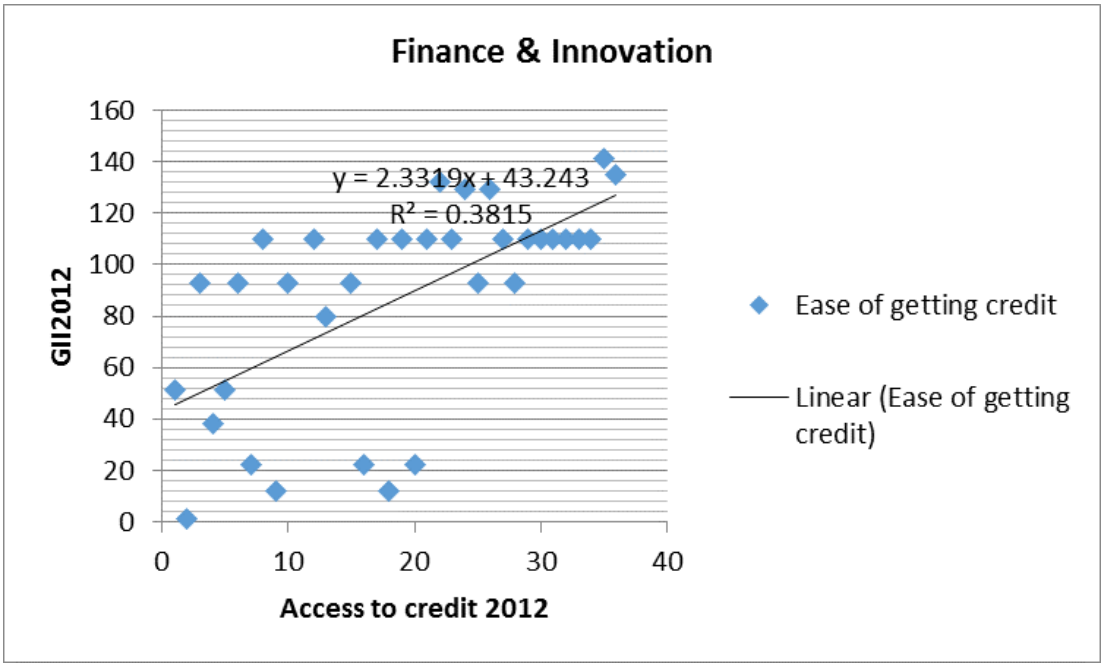

Figure 1.1: Finance and Innovation in Africa

Source: Author's compilation based on the Global Innovation Index, 2013.

African countries are lagging behind in innovation when compared to other regions (Table 1.2). Six African countries are among the bottom ten in the 2013 Global Innovation Index ranking. From column five (which gives the change in ranking between 2013 and 2012), it is evident that while nations in other regions are making some progress, most African countries are retrogressing. For example, Namibia, Swaziland, Zimbabwe, Madagascar, Tunisia, Mozambique and Zambia moved down by 36, 22, 14 and 11 positions respectively. On the other hand, countries such as Argentina, Indonesia, Uruguay and Mexico have moved up 14, 15 and 16th position up from the 2012 Global Innovation Index (GII, 2013).

Access to finance is a major constraint in Africa (Global Innovation Index GII, 2014). From Table 1.2 above, it is evident that access to credit is very low and problematic among African nations relative to their counterparts in other regions. This has a direct effect on innovation in the African continent. An important observation from the table is that there appears to be a correlation between access to finance and innovation. Indeed Figure 1.1 shows a positive slope between rankings of finance and innovation in selected African countries, implying that finance may be driving innovation. However, the wide difference in ranking between gross expenditure on research and development (R&D), ease of getting credit and domestic credit to private sector among many of the countries ignite the interest for this study to investigate whether access to finance drives innovation.

1.3 PROBLEM STATEMENT AND MOTIVATION

Innovation is important for a firm's survival, and growth. It enhances productivity and competitiveness that are important for growth and development in this ever-challenging world. Innovation has been identified as key to Africa's economics growth and development (AfDB, 2008) However, African enterprises are lagging behind the rest of the globe in innovation with six out of the bottom ten less innovative countries coming from Africa, Global Innovation Index (GII, 2013). A critical challenge faced by African firms is constrained access to finance (Beck and Demirgüç-Kunt, 2006). According to the Global Innovation Index (2013; 2015) one of the major problems faced by African firms is access to finance. Evidence shows that local banking development affects the probability of process innovation particularly for firms in high-tech sectors, in sectors more dependent upon external finance, and for firms that are small (Benfratello et al. (2008). However, a debt contract might not be suited to finance an activity such as innovation that has uncertain returns (Atanassov et al. 2007; Stiglitz 1985) while raising capital from pubic markets to fund innovation can be costly to the manager because of low tolerance for failure in the public markets (Ferreira et al. 2011). Empirical findings on studies have been mixed. For example, Ayyagari et al. (2011), Nanda and Nicholas (2011) find a positive relationship between finance and innovation whereas Fang et al. (2014), Cornaggia et al. (2012) show a negative relationship.

Furthermore, empirical literature that establishes the link between finance and innovation is limited and skewed towards developed economies (Goldman and Peres, 2015; Chemmanur and Fulghier, 2014; Baumol, 2002; Guidici and Paleri, 2000). In terms of Africa, little is known about this relationship. Hence, there is a need for empirical investigation into the impact of finance on innovation. This is especially so for developing countries like those in Africa where firm innovation lags behind the global trend and access to finance remains a major challenge to firm productivity and growth (Himmelberg and Petersen, 1994; Adams, 1994; Hadjimanolis, 2000). Other equally important and less explored are the link between finance and innovation, and the type of innovation – product and process (Schumpeter, 1942).

Does the financing option for firm innovation matter? The nature of the financing structure has different cost, impact and implications on company innovation. It is widely accepted that a firm's innovation is enhanced through access to external finance. However, the type of financing may affect innovation differently and thus could have a different impact on enterprise profitability and thus innovation. For instance, new equity finance appears to be very important to the innovation process and rapid growth of young high-technology firms (Carpenter and Petersen, 2002). On the other hand, stock markets can be an important source of (debt and equity) finance for enterprises that engage in growth models focusing on innovation and facing financing constraints (Brown, Fazzari & Petersen, 2009).
There are different types of innovation including product innovation and process innovation (Schumpeter, 1942). Literature shows that innovation is associated with debt and equity finance (Casson, 2008:208; Wang and Thornhill, 2010: 1148). Rarely is there a study that examines the link between finance and a specific type of innovation. This research (Chapter 4) examines whether the link between finance is biased towards one of the two innovation types; and whether access to finance enhances more product innovation or process innovation.

Empirical studies have examined the role of technology at macro level, whereas little is known at corporate level and even that little is skewed towards often publicly traded firms in developed economies (Caineilli *et al*., 2006; Baumol, 2002). The AU Agenda 2063 recognizes science, technology and innovation (STI) as enablers for achieving continental development goals. The Agenda also emphasizes that Africa's sustainable growth, competitiveness and economic transformation requires sustained investment in new technologies and continuous innovation especially in areas of agriculture, clean energy, education and health (African Union Commission, 2015). This poses a huge concern for development on the continent as Africa is lagging behind in terms of technological innovation (African Development Bank, 2008). Against this backdrop, there is a need to investigate the types of innovation taking place within African firms and to attempt to map out an innovation pattern for the continent, which this thesis seeks to address in one of its chapters.

In summary, the motivation for this study hinges on the fact that African enterprises are lagging behind the rest of the globe in terms of innovation (GII, 2015; AfDB, 2008) in spite of the importance of innovation. Also, access to finance is a major constraint among African firms (Beck, Demirgüç-Kunt, and Maksimovic, 2005). Furthermore, empirical literature on the link between innovation and finance is limited and even this limited literature is skewed towards large enterprises in the West.

In addition, existing empirical works have mixed findings (Tian and Xu, 2014). Are certain types of innovation more noticeable in enterprises based in specific countries and in a particular region? Equally important is the fact that to date no study has examined the finance-innovation link in Africa; making these case scenarios worth researching. Innovation is classified into product innovation and process

innovation (Schumpeter, 1942). A scarcely examined subject is whether the finance-innovation link is determined by the type of innovation (product or process); igniting yet again the need to conduct this research. The deficiency in know-how on innovation types and processes on the continent limits our understanding in the ways innovation affect productivity and competitiveness of firms which are necessary for growth and development. Given the rich firm level survey data supplied by the World Bank enterprise survey database, the last chapter (Chapter 5) of this thesis aims to close this knowledge gap by examining whether there is an innovation pattern in African firms.

1.4 RESEARCH QUESTIONS

This study examines the link between finance and innovation and consists of a collection of four standalone essays structured around the objectives of the thesis. These objectives are as follows:

1. To have an in-depth appraisal of the literature on innovation and finance.
2. To examine the link between access to finance and firm innovation.
3. To determine whether the nature and type of innovation (product or process) is important in ascertaining the link between finance and innovation.
4. To analyse the pattern of firm innovation in African countries.

1.5 RESEARCH QUESTIONS

Following the objectives, the following research questions arise:

1. What does literature tell us about innovation and finance?
2. Is there a link between finance and firm innovation in African enterprises?
3. Is the link between finance and innovation biased towards product or process innovation?
4. Do we have an innovation pattern in Africa?

1.6 AN OVERVIEW OF THE METHODOLOGY

This study made use of secondary data sourced predominantly from the World Bank Enterprise Survey (WBES) 2015 with information on innovation and sources of finance from sampled enterprises across African countries. The surveys sample from the universe of registered businesses in each country and follow a stratified random sampling methodology. The core survey uses standardized survey instruments to benchmark the investment climate of individual economies across the world and to analyse firm performance. This dataset from WBES has information on innovation selected from both manufacturing and service enterprises from 17 countries, for the period 2002 to 2015. These countries have been carefully chosen to represent each of the regional blocks in Africa. The selection of countries was influenced mainly by data availability and regional balance. The chosen countries come from all

five regions of the continent, namely East Africa, North Africa, West Africa, Southern Africa and Central Africa. In this study, 13,421 firms from seventeen countries representing the five regions of the continent were selected as presented in Chapters 3 to 5. This section also outlines the methodologies employed in the entire thesis. The author construct innovation indices and make use of these in Chapters 3, 4 and 5.

For Chapters 3 and 4, the researcher's choice of econometric technique was guided by data availability. Given the absence of consistent panel data for countries, the analysis was based on cross sectional data. We used multiple correspondent analysis (MCA) to construct innovation indices for product, process, and overall innovation index which we tagged as 'aggregate innovation index'. The indices were used for the regressions analysis. To cater for possible endogeneity and selection problems, we utilised IV techniques.

1.6.1 Construction of innovation index

The author computed product and process innovation as well as aggregate innovation indices using the OSLO (2005) definition. In computing the innovation index, we adopt the multiple correspondent analysis (MCA) and follow Booysen, Servaas, Ronelle, Micheal and Gideon (2008), Asselin (2002), Sahn and Stifel (2000), Van Kerm (1998) and Benzecri (1973) to create innovation indices from a selection of variables from the WBE survey. To ensure comparability across countries, only innovative variables that appear in the same section across the questionnaire and were phrased exactly the same were used in the analysis. Appendix 1 lists the variables, with the categories and weight for each variable. The construction of the innovation indices was based on six categorical variables as shown in Table 1.3.

Table 1.3: Variables used in computing the innovation index

No	Variable
1	Introduction of a new or significantly improved product within three years to survey
2	Enterprise owns a website
3	Firm uses email to communicate with clients
4	International quality certification
5	Foreign technology license
6	Audited financial statements by an independent auditor

Source: World Bank Enterprise Survey database, 2016.

In the literature, principal components or factor analysis (PCA) is most widely used for the construction of indices. However, PCA was fundamentally designed for continuous variables as it assumes a normal distribution of indicator variables. In contrast, multiple correspondence analysis (MCA) is more suited to

discrete or categorical variables. Therefore, we opted to employ MCA rather than PCA in constructing the innovation index employed in our analysis of firm level innovation. Moreover, the MCA assigns weight according to the significance of the variables in the innovation index. In accordance with Asselin (2002), Van Kerm (1998) and Benzecri (1973), the MCA innovation index is given generally as:

$$\boldsymbol{a_i} = \sum_{\boldsymbol{k=1}}^{\boldsymbol{k}} \boldsymbol{F_{1k}\, d_{ki}}$$

The i[th] firm innovation index is α_i, d_{ki} is the kth value of the categorical variables (with k=1…K) indicating the firm's innovation variables included in the index construction. F_{1k} is the MCA weights generated for the analysis.

The extended form of the innovation index in this paper is given as

$INNOV_i = P_{i1}W_1 + P_{i2}W_2 + \ldots P_{ij}Wj$ ……..1

Where $INNOV_i$ is the innovation composite index of firm *i,* the response of firm I to category/innovation *j* is represented by P*ij*, and W*j* is the MCA weight for dimension one applied to category *j* (Booysen *et al*., 2008).

The following equation was used to calculate a composite innovation index score, for each unit.

$^{MCA}P_i = R_{i1}W_1 + R_{i2}W_2 + \ldots + R_{ij}W_j + \ldots + R_{iJ}W_J$ 2

Where $^{MCA}P_i$ is the i[th] firm's composite innovation indicator score, R_{i1} is the response of firm i to category j, and W_J is the MCA weight for dimension one applied to category j. The MCA command in STATA 13 was used to calculate these weights (Statacorp, 2013; Van Kerm, 1998). This command estimates an adjusted simple correspondence analysis on the Burt matrix constructed with the selected variables, in this case those noted on tables in various sections (Booysen *et al*., 2008). Given that a simple correspondence analysis applied to this matrix usually results in maps of apparently poor quality, the MCA adjusts the obtained principal inertias (eigenvalues) following a method proposed by Benzecri. According to Van Kerm (1998: 214), the reported inertia explained by the first dimension is relatively high as a result of the fitting of the diagonal sub-matrices. The constructed innovation indices have been used in the essays in chapters 3 to 5.

1.6.2 Empirical strategy

To examine the role of finance in innovation, the following model was estimated:

$$I_{Innovation} = \beta_1 + \beta_2 Fin + \beta_3 X + \mu_t \quad \ldots (3)$$

Where:

$I_{Innovation}$ = *Innovation index*

Fin, represents our finance variables.

X, represents the control variables

μ_t, represents the error term

1.6.2.1 Estimation technique

To control for the likelihood of endogeneity bias between finance and innovation, this study used an Instrumental Variable (IV) model. The IV model requires an observed variable that is (i) strongly correlated with access to finance; but (ii) uncorrelated with the error term. The key assumptions of the IV model according to (Khandker, 2010) are summarized as:

Correlated with innovation index: *cov* (Z, *finance*) ≠ 0

Uncorrelated with the error term (ε): *cov* (Z,ε) = 0

Where Z is the chosen instrument.

The instrument (Z) in the first stage of the regression will have to be correlated with the finance (explanatory) variable but uncorrelated with the error term. However, in the second stage of the regression, this instrumental variable should correlate with the innovation index (dependent variable).

In the first stage regression there is an ordinary least square regression (OLS) model, with the selected instruments, Z_i, as additional independent variables. Following Janzen and Carter (2013) and Khandker *et al*. (2010) our first stage regression is given as:

$finance_i = yZ_i + \emptyset X_i + \mu_i$ … (4)

Where access to finance can be obtained from trade credit, overdraft, and asset finance, Z_i is the selected instrument, xi is a vector of covariates which affect a firm's access to finance decision and μ_i is the error term.

At the second stage, the predicted demand of access to finance ($\widehat{finance_i}$) is substituted in Eqn. (1) to obtain the outcome equation.

$I_{Innovation} = \propto X_i + \beta finance_i + \varepsilon_i$ … (5)

$I_{Innovation} = \propto X_i + \beta(\gamma Z_i + \widehat{\emptyset} X_i + \mu_i) + \varepsilon_i$ …(6)

Where $\gamma Z_i + \widehat{\emptyset} X_i + \mu_i$ is the prediction of having access to finance. Under instrumental variable the impact of finance on process innovation is $\hat{\beta}_{iv}$.

From equation 3, X is a vector of control variables and includes: age of firm, measured as age in years; size of firm captured as a categorical variable with '1' for a small enterprise employing between 5 and 19 persons, '2' for medium enterprises having between 20 and 99 employees, and '3' for large enterprises employing 100 persons and more. Top manager's experience is measured in terms of the number of years of work experience of the most senior management officer; export orientation is captured as '1' if the firm is involved in the export market or '0' otherwise. The regression also controlled for location, industry, and market participation (whether a firm participates in the main market for its product or not).

Some possible instruments were chosen and went through the first stage of the regression. These instruments differ from country to country and range from a host of factors such as guarantees and collaterals, including fixed assets, having a cheque or savings account, application for a loan/line of credit, status of enterprise, establishment paid for security, type of financial institution, audited financial statement, status of the enterprise, securing a government contract and operating license, to total cost of finished goods/materials bought for resale in the fiscal year prior to the survey.

Each of these instruments must be correlated with the explanatory variable but not with the error term. To test for the validity of these instruments, two tests were carried out: the first was the Stock and Yogo (2005) test, and Cragg and Donald (1993) tests. These tests helped to ascertain the strength of the instrument(s). The Cragg-Donald F-statistic was computed and this value was compared with the Stock and Yogo critical value. There are two options here, to choose the maximum test criterion or the maximum relative bias. The instruments are strong when the Cragg-Donald F-statistic is higher than the Stock and Yogo critical value, following the option chosen. This study however, made use of both options given that the regressions are independent and country specific. The second test is the Sargan and Basmann test of overidentifying restriction. This empirical strategy has been applied in Chapters 3 and 4.

1.7 SCOPE AND LIMITATION OF THE STUDY

The major limitation of this work is associated with the data. The World Bank Enterprise Survey (WBES) is available from 2002 to 2015. However, the survey was conducted at different periods for selected countries. Some of the countries only had data collected for a year, hence limiting the range of techniques that could be used. The study focused on African enterprises but data availability has reduced the sample sizes to firms in a few countries that have full data. However, these limitations do not affect the robustness of the current study.

1.8 STRUCTURE OF THE THESIS

This thesis consists of four essays. The first essay in Chapter 2 reviews literature on innovation and finance. The second essay in Chapter 3 is access to finance and firm innovation. The third essay (Chapter 4) is on the role of finance in product and process innovation in African enterprises. The fourth essay (Chapter 5) is on innovation patterns in African enterprises, while Chapter 6 provides a summary and conclusion.

CHAPTER 2
AN OVERVIEW OF LITERATURE ON FINANCE AND INNOVATION LINK

2.1 INTRODUCTION

Firm innovation and expansion are key drivers for economic development (African Development Bank, 2008). It has been shown that countries that are more innovative are more developed in comparison to those that are less innovative (Global Innovation Index, 2015). Innovation is more critical than ever for enterprises that want to stay competitive in this constantly demanding business environment (Al-Hakim, 2013). Innovation has been identified as a channel through which firms increase productivity (Radas and Bozic, 2009:438). Earlier studies have examined innovation and factors affecting technological development in developing countries (Crane, 1977; Garcia and Calatone, 2002). Most developing economies and African economies in particular are lagging behind the rest of the World in innovation (GII 2009-2015). For this to be reversed countries have to invest in innovative practices (African Union Commission, 2015). Achieving this requires access to finances that is a major problem for small and medium size firms (Beck and Demirgüç-Kunt, 2006). In spite of this, not much is known about the relationship between innovation and finance, a deficiency that this study examines.

Innovation is commonly classified into product and process innovation, which falls in line with the classification of innovation by Schumpeter (1942). Product innovation is the creation or introduction of goods or a service that is new or an improved version of its previous form. Process innovation entails the introduction of a new or significantly improved production or delivery method. This includes significant changes in equipment, techniques and software (OECD, 2011). Innovation is therefore the introduction of brand new products, new technology or process such as imitation of technology, activities that promote networks and knowledge transfers, and actions that enhance the enterprise's business activities (Bloch, 2007).

Innovation is important because it is a sure way to satisfy customers' needs (Balasubramanian, 2013). The world is also increasingly competitive and customer appetite for the best quality of goods or service is high. Thus, for firms to survive in a globally competitive world they have to stay innovative. A number of studies have been conducted (Chatterjee, 2014; Castellani and Zanfei, 2007; Wakelin, 1998; Greenhalgh, Taylor & Wilson., 1994) on export and internationalisation, (Breschi and Malerba, 2006; Adeboye, 1997; Senker, 1995; Mahajan, Muller & Srivastava, 1990) on models and systems of innovation, (Wong et al, 2005; Bilbao-Osorio, 2004; Duesenberry, 1956) on economic growth and development, (Chudnovsky, Lopez & Pupato., 2006; Griffith, Huergo & Mairesse, 2006; Parisia, 2006;

Kremp,and Mairesse, 2003.; Brynjolfsson and Yang, 1996; Geroski, 1989) on manufacturing and productivity, (Niosi, 2010; Vrande, Vanhaverbeke & Gassman. 2010; Schilling and Phelps, 2007; Chipika and Wilson, 2006; Autio, 1997) on issues related to Institutions, research and networking with (Ayyagari *et al*., 2011; Brown *et al*., 2009; King, 1993; Timmons and Bygrave, 1986) on innovation with a focus on finance.

In this paper, innovation literature is examined with the emphasis on firm innovation and its link to finance. This is done by examining the channels through which finance influences innovation such as: the stock market effect on firm level innovation, the impact of capital structure, and financial development on firm innovation. The rest of the paper is structured as follows: 2.2 Theoretical literature and 2.3 Empirical literature with 2.3.1 on innovation and finance, 2.3.2 on capital structure and innovation and 2.3.3 discusses financial development and innovation.

2.2 LITERATURE REVIEW

2.2.1 Theoretical literature

The literature on innovation goes as far back as the early 20th century (Schumpeter, 1911). He recognised that economic development is driven by innovation, which is at the centre of economic change brought about by “creative destruction”, (Schumpeter, 1942). A well-functioning financial system is necessary for enhancing economic and technological progress (Schumpeter 1911). Schumpeter (1934) further recognised that the innovative outcome of an economy is interconnected with the functioning of its credit and capital markets. This has been discussed more recently by King and Levine (1993a) who confirm that finance is related to economic growth via innovation. Financial intermediaries channel savings to investment and the productivity of this investment is increased by allocating funds to the most qualified firms (Greenwood and Jovanovic 1990; King and Levine 1993b). This simply points to the fact that better financial systems improve the probability of successful innovation and thereby accelerate economic growth (Levine, 1993). Financial sector development is important not only for fostering the economic growth process, but also for dampening the volatility of the growth process. Financial systems can alleviate the liquidity constraints on firms and facilitate long-term investment, which ultimately reduces the volatility of investment and growth (Aghion et al., 2010). Likewise, well-developed financial markets and institutions can help dampen the negative impact that exchange rate volatility has on firm liquidity and thus investment capacity Aghion et al. (2009) with direct impact on innovation. The Capital structure of a firm is related with its innovation. Venture capital and private equity firms foster innovation (Kortum and Lerner, 2000; Lerner *et al*., 2011) while the effect of banking development on technological progress and economic growth is positively associated (Demirgüç-Kunt and Maksimovic 1998; Levine and Zervos 1998).

Rogers (1962) envisaged innovation not just as a new product but also new ideas, technology and behaviours. He later added that it can also be an impulse to do something new or bring some social change (Rogers, 2003). Innovation has been defined more recently to go beyond core product and process to include the imitation of technology, products, and activities that promote networks and knowledge transfers, such as foreign technology license, international quality certification and other actions that impact and enhance the organization of the firm's business activities (Bloch and OECD, 2007).

The innovation process is divided into four dimensions – invention, innovation, diffusion and imitation, (Schumpeter, 1942). Further analysis showed that the invention phase has less of an impact, while the diffusion and imitation process have a greater influence on the state of an economy. Schumpeter divided innovation into: (a) new product; (b) application of new methods of production; (c) opening of new markets; (d) obtaining new sources of supply of raw material / semi-finished good and (e) new industry structure. He refers to the "new combinations" of existing resources, equipment and activities, as the entrepreneurial function (Schumpeter, 1934) which he argues is distinct from invention. Rogers (1962) expanded on the diffusion phase in his diffusion of innovation theory. Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. An innovation is an idea, practice, or object perceived as new by an individual or other unit of adoption (Rogers, 2003). The diffusion of innovation theory heavily relies on human capital. According to the theory, innovations should be widely adopted in order to attain development and sustainability. Rogers proposed four elements of diffusion of innovations which are innovation, communication channels, time and social system.

Innovation can also be an impulse to do something new or bring some social change (Rogers, 2003). The communication channels carry the messages from one individual to another. It can take any form such as word of mouth, SMS, and any sort of literary form. Time refers to the length of time it takes for the people and institutions to get adopted to the innovations or new ideas in a society. It is the time people take to get used to new ideas. For an example consider owning a website, it took a while to get spread among enterprises (especially in developing economies of Africa) when it was introduced in the market. Social system refers to all kinds of components that contribute to the build the society like establishments, institutions and groups of people.

2.2.1.1 Innovation and financing constraints

Financing constraints and their effect on firm activities is a continuous area for innovation research (Gorodnichenko and Monika Schnitzer, 2013; Planesa et al., 2001, Schiantarelli, 1995). Firms that lack

access to finance are hardly able to engage in innovation. A major problem for a firm's activities is financing constraint. Worthy of note is the debate whether stock liquidity enhances or impedes firm innovation. This has been an interesting topic because innovation is crucial for firm- and national-level competitiveness while stock liquidity can be altered by financial market regulations. Using a difference-in-differences approach that relies on the exogenous variation in liquidity generated by regulatory changes, Fang *et al*. (2014) found that an increase in liquidity causes a reduction in future innovation. They identify two possible mechanisms through which liquidity impedes innovation: increased exposure to hostile takeovers and higher presence of institutional investors who do not actively gather information or monitor. Reduction of this constraint could bring about innovative activities. However, in the presence of information asymmetry, a firm's potential suppliers of finance may be unable to provide capital for innovative activities.

Other studies show that, while the development of equity markets encourages innovation, credit market development impedes innovation (Martinsson and Petersen, 2010). Equity markets encourage innovation while stock markets discourage innovation. It could also be the case that there is a contradiction in the literature as to whether equity / debt encourages or discourages investment. Credit markets have an inherent bias towards conservative investments that discourage firms from investing in innovative projects (Morck and Nakamura, 1999). Access to finance and the constraints thereof have different impacts on different types of innovation. For example, Aghion and Tirole (1994) build on a theoretical model that demonstrates that arms-length financing is better at encouraging corporate innovation than relationship-based financing. Arms–length financing has stricter conditions than relationship-based finance. As such enterprises often go for arms-length financing for income generating activities that are likely to be innovative. The Allen and Gale (1999) model also depicts that markets are likely to be more effective than banks in the gathering and processing of information in new, uncertain positions involving innovative products and processes. Empirical evidence established that other factors such as capital structure (Wies and Moorgan, 2015), corporate governance (Lehrer et al., 1999; Chemmanur and Tian, 2010), and legislation (Mansfield, 1962; and Acharya and Subramanian, 2009) do affect innovation.

2.3 EMPIRICAL LITERATURE

2.3.1 Innovation and finance

The literature on innovation and finance has been examined by a number of authors (Acharya and Xu, 2016; Chemmanur and Fulghier, 2014; Ferreira *et al*., 2014; Lerner *et al*., 2011; Xiao and Zhao, 2011; Acs and Isberg, 1991; Oakey, 1984; Timmons and Bygrave, 1986) using different variables. Access to finance enhances the innovative activities of an enterprise. This means the sources of finance or the

financial structure of a firm, affect its innovation. A number of studies support this assertion, (Wies and Moorman, 2015; Chemmanur and Fulghier, 2014; Ferreira *et al*., 2014; Baldwin and Scott, 1987). This section will analyse how the various forms of finance affect enterprise innovation by looking at different studies especially with the growing consensus that well-functioning financial markets play a key role in driving technological innovation and growth (King and Levine, 1993a;b; Levine, Tian and Xu, 2014). A way that financial markets are conceived to play this role is by allocating capital to firms with the greatest potential to implement new processes and to commercialize new technologies. Benfratello *et al*. (2008) investigate the effect of local banking development on firms' innovative activities, using a rich data set on innovation for a large number of Italian firms over the 1990s. They found evidence that banking development affects the probability of process innovation, particularly for firms in high-tech sectors, in sectors more dependent upon external finance, and for firms that are small. Further evidence showed that product innovation is much weaker and not robust. There is also some evidence that banking development reduces the cash flow sensitivity of fixed investment spending, particularly for small firms, and that it increases the probability they will engage in R&D.

2.3.2 Capital structure and innovation:

The capital structure of an enterprise is linked to innovation (Kamien and Schwartz, 1975; O'Brian, 2003); at times with different implications. Investigating how the stock market affects a firm's innovation using a quasi-experimental research design around initial public listing (IPO), Weis and Moorman (2015) document that going public affects the level and risk of firm innovation. Although going public allows firms access to more financial capital that can fuel innovation, it also exposes them to a set of myopic incentives and disclosure requirements that can constrain innovation. For example, due to pressure exerted on managers because of liquid equity markets, they are compelled to demonstrate quick results, and so prefer short-term projects to long-term projects (Stein, 1989). This also happens for cases where the long-term project could have been better.

According to Wies and Moorgan (2015), firms that go public engage in more innovation. Lerner et al. (2011) examined a form of long-run activity, namely, investments in innovation as measured by patenting activity. They examine patents filed by 472 LBO transactions that received private equity backing between 1986 and 2005 and found no evidence that LBOs sacrifice long-term investments. LBO firm patents showed no shifts in the fundamental nature of the research, and became more concentrated in important areas of companies' innovative portfolios.

Another area of interest has been the role of venture capitalists (VC) in fostering technological innovation (Timmons and Bygrave, 1986). It is noteworthy that apart from playing an important role VC is a unique investment in terms of when, where and how it is made. According to Chemmanur and Fulghier (2014),

financial intermediaries such as venture capitalists and angels, play an important role in fostering entrepreneurial firms and promoting product market innovation. Also related to VC is the function of tolerance for failure as a vital feature of financial contracting, because this can boost or repress innovation. In a related study, Tian and Wang (2010) developed a measure of VCs' failure tolerance and find that IPO firms backed by more failure-tolerant VCs are significantly more innovative, even long after VCs exit the IPO firms. Their measure of failure tolerance is a function of how many rounds (and how long) VCs invested in a firm before its ultimate failure. Manso (2011) suggests that a proper incentive for innovation would be compensation contracts that may require substantial tolerance for early failures, as well as job security and feedback on performance.

2.3.3 Financial development and innovation.

Financial development has an impact on firm innovation. Using firm level data from a cross-section of 57 countries to examine how financial development affects innovation in small firms, Sharma (2007) found that relative to large firms in the same industry, R&D spending by small firms is more likely and sizable in countries at higher levels of financial development. It further revealed that small firms also report producing more innovations per unit R&D spending than large firms, and this gap is narrower in countries at higher levels of financial development. These patterns are stronger in industries inherently more reliant on external finance. Carlin and Mayer (2003) examine a sample of advanced OECD countries on whether financial development stimulates R&D investments. They demonstrate that industries dependent on equity finance invest more in R&D and grow faster in countries with better accounting standards. They do not find a similar increase for investment in fixed assets, or for countries with a large financial sector. This suggests that finance is associated with the funding of new technologies. Goldman and Peress (2015) developed and tested a model of financial development and technological progress, and concluded that knowledge about technologies and technological knowledge are mutually reinforcing. That is, entrepreneurs innovate more when financiers are better informed about their projects because they expect to receive more funding should their projects be successful. Xiao and Zhao (2011) examined the impact of financial development on firm innovation around the world using 28,000 firms from 46 countries in the World Bank survey. They found that stock market development significantly enhances firm innovation while banking sector development had mixed effects. This is in line with the Tian and Xu's (2014) results that equity market development is positively and significantly associated with its subsequent growth in industry-level innovation. These findings are similar to the empirical findings of (Brown *et al*., 2009; Levine *et al*., 2006; Rajan and Zingales, 1998).

The finance–innovation literature remains an interesting discussion as it produces mixed results, depending on the type of finance and proxy for innovation. Fazzari and Petersen (1993) looked at financing constraints on investment with the focus on working capital as a source of funds. The

regression outcome shows a negative coefficient for working capital investment in fixed-investment, as anticipated when working capital competes with fixed investment for a limited pool of finance. Examining the impact of financial constraints on innovation for established French firms, Savignac (2008) used a recursive bivariate probit model to simultaneously estimate the probability of having innovative activities and the probability of facing financial constraints. After controlling for endogeneity in the financial constraint variable, he found that financial constraints significantly reduce the likelihood that firms have innovative activities.

Acharya and Xu (2016) estimated the treatment effect model that directly controls for selection bias caused by the endogenous choice of going public, and found out that public firm in external finance-dependent industries are on average innovative, with more patents than private firms are.

2.4 CONCLUSION

This paper sets out to appraise the literature on innovation and finance. The paper has substantially enhanced understanding on a number of issues. The literature has revealed some patterns in the finance-innovation link. Firstly, it has shown how finance can drive innovation. Secondly, it has revealed the capital structure implications for innovation, and finally, it showed financial development implications for innovation.

From what the literature has revealed some policy recommendations can be made. Since access to finance enhances innovation, a key policy affecting financial intermediaries, particularly the banking sector that will enable increase access to finance, is important. However, it is also important to note that prudent measures must be taken to ensure that finance raised for innovation is used appropriately for innovative activities. Since equity is positively associated with innovation, financial sector policy that focus on stock market development should be pursued extensively.

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6

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CHAPTER 3

ACCESS TO FINANCE AND FIRM INNOVATION[1]

3.1 INTRODUCTION

This study examines whether access to finance enhances firm innovation. Studies on innovation have been conducted but these are mostly linked to economic growth and development while the finance literature is silent on how innovation is affected by access to finance in developing countries (Ayyagari *et al*., 2011). Another concern, however, is that African enterprises are ranked at the tail end of innovation compared to other countries (African Development Bank, 2008). According to the Global Innovation Index (2015), African countries are ranked far behind in the world innovation index, most of them between 80 and 141, out of 141 countries for the period 2010 to 2015, with the exception of Mauritius, South Africa and Seychelles. For firms to conduct any substantial innovation they require access to finance, which is a huge constraint for small and medium size firms (Beck and Demirgüç-Kunt, 2006). Access to finance remains a major problem facing enterprises (African Development Bank, 2011: 82). Also, studies have examined the role of technology at macro level whereas little is known at firm level and even that little is skewed towards often publicly traded firms in developed economies (Caineilli *et al*., 2006; Baumol, 2002). Limited studies (Adeboye, 1997; Chipika and Wilson, 2006) have been conducted on innovation within firms in Africa. These studies focus on technologies, models of innovation and issues related to networking amongst other things, whereas a crucial and less examined issue is the importance of access to finance in firm innovation. With access to firm level data from emerging economies provided by the World Bank, this study seeks to close that gap.

Broadly defined, innovation includes core innovative activities such as the introduction of new products and new technologies, but also the imitation of technology, product, and activities that promote networks and knowledge transfers, such as foreign technology license, joint ventures with foreign partners, international quality certification and other actions that impact on the organization of the firm's business activities (Bloch, 2007). The key concern has been new-to-firm innovation rather than core innovation that is of relevance to our sample of emerging economies. We take advantage of data availability to examine the impact of access to finance on firm innovation.

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[1] This paper has benefitted from earlier comments at the Global Development Finance Conference, the Economic Society of South Africa Conference and the African Finance Association Conference in 2014, 2015 and 2016 respectively. It is currently under peer review with an international Journal

Existing literature depicts that financially constrained firms find it difficult to engage in innovative pathways (Beck and Demirgüç-Kunt, 2012). Demirgüç-Kunt and Klapper (2012) also emphasise that the ability of firms in Africa to innovate is severely constrained by the lack of access to finance. Against this background, the objective of this paper is to examine whether access to finance drives firm innovation. Data on 5,304 firms across five regionally selected countries in Africa is employed. The 2SLS technique is employed to control for possible endogeneity and selection bias between finance and innovation.

Novel in a number of ways, firstly, we compute and use a decomposed innovation index with more recent classification of innovation, unlike previous studies that used R&D expenditure which has been heavily criticised in the literature (Bevere and Vandenbussche (2010). Research and development expenditures may not yield any meaningful output whereas our variables for this index are visible outcomes emanating from R&D. Computing these innovation outcome variables into an innovation index is better than a comparative study. Next, we control for possible endogeneity between finance and firm innovation. This is very critical because it is often absent in studies that examine the finance-innovation link. Failure to control for endogeneity can yield bias estimates or produce inconsistent results. Thirdly, an African context was added to the existing literature on finance and innovation. This is primarily because African firms are unique with different characteristics from firms in developed countries, especially regarding their way of doing business (Tybout, 2000). The remainder of this chapter is organised as follows: Section 2 discusses the literature; Section 3 outlines the methodology comprising index construction and post-estimation techniques; Section 4 presents and discusses the results; while Section 5 concludes and provides policy recommendations.

3.2 OVERVIEW OF RELATED LITERATURE

Innovation is the production of a new product, change in the industrial organization, change in the methods of production and transportation opening up of a new market (Schumpeter, 1942). A few years after 1942 innovation was perceived to be beyond just a new product to mean new ideas, technology, behaviours or products, Rogers (1962). In Rogers' diffusion of innovation theory, he concentrated on how something new moves from creation to use. This is important because a product (innovation) is more cherished when it is in use than when it is novel.

Schumpeter (1934) hypothesized that in the relationship between finance and innovation the innovative outcome of an economy was interconnected with the functioning of its credit and capital markets. Schumpeter (1934 and 1950) further analysed that the cost of engaging in innovative activities such as those defined earlier was enormous and thus often limited to large enterprises. This basically implies that if firms cannot meet this huge cost from their internal reserves, they are obliged to seek financial

assistance externally if they wish to innovate. This makes it normal for firms to seek funding following a hierarchical order as noted by Donaldson (1961), that enterprises with internal funds are likely to start by tapping their internal finances to carry out innovation before turning to external sources of funds – debt and equity. A fundamental concern is the fact that access to finance remains a major constraint for African enterprises (Beck and Cull, 2014).

Access to finance can alleviate capital accumulation and consequently promote innovation. If this is true, therefore, enterprises can raise funds for innovation either internally or externally through equity (Brown and Petersen, 2009). A few empirical studies have examined the relationship between finance and innovation.

It is believed that company innovation and growth is enhanced through access to finance. However, the financing options do impact growth differently and as such could impact the innovation process differently. For instance, Carpenter and Petersen (2002) examined an unbalanced panel of over 2,400 publicly traded US high-technology companies during the period 1981–1998, and found that new equity financing appears to be very important for the rapid growth of young high-technology firms. Blass and Yosha (2003) concluded that during the 1990s, publicly traded innovation-intensive manufacturing firms in Israel depended on equity.

Benfrantello et al. (2008) investigated the effect of local banking development on firms' innovative activities, using a rich data set on innovation for a large number of Italian firms over the 1990s, and evidence pointed to the fact that banking development affected the probability of process innovation, particularly for firms in high-tech sectors, in sectors more dependent upon external finance, and for firms that were small. The evidence for product innovation is much weaker and not robust. There is also some evidence that banking development reduces the cash flow sensitivity of fixed investment spending, particularly for small firms, and that it increases the probability they will engage in R&D. Because of the difficulties of accessing finance, companies resolve to find alternative sources of financing. In the US for example, using a panel of US companies from 1974–2000, Atanassov, Nanda and Seru (2009) found that innovative firms used arm's length financing such as public debt and equity whereas less innovative firms relied on relationship-based borrowing such as bank debt. However, Access to both internal and externally generated funds is important to increase innovative activities (Brown *et al*., 2009). There is increasing consensus that well-functioning financial markets play a key role in driving economic growth through their ability to spur technological innovation (King and Levine, 1993a, 1993b; Levine, 1997; Comin and Nanda, 2014). One way that financial markets are believed to play this role is by allocating capital to firms with the greatest potential to implement new processes and to commercialize new technologies. This idea, of capital markets funding the most promising projects, harks back to

Schumpeter's (1934) notion of "creative destruction" and has been studied over the last several decades in the context of financing constraints for entrepreneurs (Scherer, 1984; Beck *et al*., 2008).

Girma, Gong & Gorg (2008) examined the link between inward foreign direct investment (FDI) and innovation activity in Chinese enterprises, and found that private and collectively owned firms with foreign capital participation and those with good access to domestic bank loans are more innovative than other companies. Further on the finance-innovation link, Goldman and Peress, (2015) developed and tested a model of financial development and technological progress in which the main insight was knowledge about technologies and technological knowledge are mutually reinforcing. That is, entrepreneurs innovate more when financiers are better informed about their projects because they expect to receive more funding should their projects be successful. Conversely, financiers collect more information about projects when entrepreneurs innovate more because the opportunity cost of misinvesting, (i.e. of allocating capital to unsuccessful projects and missing out on successful ones), is larger. This positive feedback promotes economic growth and leads to a variety of dynamic patterns. Acs and Isberg (1991: 324) provide empirical evidence that capital structure is an important determinant of (technological change) innovation. Accessing finance can be difficult for both innovative and non-innovative enterprises. Against the increasing concern that it was harder for innovative firms to access finance, Lee, Neil, Sameen, Hiba and Marc (2015) examined the link between finance and innovation and results showed that innovative firms are more likely to be refused finance than other firms, and that this worsened significantly in the financial crisis. Further regressions controlling a host of company characteristics show that the deterioration in general credit conditions was more noticeable for non-innovative companies with the exception of absolute credit rationing, which still remained more severe for innovative firms.

There is an ongoing debate whether stock liquidity enhances or impedes firm innovation. Innovation is crucial for firm-level and national-level competitiveness, productivity and growth, while stock liquidity can be altered by financial market regulations. Using a difference-in-differences approach that relies on the exogenous variation in liquidity generated by regulatory changes, Fang *et al*., (2014) found that an increase in liquidity causes a reduction in future innovation. They identified two possible mechanisms through which liquidity impedes innovation: increased exposure to hostile takeovers and higher presence of institutional investors who do not actively gather information or monitor. Given this negativity between finance and innovation which is contrary to previous empirical studies that rather show a positive relationship between access to finance and innovation, the current research is important as it will confirm either the positive or negative relationship between finance and innovation or add to the mixed relationship.

3.3 METHODOLOGY

3.3.1 Data source

This study has utilized data from the World Bank Enterprise Survey (WBES) with information on innovations and sources of finance from sampled enterprises across African countries. The survey selected examples from registered businesses in the chosen country. A stratified random sampling methodology was used. This WBES survey applies standardized survey instruments to benchmark the investment climate of individual economies across the world and to analyze firm performance. It probes information relating to firm innovation by asking questions such as does your firm own a website? Do you use email to communicate with clients? Does your company make use of foreign technology? Is your firm in possession of an international quality certification? Are you accounts audited by an independent auditor? This data also brings out information about firms access to finance by asking simple questions, for example does your company have access to credit, overdraft facility or loan? Can you access trade credit and loans? The survey sampled firm at all levels – micro, small, medium and large.

Cross-sectional data was considered from manufacturing and service enterprises from five countries, for the period 2007 to 2014. These countries were carefully selected to represent each of the regional blocks in Africa. The choice of countries was influenced primarily by data availability and regional balance. The selected countries are Kenya (781 firms), Morocco (407 firms), Nigeria (2676 enterprises), South Africa (1057 enterprises) and Cameroon (383 enterprises); representing East Africa, North Africa, West Africa, Southern Africa and Central African sub-regions respectively.

The OSLO Manual (2005) and World Bank classification is followed, which provides proxy measures for innovation captured in the innovation literature. The following table highlights the proxy variables used.

Table 3.1: Variables used in computing the innovation index

No	Aggregate innovation
1	Introduction of a new or significantly improved product within three years to survey
2	Enterprise owns a website
3	Firm uses email to communicate with clients
4	International quality certification
5	Foreign technology license
6	Audited financial statements by an independent auditor

Source: World Bank Enterprise Survey database, 2016.

3.3.2 Construction of innovation index

A number of selected innovation variables (as indicated in Table 3.1) were used to create a single innovation index referred to as an aggregate innovation index. The multiple correspondent analysis (MCA) was used in constructing this innovation index. The MCA is very good at analyzing categorical variables and the innovation variable questions, making it appropriate for this study. Moreover, the multiple correspondent analysis assigns weight according to the significance of the variables in the innovation index. In accordance with Benzicri (1973), Van Kerm (1998) and Booysen *et al*. (2008), the MCA innovation index is given generally as:

$$a_i = \sum_{k=1}^{k} F_{1k}\, d_{ki}$$

The ith firm innovation index is a_i, d_{ki} is the kth value of the categorical variables (with $k=1\ldots K$) indicating the firms' innovation variables included in the index construction. F_{1k} is the MCA weights generated for the analysis.

3.3.2.1 A priori expectation of the index

At the creation of the innovation index there should not be any reverse variable. In the construction of the index the alpha command was used to detect any reverse variables. If any reverse variable was detected it was dropped. This is because reverse variables have a negative impact on the index. All the indices met the *a priori* expectation (Booysen *et al*., 2008).

3.3.2.2 Summary statistics on innovation index

Table 3.2: Summary statistics on innovation indexes

Country	Scale of reliability	Dimension 1 percentage	Mean of index	Std deviation of index
	Aggregate innovation	Aggregate innovation	Aggregate innovation	Aggregate innovation
South Africa	0.7	93	2.3	1.2
Nigeria	0.73	96	1	1.1
Morocco	0.43	92	2.7	1
Kenya	0.6	83	2.4	1.1
Cameroon	0.7	100	1.4	1.7

Source: Author's computation based on the WBES database 2016. Std Dev of index = Standard deviation of index

In Table 3.2, the scale of reliability ranges from 0.6 to 0.73 with the exception of the aggregate innovation index for Morocco. This is a good value. The low scale reliability of innovation index for Morocco is due to low responses by enterprises in that country. The dimension 1 percentages are very high with 100%

for Cameroon, and an average above 90% for the rest of the countries. The trends in the mean innovation index indicate that Morocco has the highest aggregate innovation index of (2.7), followed by Kenya (2.4), South Africa (2.3), Cameroon (1.4) and Nigeria (1). The standard deviation hovers around 1 with the exception of Cameroon.

3.3.3 Empirical strategy

To examine the role of finance in innovation, the following model is estimated:

$$I_{Innovation} = \beta_1 + \beta_2 Fin + \beta_3 X + \mu_t \quad \ldots (1)$$

Where:

$I_{Innovation}$ = *Aggregate innovation index*.

Fin, represents the finance variables

X, represents the control variables

μ_t, represents the error term

Fin represents the finance variables. Trade credit and debt finance is used which consists of asset finance and overdraft. Trade credit refers to purchases made on credit from suppliers and advances from customers, while asset finance is measured as loans taken for financing of assets, both current and non-current assets; and overdraft is measured by the establishment's overdraft facility. The *a priori* expectation is that an increased access to finance should lead to an increase in innovation. X is a vector of control variables and include: age of firm, measured as age in years; size of firm captured as a categorical variable with '1' for a small enterprise employing between five and 19 persons, '2' for medium enterprises having between 20 and 99 employees, and '3' for large enterprises employing 100 persons and more. Top manager's experience is measured in terms of the number of years of work experience of the most senior management officer; export orientation is captured as '1' if the firm is involved in the export market or '0' otherwise. The regression also controlled for location, industry, and market participation (whether a firm participates in the main market for its product or not).

3.3.3.1 Estimation Technique

The instrumental variable model is used when it is suspected that there could be a problem of endogeneity in the regression equation. The OLS is the most widely used method (Greene, 2003) but is not consistent and cannot solve the problem of endogeneity nor omitted variable bias. The instrumental variable two stage least square has been considered because it is good with cross sectional data that possibly have endogeneity problem. The IV model takes care of unobservable factors in the equation, and also takes care of the problem of measurement error in the regressor (Baum, 2008; Wooldridge, 2002). The IV model does so in two stages by (1) ensuring that the identified instrument

correlates with the explanatory variable but not with the error term in the first stage. In the second stage, the instrument should correlate with the dependent (innovation index) variable. It then proceeds to examine the strength of the instruments and specification of the equation (Baum *et al*., 2006).

To control for the likelihood of endogeneity bias between finance and innovation an Instrumental Variable (IV) model was used. The IV model requires an observed variable that is (i) strongly correlated with access to finance; but (ii) uncorrelated with the error term. The key assumptions of the IV model, according to Khandker et al. (2010) are summarized as:

Correlated with innovation index: $cov\,(Z, finance) \neq 0$

Uncorrelated with the error term (ε): $cov\,(Z,\varepsilon) = 0$

Where Z is the chosen instrument.

The instrument (Z) in the first stage of the regression will have to be correlated with the finance (explanatory) variable but uncorrelated with the error term. However, in the second stage of the regression, this instrument should correlate with the innovation index (dependent variable). Some possible instruments were chosen and went through the first stage of the regression. These instruments differ from country to country and range from a host of guarantees and collaterals such as fixed assets, having a cheque or savings accounts, application for a loan/line of credit, status of enterprise, establishment paid for security, type of financial institution, audited financial statement, status of the enterprise, securing a government contract, and operating license, to the total cost of finished goods/materials bought for resale in the fiscal year prior to survey.

Each of these instruments must be correlated with the explanatory variable but not with the error term. To test for validity of these (instruments), there are two tests; the first is the Stock and Yogo (2005) test, and Cragg and Donald (1993) test. This test helps us to ascertain the strength of the instrument(s). The Cragg-Donald F-statistic is computed and this value is compared with the Stock and Yogo critical value. There are two options here: to choose the maximum test criterion or the maximum relative bias. The instruments are strong when the Cragg-Donald F-statistic is higher than the Stock and Yogo critical value, following the option chosen. This research, however, made use of both options given that the regressions are independent and country-specific. The second test is the Sargan and Basmann test of overidentifying restriction. This tests the strength of the surplus instrument, in a situation where the model is overidentified. However, when the model is exactly identified, this test is not needed. Hence, we test that the instruments (a) correlates with the explanatory variable and (b) does not correlate with the error term, for all the regressions.

Nigeria had, as instruments, type of financial institution and collateral for trade credit and asset finance. Different types of financial institutions have different criteria for different clients to access their finances. This correlated with credit and asset finance but not with innovation. Similarly, for overdraft, application for loan or line of credit, and audited financial statement were the instruments. Prior to engaging with the bank for business it is required of a firm to have at least a cheque or savings account. And having your financial statement audited confirms the financial health of the firm and portrays it as a viable customer for more business – and so it gets an overdraft. For Kenya there were status of the enterprise, and total cost of finished goods/materials bought for resale, as instruments for trade credit while fixed assets and firm status for overdraft. Also, for asset finance, having a cheque or savings account and audited financial statement correlated with asset finance but had no direct influence on innovation.

In South Africa, the chosen instruments are the type of financial institution and application for a loan or line of credit, for asset finance, and overdraft. These instruments correlate with 'trade credit' and 'overdraft' yet do not directly influence innovation. Likewise, we had as IV for trade credit, paid security by the establishment. Establishments that are secured or proven to be safe by paying for security, are more likely to be considered by banks for transactions. This correlated with trade credit but not directly with aggregate innovation. Similarly for Morocco, in the IVs are the firm having a cheque or savings account, and applying for a loan or line of credit. It is only fair for an enterprise to apply for overdraft or trade credit if it has a cheque or saving account. Both IVs correlated with trade credit and overdraft but not with innovation.

Finally, in Cameroon, the instruments are paid security by the firm and the percentage of bribe paid to public officials for 'asset finance'. In situations where the banks evaluate that the percentage paid is negligible, it will very likely engage with the enterprise because it has confidence in the firm's ability to repay loan. The instruments correlated with asset finance but not with innovation. Similarly, having a cheque or savings account correlated with overdraft while fixed assets correlated with both overdraft and trade credit but had no direct influence on aggregate innovation.

In the first stage regression, there was an ordinary least square regression (OLS) model, with the selected instruments, Z_i, as additional independent variables. Following Janzen and Carter (2013) and Khandker *et al*. (2010) the first stage regression is given as:

$$finance_i = yZ_i + \emptyset X_i + \mu_i \quad \ldots (2)$$

Where access to finance can be obtained from trade credit, overdraft, and asset finance, Z_i is the selected instrument, xi is a vector of covariates which affect a firm's access to finance decision, and li is the error term.

At the second stage, the predicted demand of access to finance ($\widehat{finance_i}$) is substituted in Eqn. (1) to obtain the outcome equation.

$$I_{Innovation} = \propto X_i + \beta finance_i + \varepsilon_i \quad \ldots (3)$$

$$I_{Innovation} = \propto X_i + \beta(\gamma Z_i + \widehat{\emptyset} X_i + \mu_i) + \varepsilon_i \quad .... \quad (4)$$

Where $\gamma Z_i + \widehat{\emptyset} X_i + \mu_i$ is the prediction of having access to finance. Under instrumental variable the impact of finance on process innovation is $\hat{\beta}_{iv}$.

3.4 RESULTS AND DISCUSSION

This section presents the regression output and discusses the results.

Tables 3.3a and 3.3b show the results for the estimation. Table 3.3a shows results for Nigeria and South Africa while Table 3.3b contains results for Cameroon, Kenya and Morocco. Overdraft is linked to aggregate innovation in all the chosen countries – Cameroon, Kenya, Morocco, Nigeria and South Africa. Finance through overdraft distinctly enhances innovation within enterprises. This implies overdraft is a key channel via which finance enhances firm innovation. These findings are in line with Ayyagari *et al*., (2012) and observations by IFC (2013), on the importance of finance to firm innovation. In the case of the second finance variable 'trade credit', we notice a positive and significant link to aggregate innovation among firms in Nigeria, South Africa and Cameroon. Trade credit definitely drives innovation in these countries. Meaning another channel through which finance enhance firm innovation is through trade credit. This is in line with the findings of Girma *et al*. (2008) that inward direct investment and innovative activities in Chinese enterprises are related. Furthermore, the third finance variable "asset finance" drives aggregate innovation in Nigeria, South Africa and Cameroon. This show that bank "asset finance" is another channel through which finance impact innovation. This result conforms with the view of Beck (2006) who stated that African enterprises are constrained by lack of finance to conduct innovation. It should be noted that there is no asset finance for Morocco. From these findings, it is evident that finance drive firm innovation through the capital structure of the firm. This is in accordance with the works of Ferreira *et al*., 2014.

Generally, an economy with an improved financial system and increased access to finance will enhance firm innovation. This sharpens Schumpeter's perspective (1912, 1942) that well developed financial markets will normally lend to innovative firm's entrepreneurs and this has a positive impact on innovation (King and Levine, 1993a, 1993b). The positive links further entail that a more open and inclusive financial system will lead to increase in industrialisation in the country, as observed by improvements in the

competitive industrial performance index in South Africa and Morocco between 1995 and 2013 (United Nations, 2014).

With regards to the control variables, variables are discussed that are consistently significant drivers of firm innovation across the respective countries. Size of the firm is largely a significant contributor of aggregate innovation, that is larger firms are more innovative than small firms. This is noticeable across all the countries. This is very much in line with Schumpeter's (1942) ideology that large firms are better positioned to engage in innovative activities. Foreign owned firms are innovative in South Africa, Cameroon, Kenya and Morocco.

Export-oriented firms in South Africa, Morocco, Kenya and Cameroon are more innovative than to non-exporting firms. Also, firms with experienced top management in South Africa, Cameroon and Morocco are innovative. This study also controls for location and industry where data is consistently available.

Table 3.3a: Instrumental variables two stage least square regression

	Nigeria			South Africa		
Dependent variable	(1) Aggregate innovation	(2) Aggregate innovation	(3) Aggregate innovation	(1) Aggregate innovation	(2) Aggregate innovation	(3) Aggregate innovation
Overdraft	1.924***			0.420**		
	(4.04)			(1.98)		
Debt (asset) finance		2.664***			0.201**	
		(2.97)			(2.22)	
Trade credit			1.534**			0.738**
			(2.44)			(2.11)
Age	0.010**	0.017**	0.025***			
	(2.65)	(2.71)	(6.42)			
Small firm	0.142**	0.044	0.465***			
	(1.94)	(0.18)	(3.54)			
Medium firm	0.410***	0.411	1.081***	0.708***	0.684***	0.735***
	(4.68)	(1.40)	(6.42)	(10.62)	(6.63)	(10.65)
Large firm	1.031***	1.490***	2.395***	1.104***	1.116***	1.227***
	(5.63)	(4.15)	(8.18)	(11.34)	(9.52)	(13.80)
Top manager experience	-0.007**	-0.020**	-0.024***	0.005*	0.009**	0.007**
	(-2.06)	(-2.38)	(-4.00)	(1.86)	(2.47)	(2.33)
Regions (controlled)	Yes	Yes	Yes	No	No	No
Foreign ownership	0.085	-1.243**	-0.303	0.191**	0.341**	0.189**
	(1.03)	(-2.16)	(-0.09)	(2.30)	(2.95)	(2.08)
Export	-0.035	-1.459**	-0.319**	0.557***	0.610***	0.491***
	(-0.51)	(-2.70)	(-2.04)	(6.53)	(6.44)	(4.55)
Industry (controlled)	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.033	0.690**	-0.427	1.494***	1.624***	0.752
	(0.27)	(1.94)	(-1.18)	(13.44)	(14.04)	(1.62)
No. of observation	652	1257	2012	931	405	935
Wald chi-sq	151.36	115.54	342.87	650.52	317.12	551.68
	(10)	(10)	(10)	(7)	(7)	(7)
Prob > F.	0.000	0.000	0.000	0.000	0.000	0.000

NB: *t* statistics in parentheses, *, **, and *** represents 10%, 5%, and 1% respectively

Table 3.3b: Instrumental variables two stage least square regression

	Cameroon			Kenya			Morocco	
Dependent variable	(1) Aggregate innovation	(2) Aggregate innovation	(3) Aggregate innovation	(1) Aggregate innovation	(2) Aggregate innovation	(3) Aggregate innovation	(1) Aggregate innovation	(2) Aggregate innovation
Overdraft	1.513***			1.260**			1.077**	
	(4.59)			(1.96)			(1.98)	
Debt (asset) finance		0.534**			1.157			
		(2.17)			(1.55)			
Trade credit			1.327**			0.819		-3.268
			(2.83)			(1.15)		(-0.75)
Medium firm	0.121	0.288		0.289**	-0.058	0.395**	0.065	0.540
	(0.97)	(1.54)		(2.87)	(-0.22)	(2.97)	(0.47)	(1.03)
Large firm	0.586***	0.378		0.610***	0.493*	0.671***	0.566***	0.993*
	(3.68)	(1.58)		(5.48)	(1.81)	(4.96)	(3.79)	(1.69)
Top manager experience	0.009	0.003	0.011	-0.001	0.005	-0.001	0.001	0.025
	(1.65)	(0.30)	(1.27)	(-0.17)	(0.55)	(-0.22)	(0.26)	(0.68)
Industry (controlled)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Export	0.410**	0.102	0.273	0.236	-0.138	0.322**	0.264*	0.047
	(2.25)	(0.50)	(0.97)	(1.47)	(-0.40)	(2.24)	(1.76)	(0.11)
Foreign ownership	0.0754	0.681***	0.323	0.382**	0.525*	0.482**	0.514***	0.219
	(0.41)	(3.40)	(1.18)	(2.95)	(1.75)	(2.84)	(3.18)	(0.33)
Age		0.000	0.009	0.002	-0.003	0.005	-0.005	-0.017
		(0.05)	(1.35)	(0.75)	(-0.31)	(1.55)	(-0.98)	(-0.64)
Region (controlled)	Yes	Yes	No	Yes	Yes	Yes	No	No
Market participation							0.079	-0.397
							(0.53)	(-0.54)
Constant	-0.083	0.577**	-0.155	1.314***	0.480	0.960**	1.395***	3.278*
	(-0.36)	(2.22)	(-0.36)	(6.26)	(0.47)	(2.24)	(3.60)	(1.95)
No. of observation	356	160	349	696	320	684	366	366
Wald chi-sq	132.16	52.11	43.18	142.75	21.68	127.72	33.25	11.42
	(7)	(9)	(6)	(8)	(12)	(12)	(9)	(9)
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NB: *t* statistics in parentheses, *, **, and *** represents 10%, 5%, and 1% respectively

3.4.1 POSTESTIMATION TESTS

In this research possible endogeneity was controlled for using instrumental variables, then the strength and validity of the instruments used and the structural equation or model as a whole was tested. The test for overidentification was performed to test whether the equation was structurally well specified and also the fitness of the model. These were achieved by utilising the Cragg and Donald (1993) minimum eigenvalue statistics together with Stock and Yogo (2005) critical value.

Tables 3 to 16, analyse the strength of the instruments and the specification of the structural equations. In Nigeria (Tables 3 to 5), the Cragg and Donald (1993), minimum eigenvalue statistics for Tables 3, 5 and 4 are greater than the 'LIML Size of nominal 5% Wald test' critical values of Stock and Yogo (2005) at 10%, 15% and 20% respectively. We therefore reject the null hypothesis and conclude that the instruments are strong comparatively in that order. Therefore, the strength decreases in the order of Tables 3, 5 and 4. However, the overidentifying restrictions tests of Sargan (1958) and Basmann (1960) show that the structural equations are well specified. Tables 6 to 8 show the post-estimation test for South Africa. The Cragg and Donald (1993), minimum eigenvalue statistics are greater than the 'LIML Size of nominal 5% Wald test' and Stock and Yogo (2005) critical values. The null hypothesis is thus rejected, meaning the instruments are very strong. The overidentifying restrictions tests of Sargan's (1958) and Basmann's (1960) for Table 7 implies that the structural equations are well specified, while that for Tables 6 and 8 are comparatively less specified. For Cameroon Tables 9 to 11 show the postestimation test. The Cragg and Donald (1993), minimum eigenvalue statistics are greater than the 'LIML Size of nominal 5% Wald test' and critical values of Stock and Yogo (2005). This shows that the instruments are strong especially for Tables 9 and 11. The overidentifying restrictions tests of Sargan's (1958) and Basmann's (1960) likewise imply the structural equations are well specified.

In Kenya, the Cragg and Donald (1993) minimum eigenvalue statistics for Tables 12 and 14 are greater than the 'LIML Size of nominal 5% Wald test' critical values of Stock and Yogo (2005) at 10% and 30% respectively. The researcher therefore rejects the null hypothesis and concludes that the instruments are relatively strong, although there appears to be some presence of weak instruments from Table 13. However, the overidentifying restrictions tests of Sargan (1958) and Basmann (1960) show that the structural equations are well specified. Finally, in Morocco, the Cragg and Donald (1993), minimum eigenvalue statistics, for Table 15 and the nominal 5% Wald test critical value of Stock and Yogo (2005) show that it is strong, whereas that for Table 16 shows the presence of relatively weak instruments. However, the overidentifying restrictions tests of Sargan's (1958) and Basmann's (1960) shows that the structural equations are well specified. The instrumental variable vce (robust) model was also estimated

to control for any heteroscedasticity and the results do not change. The results are provided in the appendix.

3.5 CONCLUSION

This paper sets out to examine the importance of finance in firm innovation using regionally selected countries (Kenya, Morocco, Nigeria, South Africa and Cameroon). Using the World Bank enterprise survey data, this study finds that access to finance as depicted through trade credit, asset finance and overdraft enhances aggregate (firm) innovation in the respective countries.

The results however, have some implications for policy. Given that most of the channels (overdraft, trade credit and asset finance) through which finance enhances innovation are bank finance, there is the utmost need for relevant policies to enhance financial sector development, especially the banking sector, and increase access to finance for enterprises. Also, policy incentives such as tax breaks can be put in place to encourage banks to increase lending to firms. Furthermore, different financial institutions such as microfinance institutions can be supported to increase credits to enterprises and young entrepreneurs. Partnerships with organisations willing to fund firms and support start-ups should be encouraged. One such support mechanism could be specialised schemes, for example a credit guarantee scheme, to encourage and secure lending to enterprises to promote innovation.

Tables 3 to 16

The following tables 3 – 16 represent post estimation tests with instrumental variable model

Table 3: Finance on aggregate innovation index in Nigeria.

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum eigenvalue statistics = 23.1**			
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.1294				
Adj. R-square:	0.1172				
Partial R-square:	0.0671				
Prob > F =	0.0000				
F	(2, 642)				
Over-identifying Restrictions test					
Sargan (score) chi-sq (1)			0.2144	(P=0.6433)	
Basmann chi-sq (1)			0.2111	(P=0.6458)	

Source: Author's computation based on the 2014 World Bank Enterprise Survey for Nigeria

Table 4: Finance on aggregate innovation index in Nigeria

First stage regression test					
Asset finance					
Cragg and Donald (1993)		**Minimum eigenvalue statistics = 4.83**			
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.2044				
Adj. R-square:	0.1973				
Partial R-square:	0.0077				
Prob > F =	0.0081				
F	(2, 1247)				
Over-identifying Restrictions test					
Sargan (score) chi-sq (1)			4.3395	(P=0.0372)	
Basmann chi-sq (1)			4.3129	(P=0.0378)	

Source: Author's computation based on the 2014 World Bank Enterprise Survey for Nigeria

Table 5: Finance on aggregate innovation index in Nigeria

First stage regression test					
Trade credit					
Cragg and Donald (1993)		**Minimum eigenvalue statistics = 5.61**			
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0999				
Adj. R-square:	0.0950				
Partial R-square:	0.0056				
Prob > F =	0.0037				
F	(2, 2000)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.0166	(P=0.8974)
Basmann chi-sq (1)	0.0165	(P=0.8977)

Source: Author's computation based on the 2014 World Bank Enterprise Survey for Nigeria

Table 6: Finance on aggregate innovation index in South Africa

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum eigenvalue statistics = 35.4**			
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.1738				
Adj. R-square:	0.1666				
Partial R-square:	0.0712				
Prob > F =	0.0000				
F	(2, 924)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	3.2087	(P=0.0732)
Basmann chi-sq (1)	3.1887	(P=0.0741)

Source: Author's computation based on the 2007 World Bank Enterprise Survey for South Africa

Table 7: Finance on aggregate innovation index in South Africa

First stage regression test					
Asset finance					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics**	**=**
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.3292				
Adj. R-square:	0.3157				
Partial R-square:	0.2809				
Prob > F =	0.0000				
F	(2, 396)				
Over-identifying Restrictions test					
Sargan (score) chi-sq (1)			0.8110	(P=0.3678)	
Basmann chi-sq (1)			0.7946	(P=0.3727)	

Source: Author's computation based on the 2007 World Bank Enterprise Survey for South Africa

Table 8: Finance on aggregate innovation index in South Africa

First stage regression test					
Trade credit					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics**	**=**
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0424				
Adj. R-square:	0.0341				
Partial R-square:	0.0173				
Prob > F =	0.0003				
F	(2, 926)				
Over-identifying Restrictions test					
Sargan (score) chi-sq (1)			25.7316	(P=0.0000)	
Basmann chi-sq (1)			26.2051	(P=0.0000)	

Source: Author's computation based on the 2007 World Bank Enterprise Survey for South Africa

Table 9: Finance on aggregate innovation index in Cameroon

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics**	**= 20.3**
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.2152				
Adj. R-square:	0.1971				
Partial R-square:	0.1046				
Prob > F =	0.0000				
F	(2, 347)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.6966	(P=0.4039)
Basmann chi-sq (1)	0.6803	(P=0.4095)

Source: Author's computation based on the 2009 World Bank Enterprise Survey for Cameroon

Table 10: Finance on aggregate innovation index in Cameroon

First stage regression test					
Asset finance					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics**	**= 4.3**
First stage regression test			**Critical values**		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0921				
Adj. R-square:	0.0440				
Partial R-square:	0.0540				
Prob > F =	0.0151				
F	(2, 151)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.0421	(P=0.8374)
Basmann chi-sq (1)	0.0398	(P=0.8419)

Source: Author's computation based on the 2009 World Bank Enterprise Survey for Cameroon

Table 11: Finance on aggregate innovation index in Cameroon

First stage regression test					
Trade credit					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics**	**= 13.1**
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0698				
Adj. R-square:	0.0535				
Partial R-square:	0.0370				
Prob > F =	0.0002				
F	(1, 342)				

Source: Author's computation based on the 2009 World Bank Enterprise Survey for Cameroon

Table 12: Finance on aggregate innovation index in Kenya

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics**	**= 6.43**
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.1154				
Adj. R-square:	0.1038				
Partial R-square:	0.0184				
Prob > F =	0.0017				
F	(2, 686)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.3296	(P=0.5659)
Basmann chi-sq (1)	0.3209	(P=0.5711)

Source: Author's computation based on the 2013 World Bank Enterprise Survey for Kenya

Table 13: Finance on aggregate innovation index in Kenya

First stage regression test					
Asset finance					
Cragg and Donald (1993)		**Minimum eigenvalue statistics = 1.4**			
		Critical values			
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0490				
Adj. R-square:	0.0086				
Partial R-square:	0.0091				
Prob > F =	0.2471				
F	(2, 306)				
Over-identifying Restrictions test					
Sargan (score) chi-sq (1)		0.2319	(P=0.6301)		
Basmann chi-sq (1)		0.2219	(P=0.6376)		

Source: Author's computation based on the 2013 World Bank Enterprise Survey for Kenya

Table 14: Finance on aggregate innovation index in Kenya

First stage regression test					
Trade credit					
Cragg and Donald (1993)		**Minimum eigenvalue statistics = 4.0**			
		Critical values			
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0607				
Adj. R-square:	0.0439				
Partial R-square:	0.0059				
Prob > F =	0.0465				
F	(1, 671)				

Source: Author's computation based on the 2013 World Bank Enterprise Survey for Kenya

Table 15: Finance on aggregate innovation index in Morocco

First stage regression test					
Overdraft					
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**stats = 8.73**		
First stage regression test		**Critical values**			
	5%	10%	20%	30%	
2SLS relative bias	13.91	9.08	6.46	5.39	
Stock and Yogo (2005) critical values	10%	15%	20%	25%	
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92	
Summary statistics:					
R-square:	0.0109				
Adj. R-square:	0.0644				
Partial R-square:	0.0469				
Prob > F =	0.0002				
F	(2, 355)				
Over-identifying Restrictions test					
Sargan (score) chi-sq (1)		1.4803	(P=0.2237)		
Basmann chi-sq (1)		1.4416	(P=0.2299)		

Source: Author's computation based on the 2013 World Bank Enterprise Survey for Morocco

Table 16: Finance on aggregate innovation index in Morocco

First stage regression test					
Trade credit					
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 0.27**		
First stage regression test		**Critical values**			
	5%	10%	20%	30%	
2SLS relative bias	13.91	9.08	6.46	5.39	
Stock and Yogo (2005) critical values	10%	15%	20%	25%	
LIML Size of nominal 5% Wald test	6.46	4.36	3.69	3.32	
Summary statistics:					
R-square:	0.0342				
Adj. R-square:	0.0045				
Partial R-square:	0.0017				
Prob > F =	0.7614				
F	(2, 325)				
Over-identifying Restrictions test					
Sargan (score) chi-sq (1)		0.0750	(P=0.7841)		
Basmann chi-sq (1)		0.0726	(P=0.7876)		

Source: Author's computation based on the 2013 World Bank Enterprise Survey for Morocco

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Appendix 1: Table 1–Table 8

Table 1: Instrumental variable 2SLS regression

	Nigeria			South Africa		
Dependent variable	(1) Aggregate innovation	(2) Aggregate innovation	(3) Aggregate innovation	(4) Aggregate innovation	(5) Aggregate innovation	(6) Aggregate innovation
overdraft	1.962*			0.456**		
	(1.84)			(2.24)		
Debt (asset) finance		2.620**			0.201**	
		(2.50)			(2.28)	
Trade credit			1.739**			0.738**
			(2.04)			(2.03)
Age	0.010*	0.016**	0.023***			
	(1.91)	(2.59)	(5.53)			
Size (small firms)	0.131*	-0.015	0.409**			
	(2.25)	(-0.08)	(2.81)			
Size (medium firms)	0.385***	0.443*	0.972***	0.713***	0.684***	0.735***
	(4.81)	(1.75)	(5.20)	(9.84)	(5.95)	(10.19)
Size (large firms)	0.946**	1.356***	2.084***	1.109***	1.116***	1.227***
	(3.27)	(3.76)	(7.42)	(11.54)	(9.61)	(14.34)
Top manager experience	-0.006	-0.012*	-0.025***	0.005*	0.009**	0.007**
	(-1.31)	(-1.57)	(-3.61)	(1.87)	(2.51)	(2.46)
Regions (controlled)	Yes	Yes	Yes			
Foreign ownership	0.052	-1.172	-0.209	0.189*	0.341**	0.189*
	(0.49)	(-1.75)	(-0.71)	(2.23)	(2.99)	(2.16)
Export	0.002	-1.044*	-0.047	0.550***	0.610***	0.491***
	(0.02)	(-1.90)	(-0.34)	(7.26)	(7.16)	(4.63)
Industry (controlled)	Yes	Yes	Yes	Yes	Yes	Yes
	(0.89)	(0.44)	(3.14)	(-2.00)	(-1.35)	(-0.67)
Constant	-0.034	0.280	-0.868	1.537***	1.624***	0.752
	(-0.20)	(0.93)	(-1.75)	(14.32)	(14.06)	(1.54)
No. of observation	652	1257	2012	933	405	935
Wald chi-sq	133	165.8	400.6	866.7	367.5	720.5
Prob > Chi-sq	0.000	0.000	0.000	0.000	0.000	0.000

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Instrumental variable 2SLS regression

	Cameroon			Kenya			Morocco	
Dependent variable	(1) Aggregate innovation	(2) Aggregate innovation	(3) Aggregate innovation	(4) Aggregate innovation	(5) Aggregate innovation	(6) Aggregate innovation	(7) Aggregate innovation	(8) Aggregate innovation
Overdraft	1.513***			1.260*			1.077**	
	(5.93)			(2.11)			(2.37)	
Debt (asset fin)		0.534*			1.157**			
		(2.28)			(2.21)			
Trade credit			1.327**			0.819		-3.268
			(2.79)			(1.32)		(-1.01)
age		0.000	0.009	0.002	-0.003	0.005	-0.004	-0.017
		(0.05)	(1.30)	(0.75)	(-0.34)	(1.61)	(-1.06)	(-0.88)
Size_2	0.121	0.288		0.289**	-0.0584	0.395**	0.0647	0.540
	(0.97)	(1.55)		(2.81)	(-0.24)	(3.19)	(0.49)	(1.23)
Size_3	0.586***	0.378		0.610***	0.493*	0.671***	0.566***	0.993*
	(3.61)	(1.57)		(5.79)	(1.70)	(4.89)	(3.65)	(2.01)
Top manager experience	0.009	0.003	0.011	-0.001	0.005	-0.001	0.002	0.025
	(1.49)	(0.32)	(1.25)	(-0.18)	(0.52)	(-0.24)	(0.28)	(0.86)
Industry (controlled)	Yes	No	Yes	Yes	Yes	Yes	0.005**	0.007
Export	0.410**	0.102	0.273	0.236	-0.138	0.322**	0.264	0.047
	(2.32)	(0.53)	(0.92)	(1.52)	(-0.47)	(2.44)	(1.79)	(0.13)
Foreign ownership	0.075	0.681***	0.323	0.382***	0.525*	0.482***	0.514***	0.219
	(0.45)	(3.47)	(1.08)	(3.27)	(1.68)	(3.26)	(3.16)	(0.41)
Regions	No	Yes	Yes	No	Yes	Yes	No	No
Market participation							0.079	-0.397
							(0.50)	(-0.62)
_cons	-0.083	0.577**	-0.155	1.314***	0.480	0.960**	1.395***	3.278**
	(-0.43)	(2.00)	(-0.36)	(6.46)	(0.54)	(2.52)	(4.06)	(2.60)
No of observation	356	160	349	696	320	684	366	336
Wald chi-sq	195.5	51.2	40.0	160.3	22.3	135	63.3	12.6
Prob > chi-sq	0.000	0.000	0.000	0.000	0.035	0.000	0.000	0.180

t statistics in parentheses $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Table 3: Test of overidentifying restrictions

Country	**score chi-sq**	**P - value**
Nigeria	score chi-sq (1) = 0.0603	P = 0.8060
South Africa	score chi-sq (1) = 3.3698	P = 0.0664
Cameroon	score chi-sq (1) = 0.7021	P = 0.4021
Kenya	score chi-sq (1) = 1.2873	P = 0.02566
Morocco	score chi-sq (1) = 2.9077	P = 0.0882

Source: Author's computation based on the World Bank Enterprises survey data from 2007 to 2014.

Table 4: Summary statistics for Nigeria

Variable	observation	Mean	Std. Dev.	Min	Max
Aggregate innovation	2649	0.919	1.102	0.008	4.235
Trade credit	2396	0.401	0.717	0	2
Asset finance	1523	0.424	1.004	0	2
Overdraft	846	0.045	0.207	0	1
age	2335	15.600	11.665	0	116
size	2676	1.327	0.801	1	3
top manager experience	2503	12.717	9.080	0	72
Regions	2676	9.612	5.300	1	19
foreign ownership	2482	0.135	0.342	0	1
export	2676	0.185	0.400	0	1
industry	2676	37.418	16.098	15	72

Source: Author's compilation based on the 2014 World Bank Enterprise Survey for Nigeria

Table 5: Summary statistics for South Africa

Variable	observation	Mean	Std. Dev.	Min	Max
Aggregate innovation	1057	2.256	1.182	0.006	4.197
Trade credit	1057	1.202	0.701	0	2
Overdraft	1057	0.526	0.501	0	1
Asset finance	448	0.704	0.818	0	2
size	937	1.809	0.757	1	3
top manager experience	1055	13.751	10.69	1	61
foreign ownership	1057	0.13	0.336	0	1
export	1057	0.171	0.378	0	1
number of competitors	650	3.323	0.876	1	4
industry	1057	28.809	18.681	2	72
Main market share	935	10.182	11.389	0	100

Source: Author's compilation based on the 2007 World Bank Enterprise Survey for South Africa

Table 6: Summary statistics for Cameroon

Variable	observation	Mean	Std. Dev.	Min	Max
Aggregate innovation	363	1.420	1.00	0.022	3.331
Trade credit	361	0.700	0.831	0	2.
0verdraft	359	0.565	0.496	0	1
Asset finance	169	1.219	1.352	0	4
age	354	18.102	13.636	0	79
size	363	1.818	0.762	1	3
top manager experience	360	17.081	9.617	1	50
region	363	1.523	0.69	1	3
export	363	0.105	0.307	0	1
foreign ownership	363	0.182	0.386	0	1
industry	363	40.846	20.145	2	72

Source: Author's compilation based on the 2009 World Bank Enterprise Survey for Cameroon

Table 7: Summary statistics for Kenya

Variable	observation	Mean	Std. Dev.	Min	Max
Aggregate innovation	781	2.395	1.083	0.013	4.181
Trade credit	739	0.629	0.814	0	2
Overdraft	749	0.362	0.481	0	1
Asset finance	338	1.509	1.391	0	4
age	742	22.791	17.7191	1	107
size	781	1.809	0.811	1	3
top manager experience	761	18.359	10.861	1	57
industry	781	36.302	16.137	15	72
export	781	0.261	0.44	0	1
foreign ownership	768	0.117	0.322	0	1
region	781	3.306	1.206	1	5

Source: Author's compilation based on the 2013 World Bank Enterprise Survey for Kenya

Table 8: Summary statistics for Morocco

Variable	observation	Mean	Std. Dev.	Min	Max
Aggregate innovation	407	2.699	1.004	0.035	4.803
Trade credit	353	0.430	0.721	0	2
Overdraft	397	0.728	0.446	0	1
age	391	22.461	16.548	1	89
size	407	1.803	0.782	1	3
top manager experience	396	23.091	10.891	3	64
export	407	0.197	0.398	0	1
industry	407	52.916	29.323	15	99
foreign ownership	398	0.139	0.346	0	1
main market	404	0.568	0.388	0	1

Source: Author's compilation based on the 2013 World Bank Enterprise Survey for Morocco

CHAPTER 4
THE ROLE OF FINANCE IN PRODUCT AND PROCESS INNOVATION IN AFRICAN ENTERPRISES[2]

4.1 INTRODUCTION

This chapter examines whether access to finance enhances firm innovation in Africa. Innovation remains an important channel through which enterprises increase their productivity. However, African firms are ranked far behind other countries in terms of innovation (African Development Bank, 2008). African countries are ranked far behind in the world innovation index, at between 49 and 141 for the period 2009 to 2015, out of 141 countries – with most of the African countries at the bottom of the ranking (Global Innovation Index, 2015). For enterprises to carry out significant product and process innovation they require access to finance, which is a huge constraint on small and medium size firms (Beck and Demirgüç-Kunt, 2006). Access to finance is a major problem facing African enterprises (African Development Bank, 2011: 82). This prompts the question: would an increase in access to finance lead to more innovation within African enterprises?

According to the definition of innovation from the OSLO Manual (2005), innovation is broadly defined to include imitations, improvement in production processes, technologies, adaptation and knowledge transfer. Innovation is often classified into product and process innovation. Incidentally this is in line with Schumpeter's (1942) classification of innovation. Innovation can seldom occur on its own without some financial input. Thus, access to finance is critical to the process of innovation. Few studies (Adeboye, 1997; Mahemba and De Bruijn, 2003; Chipika and Wilson, 2006) have been conducted on innovation within firms in Africa (these related to manufacturing, models of innovation etc.) but a critical and yet less discussed issue is the role of finance in product and process innovation.

Available literature shows that financially constrained firms find it difficult to innovate or expand and are therefore hardly able to engage in innovative pathways (Beck and Demirgüç-Kunt, 2012). This is further buttressed by Demirgüç-Kunt and Klapper (2012), who confirm that the ability of African firms to innovate is severely constrained by the lack of access to finance. Against this background, the objective of this chapter was to examine the role of finance in product and process innovation. Data on 3,348 firms

[2] This paper has benefitted from earlier comments at the Economic Society of Southern Africa Conference and the Global Development Finance Conference in 2014 and 2016 respectively. It is currently under peer review at an international Journal

across five countries in Africa was employed. The 2SLS technique was employed to control for possible endogeneity between finance and innovation.

This paper is novel in a number of ways. First, the researcher computes and uses decomposed innovation indexes with a more recent classification of innovation (product and process innovation), unlike previous studies that use R&D expenditure which has been heavily criticised in literature (Beveren and Vandenbussche, 2010). Second, the researcher also controlled for possible endogeneity between finance and innovative companies. This is a critical issue which is mostly absent in studies that examine the finance-innovation link. Failure to control for endogeneity calls into question findings on the finance-innovation link. Furthermore, an African context is added to the literature on finance and innovation.

The rest of the paper is organised as follows: Section 2 discusses the literature review; Section 3 outlines the methodology comprising data source, index construction and post-estimation techniques; Section 4 presents the results and the discussion of the results, while Section 5 concludes and provides policy recommendations.

4.2 OVERVIEW OF RELATED LITERATURE

Innovation is an idea, practice or object perceived as new. It can also be an impulse to do something new or bring some social change (Rogers, 2003). Innovation is crucial to the continuing success of an organisation. Large firms have been aware of this as seen in the rise of in-house corporate research and development (R&D) since the twentieth century, to the extent that the literature now distinguishes ‘Mark I’ model of innovation from ‘Mark II’ model in which innovation was conceived of as a more continuous process within large firms (Phillips, 1971). The Mark I model is related with Schumpeter’s (1934) works initially published in 1911, and his Mark II model (Schumpeter, 1942). This adjustment of Schumpeter’s thinking towards the role of large often oligopolistic firms as the key agents for innovation could be thought to reinforce the conventional interpretation of his earlier theory of innovative profits, especially as these large enterprises do exercise market power. This has become known as the 'Schumpeterian hypothesis’ which postulates that the link runs from market power to innovation as a result of resources being extended from market power position (profits) into innovative activities. This Mark II model reiterated Schumpeter’s view of the distinctiveness of profits from innovation as opposed to market power, although without working through the implications of endogenous innovation in large firms for his theory. Empirical research has cast doubt upon the so-called association between market power, firm size and innovation, and suggests that smaller firms may be highly innovative as well, especially through their interactions with large firms in the same industry (Audretsch, 1995). Due to the important role SMEs play for economic and technological development, innovation in the context of smaller firms has received much interest in literature (Acs and Audretsch, 1990). It should be noted that

most of Africa's enterprises are SMEs. Although SMEs typically face considerable resource constraints, they are often successful innovators (Rammer et al, 2009).

SMEs are nimbler than their larger counterparts, so can move faster and, hence obtain monopoly rents for a longer period. The introduction of innovative products, services, processes, or business models tailored to attractive niches is an additional opportunity for SMEs to stand out from competition (Porter, 1980). This will enable them get the funds necessary for further innovation.

Schumpeter (1934) recognised the relationship between finance and innovation by hypothesising that the innovative outcome of an economy is connected with the functioning of its credit and capital markets. Schumpeter (1934, 1942 and 1950) further noticed that the cost of engaging in innovative activities such as types of product and process innovation mentioned above, is too high for most firms and as such is often the prerogative of large enterprises. This means that if firms cannot meet this huge cost from their internal reserves, they are bound to seek funds externally if they wish to pursue innovation. This makes it normal for enterprises to source their funding following a hierarchical order. Hence, enterprises with internal funds probably start by drawing on their internal finances to carry out innovation before turning to external sources of funds – debt and equity (Donaldson, 1961). A key concern however, is the fact that access to finance remains a major constraint for African enterprises (Beck and Cull 2014). Access to external finance can ease capital accumulation and therefore encourage innovation. If this is true, then enterprises can raise funds for innovation either internally or externally through equity (Brown *et al.*, 2009).

Availability of finance can enhance firm innovation. Benfratello *et al*. (2008) investigated the effect of local banking development on firms' innovative activities, using a rich data set on innovation for a large number of Italian firms over the 1990s. Evidence showed that banking development affects the probability of process innovation, particularly for firms in high-tech sectors, in sectors more dependent upon external finance, and for firms that are small. The evidence for product innovation is much weaker and not robust. There is also some evidence that banking development reduces the cash flow sensitivity of fixed investment spending, particularly for small firms, and that it increases the probability they will engage in R&D. Apart from local banking development that increases firm innovative activities, general financial development impact technological development and innovation. Testing a model of financial development and technological progress, Goldman and Peres (2015) showed that knowledge about technologies and technological knowledge are mutually reinforcing. That is, entrepreneurs innovate more when financiers are better informed about their projects because they expect to receive more funding should their projects be successful. Conversely, financiers collect more information about projects when entrepreneurs innovate more because the opportunity cost of misinvesting, i.e. of allocating capital to unsuccessful projects and missing out on successful ones, is larger. They stated

that the beneficial impact is permanent in some cases leading to unbounded income growth, but only transitory in others. Local banking improvement and financial development exposed enterprises to different types of finance with impact on innovation. Atanassov, Nanda and Seru (2005), using a panel of US companies from 1974–2000, found that innovative firms used arm's length financing such as public debt and equity; while less innovative firms relied on relationship-based borrowing such as bank debt.

The capital structure of a firm affects innovation. Acs and Isberg (1991: 324) provide empirical evidence that capital structure is an important determinant of (technological change) innovation while Blass and Yosha (2003) concluded in their study that during the 1990s, publicly traded innovation-intensive manufacturing firms in Israel depended on equity. This is further reiterated by Carpenter and Petersen (2002) who examined an unbalanced panel of over 2,400 publicly traded US high-tech companies during the period 1981–98, and found that new equity financing appears to be very important for the rapid growth of young high-technology firms. Similarly, Brown *et al*. (2009) examined a panel level data for 1,347 publicly traded, high-tech firms in USA from 1990–2004 and evidence point to the fact that access to both internal and equity finance have significant positive effects on firm innovation and productivity.

There is growing consensus that well-functioning financial markets play a key role in driving economic growth through their ability to drive technological innovation (King and Levine, 1993a, 1993b; Comin and Nanda, 2014). One of the ways that financial markets are believed to play this role is by allocating capital to firms with the greatest potential to implement new processes and to commercialize new technologies. The funding of promising projects by capital markets dates back to Schumpeter's (1942) notion of "creative destruction" and has been examined in a number of studies over the last decades in the context of financing constraints for entrepreneurs (Scherer, 1984; Beck *et al*., 2008). A later study by Hall and Lerner (2010) showed that financial markets can impact technological development and innovation through direct financing of innovation activities.

The increasing literature on the financing of innovation has advanced over the years with a focus on some key subjects. According to Kerr and Naranda (2014) financing constraints have the possibility of being considered in the context of firms engaged in R&D and innovation—with the ability to shape both the rate and the trajectory of innovation. Kerr and Naranda (2014) noted the fact that capital structure plays a key role in the outcome of innovations with Bank finance being an important source of finance, particularly for larger firms with tangible and intangible assets to pledge as collateral. According to Hall (2002) the capital structure of highly innovative enterprises often exhibits less leverage relative to those of other enterprises whereas Audretsch (1995) examined the impact of availability of funds on company performance and found that availability of funds through company profitability influences subsequent innovative activities. Kerr and Naranda (2014) further acknowledged that public markets provide deep

pockets but pose a set of agency costs that might be particularly harmful for firms engaged in exploration and novel innovations.

The rapidly expanding literature on finance and innovation is sometimes being examined from the perspective of financing constrains. Innovative firms get a high fraction of the available finance, but they might suffer from bank credit constraints. According to Planesa *et al*. (2016) who analysed survey data conducted by SESSI for the manufacturing industry and by INSEE for services in France supplemented with accounting and financial information from the Central Balance Sheet Office (CBSO) of the Banque de France while measures of company risk were obtained from the Banque de France's legal incidents database; they found out that innovative firms are adverse to this type of financing. A similar study on financial constraint and innovation started by noting that domestically owned firms fall behind the technological frontier often represented by foreign owned firms. According to Gorodnichenko and Schintner (2013) who conjectured that this gap in productivity and innovation may be due to more several financial constraints faced by domestically owned firms; their findings actually supported the conjecture that domestically owned firms are strongly hampered in their innovation and export activities by difficult and costly access to external finance. The fast-growing literature on the financing of innovation has made prominent improvements in recent years. The literature has focused on some cardinal themes. According to Kerr and Naranda (2014) financing constraints have the possibility to be considered in the context of firms engaged in R&D and innovation—with the ability to shape both the rate and the trajectory of innovation.

Another area of concern is the debate on whether stock liquidity enhances or impedes firm innovation. This topic is of interest because innovation is crucial for firm-level and national-level competitiveness and stock liquidity can be altered by financial market regulations. The question of whether stock liquidity enhances or impedes investment in innovation has been difficult to test due primarily to simultaneity between stock liquidity and innovation. In other words, liquidity may affect innovation but innovation could also affect liquidity (Fang *et al*., 2014). It is imperative for any further study including this research to be able to cater for possible simultaneity between finance and innovation. Given the mixed empirical findings underscored above, some studies show a positive relationship between finance and innovation while there is also evidence of a negative relationship between innovation and finance this study will examine the link between finance and innovation.

4.3 METHODOLOGY

4.3.1 Data source

This chapter makes use of data from the World Bank Enterprise Survey (WBES) with information on innovations and sources of finance from selected firms across African countries. The survey sample is

from registered businesses in each country and follows a stratified random sampling methodology. The core survey uses standardized survey instruments to benchmark the investment climate of individual economies across the world and to analyse firm performance. It probes information relating to firm innovation by asking questions such as: does your firm own a website? Do you use email to communicate with clients? Does your company make use of foreign technology? Is your firm in possession of an international quality certification? Are your accounts audited by an independent auditor? This data also brings out information about firms' access to finance by asking simple questions, for example does your company have access to credit, overdraft facility or loan? Can you access trade credit?

This chapter considers cross-sectional data for both manufacturing and service firms from five countries, representing all the regional blocks in Africa, for the period 2007 to 2014. The choice of countries was primarily influenced by data availability and regional balance. The chosen countries were Cameroon (383 firms), Kenya (781 firms), Morocco (407 firms), Ghana (720 firms) and South Africa (1057 firms); representing Central African, East Africa, North Africa, West Africa and Southern Africa respectively.

We follow the OSLO Manual (2005) and World Bank classification and use the WBES dataset which provides proxy measures for innovation captured in the innovation literature. The following table highlights the proxy variables used.

Table 4.1: Product and process innovation variables

No	Product	Process
1	Introduction of a new or significantly improved product within 3 years to survey	Website – enterprise owns a website
2	International quality certification	Email – uses email to communicate with clients
3	Foreign technology license	Audited financial statements

Source: World Bank Enterprise Survey database (2015)

4.3.2 Construction of innovation index

The identified innovation variables (as indicated in Table 3.1) were divided into two groups to create two indexes – a product innovation index and a process innovation index. In constructing the innovation index, this paper used the multiple correspondent analysis (MCA). The MCA is good at analyzing categorical variables and the innovation variable questions, make it appropriate for this study. Furthermore, the MCA assigns weight according to the significance of the variables in the innovation index. Following Benzicri (1973), Van Kerm (1998) and Booysen et al. (2008), the MCA innovation index is given generally as:

$$a_i = \sum_{k=1}^{k} F_{1k}\, d_{ki}$$

The *i*th firm innovation index is α_i, d_{ki} is the *k*th value of the categorical variables (with k=1…K) indicating the firms' innovation variables included in the index construction. F_{1k} is the MCA weights generated for the analysis.

4.3.2.1 A priori expectation of the index

At the creation of the innovation index there should not be any reverse variable. In the construction of the index the alpha command was used to detect any reverse variables. If any reverse variable was detected it was dropped. This is because reverse variables have a negative impact on the index. All the indices met the a priori expectation (Booysen *et al*., 2008).

4.4 SUMMARY STATISTICS ON INNOVATION INDEX

Table 4.2: Summary statistics on innovation indexes

Country	Scale of reliability		Dimension 1 percentage		Mean of index		Std Dev of index	
	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation
Cameroon	0.61	0.58	100	92	0.7	1.5	1.1	1
Ghana	0.3	0.64	100	99	0.5	1.4	1.2	1
Kenya	0.5	0.33	100	97	0.8	2.5	1.1	1
Morocco	0.25	0.3	100	94	0.8	4.7	1.1	1
South Africa	0.5	0.7	100	98	1	1.7	1	1

Source: Author's computation based on the WBES database 2015. Std Dev of index = Standard deviation of index

In Table 4.2, the scale of reliability ranges from 0.5 to 0.7 with the exception of product innovation index for Morocco and Ghana, and process innovation index for Morocco and Kenya. The low scale reliability of product innovation index for Morocco and Ghana is due to low response on product innovation. Similarly, the low reliability scale of process innovation for Morocco and Kenya is also a result of low responses on process innovation in these countries. The dimension 1 percentages are very high with 100% for the entire product innovation index. The trends in the mean innovation index indicate that South Africa has the highest product innovation index (1) followed by Kenya (0.8) and Morocco (0.8), while Morocco has the highest process innovation index of 4.7 followed by Kenya with a mean process index of 2.5.

4.5 EMPIRICAL STRATEGY

To examine the role of finance in innovation, we estimated the following model:

$$I_{Innovation} = \beta_1 + \beta_2 Fin + \beta_3 X + \mu_t \quad \ldots (1)$$

Where:

$I_{Innovation}$ = *process or product innovation index.*

Fin, represents the finance variables

X, represents the control variables

μ_t, represents the error term

Fin represents the finance variables. Debt finance was used which consists of asset finance and overdraft. Asset finance is measured as loans taken for financing of assets, both current and non-current assets, and overdraft measured by the establishment's overdraft facility. The *a priori* expectation is that an increased access to finance should lead to an increase in innovation. X is a vector of control variables and include: age of firm, measured as age in years; size of firm captured as a categorical variable with '1' for small enterprises employing between 5 and 19 persons, '2' for medium enterprises having between 20 and 99 employees, and '3' for large enterprises employing 100 persons and more. Top manager's experience measured in terms of the number of years of work experience of the most senior management officer; internationalisation or export orientation, captured as '1' if the firm is involved in the export market or '0' otherwise. These were also controlled for location, industry, and market participation (whether a firm participates in the main market for its product or not).

4.6 ESTIMATION TECHNIQUE

The instrumental variable model is used when it is suspected that there could be problem of endogeneity in the regression equation. The OLS is the most widely used method (Greene, 2003) but is not consistent and cannot solve the problem of endogeneity nor omitted variable bias. The instrumental variable two stage least square has been considered because it is good with cross sectional data that possibly have endogeneity problem. The IV model takes care of unobservable factors in the equation, and also takes care of the problem of measurement error in the regressor (Baum, (2008; Wooldridge 2002). The IV model does so in two stages by (1) ensuring that the identified instrument correlates with the explanatory variable but not with the error term in the first stage. In the second stage, the instrument should correlate with the dependent (innovation index) variable. It then proceeds to examine the strength of the instruments and specification of the equation (Baum *et al*., (2006)

In order to control for possible endogeneity bias between finance and innovation an Instrumental Variable (IV) model was used. The IV model requires an observed variable that is (1) strongly correlated with access to finance; but (2) uncorrelated with the error term. The assumptions of the IV model referred to as ''exclusion restriction' by Khandker *et al*. (2010: 88) are summarized as:

Correlated with innovation index: *cov* (Z, *finance*) $\neq 0$

Uncorrelated with the error term (ε): *cov* (Z,ε) = 0

where Z is the chosen instrument.

The instrument (Z) in the first stage of the regression will have to be correlated with the finance (explanatory) variable but uncorrelated with the error term. In the second stage of the regression, this instrument should correlate with the innovation index (dependent variable). A number of potential instruments were preselected and went through the first stage of the regression. These instruments differ from country to country and range from collateral, land/building, having a cheque or savings accounts, application for a loan/line of credit, status of enterprise, paid security, audited financial statement, securing a government contract, to operating license.

An instrument must be correlated with the explanatory variable but not with the error term. To test for validity of (instruments) there are two tests; the first is the Stock and Yogo (2005) test, and Cragg and Donald (1993) test. This test helps to ascertain the strength of the instrument(s). The Cragg-Donald F-statistic is computed and this value compared with Stock and Yogo critical value. There are two options here: to choose the maximum test criterion or the maximum relative bias. The instruments are strong when the Cragg-Donald F-statistic is higher than the Stock and Yogo critical value, following the option chosen. In this study both options have been used given that the regressions are independent and country specific. The second test is The Sargan and Basmann test of overidentifying restriction. This tests the strength of the surplus instrument, in a situation where the model is overidentified. However, when the model is exactly identified, this test is not needed. Hence the need to test that the instruments (a) correlates with the explanatory variable and (b) does not correlate with the error term, for all the regressions.

In South Africa, the chosen instruments are application for a loan or line of credit, collateral for asset finance. Similarly, for overdraft, we have as IVs collateral, overdraft interest rate, type of financial institution, percentage of bribe paid to public officials, (where the banks assess that the percentage paid is minimal or negligible, the bank is more likely to engage with the enterprise), and security paid for or paid security. Establishments that are secured or have catered for that by paying for security, are more likely to be considered by banks for transactions. The reason for these instruments is that they correlate with asset finance and overdraft but not with innovation.

Similarly, in Cameroon, the instruments selected are the percentage of total annual sale paid for informal payments, and security paid. These correlate with asset finance but have no direct influence on innovation. Likewise, fixed assets, cheque or savings accounts, and application for a loan or line of credit are correlated with overdraft but not with innovation.

In Ghana, the operating license, status of enterprise, and paid security are used as instruments for asset finance. These were chosen because they correlate with asset finance and not with innovation. Also, secured government contracts, paid security, establishment inspected by tax officials, and possession of an operating license, are correlated with overdraft in Ghana but not with innovation.

The instruments for Morocco include ownership of a cheque or savings account, application for a loan or line of credit, collateral and status (sole proprietorship, private or public Limited Corporation) of the enterprise, which are important for banks when considering whether to extend a loan or overdraft. These were used because they correlated with overdraft but not with innovation.

Finally for Kenya: an operating license (a legal requirement permitting an enterprise to operate within a country or region) was a prerequisite for the bank to engage with an establishment, application for a loan or line of credit; paid security and audited financial statement by external auditors were used as instruments. These correlated with asset finance and had no direct influence on innovation. Similarly, land/building, firm status, year establishment began operations, audited financial statement by independent auditors and type of financial institution, correlated with overdraft but had no direct influence on innovation.

The first stage regression is an ordinary least square regression (OLS) model, with the selected instruments, Z_i, as additional independent variables. Following Janzen and Carter (2013) and Khandker *et al*. (2010) our first stage regression is given as:

$$finance_i = yZ_i + \emptyset X_i + \mu_i \quad \ldots (2)$$

Where access to finance can be obtained from overdraft, and debt (asset) finance, Z_i is the selected instruments, xi is a vector of covariates which affect a firm's access to finance decision and li is the error term.

In the second stage, the predicted demand of access to finance ($\widehat{finance}_i$) is substituted in Eqn. (1) to obtain the outcome equation.

$$I_{Innovation} = \propto X_i + \beta finance_i + \varepsilon_i \quad \ldots (3)$$

$$I_{Innovation} = \propto X_i + \beta(\gamma Z_i + \widehat{\emptyset} X_i + \mu_i) + \varepsilon_i \quad \ldots(4)$$

Where $\gamma Z_i + \widehat{\emptyset} X_i + \mu_i$ is the prediction of having access to finance. Under instrumental variable the impact of finance on process innovation is $\hat{\beta}_{iv}$.

The error term is normally distributed with a mean of zero.

4.7 RESULTS AND DISCUSSION

This section presents the regression output and discusses the results.

4.7.1 Discussion of results

Tables 4.3 and 4.4 show the results for the estimation. Table 4.3 shows results for Cameroon, Ghana and Kenya and Table 4.4 contains results for South Africa and Kenya. Asset finance is linked to both product and process innovation in Cameroon, Ghana and Kenya. In South Africa asset finance only drives process innovation. Clearly finance through asset financing as a channel enhances product and process innovation in Kenya, Ghana and Cameroon while it enhances process innovation in South Africa. This finding is in line with the view of Beck (2006) who states that African firms are constrained by lack of finance to carry out innovation. In the case of the second finance variable, overdraft, we notice a positive and significant link to both product and process innovation in Cameroon, Ghana, and South Africa. Overdraft drives process innovation in Kenya, and Morocco. Meaning finance via overdraft drives both product and process innovation in South Africa, Cameroon and Ghana whereas this same channel – overdraft drives process innovation in Kenya and Morocco. These findings are consistent with Ayyagari *et al*., (2012) and observations by IFC (2013) and the Global Innovation Index (2015) on the importance of finance to enterprise innovation. This means an improved financial system enhances innovation and heightens Schumpeter's position (1912) that well developed financial markets will normally lend to innovative (corporate) entrepreneurs. This developed financial system is intricately linked to growth via innovation (Levine, 1997). This positive link also implies that a more open and inclusive financial system will lead to increased industrialisation in the country, as noted by improvements in the competitive industrial performance index in South Africa, Morocco and Senegal between 1995 and 2013 (United Nations, 2014).

With regard to the control variables, this research discusses variables that are consistently significant drivers of corporate innovation across the respective countries. Size is a significant contributor of innovation, that is larger firms are more innovative than small firms. This accords with Schumpeter (1942) who stated that large firms are better positioned to engage in innovative activities.

Export-oriented firms in Cameroon and South Africa are more innovative than non-exporting firms. Foreign owned firms are innovative in Cameroon, Ghana, Morocco and Kenya. Active participation in markets enhances innovation in South Africa and Kenya. The researcher also controlled for location and industry where data was consistently available.

4.8 REGRESSION RESULTS

Table 4.3: Instrumental variables two stage least square regression

	Cameroon				Ghana				Morocco	
	(1) Product innovation	(2) Product innovation	(3) Process innovation	(4) Process innovation	(5) Product innovation	(6) Product innovation	(7) Process innovation	(8) Process innovation	(9) Product innovation	(10) Process innovation
Overdraft	0.789**		1.778***		1.829*		3.226***		0.272	1.732***
	(2.05)		(4.88)		(1.78)		(2.97)		(0.55)	(2.67)
Asset finance		0.556*		0.486*		0.670**		0.762***		
		(1.68)		(1.88)		(2.04)		(3.09)		
Age (in years)	0.002	-0.005	0.005	0.001	-0.001	0.008	-0.011*	0.013	-0.003	-0.005
	(0.41)	(-0.47)	(1.08)	(0.17)	(-0.17)	(1.04)	(-1.24)	(1.45)	(-0.71)	(-1.07)
Size (medium firms)	0.085	0.101	0.066	0.365*	0.124	0.228	0.396**	0.652***	0.148	-0.138
	(0.62)	(0.40)	(0.46)	(1.86)	(0.82)	(0.97)	(2.27)	(3.49)	(1.07)	(-0.84)
Size (large enterprises)	0.447**	2.40	4.13**	0.356	0.062	0.129	0.428	0.511**	0.354**	0.382**
	(2.55)	(0.75)	(2.17)	(1.42)	(0.25)	(0.42)	(1.53)	(2.08)	(2.33)	(2.15)
Top manager experience	0.003	-0.003		0.007	-0.012**	-0.015	0.002	-0.025**	0.000	-0.000
	(0.48)	(-0.30)		(0.74)	(-1.98)	(-1.37)	(0.33)	(-2.98)	(0.09)	(-0.09)
Export Status	0.474**	0.321	0.234	0.016	0.160	0.169	0.003	-0.006	0.200	0.135
	(2.42)	(1.20)	(1.09)	(0.07)	(0.74)	(0.54)	(0.01)	(-0.03)	(1.31)	(0.76)
Main market participation									-0.07	0.194
									(-0.05)	(1.16)
Region (controlled for)	Yes	Yes	No	No	No	No	No	No	No	No
Industry (controlled for)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Foreign ownership	0.514**	0.920***	-0.120	0.470**	0.920***	0.821***	0.692***	0.588***	0.330**	0.439**
	(2.49)	(3.55)	(-0.56)	(2.24)	(6.26)	(3.73)	(4.16)	(3.42)	(2.00)	(2.28)
Constant	-1.141	-0.260	0.619**	0.798***	0.554***	0.092	1.533***	1.421***	0.044	3.423***
	(-0.50)	(-0.77)	(2.26)	(2.92)	(2.97)	(0.28)	(7.26)	(5.59)	(0.11)	(6.55)
No. of observation	344	158	351	160	655	330	666	336	366	366
F-stats	10.33	5.179	11.22	3.753	.	3.344	7.634	4.729	2.293	2.898
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.002

NB: *t* statistics in parentheses, *, **, and *** represents 10%, 5%, and 1% respectively

Table 4.4: Instrumental variables two stage least square regression

	South Africa				Kenya			
	(1) Product innovation	(2) Product innovation	(3) Process innovation	(4) Process innovation	(5) Product innovation	(6) Product innovation	(7) Process innovation	(8) Process innovation
Overdraft	2.252*		0.290***		3.047		2.791***	
	(1.88)		(5.19)		(1.06)		(3.17)	
Asset finance		-0.088		0.239***		0.670*		1.289**
		(-1.17)		(3.07)		(1.85)		(2.06)
Size (medium firms)	-0.082	0.414***	0.659***	0.578***	-0.089	-0.217*	0.226	0.064
	(0.48)	(3.33)	(11.37)	(6.11)	(-0.38)	(-1.15)	(1.54)	(0.22)
Size (large enterprises)	0.192	0.744***	0.948***	0.874***	0.056	0.428**	0.384**	0.256
	(0.62)	(5.32)	(12.46)	(8.20)	(0.17)	(2.17)	(2.34)	(0.88)
Top manager experience	-0.008	0.002	0.006**	0.010***	-0.018*	0.002		0.012
	(-1.18)	(0.12)	(2.48)	(2.84)	(-1.08)	(0.33)		(1.05)
Export	0.065	0.501***	0.414***	0.438***		0.089	-0.227	
	(0.25)	(4.51)	(5.88)	(5.02)		(0.43)	(-1.01)	
Industry (controlled for)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Region (controlled for)	No	No**	No	No	No	No	No	No
Market (participation)	0.008*	0.006*	0.005**	0.005*				
	(1.87)	(1.72)	(2.28)	(1.79)				
Age					0.001	0.002	-0.009*	-0.009
					(0.18)	(0.34)	(-1.97)	(-1.02)
Foreign ownership	0.648***	0.671***			0.298	0.462**	0.174	0.262
	(4.67)	(4.94)			(1.20)	(2.16)	(0.95)	(0.87)
Constant	-0.705	0.815**	0.739***	0.872***	0.710**	-0.044	1.599***	0.605
	(-0.94)	(2.13)	(3.78)	(2.92)	(1.99)	(-0.07)	(7.90)	(0.55)
No. of observation	933	406	931	404	696	320	707	320
F-stats	17.64	22.22	66.89	31.76	3.235	4.131	8.079	1.027
Prob > F	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.415

NB: *t* statistics in parentheses, *, **, and *** represents 10%, 5%, and 1% respectively

4.9 POSTESTIMATION TESTS

After controlling for possible endogeneity using instrumental variables, it was important to test the strength and validity of the instruments used and the structural equation or model as a whole. The test for over-identification was performed to test whether the equation was structurally well specified and also the fitness of the model. To achieve these, the Cragg and Donald (1993) minimum eigenvalue statistics were utilised, together with Stock and Yogo (2005) critical value.

With reference to tables A1 to A18, in the appendix, the strength of the instruments was analysed and the specification of the structural equations. In Cameroon (Tables A1 to A4), the Cragg and Donald (1993) minimum eigenvalue statistics for Tables A1 and A3 are greater than the 'LIML Size of nominal 5% Wald test' critical values of Stock and Yogo (2005) at 10%. Therefore the null hypothesis was rejected and it was concluded that the instruments were strong, although there appeared to be some presence of weak instruments from A2 and A4 (some of the alternate specification). However, the over-identifying restrictions tests of Sargan (1958) and Basmann (1960) showed that the structural equations were well specified. Tables A5 to A8 show the post estimation test for Ghana. The Cragg and Donald (1993) minimum eigenvalue statistics are greater than the 'LIML Size of nominal 5% Wald test' and Stock and Yogo (2005) critical values. The null hypothesis is thus rejected, meaning the instruments were relatively strong. The overidentifying restrictions tests of Sargan (1958) and Basmann (1960) for Tables A5, A6, A7 and A8 also implied the structural equations were well specified. For Morocco Tables A9 to A10 shows the post estimation test. The Cragg and Donald (1993) minimum eigenvalue statistics are greater than the 'LIML Size of nominal 5% Wald test' and critical values of Stock and Yogo (2005). This shows that the instruments are relatively strong. The over-identifying restrictions tests of Sargan (1958) and Basmann (1960) also implied the structural equations were well specified.

In South Africa, the Cragg and Donald (1993) minimum eigenvalue statistics for tables A12, A13 and A14 are greater than the 'LIML Size of nominal 5% Wald test' critical values of Stock and Yogo (2005) at 10%. Therefore the null hypothesis was rejected and it was concluded that the instruments were strong, although there appeared to be some presence of weak instruments from A11, an alternate specification. However, the over-identifying restrictions tests of Sargan (1958) and Basmann (1960) showed that the structural equations were well specified. Finally, in Kenya, the Cragg and Donald (1993) minimum eigenvalue statistics for A17 and the nominal 5% Wald test critical value of Stock and Yogo (2005) show that it is strong, whereas that for Tables A15, A16 and A18 showed the presence of relatively weak instruments. However, the over-identifying restrictions tests of Sargan (1958) and Basmann (1960) showed that the structural equations were well specified. The instrumental variable vce (robust) model was estimated as well to control for any heteroscedasticity and the results do not change. The results are provided in the appendix.

4.10 CONCLUSION

This chapter set out to examine the role of finance in product and process innovation in African enterprises with five regionally selected countries (Cameroon, Ghana, Kenya, Morocco and South Africa). Using the World Bank Enterprise Survey data, it was found that finance enhanced product and process innovation in the respective countries.

The results have some implications for policy. It is imperative for relevant policies to enhance financial sector development, particularly the banking sector, and increase access to finance for enterprises. Policy incentives such as tax breaks can be put in place to encourage banks to increase lending to firms. Furthermore, other financial institutions like microfinance institutions can be supported to increase credit to enterprises and young entrepreneurs. One such support mechanism could be specialised schemes like a credit guarantee scheme to encourage and secure lending to enterprises in order to engineer innovation.

Tables A1–A18

The following tables A1 – A18 represent post estimation tests with instrumental variable model

Table A1: Finance on product innovation in Cameroon

First stage regression test					
Overdraft					
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 16.0**		
		Critical values			
Stock and Yogo (2005) critical values	10%	15%	20%	25%	
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92	
Summary statistics:					
R-square:	0.2140				
Adj. R-square:	0.1928				
Partial R-square:	0.0875				
Prob > F =	0.0000				
F	(3, 334)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.0219	(P=0.8824)
Basmann chi-sq (1)	0.0212	(P=0.8841)

Source: Author's computation based on the 2009 World Bank Enterprise Survey for Cameroon

Table A2: Finance on product innovation in Cameroon

First stage regression test					
Asset finance					
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 4.1**		
		Critical values			
Stock and Yogo (2005) critical values	10%	15%	20%	25%	
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92	
Summary statistics:					
R-square:	0.0945				
Adj. R-square:	0.0459				
Partial R-square:	0.0519				
Prob > F =	0.0000				
F	(2, 149)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.0056	(P=0.9400)
Basmann chi-sq (1)	0.0053	(P=0.9418)

Source: Author's computation based on the 2009 World Bank enterprise survey data for Cameroon

Table A3: Finance on process innovation Cameroon

First stage regression test				
Overdraft				
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 15.1**	
First stage regression test		**Critical values**		
	5%	10%	20%	30%
2SLS relative bias	13.91	9.08	6.46	5.39
Stock and Yogo (2005) critical values	10%	15%	20%	25%
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92
Summary statistics:				
R-square: 0.2168				
Adj. R-square: 0.1961				
Partial R-square: 0.1174				
Prob > F = 0.0000				
F (3, 341)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	1.4104	(P=0.4940)
Basmann chi-sq (1)	1.3757	(P=0.5027)

Source: Author's computation based on the 2009 World Bank enterprise survey data for Cameroon

Table A4: Finance on process innovation in Cameroon

First stage regression test				
Asset finance				
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 3.16**	
		Critical values		
Stock and Yogo (2005) critical values	10%	15%	20%	25%
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92
Summary statistics:				
R-square: 0.1218				
Adj. R-square: 0.0587				
Partial R-square: 0.0436				
Prob > F = 0.0451				
F (2, 139)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.3303	(P=0.5655)
Basmann chi-sq (1)	0.3067	(P=0.5797)

Source: Author's computation based on the 2009 World Bank enterprise survey data for Cameroon

Table A5: Finance on product innovation in Ghana

First stage regression test					
Overdraft					
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 5.0**		
		Critical values			
Stock and Yogo (2005) critical values	10%	15%	20%	25%	
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92	
Summary statistics:					
R-square:	0.1325				
Adj. R-square:	0.1171				
Partial R-square:	0.0194				
Prob > F =	0.0073				
F	(2, 504)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	1.8482	(P=0.1740)
Basmann chi-sq (1)	1.8188	(P=0.1775)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Ghana

Table A6: Finance on product innovation in Ghana

First stage regression test					
Asset finance					
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 6.01**		
		Critical values			
Stock and Yogo (2005) critical values	10%	15%	20%	25%	
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92	
Summary statistics:					
R-square:	0.0761				
Adj. R-square:	0.0531				
Partial R-square:	0.0325				
Prob > F =	0.0027				
F	(2, 231)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.9598	(P=0.3272)
Basmann chi-sq (1)	0.9363	(P=0.3332)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Ghana

Table A7: Finance on process innovation in Ghana

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 5.33**	
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.1317				
Adj. R-square:	0.1165				
Partial R-square:	0.0204				
Prob > F =	0.0051				
F	(2, 512)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.3721	(P=0.5319)
Basmann chi-sq (1)	0.3652	(P=0.5456)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Ghana

Table A8: Finance on process innovation in Ghana

First stage regression test					
Asset finance					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 6.34**	
First stage regression test			**Critical values**		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0775				
Adj. R-square:	0.00549				
Partial R-square:	0.0373				
Prob > F =	0.0020				
F	(2, 327)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.0976	(P=0.7548)
Basmann chi-sq (1)	0.0949	(P=0.7579)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Ghana

Table A9: Finance on product innovation in Morocco

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 5.9**	
First stage regression test			**Critical values**		
		5%	10%	20%	30%
2SLS relative bias		16.85	10.27	6.71	5.34
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.1664				
Adj. R-square:		0.1128			
Partial R-square:		0.1211			
Prob > F =		0.0002			
F		(4, 171)			

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.9695	(P=0.7866)
Basmann chi-sq (1)	0.9975	(P=0.8020)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Morocco

Table A10: Finance on process innovation in Morocco

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 8.56**	
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0791				
Adj. R-square:		0.0559			
Partial R-square:		0.0459			
Prob > F =		0.0000			
F		(2, 356)			

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.3296	(P=0.5659)
Basmann chi-sq (1)	0.3209	(P=0.5711)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Morocco

Table A11: Finance on product innovation in South Africa

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 2.64**	
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
2SLS Size of nominal 5% Wald test		19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.1153				
Adj. R-square:		0.1076			
Partial R-square:		0.0057			
Prob > F =		0.0718			
F		(2, 924)			

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.1819	(P=0.6697)
Basmann chi-sq (1)	0.1802	(P=0.6712)

Source: Author's computation based on the 2007 World Bank enterprise survey data for South Africa

Table A12: Finance on product innovation in South Africa

First stage regression test					
Asset finance					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 58.3**	
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.2676				
Adj. R-square:		0.2510			
Partial R-square:		0.2273			
Prob > F =		0.0000			
F		(2, 396)			

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.6486	(P=0.4206)
Basmann chi-sq (1)	0.6336	(P=0.4260)

Source: Author's computation based on the 2007 World Bank enterprise survey data for South Africa

Table A13: Finance on process innovation in South Africa

First stage regression test				
Overdraft				
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**stats = 3014.01**	
First stage regression test		**Critical values**		
	5%	10%	20%	30%
2SLS relative bias	13.91	9.08	6.46	5.39
Stock and Yogo (2005) critical values	10%	15%	20%	25%
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92
Summary statistics:				
R-square: 0.9177				
Adj. R-square: 0.9167				
Partial R-square: 0.9076				
Prob > F = 0.0000				
F (3, 921)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	3.4606	(P=0.1772)
Basmann chi-sq (1)	3.4362	(P=0.1794)

Source: Author's computation based on the 2007 World Bank enterprise survey data for South Africa

Table A14: Finance on process innovation in South Africa

First stage regression test				
Asset finance				
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 63.0**	
First stage regression test		**Critical values**		
	5%	10%	20%	30%
2SLS relative bias	13.91	9.08	6.46	5.39
Stock and Yogo (2005) critical values	10%	15%	20%	25%
LIML Size of nominal 5% Wald test	6.46	4.36	3.69	3.32
Summary statistics:				
R-square: 0.3330				
Adj. R-square: 0.3194				
Partial R-square: 0.3235				
Prob > F = 0.0000				
F (3, 395)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	1.1289	(P=0.5686)
Basmann chi-sq (1)	1.1069	(P=0.5750)

Source: Author's computation based on the 2007 World Bank enterprise survey data for South Africa

Table A15: Finance on product innovation in Kenya

First stage regression test				
Overdraft				
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 2.63**	
First stage regression test		**Critical values**		
	5%	10%	20%	30%
2SLS relative bias	13.91	9.08	6.46	5.39
Stock and Yogo (2005) critical values	10%	15%	20%	25%
LIML Size of nominal 5% Wald test	6.46	4.36	3.69	3.32
Summary statistics:				
R-square: 0.1538				
Adj. R-square: 0.1009				
Partial R-square: 0.0476				
Prob > F = 0.0520				
F (3, 166)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	1.0251	(P=0.5990)
Basmann chi-sq (1)	0.9649	(P=0.6173)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Kenya

Table A16: Finance on product innovation in Kenya

First stage regression test				
Asset finance				
Cragg and Donald (1993)	**Minimum**	**eigenvalue**	**statistics = 2.4**	
		Critical values		
Stock and Yogo (2005) critical values	10%	15%	20%	25%
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92
Summary statistics:				
R-square: 0.0501				
Adj. R-square: 0.0156				
Partial R-square: 0.0170				
Prob > F = 0.0932				
F (2, 276)				

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.0168	(P=0.8966)
Basmann chi-sq (1)	0.0162	(P=0.8986)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Kenya

Table A17: Finance on process innovation in Kenya

First stage regression test					
Overdraft					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 8.02**	
First stage regression test			**Critical values**		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.1306				
Adj. R-square:		0.1207			
Partial R-square:		0.0255			
Prob > F =		0.0004			
F		(2, 613)			

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	12.8145	(P=0.003)
Basmann chi-sq (1)	12.9159	(P=0.003)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Kenya

Table A18: Finance on process innovation in Kenya

First stage regression test					
Asset finance					
Cragg and Donald (1993)		**Minimum**	**eigenvalue**	**statistics = 2.61**	
			Critical values		
Stock and Yogo (2005) critical values		10%	15%	20%	25%
LIML Size of nominal 5% Wald test		8.68	5.33	4.42	3.92
Summary statistics:					
R-square:	0.0431				
Adj. R-square:		0.0164			
Partial R-square:		0.0179			
Prob > F =		0.0753			
F		(2, 287)			

Over-identifying Restrictions test		
Sargan (score) chi-sq (1)	0.8999	(P=0.3428)
Basmann chi-sq (1)	0.8753	(P=0.3495)

Source: Author's computation based on the 2013 World Bank enterprise survey data for Kenya

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APPENDIX 2: Tables 1 to 8

Table 1: Instrumental variable 2SLS regression using vce (robust)

	Cameroon				Ghana				Morocco	
Dependent variable	(1) Product innovation	(2) Product innovation	(3) Process innovation	(4) Process innovation	(5) Product innovation	(6) Product innovation	(7) Process innovation	(8) Process innovation	(9) Product innovation	(10) Process innovation
Overdraft	0.789***		1.778***		1.829**		3.226**		0.272	1.732**
	(3.17)		(6.04)		(2.38)		(2.77)		(0.53)	(2.71)
Debt (asset) finance		0.556*		0.486**		0.670**		7.63***		
		(1.95)		(2.01)		(2.39)		(3.31)		
Age (in years)	0.002	-0.004	0.006	0.001	0.001	0.001	-0.011	0.011**	-0.003	-0.005
	(0.40)	(-0.46)	(1.31)	(0.22)	(0.11)	(0.93)	(-1.14)	(2.01)	(-0.74)	(-1.21)
Size (small firm)	0.085	0.101	0.066	0.365	0.124	0.228	0.396**	0.652***	0.148	-0.138
	(0.71)	(0.43)	(0.44)	(1.89)	(0.75)	(1.08)	(2.30)	(3.88)	(1.07)	(-0.89)
Size (medium firm)	0.447**	0.240	0.413**	0.357	0.062	0.129	0.428	0.511**	0.354**	0.382**
	(2.45)	(0.85)	(2.22)	(1.44)	(0.19)	(0.34)	(1.46)	(2.04)	(2.38)	(1.99)
Size (large firm)					-0.286	-0.106	-0.076	0.150		
					(-1.24)	(-0.31)	(-0.24)	(0.66)		
Top manager experience	0.003	-0.003		0.007	-0.012	-0.015	-0.002	-0.025***	0.001	-0.001
	(0.50)	(-0.32)		(0.77)	(-1.68)	(-1.36)	(-0.32)	(-3.20)	(0.10)	(-0.09)
Export	0.474**	0.321	0.234	0.016	0.160	0.169	0.003	-0.006	0.200	0.135
	(2.03)	(1.11)	(1.24)	(0.09)	(0.73)	(0.47)	(0.01)	(-0.03)	(1.22)	(0.86)
Market participation									Yes	Yes
Region (controlled)	Yes	Yes	No	Yes	No	No	No	No	No	No
Industry (controlled)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Foreign ownership	0.514**	0.920***	-0.120	0.470**	0.920***	0.821***	0.692***	0.588***	0.330*	0.439**
	(2.63)	(3.39)	(-0.63)	(2.70)	(5.22)	(3.58)	(4.20)	(3.15)	(1.78)	(2.45)
Constant	-0.141	-0.260	0.619*	0.798**	0.554**	0.092	1.533***	1.421***	0.044	3.423***
	(-0.54)	(-0.84)	(2.43)	(2.73)	(2.76)	(0.29)	(8.35)	(5.20)	(0.11)	(6.57)
No of observation	344	158	351	160	655	330	666	336	366	366
Wald chi-sq	177	50	92	36	48	26	80.7	75.5	50.3	137.5
Prob > chi-sq	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Instrumental variable 2SLS regression using vce (robust)

	South Africa				Kenya			
Dependent variable	(1) Product innovation	(2) Product innovation	(3) Process innovation	(4) Process innovation	(5) Product innovation	(6) Product innovation	(7) Process innovation	(8) Process innovation
Overdraft	2.252**		0.290***		2.469		2.791***	
	(2.05)		(4.99)		(0.71)		(3.53)	
Debt (asset) finance		-0.088		0.239***		0.889*		1.424**
		(-1.25)		(3.07)		(2.06)		(2.69)
Age (in years)					0.003	-0.001	-0.009	-0.014
					(0.31)	(-0.12)	(-1.96)	(-1.40)
Size (medium firms)	0.0818	0.414***	0.659***	0.578***	-0.032	-0.178	0.226	0.091
	(0.51)	(3.69)	(10.31)	(5.45)	(-0.13)	(-0.78)	(1.57)	(0.31)
Size (large firms)	0.192	0.744***	0.948***	0.874***	0.284	0.612**	0.384*	0.334
	(0.64)	(5.20)	(13.93)	(8.54)	(0.79)	(2.38)	(2.47)	(1.03)
Top manager experience	-0.008	0.001	0.006**	0.009**	-0.016	0.002		0.013
	(-1.22)	(0.12)	(2.66)	(3.08)	(-0.81)	(0.23)		(1.03)
Foreign ownership	0.648***	0.671***			0.355	0.563**	0.174	0.275
	(4.66)	(4.35)			(1.33)	(2.01)	(0.97)	(0.79)
Export	0.065	0.501***	0.414***	0.438***		0.011	-0.227	
	(0.27)	(4.05)	(7.65)	(6.19)		(0.05)	(-1.05)	
Industry (controlled)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Region (controlled)	No	No	No	No	No	No	No	No
Market participation	0.008	0.007*	0.005**	0.005*				
	(1.65)	(1.69)	(2.41)	(1.85)				
Constant	-0.705	0.815	0.739***	0.872***	0.378	-0.649	1.599***	0.390
	(-1.00)	(1.61)	(3.37)	(3.96)	(1.14)	(-0.88)	(8.61)	(0.38)
No of observation	933	406	931	404	683	314	707	320
Wald chi-sq	168.5	228	750	270.6	608.7	50.7	54	10.2
Proc > Chi-sq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.809

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Test of overidentifying restrictions; (The role of finance in product and process innovation)

Country	score chi-square	P-value
Cameroon	score chi-sq (1) = 0.0710	P = 0.7899
Ghana	score chi-sq (1) = 2.8539	P = 0.0912
Morocco	score chi-sq (2) = 5.6768	P = 0.0585
South Africa	score chi-sq (1) = 0.1920	P = 0.6613
Kenya	score chi-sq (1) = 0.0393	P = 0.8429

Source: Author's computation based on the World Bank Enterprises survey data from 2007 to 2014.

Tables 4-8 show the summary statistics for variables used

Table 4: Summary statistics for Cameroon

Variable	observation	Mean	Std. Dev.	Min	Max
Product innovation	357	0.658	1.074	0.045	2.938
Process innovation	363	1.524	1.003	0.001	3.105
0verdraft	359	0.565	0.496	0	1
Asset finance	169	1.219	1.352	0	4
age	354	18.102	13.636	0	79
size	363	1.818	0.762	1	3
top manager experience	360	17.081	9.617	1	50
region	363	1.523	0.69	1	3
export	363	0.105	0.307	0	1
foreign ownership	363	0.182	0.386	0	1
industry	363	40.846	20.145	2	72
domestic ownership	363	0.906	0.292	0	1
Sales	347	18.779	2.495	13.816	26.085
informal competitors	343	0.883	0.321	0	1

Source: Author's compilation based on the World Bank enterprise survey database 2009 for Cameroon

Table B5: Summary statistics for Ghana

Variable	observation	Mean	Std. Dev.	Min	Max
Product innovation	708	0.537	1.152	0.007	4.446
Process innovation	720	1.417	1.004	0.002	2.893
Asset finance	355	0.696	1.144	0	4
Overdraft	711	0.231	0.422	0	1
age	687	14.234	11.503	0	104
size	720	1.8722	1.372	1	5
top manager experience	706	16.242	9.323	2	64
sales	555	12.369	2.359	7.313	20.071
foreign ownership	719	0.159	0.367	0	1
export	720	0.092	0.289	0	1
industry	720	37.478	15.307	15	72

Source: Author's compilation based on the World Bank enterprise survey database 2013 for Ghana

Table 6: Summary statistics for Morocco

Variable	observation	Mean	Std. Dev.	Min	Max
Product innovation	406	0.825	1.051	0.11	3.718
Process innovation	407	4.879	1.036	0.02	5.847
Overdraft	397	0.728	0.446	0	1
age	391	22.461	16.548	1	89
size	407	1.803	0.782	1	3
top manager experience	396	23.091	10.891	3	64
export	407	0.197	0.398	0	1
industry	407	52.916	29.323	15	99
foreign ownership	398	0.139	0.346	0	1
main market	404	0.568	0.388	0	1

Source: Author's compilation based on the World Bank enterprise survey database 2013 for Morocco

Table 7: Summary statistics for South Africa

Variable	observation	Mean	Std. Dev.	Min	Max
Product innovation	937	0.811	1.01	0.013251	3.221
Process innovation	1057	1.65	1	0.000508	2.731
Overdraft	1057	0.526	0.501	0	1
Asset finance	448	0.984	1.298	0	4
size	937	1.809	0.757	1	3
top manager experience	1055	13.751	10.69	1	61
foreign ownership	1057	0.13	0.336	0	1
export	1057	0.171	0.378	0	1
number of competitors	650	3.323	0.876	1	4
industry	1057	28.809	18.681	2	72
Main market share	935	10.182	11.389	0	100

Source: Author's compilation based on the World Bank enterprise survey database 2007 for South Africa

Table 8: Summary statistics for Kenya

Variable	observation	Mean	Std. Dev.	Min	Max
Product innovation	781	1.195	0.971	0	3.326
Process innovation	781	2.514	1.006	0.009	3.554
Overdraft	749	0.362	0.481	0	1
Asset finance	338	1.509	1.391	0	4
age	742	22.791	17.7191	1	107
size	781	1.809	0.811	1	3
top manager experience	761	18.359	10.861	1	57
sales	665	17.707	2.341	11.918	25.511
industry	781	36.302	16.137	15	72
export	781	0.261	0.44	0	1
foreign ownership	768	0.117	0.322	0	1
region	781	3.306	1.206	1	5

Source: Author's compilation based on the World Bank enterprise survey database 2013 for Kenya

CHAPTER 5
INNOVATION PATTERN IN AFRICAN ENTERPRISES

5.1 INTRODUCTION

This study examines innovation patterns in African firms. Innovation is an important channel with which firms increase productivity and economic growth. Innovation is often classified into product and process innovation in line with Schumpeter (1942). Product innovation includes the introduction of new or significantly improved product, having an international quality certification or foreign technology license while process innovation involves one or a combination of website ownership, use of email and audited financial statement (Bloch, 2007). The AU Agenda 2063 recognizes science, technology and innovation (STI) as enablers for achieving continental development goals. The Agenda also emphasizes that Africa's sustainable growth, competitiveness and economic transformation require sustained investment in new technologies and continuous innovation (African Union Commission, 2015). This poses a huge concern for development on the continent. For instance, with the exception of South Africa and Mauritius, most countries are lagging behind in global innovation.

According to the Global Innovation Index (GII, 2010) the top three African countries on the innovation index were Mauritius, South Africa and Egypt, ranked at 51, 73 and 74 respectively out of 125. All the other African countries were farther behind. However, there was a high retrogression in global innovation ranking between 2010–2015 in innovation for most African; for example South Africa was relegated from 51 to 60, Egypt from 74 to 100, Kenya from 83 to 92, Namibia from 92 to 107 and Nigeria from 96 to the 128 for this period. More seriously, African countries dominate the bottom of the global innovation ranking. Among the last 20 nations for the period 2010 and 2015, there are ten African countries – Sudan, Niger, Togo, Burundi, Angola, Algeria, Ethiopia, Zimbabwe, Benin and Cote D'Ivoire (Global Innovation Index, 2010–2015). For Africa to close this gap, it has to carry out significant innovation especially within its enterprises.

Africa, however, is becoming increasingly innovative and is increasing its global competitiveness. A good number of start-ups are providing solutions to business problems in Africa and deepening the competitive capabilities of economies in the region to diversify. In spite of this, Africa is still heavily underperforming in core areas that should help it redesign its economies and make these more sustainable (Ekekwe, 2015).

According to the OSLO Manual (2005) innovation is broadly defined to include imitations, improvement in production processes, technologies, adaptation and knowledge transfer. Studies of innovation in Africa are limited. Some of these include studies by Oluwatobi et al., 2015; Adeboye, 1997; Mahemba and De Bruijn, 2003; Chipika and Wilson, 2006. A critical and yet less discussed

issue is the computation of innovation indexes and classification according to the different innovation patterns. Against this background, this chapter computes and decomposes innovation accordingly into product and process and attempts to compare them by both country level and regional level.

This chapter is novel in a number of ways. Firstly, the researcher computes decomposed innovation indexes (aggregate, product and process innovation) using the multiple correspondent analysis with innovation outcomes from the World Bank Enterprise Survey database, unlike previous studies that frequently use R&D expenditure that has been criticised (Beveren and Vandenbussche, 2010). Furthermore, an African context is given to the literature on innovation.

The rest of the chapter is organised as follows: Section 2 discusses the literature review; Section 3 outlines the data source, methodology, index construction; Section 4 presents the results and discussions while Section 5 concludes and provides policy recommendations.

5.2.1 Overview of related literature

Schumpeter (1934) realised that economic development is driven by innovation. He defined development as the historical process of structural changes that are engineered by innovation. He was confident that innovation was at the centre of economic change brought about by "creative destruction". Innovation is a "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, and incessantly creating a new one" (Schumpeter, 1942). The innovation process is divided into four dimensions – invention, innovation, diffusion and imitation. Further analysis by Schumpeter (1942) showed that the invention phase, or basic innovation, had less of an impact, while the diffusion and imitation process had a greater influence on the state of an economy. He divided innovation into the following: (a) new product; (b) application of new methods of production, (c) opening of new markets (d) acquiring new sources of supply of raw material / semi-finished good (e) new industry structure. Others have contributed to the process of innovation (Schon, 1963; Roberts, 1968) yet Schumpeter remains the key contributor to the innovation evolution. He refers to the "new combinations" of existing resources, equipment and activities as entrepreneurial function (Schumpeter, 1934: 65) which he argues are distinct from invention. According to him innovation is a unique social activity carried out within the economic sphere and having a commercial purpose, whereas inventions can be carried out everywhere and without any intent of commercialisation. Most innovation in developing economies is in the form of imitation (Ayyagari *et al*., 2011).

The different regions of the world have thrived on different innovation models. These innovation models are referred to as US, European (or early industrial revolution) and development-driven models respectively (Adeboye,1997). According to Adeboye (1997) the US innovation model is often driven by high quality scientists, engineers and technologists and sustained by large R&D spending. The European model stresses broad skills, versatility, and agility in learning new skills and

information sharing as well as intense interaction among entrepreneurs, the workforce, customers and producers, while the last model is hugely dependent on transfer, adoption and adaptation of existing knowledge. This third model seems realistic for emerging economies such as those of Africa and articulates one of the benefits of the globalisation of knowledge transfer.

5.2.2 Overview of technological innovations in Africa

Africa is often referred to as the cradle of civilization. Historical records show that before the Industrial Revolution and the renaissance period in Western Europe, Africa was at the cutting edge of technological innovation. Early technological innovations abound on the continent, ranging from the iron and bronze mining in Egypt and Nigeria respectively, to the highly sophisticated and innovative methods of preserving the human corpse and the architectural prowess displayed in building the Egyptian pyramids, and the early form of university education in ancient Timbuktu (Ehret, 2002). The colonization and invasion of the continent by Europeans and Arabs in the 19th century adversely affected the traditional development and entrepreneurial edge of the African people and thus rendered them less innovative, and impoverished them.

There has been a recent upsurge in innovation of new technology in Africa especially with regards to the use of mobile phone technology and information technology in the past three decades. The impact of the development and adoption of new technological innovations in Africa can be felt in almost every sector of African economies. In finance, the use of mobile phones and credit cards for payments and transfers as well as the adoption of internet technology and Automated Teller Machines in banking has improved the velocity of money in the economy, thus facilitating the development of the financial sector on the continent. For instance, innovation in the use of mobile money technology such as M-Pesa in Kenya, Eco-cash in Zimbabwe and other similar ventures as a digital payment platform in Tanzania, have facilitated the rapid expansion of access to financial services to the previously unbanked (Jack and Suri, 2011). In the agricultural sphere, African farmers are increasingly using innovative techniques to boast agricultural productivity and earn higher incomes. For instance, in rural Niger, agricultural price information systems have been developed to enable farmers to obtain information about market prices through the use of mobile phones, thereby reducing market search costs by 50 percent (Aker and Mbiti, 2010). Similarly, innovations in areas of warehouse receipt financing systems in Tanzania, Zambia, Malawi, and Uganda have developed collateralizing agricultural produce such as grains, so as to enable often poor rural farmers to have increased access to credit (Coulter, Jonathan and Onumah, 2002). An innovation in healthcare enables pregnant women to receive antenatal and postnatal healthcare advice via their mobile phones, thereby reducing the incidence of infant and maternal mortality (Noordam *et al*., 2011). In summary, there is evidence that technological innovation in Africa is increasingly impacting on the lives of people in all spheres of life and in almost every part of the continent.

5.3 METHODOLOGY

5.3.1 Data source

Data used is from the World Bank Enterprise Survey (WBES) with information on innovation selected from both manufacturing and service enterprises from 17 countries, for the period 2002 to 2015. The dataset collected information relating to firm innovation by asking questions such as: Does your firm own a website? Do you use email to communicate with clients? Does your company make use of foreign technology? Is your firm in possession of an international quality certification? Are your accounts audited by an independent auditor? The countries for this study were carefully chosen to represent each of the regional blocks in Africa. The selection of countries was influenced mainly by data availability and regional balance. The chosen countries come from all five regions of the continent, namely East Africa, North Africa, West Africa, Southern Africa and Central Africa. This section also outlines the methodology employed in the construction of the innovation index and the use of this measure in analysing the innovation pattern within African enterprises.

This research follows the World Bank enterprise and OSLO Manual (2005) classification that provides proxy measures for innovation captured in the innovation literature. According to this manual, product innovation involves the introduction of new products and new technologies, but also the imitation of technology, product, foreign technology license and international quality certification, while process innovation entails innovative activities such as website ownership, use of emails and a firm having their financial statement audited. The fundamental concern in this definition is new-to-firm innovation rather than core innovation, which is of relevance to the sample of emerging African economies. These definitions are captured in Table 5.1.

Table 5.1: Variables used for constructing product, process and aggregate innovation indexes

No	Product	Process
1	Introduction of a new or significantly improved product within 3 years to survey	Website – enterprise owns a website
2	International quality certification	Email – uses email to communicate with clients
3	Foreign technology license	Audited financial statements

Source: World Bank Enterprise (WBE) Survey (2016)

5.3.2 Construction of innovation index

Product and process innovation were computed as well as aggregate innovation indexes using the definitions in Table 4.1. In computing the innovation index, the multiple correspondent analysis (MCA) was adopted and Booysen (2008), Asselin (2002), Sahn and Stifel (2000), Van Kerm (1998) and Benzecri (1973) were followed to create innovation indexes from a selection of variables from the WBE survey. To ensure comparability across countries, only innovative variables that appeared in the same section across the questionnaire were phrased in exactly the same way and were

included in the analysis. Appendix 1 lists the variables, with the categories and weight for each variable noted in the third column. The construction of the innovation indexes was based on six categorical variables as shown in Table 5.1.

In the literature, the principal components or factor analysis (PCA) is most widely used for the construction of indices – asset, innovation. Nevertheless, the PCA was fundamentally designed for continuous variables as it assumes a normal distribution of indicator variables. In contrast, multiple correspondence analysis (MCA) is more suited to discrete or categorical variables. Therefore, it was decided to employ MCA rather than PCA in constructing the innovation index employed in this analysis of firm level innovation. The MCA is very good at analyzing categorical variables since the innovation variable questions i.e. categorical in their outcome responses they make it appropriate for this study. Moreover, the multiple correspondent analysis assigns weight according to the significance of the variables in the innovation index. In accordance with Asselin (2002), Van Kerm (1998) and Benzecri (1973) the MCA innovation index is given generally as:

$$\boldsymbol{a_i = \sum_{k=1}^{k} F_{1k}\, d_{ki}}$$

The ith firm innovation index is α_i, d_{ki} is the kth value of the categorical variables (with $k=1\ldots K$) indicating the firms' innovation variables included in the index construction. F_{1k} is the MCA weights generated for the analysis.

The extended form of the innovation index in this paper is given as

$$INNOV_i = P_{i1}W_1 + P_{i2}W_2 + \ldots P_{ij}Wj \qquad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where $INNOV_i$ is the innovation composite index of firm *i,* the response of firm I to category/innovation *j* is represented by Pij, and Wj is the MCA weight for dimension one applied to category *j* (Booysen *et al*., 2008).

The following equation was used to calculate a composite innovation index score for each unit.

$$^{MCA}P_i = R_{i1}W_1 + R_{i2}W_2 + \ldots + R_{ij}W_j + \ldots + R_{iJ}W_J \qquad \ldots\ldots\ldots\ldots\ldots 2$$

Where $^{MCA}P_i$ is the ith firm's composite innovation indicator score, R_{i1} is the response of firm i to category j, and W_J is the MCA weight for dimension one applied to category j. The *mca* command in STATA 13 was used to calculate these weights (Statacorp, 2013; Van Kerm, 1998). This command estimates 'an adjusted simple correspondence analysis on the Burt matrix constructed with' the selected variables, in our case those noted in Table 4.1 (Booysen *et al*., 2008). Given that a simple correspondence analysis applied to this matrix usually results in maps of apparently poor quality, the MCA adjusts the obtained principal inertias (eigenvalues) following a method proposed by Benzecri. According to Van Kerm (1998: 214), the reported inertia explained by the first dimension is relatively high because of the fitting of the diagonal sub-matrices.

In the construction of these innovation indexes, the index for each country was calculated separately and per period. This means that the experience of one country can give it advantage over the others in the same period, irrespective of differences in the number of firms in each country. Therefore, the emphasis in this chapter was on the spatial comparison of innovation in each of the nineteen countries, and also of the five regions. According to Appendix 1, which reports the weights for each index component, components that reflect higher innovative values contribute positively to the innovation index, while components that reflect lower innovative values contribute negatively to the innovation index. The output shows for example that owning a website, using email, having audited financial statement, being in possession of an international quality certification, and having a foreign technology license increases a firm's innovation index score.

5.3.2.1 A priori expectation of the index

At the creation of the innovation index there should not be any reverse variable. In the construction of the index the alpha command was used to detect any reverse variables. If any reverse variable was detected it was dropped. This is because reverse variables have a negative impact on the index. All the indices met the a priori expectation (Booysen *et al*., 2008).

5.4 PRESENTATION, RESULTS AND DISCUSSION

5.4.1 Innovation and characteristics of the sampled enterprises and countries

Using the most recent years, we can rank the countries as shown in Tables 452, 5.3 and 5.4.

A review of Table 5.2 shows that Kenya leads the continent in aggregate innovation index also referred to as overall innovation index with a mean of 2.5. Botswana and Morocco are second and third with means of 2.3 and 2.2., respectively. Kenya's leading position is in line with reality, as Kenya owns a number of innovative products and processes. It is host to one of the continent's IT hubs such as the Silicon Savannah, iCow, Eneza, iHub, and Konza Technology City producing very good start-ups with the potential of being listed on global stock exchanges (Moime, 2016), Kenya has what it takes to lead the continent in the aggregate innovation index. Botswana and Morocco are upper middle-income and lower middle-income countries meaning they are relatively rich thus able to invest in technology. These countries possess the potentials to advance in technology and innovation. An increase in technological advancement will, *ceteris paribus* lead to an increase in productivity and competitiveness that are essential for growth and development. Mali, Senegal and DRC are the least innovative countries on the continent as per our sample. Ironically, these are all former French related colonies, for example Mali and Senegal for France, and Democratic Republic of the Congo for Belgium.

Table 5.2: The mean of aggregate innovation index ranked in order

Aggregate innovation		
Rank	**country**	**index**
1	Kenya	2.5
2	Botswana	2.3
3	Morocco	2.2
4	Malawi	2
5	Rwanda	1.9
6	South Africa	1.7
7	Egypt	1.6
8	Zambia	1.6
9	Ethiopia	1.6
10	Cameroon	1.5
11	Ghana	1.5
12	Burkina Faso	1.4
13	Angola	1
14	Nigeria	0.9
15	Democratic Republic of Congo	0.9
16	Senegal	0.8
17	Mali	0.6

Source: Author's compilation based on the World Bank Enterprise Survey database 2002 – 2015

A quick overview of Table 5.3 shows that Rwanda leads the continent in product innovation with a mean of 2.5. Kenya comes in second position with a mean of 2.4 and South Africa (2.3) in third place respectively. According to the Global Competitive Report (2015–2016), Rwanda ranks third in Sub-Saharan Africa, and competition is a precursor for innovative activities, meaning Rwanda has the ability to advance its technological production and become more competitive with direct impact on growth and development. This is reflexive of Rwanda that progressed from a low to a middle-income country within the last five years (World Bank, 2015). South Africa is ranked as the second most innovative country in Sub-Saharan Africa, Global Innovation Index (GII, 2016), and known for hosting leading IT hubs like the Cape Silicon. South Africa is comparatively more advanced than the rest of the continent and host to the continent's top four banks. Access to finance enhances innovation as shown in this thesis (Chapters 3 & 4). South Africa is the second most competitive country on the continent, (Global Competitive Report, 2015–2016). With access to finance, South Africa is able to invest in innovation that results directly to in increased productivity and competitiveness. These are necessary conditions for economic growth and development. The Democratic Republic of the Congo and Mali are the least innovative countries with a mean of 0.8 each. These are low-income countries where the financial system is still improving.

Table 5.3: The mean of product innovation ranked in descending order

Ranking	Country	Index.
1	Rwanda	2.5
2	Kenya	2.4
3	South Africa	2.3
4	Malawi	2.3
5	Ghana	1.9
6	Egypt	1.8
7	Burkina Faso	1.8
8	Botswana	1.7
9	Morocco	1.7
10	Cameroon	1.5
11	Ethiopia	1.4
12	Angola	1
13	Nigeria	1
14	Zambia	1
15	Senegal	0.9
16	Mali	0.8
17	DRC	0.8

Source: Author's compilation based on the World Bank Enterprise Survey database 2002 – 2015

Table 5.4 shows that Kenya leads in process innovation with a mean of 0.9 and is closely followed by South Africa with a mean of 0.8. Kenya's leading position is in line with the times since Kenya is one of the most innovative countries on the continent. Kenya is the third most innovative country on the continent after Mauritius and South Africa (GII, 2016). South Africa has stayed on top of the ranks by ensuring that it is among the top 2 in the continent at all times in the Global Innovation Index (GII, 2010–2016). Kenya and South Africa are more advanced technologically on the continent, and host to technological hubs such as the Silicon Savannah and Cape Silicon. The spill over effect from these hubs is increased productivity with a positive impact on growth and development. The least innovative country in process innovation is Ethiopia with a mean of 0.4.

Table 5.4: The mean of process innovation ranked in descending order

Process innovation		
Ranking	**Country**	**Index**
1	Kenya	0.9
2	South Africa	0.8
3	Angola	0.8
4	Botswana	0.7
5	Cameroon	0.7
6	Egypt	0.7
7	Zambia	0.7
8	Morocco	0.6
9	Burkina Faso	0.6
10	Malawi	0.6
11	Rwanda	0.5
12	Senegal	0.5
13	Ghana	0.5
14	Nigeria	0.5
15	Mali	0.5
16	Democratic Republic of Congo	0.5
17	Ethiopia	0.4

Source: Author's compilation based on the World Bank Enterprise Survey database 2002 – 2015

A quick overview of Tables 2–18, where the index changes (differences) are tabulated, shows that Kenya made the most significant improvement of 100%, in aggregate innovation, followed by Morocco in second place with 60% increase and Angola with 30% improvement during the period under survey. South Africa witnessed the greatest decline of over 700% in aggregate innovation during period under survey while Senegal and Cameroon also declined by 80% in overall innovation over the same period. Kenya's improvement is normal as it already leads in technology while the improvement seen in Angola indicates that it has the potential to foster innovation with resultant impact on productivity as well as competitiveness. If this is the case, it will lead to overall economic growth and development.

With respect to product innovation, Morocco had the greatest improvement of 120% while Ghana had 100% and Kenya observed a 70% improvement in product innovation. South Africa witnessed the sharpest decline of 160%, with Ethiopia 60% and Senegal 50% decline in product innovation respectively over the period of survey. Ethiopia and South Africa have been witnessing some unrest (particularly from labour Federations – COSATU in the case of South Africa) and such conditions are not conducive for enterprises that want to engage in serious innovative activities. The improvements witnessed by Morocco, Ghana and Kenya are reflexive of their improvement globally, (Global Innovation Index, 2015).

A quick look at Tables 2–18, indicates that Angola had a significant improvement of 40% in process innovation compared to Kenya that saw a 30% increment while Ghana, Botswana and DRC witnessed minimal improvement of 20%. Morocco experienced the greatest decline of 110% in process innovation followed by Ethiopia with 60% decline and Malawi with 50% decline during the period under survey. The increment signals that those countries have the potential to increase productivity and competitiveness, which is required for growth and development.

Table 2: The mean of the innovation indexes for Angola

	2006		2010		Difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	0.7	1.1	1	1	0.3
Process innovation	0.4	1.3	0.8	1	0.4
Aggregate innovation	0.7	1	1	1	0.3

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 3: The mean of the innovation indexes for Botswana

	2006		2010		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	1.2	1	1.7	1	0.5
Process innovation	0.5	1	0.7	1.2	0.2
Aggregate innovation	1.3	1	2.3	1	1

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 4: The mean of the innovation indexes for Burkina Faso

	2006		2009		Difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	NA	NA	1.8	1.1	-
Process innovation	NA	NA	0.6	1.1	-
Aggregate innovation	NA	NA	1.4	1	-

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 5: The mean of the innovation indexes for Cameroon

	200		2009		Difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	1.9	1.2	1.5	1	-0.4
Process innovation	0.6	1	0.7	1	0.1
Aggregate innovation	2.3	1.4	1.5	1	-0.8

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 6: The mean of the innovation indexes for Democratic Republic of the Congo (DRC)

	2006		2013		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	0.6	0.9	0.8	1	0.2
Process innovation	0.3	1	0.5	1.1	0.2
Aggregate innovation	0.7	1	0.9	1	0.2

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2013

Table 7: The mean of the innovation indexes for Egypt

	2007		2013		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	NA	NA	1.8	1	-
Process innovation	NA	NA	0.7	1	-
Aggregate innovation	NA	NA	1.6	1	-

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 8: The mean of the innovation indexes for Ethiopia

	2011		2015		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	2	1	1.4	1	-0.6
Process innovation	1	1	0.4	1	-0.6
Aggregate innovation	2.1	1	1.6	1	-0.5

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2011 and 2015

Table 9: The mean of the innovation indexes for Ghana

	2007		2013		Difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	0.9	1	1.9	1	1
Process innovation	0.3	1	0.5	1.2	0.2
Aggregate innovation	1	1	1.5	1	0.5

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 10: The mean of the innovation indexes for Kenya

	2007		2013		Difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	1.7	1.2	2.4	1.1	0.7
Process innovation	0.6	1	0.9	1.1	0.3
Aggregate innovation	1.5	1	2.5	1	1

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 11: The mean of the innovation indexes for Malawi

	2009		2014		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	2.2	1.3	2.3	1	0.1
Process innovation	1	1.2	0.6	1	-0.4
Aggregate innovation	1.7	1	2	1	0.3

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 12: The mean of the innovation indexes for Mali

	2003		2007		Difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	1.1	1	0.8	1	-0.3
Process innovation	0.6	1	0.5	1	-0.1
Aggregate innovation	1.1	1	0.6	1	-0.5

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 13: The mean of the innovation indexes for Morocco

	2004		2007		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	0.5	1	1.7	1	1.2
Process innovation	1.7	1	0.6	1.1	-1.1
Aggregate innovation	1.6	1	2.2	1	0.6

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2004 and 2007

Table 14: The mean of the innovation indexes for Nigeria

	2009		2014		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	NA	NA	1	1	-
Process innovation	NA	NA	0.5	1.1	-
Aggregate innovation	NA	NA	0.9	1	-

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 15: The mean of the innovation indexes for Rwanda

	2006		2011		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	NA	NA	2.5	1.1	-
Process innovation	NA	NA	0.5	1	-
Aggregate innovation	NA	NA	1.9	1	-

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2011

Table 16: The mean of the innovation indexes for Senegal

	2007		2014		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	1.4	1	0.9	1.1	-0.5
Process innovation	0.6	1	0.5	1.1	-0.1
Aggregate innovation	1.6	1	0.8	1	-0.8

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2014

Table 17: The mean of the innovation indexes for South Africa

	2003		2007		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	3.8	1	2.3	1.2	-1.6
Process innovation	1	1	0.8	1	-0.2
Aggregate innovation	9.3	1.1	1.7	1	-7.6

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 18: The mean of the innovation indexes for Zambia

	2002		2013		difference
	mean	Standard deviation	mean	Standard deviation	mean
Product innovation	2.3	1.1	1.5	1	-0.8
Process innovation	0.5	1	0.7	1.1	0.2
Aggregate innovation	2.6	1	1.6	1	-1

Source: Source: Author's compilation based on the World Bank Enterprise survey database 2002 and 2013

5.5 REGIONAL COMPARISON OF KEY INNOVATION INDICES – AGGREGATE, PROCESS AND PRODUCT INNOVATION

Figures 5.1 to 5.3 depict the regional innovation indexes. Analysis follows below each figure. For more information, a tabular representation is in appendix B. The discussion follows these graphs.

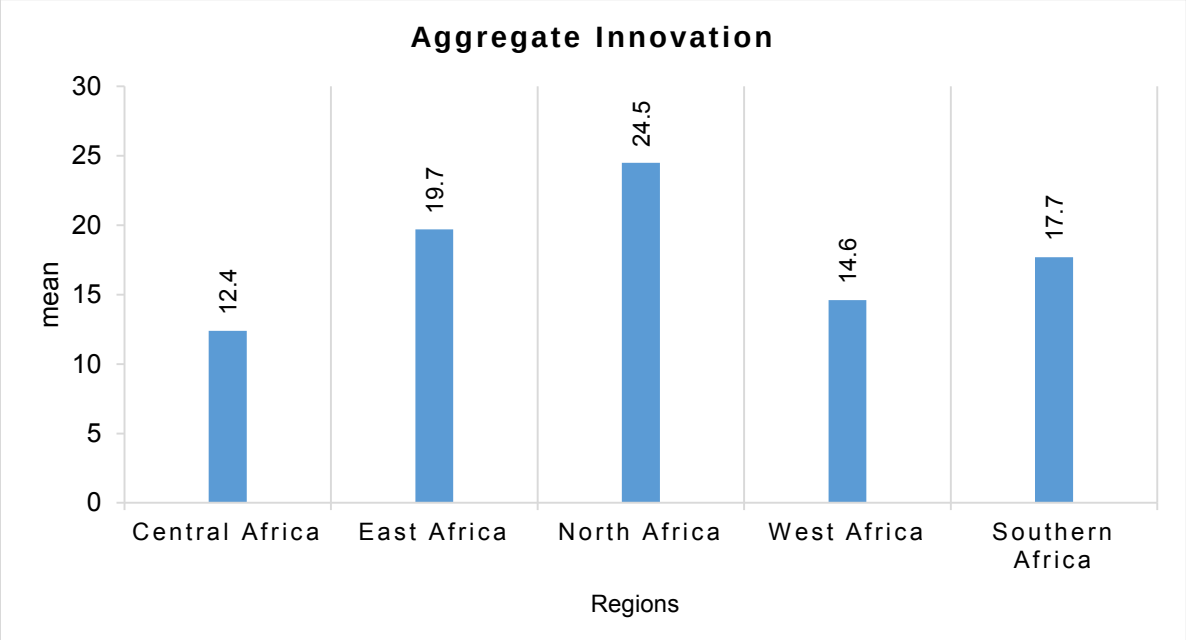

Figure 5.1: Aggregate innovation in Africa

Source: Author's compilation based on the World Bank Enterprise Survey 2015.

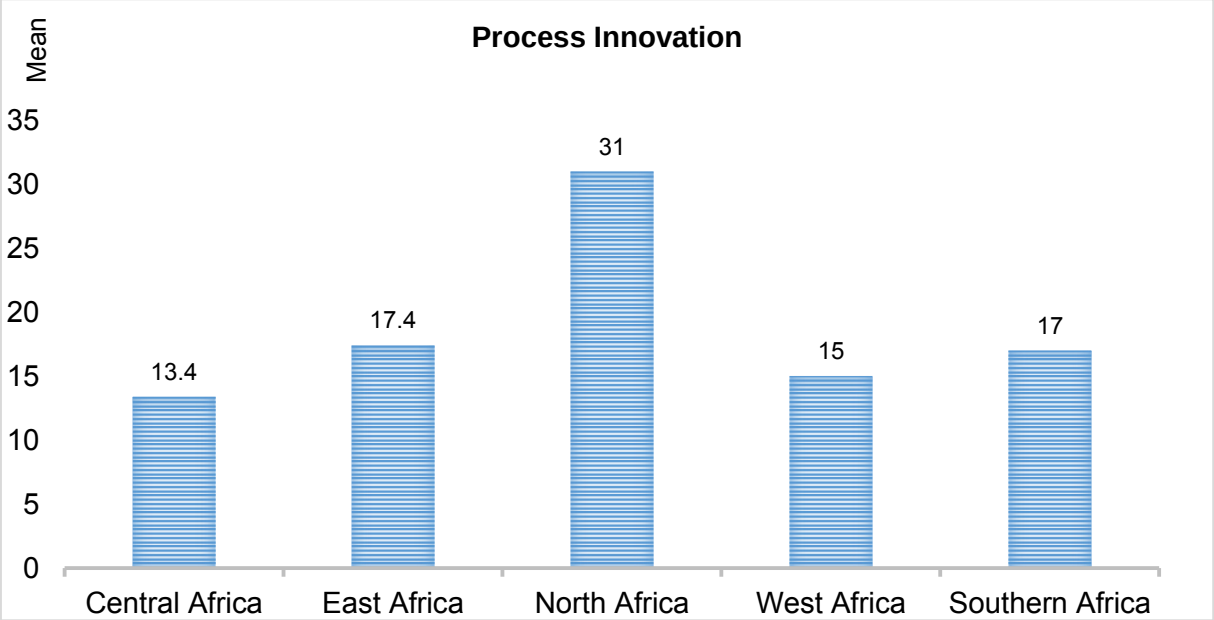

Figure 5.2: Process innovation in Africa

Source: Author's compilation based on the World Bank Enterprise Survey 2015

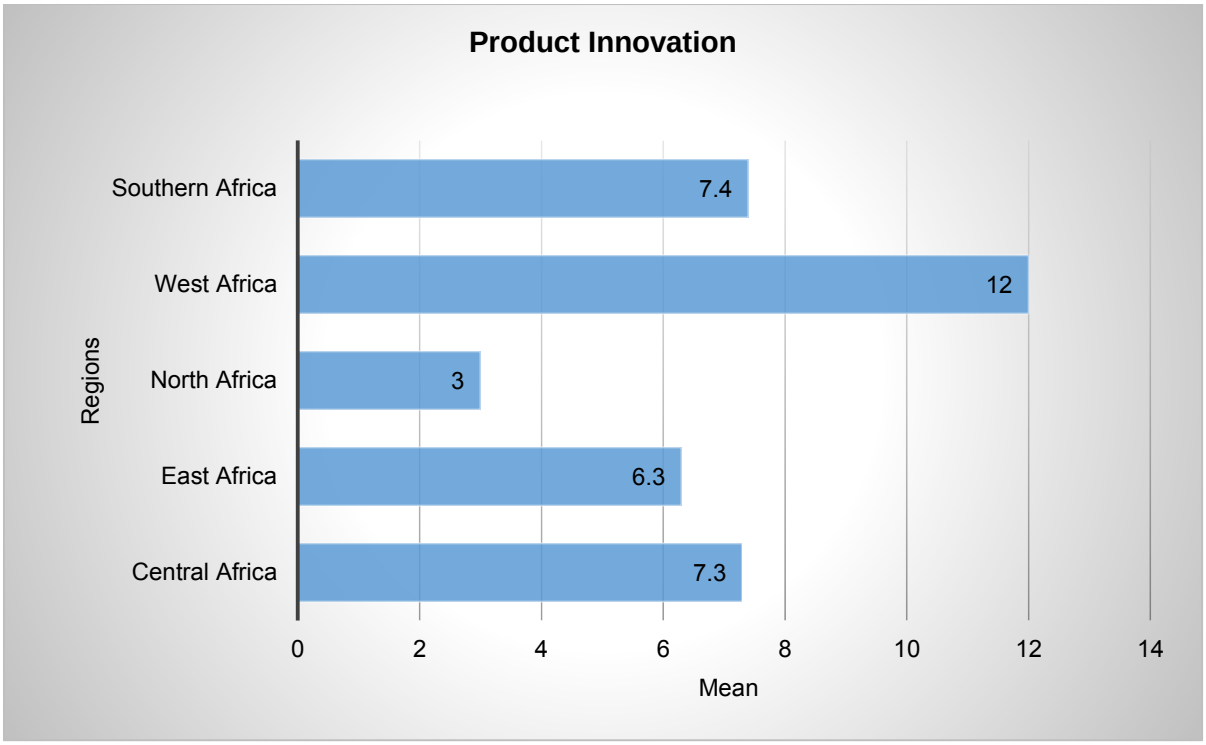

Figure 5.3: Product innovation in Africa

Source: Author's compilation based on the World Bank Enterprise Survey 2015.

Figures 5.1, 5.2 and 5.3 are taken from tables 19, 20 and 21. A quick overview of figure5.1 shows that North Africa leads the continent in aggregate innovation with a mean of 24.5. East Africa comes in second position with a mean of 19.7; Southern Africa is in third place with a mean of 17.7 while Central Africa is least with a mean of 12.4. The overall good performance of East Africa and Southern Africa reflects the regions effort towards innovation. This is championed with innovation hubs such as the Silicon Savannah in Kenya and Cape Silicon in South Africa respectively that are also the countries leading East and Sothern African regions. North African's first position is ironical as its countries are ranked behind on the Global Innovation Index (GII, 2016). There is keen competition in process innovation on the African continent. With reference to Figure 5.2, North Africa takes the lead in process with a mean of 31; East Africa is in second place with a mean of 17.4, closely followed by Southern Africa in third place with a mean of 17. However, West Africa comes in fourth place with 15 while the Central African sub-region is at the bottom of the process innovation scale. This keen competition in process innovation is dominated by imitation and use of foreign technology.

From Figure 5.3, it can be seen that West Africa champions product innovation on the continent with a mean of 12. This leading position could be propelled by the innovative IT hub in Nigeria, also by the increasing competition among firms in the region. The region is relatively stable as well. The second most dominant region in product innovation is Southern Africa (7.4) closely followed by Central African sub-regions in third place with a mean of 7.3, while North Africa is the least and far behind the other regions with a mean of 3. The tight competition between the sub-regions could be due to the emergence of IT and innovation centres in Nigeria – West Africa, Silicon Mountain in

Buea, Cameroon (Central Africa), Cape Silicon in Cape Town, South Africa (Southern Africa) and allowing them to benefit from the ease of interaction among them and transfer of knowledge with each other.

Table 19: Aggregate Innovation in Africa by region

Sub-region	Scale of reliability	Mean	Minimum	Maximum
Central Africa	0.6	1.24	0.04	3.56
East Africa	0.65	1.97	0.02	4.3
North Africa	0.47	2.45	0.04	5.1
West Africa	0.64	1.46	0.02	4.33
Southern Africa	0.65	1.77	0.03	3.95

Source: Author's computation based on the World Enterprise Survey database 2007 - 2015

Table 20: Product Innovation in Africa by region

Sub-region	Scale of reliability	Mean	Minimum	Maximum
Central Africa	0.44	0.73	0.02	3.5
East Africa	0.42	0.63	0.05	3.85
North Africa	0.3	0.3	0.02	5.1
West Africa	0.35	1.2	0.05	5.2
Southern Africa	0.51	0.74	0.03	3.3

Source: Author's computation based on the World Enterprise Survey database 2007 - 2015

Table 21: Process Innovation in Africa by region

Sub-region	Scale of reliability	Mean	Minimum	Maximum
Central Africa	0.6	1.34	0.02	3.5
East Africa	0.56	1.74	0.03	3.3
North Africa	0.41	3.1	0.05	4.4
West Africa	0.61	1.5	0.02	3.2
Southern Africa	0.59	1.7	0.05	3.3

Source: Author's computation based on the World Enterprise Survey database 2007 – 2015

5.6 CONCLUSION AND POLICY RECOMMENDATION

This study examined the innovations taking place in African enterprises and sought to carve an innovation pattern for the continent. Using data from the World Bank Enterprise Survey, the study found that there was a general improvement in innovation within African firms. Specifically, the study found that Rwandan enterprises dominated in product innovation and were closely followed in

second positon by Kenyan firms, while incidentally, Kenyan enterprises also lead in process innovation with South African enterprises in second position. In overall (aggregate) innovation, Kenyan enterprises set the pace and rightfully so, with cutting-edge technology such as M-Pesa, iCow, and Eneza among others.

At the regional level, North Africa dominated the continent in process innovation, closely followed by East Africa while Central Africa was the least. Though product innovation develops at a relatively slower rate, West Africa set the pace while North Africa was least in product innovation. In overall (aggregate) innovation, North Africa leads with East Africa and Southern Africa in second and third positions respectively, while Central Africa is last. There was a correlation between process innovation and overall (aggregate) innovation at the regional level since the position of each region in process innovation was exactly the same with its position at the aggregate level. This suggest that {an improvement in process innovation} the enactment of policies that foster process innovation would also promote enhance aggregate innovation at the regional level.

Given the findings, it is necessary for firms to be interconnected with innovation hubs and centres such as Cape Silicon in South Africa, Silicon Savannah in Kenya, and Silicon Mountain in Buea, Cameroon to benefit from their advance technological knowledge and share strategic information that can enable them to be more innovative. In addition, it would be important for government to create incentives such as an annual competition that rewards firms with innovative outcomes or solutions to society's problems. Government can collaborate with other willing stakeholders to create a fund that will extend credits, loans and funds to more firms. Furthermore, governments can set policies that reward financial intermediaries that have constantly extended funding to more enterprises especially those that are unable to access funding from formal financial institutions.

APPENDIX 3: Table 1a – Table 17c

Table 1a: Weights generated from MCA - Aggregate innovation for Angola

		2006	2010
Variables	Categories	Weights	1.621
Email	Use email	2.180	-0.751
	Does not us email	-0464	1.895
Website	Own a website	0.717	-0.550
	Does not own a website	-0079	1.149
Foreign Technology	Use foreign technology	4.834	-0.714
	Does not use foreign technology	-0.317	1.975
International certification	Use international certification	5.147	-0.629
	Does not use international certification	-0.229	-0.629
Audited financial statement	Have audited financial statement	5.229	1.527
	Does not have audited financial statement	-0.223	-0.443

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 1b: Weights generated from MCA - Product innovation

		2006	2010
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	3.922	1.321
	Does not use foreign technology	-0.255	-0.757
International certification	Use international certification	4.761	1.706
	Does not use international certification	-0.210	-0.586

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 1c: Weights generated from MCA - Process innovation

		2006	2010
Variables	Categories	weights	weights
Email	Use email	2.191	1.538
	Does not use email	-0.761	-0.816
Website	Own website	2.443	0.855
	Does not own a website	-0.248	0.855
Audited financial statement	Have audited financial statement	2.838	1.444
	Does not have audited financial statement	-0.256	-0.366

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 2a: Weights generated from MCA - Aggregate innovation for Botswana

		2006	2010
Variables	Categories	Weights	Weights
Email	Use email	0.830	0.457
	Does not us email	-1.141	-2.042
Website	Own a website	2.176	1.626
	Does not own a website	-0.520	-0.890
Foreign Technology	Use foreign technology	2.002	2.274
	Does not use foreign technology	-0.506	-0.595
International certification	Use international certification	2.307	2.082
	Does not use international certification	-0.433	-0.586
Audited financial statement	Have audited financial statement	0.622	0.114
	Does not have audited financial statement	-1.463	-0.434

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 2b: Weights generated from MCA - Product innovation

		2006	2010
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	1.989	1.970
	Does not use foreign technology	-0.503	-0.508
International certification	Use international certification	2.309	1.900
	Does not use international certification	-0.433	-0.526

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 2c: Weights generated from MCA - Process innovation

		2006	2010
Variables	Categories	weights	weights
Email	Use email	1.135	0.410
	Does not us email	-1.003	-2.238
Website	Own website	2.532	1.476
	Does not own a website	-0.435	-0.825
Audited financial statement	Have audited financial statement	0.618	0.541
	Does not have audited financial statement	-1.230	-1.599

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 3a: Weights generated from MCA - Aggregate innovation for Burkina Faso

		2006	2009
Variables	Categories	Weights	Weights
Email	Use email	NA	0.689
	Does not us email	NA	-2.100
Website	Own a website	NA	1.544
	Does not own a website	NA	-0.603
Foreign Technology	Use foreign technology	NA	1.350
	Does not use foreign technology	NA	-0.210
International certification	Use international certification	NA	1.928
	Does not use international certification	NA	-0.523
Audited financial statement	Have audited financial statement	NA	0.950
	Does not have audited financial statement	NA	-1.398

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 3b: Weights generated from MCA - Product innovation

		2006	2009
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	NA	2.566
	Does not use foreign technology	NA	-0.390
International certification	Use international certification	NA	1.947
	Does not use international certification	NA	-0.514

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 3c: Weights generated from MCA - Process innovation

		2006	2009
Variables	Categories	weights	weights
Email	Use email	NA	0.775
	Does not us email	NA	-1.503
Website	Own website	NA	1.847
	Does not own a website	NA	-0.526
Audited financial statement	Have audited financial statement	NA	0.917
	Does not have audited financial statement	NA	-0.942

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 4a: Weights generated from MCA - Aggregate innovation for Cameroon

		2006	2009
Variables	Categories	Weights	Weights
Email	Use email	1.082	0.697
	Does not us email	-1.373	-1.393
Website	Own a website	2.074	1.480
	Does not own a website	-0.529	-0.901
Foreign Technology	Use foreign technology	1.986	1.967
	Does not use foreign technology	-0.289	-0.486
International certification	Use international certification	2.077	1.667
	Does not use international certification	-0.503	-0.590
Audited financial statement	Have audited financial statement	0.379	0.603
	Does not have audited financial statement	-2.105	-1.256

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 4b: Weights generated from MCA - Product innovation

		2006	2009
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	2.620	2.011
	Does not use foreign technology	-0.382	-0.497
International certification	Use international certification	2.032	1.682
	Does not use international certification	-0.492	-0.595

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 4c: Weights generated from MCA - Process innovation

		2006	2009
Variables	Categories	weights	weights
Email	Use email	0.954	0.871
	Does not us email	-1.188	-1.448
Website	Own website	2.163	1.481
	Does not own a website	0.546	-0.753
Audited financial statement	Have audited financial statement	0.350	0.529
	Does not have audited financial statement	-1.961	-1.181

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2009

Table 5a: Weights generated from MCA - Aggregate innovation for Democratic Republic of the Congo (DRC)

		2006	2010
Variables	Categories	Weights	weights
Email	Use email	1.887	1.193
	Does not us email	-0.460	-0.881
Website	Own a website	3.234	2.881
	Does not own a website	-0.311	-0.607
Foreign Technology	Use foreign technology	5.235	3.288
	Does not use foreign technology	-0.183	-0.285
International certification	Use international certification	3.607	2.643
	Does not use international certification	-0.290	-0.285
Audited financial statement	Have audited financial statement	2.14	1.322
	Does not have audited financial statement	-0.523	-0.415

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 5b: Weights generated from MCA - Product innovation

		Y2006	2010
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	5.348	3.256
	Does not use foreign technology	-0.187	-0.307
International certification	Use international certification	3.529	2.944
	Does not use international certification	-0.283	-0.340

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 5c: Weights generated from MCA - Process innovation

		2006	2010
variables	Categories	weights	weights
Email	Use email	2.453	1.208
	Does not us email	-0.515	-0.960
Website	own website	4.102	2.329
	Does not own a website	-0.312	-0.531
Audited financial statement	Have audited financial statement	1.478	1.227
	Does not have audited financial statement	-0.310	-0.491

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2010

Table 6a: Weights generated from MCA - Aggregate innovation for Egypt

		2007	2013
Variables	Categories	Weights	Weight
Email	Use email	NA	2.47
	Does not us email	NA	-1.390
Website	Own a website	NA	1.425
	Does not own a website	NA	-1.181
Foreign Technology	Use foreign technology	NA	2.045
	Does not use foreign technology	NA	-0.168
International certification	Use international certification	NA	2.014
	Does not use international certification	NA	-0.,499
Audited financial statement	Have audited financial statement	NA	0.271
	Does not have audited financial statement	NA	-0.868

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 6b: Weights generated from MCA - Product innovation

		2007	2013
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	NA	3.498
	Does not use foreign technology	NA	-0.286
International certification	Use international certification	NA	2.012
	Does not use international certification	NA	-0.497

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 6c: Weights generated from MCA - Process innovation

		2007	2013
Variables	Categories	weights	weights
Email	Use email	NA	1.120
	Does not us email	NA	-1.274
Website	Own website	NA	1.288
	Does not own a website	NA	-1.071
Audited financial statement	Have audited financial statement	NA	0.244
	Does not have audited financial statement	NA	-0.791

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 7a: Weights generated from MCA - Aggregate innovation for Ethiopia

		2011	2015
Variables	Categories	Weights	Weights
Email	Use email	0.573	1.030
	Does not us email	-2.160	-1.360
Website	Own a website	1.179	1.832
	Does not own a website	-1.262	-0.800
Foreign Technology	Use foreign technology	1.126	1.885
	Does not use foreign technology	-0.826	-0.247
International certification	Use international certification	1.229	2.697
	Does not use international certification	-0.283	-0.393
Audited financial statement	Have audited financial statement	0.618	0.489
	Does not have audited financial statement	-1.612	-1.247

Source: Author's compilation based on the World Bank Enterprise survey database 2011 and 2015

Table 7b: Weights generated from MCA - Product innovation

		2011	2015
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	1.171	2.773
	Does not use foreign technology	-0.854	-0.361
International certification	Use international certification	2.088	2.633
	Does not use international certification	-0.479	-0.380

Source: Author's compilation based on the World Bank Enterprise survey database 2011 and 2015

Table 7c: Weights generated from MCA - Process innovation

		2011	2015
Variables	Categories	weights	weights
Email	Use email	0.542	0.943
	Does not us email	-1.998	-1.279
Website	Own website	1.105	1.563
	Does not own a website	-0.971	-0.692
Audited financial statement	Have audited financial statement	0.576	0.606
	Does not have audited financial statement	-1.463	-1.176

Source: Author's compilation based on the World Bank Enterprise survey database 2011 and 2015

Table 8a: Weights generated from MCA - Aggregate innovation for Ghana

		2007	2013
Variables	Categories	Weights	weights
Email	Use email	1.940	0.860
	Does not us email	-0.670	-1.470
Website	Own a website	3.326	1.766
	Does not own a website	-0.284	-0.783
Foreign Technology	Use foreign technology	1.959	1.789
	Does not use foreign technology	-0.284	-0.300
International certification	Use international certification	3.895	2.214
	Does not use international certification	-0.271	-0.242
Audited financial statement	Have audited financial statement	1.480	1.061
	Does not have audited financial statement	-0.771	-1.208

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 8b: Weights generated from MCA - Product innovation

		2007	2013
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	2.625	2.430
	Does not use foreign technology	-0.381	-0.412
International certification	Use international certification	3.791	2.950
	Does not use international certification	-0.264	-0.339

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 8c: Weights generated from MCA - Process innovation

		2007	2013
Variables	Categories	weights	weights
Email	Use email	1.542	0.754
	Does not us email	-0.759	-1.373
Website	Own website	2.942	1.442
	Does not own a website	-0.288	-0.712
Audited financial statement	Have audited financial statement	1.222	0.823
	Does not have audited financial statement	-0.804	-1.140

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 9a: Weights generated from MCA - Aggregate innovation for Kenya

		2007	2013
Variables	Categories	Weights	Weights
Email	Use email	0.732	0.427
	Does not us email	-1.676	-2.265
Website	Own a website	2.371	1.185
	Does not own a website	-0.519	-1.265
Foreign Technology	Use foreign technology	2.033	1.687
	Does not use foreign technology	-0.336	-0.515
International certification	Use international certification	2.349	1.563
	Does not use international certification	-0.480	-0.830
Audited financial statement	Have audited financial statement	0.311	0.222
	Does not have audited financial statement	-2.357	-1.658

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 9b: Weights generated from MCA - Product innovation

		2007	2013
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	2.360	1.815
	Does not use foreign technology	-0.406	-0.551
International certification	Use international certification	2.213	1.365
	Does not use international certification	-0.452	-0.733

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 9c: Weights generated from MCA - Process innovation

		2007	2013
Variables	Categories	weights	weights
Email	Use email	0.950	0.520
	Does not us email	-1.264	-2.231
Website	Own website	2.175	0.983
	Does not own a website	-0.418	-1.057
Audited financial statement	Have audited financial statement	0.619	0.378
	Does not have audited financial statement	-1.436	-2.116

Source: Author's compilation based on the World Bank Enterprise survey database 2007 and 2013

Table 10a: Weights generated from MCA - Aggregate innovation for Malawi

		2009	2014
Variables	Categories	Weights	Weights
Email	Use email	0.688	0.590
	Does not us email	-2.522	-1.962
Website	Own a website	1.00	1.046
	Does not own a website	-0.274	-1.128
Foreign Technology	Use foreign technology	1.507	1.928
	Does not use foreign technology	-0.344	-0.664
International certification	Use international certification	1.760	2.127
	Does not use international certification	-0.704	-0.532
Audited financial statement	Have audited financial statement	0.580	0.388
	Does not have audited financial statement	-2.127	-0.647

Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 10b: Weights generated from MCA - Product innovation

		2009	2014
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	2.094	1.690
	Does not use foreign technology	-0.478	-0.592
International certification	Use international certification	1.581	1.977
	Does not use international certification	-0.632	-0.506

Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 10c: Weights generated from MCA - Process innovation

		2009	2014
Variables	Categories	weights	weights
Email	Use email	0.739	0.591
	Does not us email	-1.732	-1.875
Website	Own website	1.528	1.197
	Does not own a website	-0.45	-0.902
Audited financial statement	Have audited financial statement	0.608	0.868
	Does not have audited financial statement	-1.672	-0.936

Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 11a: Weights generated from MCA - Aggregate innovation for Mali

		2003	2007
Variables	Categories	Weights	weights
Email	Use email	1.525	1.897
	Does not us email	-1.062	-0.655
Website	Own a website	2.141	3.564
	Does not own a website	-0852	-0372
Foreign Technology	Use foreign technology	1.607	3.200
	Does not use foreign technology	-0.151	-0.207
International certification	Use international certification	2.545	3.228
	Does not use international certification	-0.142	-0.280
Audited financial statement	Have audited financial statement	0.981	1.704
	Does not have audited financial statement	-0.968	-0489

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 11b: Weights generated from MCA - Product innovation

		2003	2007
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	2.937	2.774
	Does not use foreign technology	-0.341	-0.361
International certification	Use international certification	3.795	1.742
	Does not use international certification	-0.264	-0.574

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 11c: Weights generated from MCA - Process innovation

		2003	2007
Variables	Categories	weights	weights
Email	Use email	1.229	1.079
	Does not us email	-0.870	-1.368
Website	Own website	1.748	1.418
	Does not own a website	-090	-0.972
Audited financial statement	Have audited financial statement	0.851	0.413
	Does not have audited financial statement	-0.851	-0.351

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 12a: Weights generated from MCA - Aggregate innovation for Morocco

		2003	2007
Variables	Categories	Weights	Weights
Email	Use email	0.247	0.466
	Does not us email	-0.953	-1.98
Website	Own a website	2.098	1.763
	Does not own a website	-0.612	-0.731
Foreign Technology	Use foreign technology	3.013	2.273
	Does not use foreign technology	-0.236	-0.327
International certification	Use international certification	3.295	2.408
	Does not use international certification	-0.399	-0.483
Audited financial statement	Have audited financial statement	1.399	2.328
	Does not have audited financial statement	-1.041	-0.435

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 12b: Weights generated from MCA - Product innovation

		2003	2007
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	4.248	2.656
	Does not use foreign technology	-0.235	-0.376
International certification	Use international certification	3.262	2.258
	Does not use international certification	-0.307	-0.443

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 12c: Weights generated from MCA - Process innovation

		2003	2007
Variables	Categories	weights	weights
Email	Use email	0.399	0.432
	Does not us email	-1.566	-2.285
Website	Own website	2.077	1.402
	Does not own a website	-0.613	-0.867
Audited financial statement	Have audited financial statement	1.210	1.813
	Does not have audited financial statement	-0.910	-0.439

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 13a: Weights generated from MCA - Aggregate innovation for Nigeria

		2009	2014
Variables	Categories	Weights	Weights
Email	Use email	NA	2.018
	Does not us email	NA	-0.643
Website	Own a website	NA	2.425
	Does not own a website	NA	-0.507
Foreign Technology	Use foreign technology	NA	2.428
	Does not use foreign technology	NA	-0.310
International certification	Use international certification	NA	2.700
	Does not use international certification	NA	-0.321
Audited financial statement	Have audited financial statement	NA	1.831
	Does not have audited financial statement	NA	-0.466

Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 13b: Weights generated from MCA - Product innovation

		2009	2014
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	NA	2.816
	Does not use foreign technology	NA	-0.355
International certification	Use international certification	NA	2.930
	Does not use international certification	NA	-0.341

Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 13c: Weights generated from MCA - Process innovation

		2009	2014
Variables	Categories	weights	weights
Email	Use email	NA	1.731
	Does not us email	NA	-0.645
Website	Own website	NA	2.185
	Does not own a website	NA	-0.524
Audited financial statement	Have audited financial statement	NA	1.539
	Does not have audited financial statement	NA	-0.481

Source: Author's compilation based on the World Bank Enterprise survey database 2009 and 2014

Table 14a: Weights generated from MCA - Aggregate innovation for Rwanda

		2006	2011
Variables	Categories	Weights	weights
Email	Use email	NA	0.342
	Does not us email	NA	-2.683
Website	Own a website	NA	1.431
	Does not own a website	NA	-0.967
Foreign Technology	Use foreign technology	NA	1.583
	Does not use foreign technology	NA	-0.420
International certification	Use international certification	NA	1.873
	Does not use international certification	NA	-0.450
Audited financial statement	Have audited financial statement	NA	0.839
	Does not have audited financial statement	NA	-1.422

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2011

Table 14b: Weights generated from MCA - Product innovation

		2006	2011
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	NA	1.961
	Does not use foreign technology	NA	-0.510
International certification	Use international certification	NA	1.91
	Does not use international certification	NA	-0.510

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2011

Table 14c: Weights generated from MCA - Process innovation

		2006	2011
Variables	Categories	weights	weights
Email	Use email	NA	0.522
	Does not us email	NA	-1.963
Website	Own website	NA	0.887
	Does not own a website	NA	-0.799
Audited financial statement	Have audited financial statement	NA	0.887
	Does not have audited financial statement	NA	-1.143

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2011

Table 15a: Weights generated from MCA - Aggregate innovation for Senegal

		2006	2011
Variables	Categories	Weights	Weights
Email	Use email	1.342	1.583
	Does not us email	-1.592	-0.835
Website	Own a website	1.664	2.795
	Does not own a website	-1.170	-0.363
Foreign Technology	Use foreign technology	1.240	2.714
	Does not use foreign technology	-0.211	-0.247
International certification	Use international certification	1.904	3.593
	Does not use international certification	-0.106	-0.260
Audited financial statement	Have audited financial statement	0.479	1.802
	Does not have audited financial statement	-0.946	-0.588

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2011

Table 15b: Weights generated from MCA - Product innovation

		2006	2011
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	2.427	3.317
	Does not use foreign technology	-0.412	-0.302
International certification	Use international certification	4.000	3.718
	Does not use international certification	-0.250	-0269

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2011

Table 15c: Weights generated from MCA - Process innovation

		2006	2011
Variables	Categories	weights	weights
Email	Use email	1.087	1.359
	Does not us email	-1.294	-0.810
Website	Own website	1.346	2.630
	Does not own a website	-0.996	-0.374
Audited financial statement	Have audited financial statement	0.354	1.679
	Does not have audited financial statement	-0.716	-0.545

Source: Author's compilation based on the World Bank Enterprise survey database 2006 and 2011

Table 16a: Weights generated from MCA - Aggregate innovation for South Africa

		2003	2007
Variables	Categories	Weights	Weights
Email	Use email	0.076	0.523
	Does not us email	-4.890	2.255
Website	Own a website	0.766	1.173
	Does not own a website	-1.912	-1.093
Foreign Technology	Use foreign technology	2.060	1.745
	Does not use foreign technology	-0.598	-0.301
International certification	Use international certification	1.572	1.340
	Does not use international certification	-1.177	-0.804
Audited financial statement	Have audited financial statement	0.051	0.528
	Does not have audited financial statement	-1.637	-1.774

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 16b: Weights generated from MCA - Product innovation

		2003	2007
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	1.863	2.408
	Does not use foreign technology	-0.537	-0.415
International certification	Use international certification	1.165	1.291
	Does not use international certification	-0.858	-0.775

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 16c: Weights generated from MCA - Process innovation

		2003	2007
Variables	Categories	weights	weights
Email	Use email	0.150	0.706
	Does not us email	-9.744	-1.611
Website	Own website	0.780	1.246
	Does not own a website	-1.951	-0.844
Audited financial statement	Have audited financial statement	0.025	0.578
	Does not have audited financial statement	-0.793	-1.405

Source: Author's compilation based on the World Bank Enterprise survey database 2003 and 2007

Table 17a: Weights generated from MCA - Aggregate innovation for Zambia

		Y1	Y2	Y3 (2013)
Variables	Categories	Weights	Weights	Weights
Email	Use email	0.483	1.179	0.794
	Does not us email	-2.490	-1.312	-1.382
Website	Own a website	1.830	2.542	1.928
	Does not own a website	-0.648	-0.537	-0.613
Foreign Technology	Use foreign technology	3.651	0.981	1.832
	Does not use foreign technology	-0.282	-0.283	-0.495
International certification	Use international certification	2.290	2.168	1.910
	Does not use international certification	-0.276	-0.435	-0.516
Audited financial statement	Have audited financial statement	0.404	0.02	0.879
	Does not have audited financial statement	-2.310	-1.337	-0.942

Source: Author's compilation based on the World Bank Enterprise survey database 2002 and 2007

Table 17b: Weights generated from MCA - Product innovation

		Y1	Y2
Variables	Categories	weights	weights
Foreign technology	Use foreign technology	3.437	1.929
	Does not use foreign technology	-0.291	-0.518
International certification	Use international certification	2.884	1.945
	Does not use international certification	-0.347	-0.514

Source: Author's compilation based on the World Bank Enterprise survey database 2002 and 2007

Table 17c: Weights generated from MCA - Process innovation

		Y1		Y2
Variables	Categories	weights		weights
Email	Use email	0.453		0.885
	Does not us email	-2.251		-1.328
Website	own website	1.879		1.816
	Does not own a website	-0.674		-0.556
Audited financial statement	Have audited financial statement	0.351		0.800
	Does not have audited financial statement	-2.035		-1.018

Source: Author's compilation based on the World Bank Enterprise survey database 2002 and 2007

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CHAPTER 6
CONCLUSION, SUMMARY AND RECOMMENDATION

6.1 INTRODUCTION

Most empirical literature on innovation hardly discusses the role of finance, and empirical studies have mixed findings (Tian and Xu, 2014). According to the African Development Bank (2008: 29) African firms are lagging behind the rest of the world in innovation, and Africa needs technology (innovation), a critical mass of skilled personnel to serve as a catalyst for economic revival and the development of the continent. The Forum for Agricultural research in Africa (2012: 7) noted that for African agriculture and agribusinesses to increase productivity they need to innovate. However, access to finance is a major constraint to African enterprises (African Competitive Report, 2013: 20; Beck and Demirgüç-Kunt, 2006). Literature has shown that financially constrained firms find it difficult to innovate (Acs and Audretsch, 1990). Also, studies have examined the role of technology at macro level whereas little is known at firm level and even that little is skewed towards often publicly traded firms in developed economies (Caineilli et al., 2006; Baumol, 2002). In terms of Africa, little is known about this relationship. Hence, it becomes problematic to propose any sound policy that can contribute to alleviating the low level of innovation among African enterprises.

Against this backdrop, this study investigated the relationship between access to finance and innovation. It further examined the role of finance in product and process innovation using regionally selected African countries namely, Cameroon, Ghana, Kenya, Morocco and South Africa. It also appraised the literature on finance and innovation. Finally, the study analysed the different innovation types within enterprises and attempted to carve an innovation pattern for Africa.

The empirical analyses in this study used both descriptive statistics, such as simple ratios and averages, as well as figures and econometric models to explore the link between finance and innovation. The empirical analyses commenced by first computing innovation indices using more recent output classification of enterprise innovation (into aggregate, product and process innovation) by applying the multiple correspondent analysis (MCA). This caters for the weakness of previous studies that used R&D expenditure as proxy for innovation, which has been criticised in the literature (Beveren *et al*., 2010). To explore the relationship between innovation and finance, the study used instrumental variable technique. Mindful of the limitations of previous studies that employ cross-country and panel data approaches, this method was used to control for potential endogeneity and selection bias. The method was further used to explore the causal relationship between access to finance and firm innovation.

The purpose of this chapter is threefold. First to provide a general summary of the key findings of this study focusing on the evidence presented in Chapters 3 to 5. Secondly, to provide policy

recommendations based on findings; and lastly, to highlight the contribution of this study to existing literature.

6.2 SUMMARY, KEY FINDINGS AND POLICY IMPLICATIONS

This section summarises the findings regarding firm innovation as well as its relationship with access to finance. It further discusses possible policy implications of the results.

6.2.1 An overview of literature on finance and innovation link.

This section appraised the literature on innovation with special interest in finance. Firstly, it enhanced an understanding in the evolution of innovation. It further shed light on the different types of innovation. Thirdly, it has broadened knowledge of the relationship between innovation and finance and traced it back to the 1930s. Empirical evidence shows that there is a positive link between access to finance (debt and equity) and innovation, though in some rare instances it is mixed.

Findings also show that firm innovative activities are related with tertiary and research institutions. Findings from the review raise implications for policy. For example, policies that enhance financial sector development especially the banking industry and ensure increased access to finance for more enterprises should be pursued. There is a need to create a partnership scheme that brings together organisations willing to support start-ups, and extend funding to more enterprises.

6.2.2 Access to finance and firm innovation

This paper investigated the relationship between innovation and access to finance using firm level data on selected African countries. An aggregate innovation index was used computed with the multiple correspondent analysis (MCA) on access to finance. After controlling for possible endogeneity using the instrumental variable technique, results showed that access to finance as depicted through trade credit, asset finance and overdraft enhanced aggregate innovation in all selected countries – South Africa, Kenya, Nigeria, Cameroon and Morocco. This mean that the channels through which finance enhance firm innovation are overdraft, “asset finance” and trade credit. These findings have implications for financial policy for Africa and emerging economies.

This study calls for relevant policies that enhance financial sector development, especially the banking sector and increase access to finance for enterprises. Furthermore, different financial institutions such as microfinance can be supported to increase credits to enterprises and young entrepreneurs. Partnerships with organisations willing to support start-ups and fund firms that lack access to formal financial institutions should be encouraged. One such support mechanism could be a specialised scheme like a credit guarantee scheme, to encourage and secure lending to more enterprises particularly those that find it difficult to access formal financial institutions, to promote innovation.

6.2.3 The role of finance in product and process innovation

This project examined the role of finance in product innovation and process innovation. It used product and process innovation indices computed from different innovation output variables using the multiple correspondent analysis. Applying the instrumental variable technique, results showed that finance plays a critical role in driving both product innovation and process innovation. The two forms of debt finance, “asset finance” and overdraft facility, significantly increased firm innovation. Specifically, asset finance enhances process innovation in South Africa and both product and process innovation in Cameroon, Ghana and Kenya. This mean finance through asset finance enhance process innovation in South Africa while enhancing both product and process innovation in Cameroon, Ghana and Kenya. Overdraft is significantly linked to both product and process innovations in all five regionally selected countries for this study – Cameroon, Ghana, Kenya, Morocco and South Africa. Meaning finance via overdraft facility drives product innovation and process innovation in African enterprises.

These results have implications for financial policy for Africa. There is utmost need for relevant policies to enhance financial sector development, particularly the banking sector, and increase access to finance for enterprises. Secondly, policy incentives such as tax breaks should be granted to financial intermediaries that have proven to extend more credits to enterprises that lack access to formal financial institutions. In addition, financial intermediaries and donors should support mechanisms or specialised schemes like a credit guarantee scheme to encourage and secure lending to more enterprises in order to engineer innovation.

6.2.4 Innovation patterns in African enterprises

Findings show that Kenyan enterprises lead the continent in process innovation with South African enterprises in second place. Rwandan firms take the lead in product innovation while Kenya again dominates the continent in overall - aggregate innovation. However, during the same period Morocco witnessed the most significant improvement in product innovation while Angola observed the greatest improvement.

At the regional level, North Africa is leading the continent in aggregate innovation with East Africa in second place. There is tight competition in process innovation. North Africa dominates the continent in process innovation closely followed by East Africa and Southern Africa. West Africa champions the continent in product innovation whereas North Africa is the last in product innovation.

Given these findings, policies that promote continuous investment in research and development should be encouraged. To further the frontiers of innovation in Africa requires continuously improving

the technological environment and this can be achieved by promoting collaboration and knowledge sharing between innovation technology centres, tertiary institutions and enterprises.

6.3 CONTRIBUTION OF THE CURRENT STUDY

This study deviated from the traditional proxies used for innovation like patents, R&D that has been criticised (Beveren and Vandenbussche, 2010). Firstly, innovation indices (product innovation, process innovation and aggregate innovation) were computed using innovative outcome variables from the World Bank enterprise survey (WBES) database. The multiple correspondent analysis (MCA) was used to compute these innovation indices. The MCA is good at analysing categorical variables and more importantly, the MCA assigns weight according to the significance of the variables in the innovation index. This innovation index is a novelty in the innovation literature.

Secondly, instrumental variable technique was used to control for possible endogeneity and selection bias between finance and innovation. This is crucial as it is often absent in studies that examine the finance-innovation link using firm level data. By controlling for possible endogeneity, we render the findings robust and consistent.

Thirdly, this study creates innovation indices at country level, and at regional (East Africa, North Africa, West Africa, South Africa and Central Africa) levels. These innovation indices created at both country and regional levels can be used to carve an innovation pattern for Africa. This is the first attempt at such a study.

Fourthly and finally, this study has established a link between finance and innovation by showing that access to finance enhanced firm innovation. It further showed the channels through which finance enhanced innovation in African enterprises. Findings from this study showed that asset finance enhance product and process innovation in Cameroon, Ghana and Kenya and Process innovation in South Africa. Overdraft drive both product and process innovation in South Africa, Ghana and Cameroon and drive process innovation in Kenya and Morocco. However, finance through overdraft facility enhanced aggregate (overall) innovation in all the selected countries. Signifying that overdraft facility is a key channel through which finance drive innovation in African firms. In so doing, the research contributes to the literature on finance and innovation specifically by adding an African context to it. This is important because African firms are unique and have different characteristics from firms in developed countries, particularly in their way of doing business (Tybout, 2000).

6.4 CONCLUSION

This study examined the relationship between innovation and access to finance in African enterprises. It also analysed the role of finance in product and process innovation. Using instrumental variable technique the study has established a link between finance and firm innovation. It has shown that access to finance contributes positively towards firm innovation. The research has established that access to finance enhances both product innovation and process innovation.

This research constructed innovation indexes using the MCA and did a comparative analysis of innovation at country and regional levels. Findings show that Rwandan enterprises lead the African continent in product innovation, while Kenyan firms lead in process innovation and aggregate innovation respectively at country level. At the regional level, West Africa leads the continent in product innovation while North Africa champions process innovation and aggregate innovation respectively.

Given that this study has established a link between access to finance and firm innovation, and also that finance enhances innovation, policies should be pursued that enhance financial sector development and specifically the banking sector to increase access to finance for enterprises. This is important because this study shows that a critical factor for firm innovation is access to finance.

If African firms have to increase innovation, governments should pursue policies that incentivise firms such as granting tax rebates to financial intermediaries that have shown evidence of extending finance to more firms. In addition, policies design should target micro and small firms that are often excluded from the formal financial sector. The rationale could be to extend credit facility at a relatively lower cost and encourage them to innovate.

Furthermore, policy incentives such as tax breaks would encourage banks to increase lending to firms. In addition, creating a support mechanism such as a credit guarantee scheme to increase and secure lending to enterprises is important. It will be worthwhile to establish a network between enterprises, R&D institutions and technological centres, and tertiary institutions to share knowledge that will promote innovative activities.

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