UNIVERSITY OF CAPE COAST

EFFECT OF KNOWLEDGE SOURCES ON FIRM LEVEL INNOVATION IN GHANA

BY

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Thesis submitted to the Department of Economic studies of the School of Economics, College of Humanities and Legal Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy degree in Economics

JULY 2019

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature ………………………… Date ………………………

Name: Divine Mawusi Fiave

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature…………………...Date ……………………..

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ABSTRACT

This study analysed the effect of knowledge sources on firm level innovation in Ghana. To achieve this objective, the study applied a logit model on the 2013 Ghana Enterprise Survey and the 2014 Ghana Innovation Follow-up Survey with a total of 549 firms in all. It was found that the effects of knowledge sources are higher for process innovation than for product innovation. Specifically, internal R&D and training of workers were found to have a positive effect on both product and process innovations when internal sources of knowledge are considered in isolation. Purchase of equipment was also found to have a positive effect on both product and process innovation when considering the separate effect of external sources of knowledge. However, in the presence of both internal and external sources of knowledge, training of workers and purchase of equipment were found to have a positive and significant effect on product innovation whiles internal R&D, training of workers and purchase of equipment had a significant effect on process innovation. It was interesting to find an insignificant joint effect of internal R&D and purchase of equipment on product and process innovations. In the spirit of enhancing innovation in Ghana, this study recommends that the Ministry of Environment Science, Technology and Innovation formulate a policy that will ensure that firms devote a portion of their income for conducting internal R&D and also undertake in-house training. In addition, the Ministry of Finance should also offer tax incentives or subsidies for firms to acquire productive equipment and machinery in or outside the country.

KEY WORDS

Absorptive Capacity

External sources of Knowledge

Internal Sources of Knowledge

Process innovation

Product Innovation

ACKNOWLEDGEMENTS

I would like to express my profound gratitude to my supervisors, Dr. Ferdinand Ahiakpor and Dr. Benedict Afful Jnr. both of the School of Economics, University of Cape Coast, for their guidance and suggestions that led to the completion of this work. You are the ideal supervisors for this thesis.

I am also indebted to Mr. James Dickson Fiagborlo and Mr. Abbas Adams, PhD students of the School of Economics, University of Cape Coast for their contributions in shaping this thesis.

I wish to thank my family for their support and prayers especially my mother, Marie Jeanne Wordui, my sister, Comfort Akorfa Dzikunu, and my brothers Emmanuel Fiave, Prosper Agbesi Fiave and John Dzikunu.

To my elder brother, Prosper Agbesi Fiave, I say a big thank you for your financial support throughout my MPhil Programme. Rev. Fr. Donald Hinfey, SJ, also deserves special mention for his unflinching support to me.

In addition, I thank the African Economic Research Consortium for sponsoring my participation in the 2018 “Joint Facility for Electives (JFE)” at the Kenya School of Monetary Studies in Nairobi, Kenya.

Finally, I wish to thank all my programme mates at the School of Economics of the University of Cape Coast and my colleagues at the 2018 (JFE) who have helped in diverse ways in the course of writing this thesis.

DEDICATION

To Prosper Agbesi Fiave and the late Simon Kwame Fiave.

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LIST OF ACRONYMS / ABBREVIATIONS

ASTII	African Science, Technology and Innovation Indicator
CSIR	Council for Scientific and Industrial Research
ES	Enterprise Survey
GCI	Global Competitiveness Index
GIFS	Ghana Innovation Follow-up Survey
GII	Global Innovation Index
ICT	Information and Communication Technology
OECD	Organisation for Economic Corporation and Development
R&D	Research and Development
RDT	Resource Dependency Theory
STEPRI	Science and Technology Policy Research Institute
STI	Science Technology and Innovation
WEF	World Economic Forum
WIPO	World Intellectual Property Organisation

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CHAPTER ONE

INTRODUCTION

Background to the Study

Innovation is seen as one of the crucial factors that determine the survival and growth of firms (OECD, 2007). Again, it has been identified as one of the most important sources of competitive advantage (Gunday, Ulusoy, Kilic, & Alpkan, 2011; Abidin, Mohtar, & Yusoff, 2013; Jarle, Amundsen, Merethe & Hansen, 2014). The fourth Oslo Manual (OECD, 2018) defines innovation as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)".

Some international bodies periodically measure the rate of innovativeness of economies. For example, the World Intellectual Property Organisation (WIPO) publishes the Global Innovation Index. This index is a measure of the inputs to innovation and the resulting outcomes of various economies. In the 2018 Global Innovation Index, Ghana was ranked 107 out of 126 economies (WIPO, 2018).

In addition, the World Economic Forum (WEF) publishes the Global Competitiveness Index (GCI). The WEF defines national competitiveness as "a set of institutions, policies and factors that determine the level of productivity of a country" (WEF, 2018). Innovation capability is one of the pillars considered by the WEF in determining the competitiveness of nations. Innovation capability is the capacity to turn ideas into new goods and services. In the 2018 GCI, Ghana was ranked 106 out of 140 economies (WEF, 2018). The rankings of Ghana in the Global Innovation Index as well as in the Global Competitiveness Index report indicate that Ghana is not doing well in terms of innovation.

One of the critical factors that is often considered as a key resource and a pre-requisite for innovation is knowledge. Studies have found that innovation is the result of new knowledge that is generated, exploited and manipulated by firms to create new products and services (Knoben & Oerlemans, 2010; Stolwijk, Vanhaverbeke, Ortt, Pieters, Hartigh & Beers, 2012; Shearmur, Doloreux & Laperrière, 2015). According to Kaya and Patton (2011), knowledge-based resources increases firm's capability to identify and exploit opportunities.

Knowledge for innovation purposes comes from two main sources: the internal and the external sources (Lundvall, 1988; Cohen & Levinthal, 1990; van den Ende, Frederiksen & Prencipe, 2015; Dikova, 2015; Utami, Indarti, Sitalaksmi & Makodian, 2017). The internal source of knowledge refers to knowledge from within the boundaries of a firm whilst external knowledge acquisition occurs when the firm brings in new knowledge from outside sources.

The internal source of knowledge for innovation can be obtained through in-house research and development (R&D) activities (Cusmano, Morrison & Rabellotti, 2010), in-house knowledge dissemination (Deichmann & Van den Ende, 2014), knowledge of the top manager of the firm and employees (Mu, Bossink & Vinig, 2018) and internal education and training (Dostie, 2014 ; Boring, 2017).

The internal sourcing of knowledge for innovation requires a focus on the core competences and technological capabilities of a firm and the control over the development of technology (Gopalakrishnan, Kessler & Scillitoe, 2010). Knowledge from internally sourced technologies is usually firm specific, exclusive, tacit and difficult to interpret and imitate by other firms. Internally sourced technologies are usually easier to integrate with the knowledge base of the firm than externally sourced technologies. The "resource based" view and the "knowledge based" view of the firm consider internal resources such as a firm's internal knowledge as key for sustainable competitive advantage (Utami et al., 2017).

External source of knowledge for innovation involves the introduction of new knowledge from outside sources. Several factors contribute to the rise in sourcing of external knowledge for innovation. Chesbrough (2003) identified: the increasing availability and mobility of skilled workers, the growth of the venture capital market, and the increasing capability of external suppliers as the key factors. Chesbrough (2003) referred to the efforts of firms to search beyond their organizational boundaries for the knowledge required to innovate as "open innovation" (Chesbrough, 2003).

The external sources of knowledge for firms occur through various collaborations, such as joint ventures, alliances, mergers and acquisitions (Hillman, Withers & Collins, 2009). There are various actors in external collaborations of firms such as consultants, customers, competitors, universities, government offices and suppliers amongst others (Chiang & Hung, 2010). External knowledge can also be sourced through the purchase of machinery and equipment, recruitment of qualified personnel, conferences, training, and licensing amongst others.

Understanding how knowledge sources influences innovation and productivity has been a subject of theoretical and empirical debate in recent years. The resource and knowledge-based view emphasise the need to look within the firm for resources or knowledge for production and innovation (Penrose, 1959; Barney, 1991; Grant, 1996) The resource dependency theory explains the view that a firm acquires resources (i.e. knowledge) from the external sources because it has limited internal resources (Pfeffer &Salancik, 2003). The absorptive capacity theorists are of the view that external knowledge acquisition is useful only if a firm possesses an existing base of knowledge enabling it to utilize such knowledge (Cohen & Levinthal, 1990; Zahra & George, 2002).

A large number of countries have stressed innovation policies as a means to promote long-term growth and build a knowledge economy, based on a qualified and well-paid work force. The United States for example in 2005 launched the "Innovate America" strategy (America, 2005). In the year 2000, the European Union adopted the "Lisbon Agenda" (OECD, 2007). The aim of the "Lisbon Agenda" was to make the European Union the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion (Conclusion, 2000). In addition, in 2010 the government of Ghana launched the National Science, Technology and Innovation (STI) policy (MEST, 2010). The aim of Ghana's STI policy is to harness fully the nation's total science and technology capacity to achieve national objectives for poverty reduction, competitiveness of enterprises, sustainable environmental management and industrial growth.

Though the Government of Ghana launched its STI policy in 2010, the extent to which knowledge sources impact innovation is not known. It is unclear whether firms benefit from innovation policies that promote internal knowledge capability, or those that favour external knowledge acquisition or a combination of both sources of innovation. This is mainly due to lack of data on innovation and innovation related activities

This empirical study adopts a logistic regression model and applies the maximum likelihood estimation technique on data on 549 innovative firms sourced from the first Ghana Enterprises Survey conducted in 2013 and the Ghana Innovation Follow-up Survey conducted in 2014. These datasets are the first survey that followed the global standard methodology for collection of information on innovation in Ghana.

For a developing country like Ghana, this study will help identify the extent to which knowledge sources influence firm level attempts to develop product and process innovations in Ghana. This will help improve the organisational restructuring, knowledge management practices and capacities that firms should have to benefit from utilizing the various knowledge sources.

Statement of the Problem

The importance of innovation for firms cannot be overemphasized**.** Innovation brings down the operational costs (Benitez-Amado, Llorens-Montes & Nieves Perez-Arostegui, 2010) enhances firm’s profitability (Adewoye & Akanbi, 2012), increases the effectiveness of the production process (Sabbaghi & Vaidyanathan, 2008) and also leads to significant reduction in firm mortality (Sinha & Noble, 2008)

Ghana has been making efforts through policies to help increase the innovativeness of firms and citizens in general. The recent Ghana STI policy, which was launched in 2010, was aimed at harnessing fully the nation's total science and technology capacity and knowledge to achieve national objectives for poverty reduction, competitiveness of enterprises, sustainable environmental management and industrial growth (MEST, 2010).

An important unresolved question in innovation strategy is whether a firm's ability to innovate is better enhanced by using knowledge internally within the firm or by using knowledge from external sources (Almirall & Casadesus-Masanell, 2010). Three streams of problems can be identified with the use of knowledge and innovation outcomes.

First, some theoretical and empirical researches are of the view that individual firms are rarely capable of innovating independently (Chesbrough, 2003; Lundvall & Nielsen, 2007; Lazzarotti, Manzini, & Pellegrini, 2015). They emphasize the use of external sources of knowledge for innovation success. For this approach, the success of innovation is linked to the use of heterogeneous knowledge sources such as universities and public research institutes, conferences, patents, licenses, purchase of equipment amongst others.

The second stream warned against overstating the importance of external knowledge sources. They emphasize the influence of internal capacities and resources on a firm's ability to innovate. Studies by Becheikh, Landry and Amara (2006) and Freel (2003) highlight the importance of internally generated knowledge on innovation success. Other studies have found a positive relationship between the use of internal complementary resources such as in house training of workers, marketing, commercialisation and the success of innovation (Doloreux & Shearmur, 2013; Mongo, 2013). Coombs, Narandren and Richards (1996) warned that outsourcing R&D activities may weaken the core competences of the firm.

The third stream emphasizes that the propensity to innovate is not directly linked to the sole use of internal or external knowledge sources (Doloreux & Shearmur, 2013). According to Vega-Jurado, Gutiérrez-Gracia, Fernández-de-Lucio and Manjarrés-Henríquez (2008), a strategy directed towards the acquisition of external knowledge alone cannot promote innovation. In addition, internal R&D has long been considered the most important decisive factor for competitive advantage (Lokshin, Belderbos & Carree, 2008; Tsai & Wang, 2009). However, the cost of internal R&D has been skyrocketing while its productivity has fallen (David, Mehta, Norris, Singh & Tramontin, 2010; Paul, Mytelka, Dunwiddie, Persinger, Munos, Lindborg & Schacht, 2010). In the face of the increasingly prominent role of external knowledge sources such as purchase of equipment and machinery, it is unclear how firms optimize their internal R&D activities in the presence of externally sourced knowledge such as purchase of equipment.

Some studies suggest that external knowledge sourcing such as purchase of equipment and machinery can only be effective in the presence of high levels of internal R&D (Lokshin et al., 2008; Tsai & Wang, 2009). However, other findings indicate that external knowledge sourcing can be detrimental for firms with strong internal capabilities (Vega-Jurado et al., 2008). Again, some studies (Chesbrough, 2003; Huston and Sakkab, 2006) show the potential of external knowledge sources such as purchase of equipment while reducing the level of in-house R&D. In contrast, other firms experienced substantial problems such as loss of control of own knowledge and ‘withered’ core competencies when relying on external knowledge while reducing the level of internal R&D (Christensen, 2006; Frishammer, Ericsson & Patel, 2015).

Fu, Pietrobelli, and Soete (2010) are of the view that firms in developing countries might be better off improving their ability to acquire existing external knowledge, instead of trying to innovate within the firms because innovation is costly, risky, and path-dependent. Griffith, Redding, and Reenen (2004) argue that tapping existing knowledge is not easy. They posit that the adaptation of knowledge requires well-directed technological efforts as well as sufficient human and financial resources and absorptive capacity; which are essentially the same pre-requisites needed for internal innovation. In Ghana, purchase of equipment is increasingly becoming a major strategy for innovation. However, the extent to which equipment affects firm level innovation given the internal R&D capability of firms is not known.

In the Ghanaian context, some studies have been done on firm level innovation but the extent to which knowledge sources affect the propensity to innovate is unclear. For example, Tetteh and Essegbey (2014) studied firm level innovation among small, medium and large firms within the Ghanaian manufacturing and service sector. Using descriptive and inferential statistics on the African Science, Technology and Innovation Indicator (ASTII) survey conducted in Ghana in 2012, they found that 66% of the innovations were developed within the country while 34% originated from abroad. However, this study did not indicate the actual source of knowledge that led to the 66% of the innovations generated in the country.

Afful and Owusu (2017) attempted to explore the sources of innovation in Ghana but unfortunately limited the scope to only the manufacturing sector. Even though their findings were very insightful, it did not really give a complete picture about innovation activities in Ghana since the manufacturing sector contributes about a quarter (25.5%) to the Gross Domestic Product of Ghana (Ghana Statistical Service, 2019).

The current study builds on the works of Afful and Owusu (2017) by examining a much broader scope by including the service sector which contributes about 56.2% to the GDP (GSS,2019). In addition, this study also seeks to include other key variables that have been identified in the literature to influence innovation such as purchase of equipment and machinery, the top manager's years of experience, location status of firms, purchase of intangible technologies such as patents, licenses, trademarks, trade secret rights, and copyrights among others.

Objectives of the Study

The general objective of the study is to analyse the effect of different knowledge sources on firm level innovation in Ghana.

Specifically, the study seeks to

1. Assess the effect of internal knowledge sources on innovation.
2. Examine the effect of external knowledge sources on innovation
3. Analyse the joint effect of internal R&D and purchase of equipment on innovation.

Research Hypothesis

To address the objectives of the study, the following hypotheses will be tested:

H_0: Internal knowledge sources have no significant effect on innovation.

H_1: Internal knowledge sources have a significant effect on innovation.

H_0: External knowledge sources have no significant effect on innovation.

H_1: External knowledge sources have a significant effect on innovation

H_0: Internal R&D and purchase of equipment jointly have no significant effect on innovation.

H_1: Internal R&D and purchase of equipment jointly have a significant effect on innovation.

Significance of the Study

In the highly competitive global environment, policies on innovation are interested in how it provides an effective solution to maintain, regulate, sustain or strengthen growth of an organization.

Examining the effect of different knowledge sources on innovation performance helps to determine the capacities a firm should have in order to implement successful innovations. It will also help to determine whether firms will benefit more from policies that promote in- house innovation or policies that promote the external development of innovations.

In addition, this study will help managers in the design of effective knowledge management policies and the organizational restructuring that is needed to suit the different sources of knowledge. This is because the governance system within some organisations is often more hierarchical in nature, while coordination involving strategic alliances requires a more discrete negotiation concerning specific contractual conditions or mutual expectations of reciprocity.

Delimitation of the Study

This study examines the effect of knowledge sources on innovation performance of firms in Ghana. Though there are several sources of knowledge for the development of innovations, for the study at hand, they are categorized into internal and external sources. Based on the availability of data, the study operationalizes the internal source to be composed of internal research and development, manager's years of experience and training of production staff. The study operationalises the external source to be composed of external R&D, purchase of equipment and machinery; and the purchase or license any patented or non-patented inventions.

In addition, there are different types of innovations: product, process, marketing, organisational, radical and incremental innovations amongst others. However, this study will focus on the two major types: product and process innovations. A total of 549 sampled firms from the manufacturing and service sectors are used in this study.

Organisation of the Study

The remaining chapters are organised as follows: Chapter Two provides a review of the concept of innovation and the theoretical and empirical literature on the effects of internal and external knowledge sources on innovation. Chapter Three deals with the methodology adopted for the study. It identifies the data source and specifies the model and describes the estimation method used to estimate the innovation function. Chapter Four presents the results and discussion of the effects of various knowledge sources on product and process innovations. Finally, the summary, conclusion and policy recommendations as well as areas for study in the future are discussed in Chapter Five.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter reviews theoretical and empirical studies on the effects of knowledge sources on firm level innovation. This section is divided into three main thematic areas. The first section focuses on the concept of innovation and a review of innovation policies in Ghana. The second section provides a review of the theoretical literature on the sources of knowledge for innovation. The last section explores some empirical studies conducted on the effects of knowledge sources on innovation.

The Concept and Definitions of Innovation

Innovation is a concept often used within different disciplines and contexts; as such, the word 'innovation' means different things to different people. The definitions of the concept of innovation are characterised by change, newness or novelty, or efficiency in terms of commercialisation of a new product or process.

The modern day definition of innovation is usually accredited to Schumpeter (1912). He defined innovation in five ways:

1. The introduction of a new good unknown to the consumer or a new quality of a good.
2. The introduction of a new method of production; a method, which has not been applied in the given sector to date but is not necessarily based on a new scientific discovery.

3. The opening of a new market; one which has not yet been occupied by products from the given sector and country, regardless of whether that market already exists.
4. The conquest of a new source of supply of primary inputs, raw materials and intermediate inputs
5. The carrying out of a new organisation of industry, such as the creation or destruction of a market monopoly (Godin, 2008).

Again, in the 1930's, Schumpeter explained innovation within the context of "creative destruction" where entrepreneurs had incentive to undertake innovations to replace old products and services in response to declining profit margins. Survival considerations is what motivates firm innovative behaviour (Nicholas, 2003).

Innovation as a Novelty or Means for Change

Some definitions consider innovations as something new whereas others see it as an avenue for change. Barnett (1953) defines innovation as **"**any thought, behavior, or thing that is new because it is qualitatively different from existing forms". According to Rogers (2003) innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption".

Some definitions suggest innovation is an avenue for change (Drucker ,1985; O'Sullivan & Dooley, 2008). Drucker (1985) defines innovation as "the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced". For O'Sullivan and Dooley (2008) innovation is the application of practical tools and techniques that make changes, large and small, to products, processes, and services that result in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization.

Innovation as a Novelty and a process

Innovation has also been defined as a process. Robertson (1967), defines innovation as "a process by which a new idea, behavior, or thing, which is qualitatively different from existing forms, is implemented and applied in practice". Aiken and Hage (1971) see innovation as **"**the generation, acceptance, and implementation of new ideas, processes, products, or service for the first time within an organization setting". For Rasul (2003), it is "the process whereby ideas or new or improved products, processes or services are developed and commercialized in the marketplace".

The Oslo Manuals Definitions of Innovation

The Oslo Manual of the OECD provides guidelines for collecting and interpreting data on innovation. Over the years, the Oslo Manual has given varying definitions of what constitutes an innovation.

The first edition of the Oslo Manual (OECD,1992) defines innovations as all those scientific, technical, commercial and financial steps necessary for the successful development and marketing of new or improved manufactured products, the commercial use of new or improved processes or equipment or the introduction of a new approach to a social service" (OECD, 1992). The first edition was limited to only the manufacturing sector and it considered innovation to be only technological products or processes (OECD, 1992). The second edition Oslo Manual (OECD/Eurostat, 1997) was broadened to include services but innovation still basically involved technological products and processes.

The third Oslo Manual (OECD, 2005) defines innovation as “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations”. According to the third edition, “The minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new or significantly improved to the firm. This includes products, processes and methods that firms are the first to develop and those that have been adopted from other firms or organisations.” Four types of innovations could be distinguished from the third Oslo Manual: Product, Process, marketing and organizational innovations (OECD, 2005).

The fourth Oslo manual (OECD, 2018) defines innovation as “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).” Compared to the third edition, there has been a reduction in the classification of innovations into two: products and business process innovations. In the fourth edition of the manual the basic requirement for an innovation is that it must be significantly different from the firm’s previous products or business processes.

Invention and Innovation

There is often a confusion in the usage of the words innovation and invention. As far back as 1934, Joseph Schumpeter points out that innovation needs to be distinguished from invention. Schumpeter described invention as an intellectual creativity and has no importance in economic analysis. Innovation on the other hand is the economic decision to apply or adopt an invention (Schumpeter, 1934).

Some scholars (Freeman, 1982; Rouse,1992; Fagerberg & Verspagen, 2006) provide a clearer distinction between *innovation* and *invention*. According to Freeman (1982) an *invention* is "an idea, a sketch or model for a new or improved device, product, process or system" whereas "an i*nnovation* in the economic sense is accomplished only with the first commercial transaction involving the new product, process, system or device". For Rouse (1992) invention is the creation of a new device or process whereas innovation is the introduction of change through something new.

According to Fagerberg and Verspagen (2006), invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice. He stated that inventions may be carried out anywhere, for example in universities, whereas innovations occur mostly in firms, though they may also occur in other types of organizations. He further stated that, to turn an invention into an innovation, a firm normally needs to combine several different types of knowledge, capabilities, skills, and resources. The role of the innovator, or the person or organizational unit responsible for combining the factors may be quite different from that of the inventor. Indeed, history is replete with cases in which the inventor of major technological advances fails to reap the profits from his breakthroughs.

The above discussions on the definition of innovation shows clearly that there is no concrete, single and generally accepted definition of innovation (Zhou & Li, 2012). Innovation is however characterized by newness, change and commercialization of an idea.

Classification of Innovations

According to the definition of innovation in the third edition of the Oslo manual (OECD, 2005), four types of innovations can be identified: product**,** process**,** marketing and organisational innovation.

Product Innovation

Product innovation is a good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics.

The fourth edition of the Oslo Manual (OECD, 2018) defines product innovation as a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market. One difference in the composition of product innovation between the third and fourth edition of the Oslo manual is that product design characteristics was considered under marketing innovation. However, it is part of product innovation in the fourth edition of the manual.

Process Innovation

According to the third edition of the Oslo Manual (OECD, 2005), process innovation is a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. Some subcomponents of process innovation in the third edition of the Oslo manual include production delivery and logistics, ancillary services, including purchasing, accounting and Information and Communication Technology (ICT) services.

The fourth edition of the Oslo manual has qualified process innovation as a “business process innovation”. A business process innovation is a new or improved business process for one or more business functions that differs significantly from the firm’s previous business processes and that has been brought into use by the firm. A notable difference in the conception of process innovation between the third and the fourth editions of the Oslo Manual is that in the third Oslo manual ancillary services such as purchasing, accounting and ICT services which were considered as part of process innovation. These are considered as administration and management function of the business.

Marketing Innovation

There are several definitions of market innovations. According to Tinoco (2010), marketing innovation is the generation and implementation of new ideas for creating, communicating, and delivering value to customers and managing customer relationships in ways that benefit the organisation. The third Oslo Manual, OECD (2005) defines it as a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. Marketing innovations are aimed at better addressing customer needs, opening up new markets, or newly positioning a firm's product on the market, with the objective of increasing the firm's sales.

Organisational Innovation

Organisational innovation also means different things to different people. Damanpour (2014) calls it administrative or management innovation. He conceptualised it as how managers do what they do. Hollen, Van Den Bosch, and Volberda (2013), view organizational innovation as: "firm-specific, new to the firm management activities associated with setting objectives, motivating employees, coordinating activities and making decisions, which arise due to new inter-organisational relations and are intended to further organisational goals."

The definition in the third Oslo Manual (OECD, 2005) is at the same time broad and simple: organizational innovation is the implementation of a new organizational method in a firm's business practices, workplace organization or external relations. This definition comprises three mains branches:

1. business practices (new methods for organizing routines and procedures);
2. workplace organization (new ways of distributing responsibilities involving employees); and
3. external relations (new ways of organizing relations with other firms or public institutions).

Overview of Innovation Policies in Ghana

According to Amankwah-Amoah (2016), three patterns could be identified from the evolution of STI policies in Ghana: The Kwame Nkrumah era, (1957-1966), the post Nkrumah era, (1967 -1990s) and the "New dawn" (from 2000 onwards).

The Nkrumah Era

The foundation of Ghana's STI Policy can be traced to the Kwame Nkrumah era. At the dawn of Ghana's independence, Kwame Nkrumah pointed out that most of the challenges facing Ghana could be overcome through the development of science and technology. Since Ghana gained independence from colonial rule in 1957, the formulation of science and technology policies started with greater intensity to help foster indigenous innovation and development.

In a speech delivered by the founding Prime Minister of Ghana, Kwame Nkrumah, at the last meeting of the old legislative assembly on the 5th of March, 1957, a clear vision of rapid development based on the application of science and technology was spelt out.

> *He said: "Our whole educational system must be geared to producing a scientifically-technically minded people. Because of the limitations placed on us, we have to produce, of necessity, a higher standard of technical education than is necessary in many of the most advanced countries of the Western world. I believe that one of the most important services which Ghana can perform for Africa is to devise a system of education based at its university level on concrete studies of the problems of the tropical world. The*

University will be the coordinating body for education research, and we hope that it will eventually be associated with research institutes dealing with agriculture, biology, and the physical and chemical sciences which we hope to establish…."(McWilliam & Kwamena-Poh, 1975).

For Years Nkrumah sought to use Education as a policy tool to make Ghanaians more scientifically and technologically advanced than during the colonial period (Asabere-Ameyaw, Dei, & Raheem, 2012). He believed the standards of living and the pressing social issues could be addressed if the new Ghana developed knowledge and expertise in areas such as engineering, medicine, tropical agriculture and hygiene. This belief led him to establish the University of Science and Technology (now Kwame Nkrumah University of Science and Technology) for scientific human capital development. In 1962, the University College of Science Education (now called University of Cape Coast) was also established to train science and mathematics teachers for secondary schools across the country (Ahia & Fredua-Kwarteng, 2012). The Ghana Atomic Energy commission was also established to support academic and research institutions in the country.

To further promote the development of science and technology in Ghana, the Research Act 21 was passed in 1958. This Act led to the establishment of the National Research Council. The principal aim of the council was to organize and coordinate scientific research to aid policy formulation and industrialization of the new Ghana. The National Research council was chaired by President Nkrumah. The National Research Council has now been transformed into the Council for Scientific and Industrial Research

(CSIR) (Amankwah-Amoah, 2016). In 1959, the Ghana Academy of Learning was established. The functions of the Ghana Academy of Learning and the National Council of Learning were merged with the establishment of the Ghana Academy of Sciences in 1963. The Ghana Academy of Sciences organised and coordinated all research activities in the country.

Science and technology was a key component of the Seven-Year Development Plan of Kwame Nkrumah (1963/64 to1969/70) (Amankwah-Amoah, 2016). The Nkrumah era allowed indigenous development and innovation to flourish. In 1961, the Akosombo Hydroelectric Project started and offered opportunities for locals to develop expertise in science, engineering and construction. This project also allowed for technological learning from the foreign experts who were working on the project alongside the local workers.

To ensure that finance does not impose unnecessary barrier to the development of Science and technology and the development plan of the Government, several state-owned financial institutions were established. The Bank of Ghana, the Ghana Commercial Bank, the Agricultural Development Bank, The Merchant Bank, the Bank for Housing and Construction, the National Investment Bank amongst others.

During the colonial era, foreigners dominated the private sector. In the early years of independence, these foreign firms were viewed with suspicion as not being indigenous enough to warrant government support. Government policies and subsidies were directed at the state-owned firms. The nationalisation of some local firms and foreign assets discouraged entrepreneurship and indigenous innovation (Amankwah-Amoah, 2016).

The Post Nkrumah Era

The immediate period following the overthrow of the Nkrumah regime was a period during which according to Amankwah-Amoah (2016) "the seeds for the destruction and disruption of science and technology policy were sown". The early period following the overthrow of Kwame Nkrumah (late 1960's-1970) was a period characterised not only by a slowdown in economic activity but also the dismantling of major STI initiatives during the Nkrumah period.

Political instability affected effective scientific collaboration between universities and policy makers. During the mid-1970's Government's concern was on how to gain influence and control over the universities. According to Peil (1996) in 1977, the head of state, General Acheampong expressed his frustrations in removing university professors from their posts. He is noted to have said it was "much more difficult to remove university professors than a Chief Justice" (Peil, 1996). As consequence of the political instability, there was a depletion of scientific knowledge and expertise. This was because there was a migration of scientists, engineers, academics and other highly skilled individuals to more stable countries.

Another distinctive characteristic of the post Nkrumah era was the lack of explicit policy for STI (Vitta, 1990).Various governments between 1970 and 1980 pronounced their desire to use science and technology for development but there was no policy to back these desires. In addition, the military regimes that followed the Nkrumah era dropped Nkrumah's Doctrine and his drive to develop an educational system and innovative capacity of Ghanaians. The era of enthusiasm for science and technology with KNUST at the center was replaced with the political survival of military leaders and their regimes. As such, their topmost priority was how to perpetuate their stay in power. The early 1970's and 1980's also saw the erosion of the gains in industrialising Ghana, which started under Kwame Nkrumah (Amankwah-Amoah, 2016).

From the late 1980's the Ghanaian economy began to experience some sustained period of political and an economic stability. There were some signs of the rebirth of science technology and Innovation policy in Ghana. In the late 1980's the Ghana Education Service developed Science Resource Centers in a number of schools with the aim of promoting science education (Amankwah-Amoah, 2016)

The government also began to lay emphasis on science and technology policy research. The technology transfer center was founded in 1987 as a branch of the CSIR. This center was renamed the policy research and strategic planning institute in 1992. In 1994, the institute was reintegrated into the structure of the CSIR and renamed the Science and Technology Policy Research Institute (STEPRI). The STEPRI's primary role entails the "development, transfer, utilization and management of STI in accordance with the context-specific needs and priorities of Ghana and Africa"

In 1998, the Institute of Industrial Research was established following the merger of the previous Industrial Research Institute and Scientific Instrumentation Centre (MEST, 2010). Its mission is "to drive national development and global competitiveness in industry through scientific and technological research" (MEST, 2010). In 1996, all public research institutes were included under the umbrella of the CSIR. The CSIR coordinates research activities among research centers in the country with the aim of building capacity and fostering development (Amankwah-Amoah, 2016)

From the Year 2000 Onwards

From the year 2000 there seems to be a re-prioritisation and convergence of Science Technology and Innovation policies. In the year 2000, the first National science and Technology policy was launched. This was the first major national STI policy (MEST, 2010). The principal aim of this document is on how to harness and utilize science and technology at all levels of society. The Government of Ghana planned to attain a middle-income status by the year 2020 (UNCTAD, 2011). Science, technology and innovation is key to the attainment of the vision 2020 agenda. As such, one major step toward achieving this goal is ensuring that 60% of all students in the public universities and 80% in the vocational institutions are studied science or science related subjects (MEST, 2010).

In the year 2006, there was a major blow to attempts at promoting STI. This was because of government's decision to dissolve the Ministry of Environment, Science and Technology in an attempt to reduce the number of ministries. The Science portfolio was fused into the Ministry of Education to become the Ministry of Education, Science and Sports (MESS). Resources for the development and promotion of science and technology were negatively affected due to limited focus. However, in 2009, the Ministry of Science and Technology was restored. This new ministry was responsible for the country's science and technology policy framework and the coordination of the activities of all the thirteen research institutes of the CSIR.

In February, 2010, the national STI policy was relaunched. This was with the aim of enhancing and fostering the application of STI into the national development strategy. Specific objectives of the new policy are among others to:

1. facilitate mastering of scientific and technological capabilities
2. provide the framework for inter-institutional efforts in developing STI and programmes in all sectors of the economy to provide the basic needs of the society;
3. create the conditions for the improvement of scientific and technological infrastructure for research and development and innovation (MEST, 2010).

The principal thrust of the national STI Policy is to ensure that science and technology drives all sectors of the economy. The new policy has sector specific strategies. The Ministry of Environment, Science and Technology has responsibility for the STI policy and is expected to manage and implement Government's STI policies (MEST, 2010).

The new policy has special financing mechanisms for STI. To ensure the availability of funds at all times to meet the demands of innovation. Government will among other things:

1. take stock of all existing funding lines established to support development in science and technology and industry with the aim of streamlining them to achieve economies in their operations.
2. strengthen and modify the National Science and Technology Foundation to incorporate support for innovation in its sphere of operations.
3. accelerate the allocation of a minimum of 1% of the Gross Domestic Product (GDP) to support the science and technology sector.

4. institute an attractive tax incentive mechanism for contributors to the instituted funds or directly to R&D activities, but in such a way as not to erode the national tax base (MEST, 2010).

Sources of Innovation

The innovation output of firms come from various sources. Some this include internal or external research and development, purchase of new process equipment, knowledge spillovers, training of production staff to become innovative, applying for patents, recruiting skilled personnel to develop innovative products, technology transfers, reverse engineering, imitation, amongst others. However, the various sources of innovation can be grouped into two: internal and external sources (Lundvall, 1988; Cohen & Levinthal, 1990).

Internal Sources of Innovation

Generally, internal source of innovation refers to innovation that takes place within the boundaries of the firm. The resource base view and the knowledge-based emphasis the importance of firm's internal resources and knowledge as the source of competitive advantage. Internal innovation relies on internal resources and knowledge from two principal actors: employees (Elche-Hotelano, 2011; Salge, Farchi, Barrett & Dopson, 2013) and the owners of the firm (Indarti, 2011). Firms get new ideas from their employees and transfers this knowledge into innovations. The owners support the innovation process by their role as the decision maker of the innovation. Internal knowledge for innovation occurs through activities such as in-house R&D (Cusmano et al., 2010), internal knowledge dissemination (Deichmann & Van den Ende, 2014), internal education and training (Dostie, 2014).

According to Falkenberg, Woiceshyn and Karagianis (2003), internally sourced knowledge is usually tacit, path dependent and based on cumulative experience. It also involves production costs, the risk of unproductive research and development, and the direct cost of research infrastructure. In addition, the output of internal knowledge depends on the transformative capacity of the firm; which is defined as the ability of the firm to continually redefine product portfolio based on technological knowledge and skills within the firm.

Gopalakrishnan et al. (2010) posit that internal sourcing of knowledge requires a focus on the core competences and technological capabilities of the firm. Tsai and Wang (2009) are also of the view that internal knowledge activities such as internal R&D are indispensable for the development of competences that are difficult to find outside the firm. Some studies have stressed that the level of firm's pre-existing internal knowledge determines its ability to identify and exploit external knowledge (Cohen & Levinthal, 1990; Cockburn & Henderson, 1998; Zahra & Hayton, 2008; Grimpe & Sofka, 2009). As such, firms that conduct their own R&D are more successful in leveraging external knowledge. Higher levels of internal R&D is associated with high levels of innovation performance (Hseih, Love, & Ganotakis, 2011; Gallié & Legros, 2012; Conte & Vivarelli, 2014).

Despite the importance of firm's internal knowledge capabilities, recent studies have cautioned that over relying on internal knowledge could lead to path dependence, competency traps and organisational myopia; thus the need for internal knowledge to be balanced with external knowledge (Rosenkopf & Nerkar, 2001; Vanhaverbeke, Duysters & Noorderhaven, 2002; Chesbrough, 2003; Tsai & Wang, 2009).

External Sources of Innovation

External sourcing of innovation occurs when the firm looks beyond its boundaries for knowledge to innovate. The Resource Dependency Theory (RDT) posits that firms rely on resources from their external environment to survive. RDT also claims that a firm collaborates with external partners to get external knowledge through its various collaborations, such as joint ventures, alliances, mergers and acquisitions (Hillman et al., 2009). Other actors for external sources of innovation include knowledge from customers, suppliers, competitors, consultants, universities, and government offices (Chiang & Hung, 2010; Indarti, 2010; Laursen & Salter, 2014).

According to Chesbrough (2003) the increasing availability and mobility of skilled workers, the growth of the venture capital market, and the increasing capability of external suppliers are the key reasons for the rise of external sourcing of innovation. According to Woiceshyn and Karagianis (2003), external knowledge is mobile and explicit; it involves transaction costs and costs related to networks and searches. In addition, the output of external knowledge usually depends on the absorptive capacity of the firm; which is the ability to exploit technological opportunities outside the firm. The output also depends on learning by watching and learning by participation.

Some advantages of external sourcing of innovation have been identified (Chesbrough, Vanhaverbeke & West, 2006; Lee, Park, Yoon & Park, 2010; Veer, Lorenz & Blind, 2012). They include diversification of R&D investments, easier market entry, resource acquisition advantages, broader base of ideas and technological synergy effects. However, Ullrich and Vladova (2016) identified some dark sides of external innovation. Some of these include intellectual property spillover, strong dependence on external knowledge, and loss of key knowledge control, flexibility, creativity and strategic power.

Theoretical Literature

In analysing the extent to which different knowledge sources affect firm level innovation in Ghana, three theoretical views can be explored: the resource and the knowledge-based view, the resource dependency theory and the theory of absorptive capacity.

The Resource and Knowledge Based View of the Firm

The resource-based view sees the firm as an organisation with unique resources and capabilities. Firm's internal resources are the basis of this theory. The theory holds that competitive advantage can be achieved and sustained more easily depending on the extent to which firms internally exploit and govern their valuable, rare, inimitable, and non-substitutable resources rather than external factors.

The origin of the resource-based view of the firm is usually associated with the works of Edith Penrose in 1959. In her work "The theory of the growth of the firm", she posits that a firm is not just an administrative unit, but is also a collection of productive resources. Supporters of this view (Wernerfelt, 1984; Barney, 1991; Grant, 1991; Peteraf, 1993; Makhija, 2003) argue that organisations should look inside the company to find the sources of competitive advantage instead of looking at the competitive environment for it.

Barney (1991) stated two critical assumptions of the resource-based view. These are the heterogeneity and the immobility of resources. The heterogeneity assumption is that the skills, capabilities and other resources that a firm possess vary from one firm to another. The immobility of resources assumption of this theory is that in the short run resources are fixed and do not move easily from one firm to the other. The immobility assumption makes it impossible for firms to have the resources of their competitors and implement their strategies. Intangible resources, such as brand equity, processes, knowledge or intellectual property are usually immobile.

The resource-based view allows researchers to associate resources to the competitive advantage of firms. Roos, Bainbridge, and Jacobsen (2001) are of the view that competitive advantage does not come from industry dynamics but from the way a firm uses the resources it has. According to Barney (1991) there are certain conditions that resources must have to enable the firm to sustain its competitive advantage; the resources must be: valuable, rareness, imperfect imitability and non-substitutability (VRIN criteria). Seth and Thomas (1994) posit that the differences in efficiency between firms are due to the difficulty in imitating the resources each firm has. Amit and Schoemaker (1993) are of the view that firm specific factors account for the systematic variations in profits and performance of firms.

The resource-based view has often been criticised. Priem and Butler (2001) argue that it is difficult to find a resource that meets all of the “valuable, rareness, imperfect imitability and non-substitutability (VRIN criteria). They further indicated that the resource-based view has a limited ability to make reliable predictions. Other criticisms of the theory are that different resource configurations can generate the same value for firms and thus would not be competitive advantage.

Tywoniak (2007) posits however, that the usefulness of RBV appears to be greater in terms of generating understanding and providing a structure for strategizing. Barney (2001) supports this view by arguing that resource-based logic can help managers more completely understand the kinds of resources that help generate sustained strategic advantages, help them use this understanding to evaluate the full range of resources their firm may possess, and then exploit those resources that have the potential to generate sustained strategic advantage.

An important extension of the resource base theory is the Knowledge based theory. The key proposition of the knowledge-based view is that knowledge is the most important strategic resource of the firm. Its proponents: Nonaka (1994), Grant (1996), Spender (2003) and Carlsson (2003) argue that for a firm to maximize the value of its resources then it must possess superior knowledge. They are of the view that it is due to superior knowledge that firms are able to produce new products and to lower the cost of production. The emphasis on knowledge as a source of competitive advantage is gaining attention due to the move of many countries to become knowledge-based economies.

The Resource Dependency Theory

Resource dependence theory (RDT) is concerned with how organisational behaviour is affected by external resources the organisation utilises. The resource dependence theory originated from Pfeffer and Salancik whose 1978 publication titled "The External Control of Organizations: A Resource Dependence Perspective" highlighted the procurement of external resources as an important tenet for the strategic management of an organization.

The underlying assumption of the resource dependence theory is that resources are limited and the survival and growth of a given organization depends on inputs from other organisations. The theory posits that the main reason why organisations come together is to acquire the resources that are essential for their growth and survival. The theory also assumes that resources originate from the environment and are the basis of power. It then follows that the more an organization depends on resources from the environment, the more the interaction between the organisation and the environment.

As succinctly described by Malatesta and Smith (2014) organisations require resources from their environment, which, when successfully obtained, produce power, influence, and long-term stability. Organizations possessing necessary resources are in a power position, whereas the organisations depending on others for resources are vulnerable to control. Thus, according to the theory, power and resource dependence are inversely related: organisation A’s power over organization B is equal to organization B’s dependence on organization A’s resources

Drees and Heugens (2013) indicated that the RDT is used by academicians to explain the many kinds of collaboration among firms such as R&D collaborations, research collaborations, joint marketing agreements, joint ventures, and alliances amongst others. Hillman et al. (2009) argues that the resource dependence underlying model is an accurate portrayal of mergers and acquisitions, acquisition of some equipment machinery and software, inter-organisational relationships and board of directors of firms.

The RDT has some criticisms: Nienhüser (2008) claims that the RDT does not sufficiently justify why organizations should be viewed as political systems and not as technical or economic systems (Nienhüser, 2008). The RDT is often criticized based on the lack of empirical testing of its basis premises. The hypothesis that organizations are constrained with their organizational environment and try to manage resource dependencies, has become almost generally accepted without sufficient testing (Pfeffer & Salancik, 2003) some authors claim that the RDT is not a useful theory in order to serve as foundation for testable empirical research and they suggest a reformulation of the theory (Casciaro & Piskorski, 2005). Nienhüser (2008) also indicated that predictions of the resource dependence theory are similar to those the transaction cost theory.

The Theory of Absorptive Capacity

The absorptive capacity theory has often been used to explain the view that external knowledge acquisition is useful only if a firm possesses an existing base of knowledge that enables it to utilise such knowledge (Vega-Jurado et al., 2008; Osoro et al.,2016).

The origin of the theory of absorptive capacity is associated with Cohen and Levinthal (1990). They defined absorptive capacity as “the ability of the firm to recognise the value of new, external information, assimilate it and apply it to commercial ends”. They argued that absorptive capacity can increase innovative activities within firms. They proposed that absorptive capacity is essentially a function of a firm’s prior related knowledge affecting its innovative capabilities. They were of the view that internal research and development activities increases the absorptive capacity of firms and makes external knowledge useful when it is combined with pre-existing knowledge.

Several scholars have given different conceptualisations and dimensions to the theory of absorptive capacity. Lane and Lubatkin (1998) introduced the concept of relative absorptive capacity. They defined it as the ability of a firm to learn from another firm, it is contingent on similarities in knowledge bases, organisational structures and compensation practices and dominant logics of both firms.

Zahra and George (2002) see absorptive capacity as a dynamic capability consisting of four dimensions: Recognition, assimilation, transformation and exploitation. They defined absorptive capacity as a dynamic organizational capability encompassing organisational processes and routines, through which companies acquire, assimilate, transform and apply external knowledge.

Lane, Koka and Pathak (2006), introduced a process-based definition of absorptive capacity. According to them, absorptive capacity is a firm's capability to recognise potentially valuable new knowledge through exploratory learning, assimilate valuable new knowledge through transformative learning, and use the assimilated knowledge.

Todorova and Durisin (2007), however, questioned Zahra and George's (2002) and Lane et al. (2006) conceptualisation by defining absorptive capacity as a firm's ability to recognise the value of external knowledge, acquire, assimilate or transform, and exploit external knowledge. From this definition, transformation is not a consequence of the assimilation, but it can be considered as an alternative to assimilation.

Several authors posited that absorptive capability influences corporate outputs such as performance, innovation, responsiveness, internationalisation and competitive advantage through enriching knowledge bases in firms (Kostopoulos, Papalexandris, Papachroni & Ioannou, 2011; Zhou & Li, 2012; Tzokas, Kim, Akbar & Al-Dajani, 2015; Wu & Voss, 2015).

A review of the literature on absorptive capacity reveal that some scholars have attempted to classify the concept. Two major classifications can be identified. Some researchers have considered absorptive capacity as a static resource in firms and used R&D investments, the number of patents and educated persons as proxies for Absorptive capacity (Escribano et al., 2009; Huang & Rice, 2009).

Another group of researchers take a capability-based approach (Zahra & George, 2002; Lane et al., 2006; Todorova & Durisin, 2007; Flatten et al, 2011; Biedenbach & Müller, 2012). They consider absorptive capacity as a capability embedded in firms' routines and processes for acquisition, assimilation and exploitation of new external knowledge. They are of the view that using proxies for absorptive capacity do not reveal the complexity of firm's capability and the content of knowledge. Makadok (2001) is of the view that considering ACAP as a capability and a higher order resource seems to be more consistent with the resource-based view suggesting that superior performance mainly originates from higher order resources that are difficult to obtain and imitate, and built over time.

Empirical Literature

Firms derive their knowledge for innovation from different sources. This study analysed six sources of knowledge that have been found to influence innovation. Namely: internal R&D, training of workers, manager's years of experience, external R&D, purchase of equipment or machinery, and purchase of intangible technology. In addition, some firm characteristics have also been found to influence innovation. This sub-section provides an empirical review of the effect of some sources of knowledge on innovation.

Internal R&D has often been identified in empirical studies as having a positive impact on innovation performance. Paula and Silva (2017) used data from Eurostat's 2010 Community Innovation Survey and applied multi group structural equation modelling to investigate the complementarity of internal and external R&D on innovation development and its effect on financial performance among European manufacturing firms. They found that internal R&D has a positive effect on firm's innovative performance. Baumann and Kritikos (2016) analysed the link between R&D, innovation and firm productivity between micro, small and medium enterprises. Using all the waves from 2005 through 2012 of the German Small and Medium enterprises panel. They found a positive correlation between R&D intensity and the propensity to introduce innovations.

Osoro et al. (2016) studied the effects of knowledge sources on firm level innovation in Tanzania. Using data from the 2013 Tanzanian Enterprise Survey and the 2014 Tanzanian Innovation Survey and applying a logistic regression estimation technique, they found internal R&D have a positive and significant influence on product and process innovation activities among firms in Tanzania.

Some studies found that internal R&D is more important for product innovation than process innovation. Conte and Vivarelli (2014) studied the relationship between investments in innovation and the propensity to introduce product and or process innovations among Italian manufacturing firms.

Estimating a Tobit model based on data from the third Italian Community Innovation Survey conducted in 2002, they found that expenditures on R&D has a positive and significant effect in enhancing product innovations. Kim et al. (2016) also studied the effects of government support programs and R&D activities for the product innovation of service industry in Korea. Applying Logistic regression analysis on data from the Korea Innovation Survey (KIS) (2012), internal R&D was found to be an important factor influencing product innovation for both large enterprises and SMEs.

External R&D also plays an important role in innovation development. There are however contrasting results of the effect of external R&D on firm's innovative performance. Some empirical studies found a positive relationship. Paula and Silva (2018) investigated the complementarity of internal and external R&D on innovation development and its effect on financial performance among European manufacturing firms. They used Eurostat's 2010 Community Innovation Survey (CIS) and applied multi group structural equation modelling. They found external R&D to have a positive influence on firm innovative performance.

Some studies suggested an inverted U-shaped relationship between external R&D and innovative performance. Grimpe and Kaiser (2010) studied the "gains and pains from R&D outsourcing". Using a panel data set of the German community innovation surveys conducted in the years 2001, 2005 and 2009 using a random effect panel tobit model, they found that external R&D increases innovative performance up to a point beyond with increases in external R&D will reduce firm's performance.

Osoro et al. (2016) studied the effects of knowledge sources on innovative performance in Tanzania. Applying a logistic regression on data from the Tanzanian Enterprise Survey and the Tanzanian Innovation Follow-up survey. They did not find any significant relationship between external R&D and firm's innovative performance.

In modern times the importance of purchase of equipment in innovation cannot be overemphasized. The fourth European Community Innovation Survey reveal that half of innovating firms in Europe did not conduct R&D whilst 70 percent of the innovating firms purchase equipment and machinery (Vega-Jurado et al., 2008).

Potters (2009) studied the impact of innovation activities on innovation output among 3247 innovative firms in Spain. Using data from the third wave of the Spanish community innovation survey, and applying different knowledge production functions, he found that purchase of equipment leads to process innovations.

Goedhuys and Veugelers (2012) studied firm level innovation strategies among Brazilian firms. Using the World Bank ICS 2000–2002 data from Brazilian manufacturing firms and applying a bi- variate probit model they found that purchase of equipment is the main innovation strategy that ensures successful product and process innovations.

Silva, Simoes, Sousa, Moreira, and Mainardes (2014) studied the importance of innovation expenditure among Portuguese service sector firms. Using the logistic regression model on the fourth Portuguese Community Innovation Survey, they found a positive relationship between financial investments in purchase of equipment and firms and the propensity to innovate.

Osoro et al. (2016) also found purchase of equipment to have a positive and significant impact on product and process innovations in Tanzania.

Regarding the effect of training of workers on innovation performance, Dostie (2014) used the Canadian 1999 to 2006 workplace and employee survey data to study the link between innovation productivity and training among Canadian firms. The results showed that worker training increases product and process innovation. On the job training also had a positive impact on productivity through process innovation. Børing (2017) investigated the relationship between employee training and firm's innovation activities in Norway. Using data from the seventh wave Norwegian community innovation survey conducted in 2010 and the Norwegian matched employer- employee register data 2010, he found a positive correlation between firm's employee training and their innovative activities.

Some studies did not find training of workers to have a significant influence on product or process innovations. Osoro et al. (2016) also did not find training of workers to have a significant influence on product and process innovations in Tanzania. Naranjo-Valencia, Naranjo-Herrera, Serna-Gómez, and Calderón-Hernández (2018) studied the effect of training on Innovation among Colombian industrial firms. Using various multivariate analysis techniques such as ANOVA, cluster analysis and multiple regression, they did not find a strong relation between training of workers and innovation.

An often neglected but important attribute with regard to innovative activity is the experience of the top manager. Experienced managers are more likely to have a better insight into better business opportunity and it is generally expected to have a positive relationship with innovative activity. Balsmeier and

Czarnitzki (2014) studied the industry specific managerial experience for innovative firm performance for 27 Central and Eastern European countries. Using Probit and Tobit model on data from the 2008-2009 Business Environment and Enterprise Performance Survey (BEEPS), the regression results indicated that managerial experience increases the share to innovative sales due to new products.

Li (2017) studied the impact of top managers' team knowledge and experience on strategic decisions and performance among Taiwanese firms. The results show a positive relationship between the top manager's functional heterogeneity and innovation.

Intangible knowledge in the form of patents, licenses, trade secret rights, copyrights amongst others have in recent times caught attention among researchers as an important determinant of innovation success. The European Union Intellectual Property Office (EUIPO) in collaboration with the Centre for European Economic Research in Mannheim (ZEW) examined the impact of the use of trade secrets and patents on the performance of German firms. They used data from the German innovation survey conducted in 2010 and 2012 and found the following: when innovations are new to the market patents are more likely to be used. Also they found that the use of trade secrecy increases the likelihood of process innovations than product innovations.

Sivalogathasan (2016) studied the influence of intangible assets on firm level innovation among firms in the textile and apparel industry in Sri Lanka. Using a sample of 304 firms and applying the single indicator structural equation modelling, they found that intellectual capital has a positive and significant relationship with innovation capability. However, in Tanzania, Studies by Osoro et al (2016) on the effect of knowledge sources on innovation performance did not find any significant influence of intangible knowledge on the propensity to introduce product or process innovations.

Chen, Vanhaverbeke and Du (2016), studied the interaction between internal R&D and different types of external knowledge sources. Using two waves of survey conducted among innovative firms in Zhejiang province, P.R. China in 2006–2007 and 2013, they found that both internal R&D activities and external knowledge sourcing have a positive effect on firms' innovation performance. Hou and Mohnen (2013) studied the complementarity between internal R&D Technology purchase among small and medium size Chinese manufacturing firms. Applying a Probit and a Tobit model on World Bank Investment Climate Survey of China conducted in 2003, they found internal R&D and Technology purchase jointly has a significant effect on product innovations.

In addition, Egbetokun, Mendi and Mudida (2016) did a comparative study on complementarity in firm level innovation strategies between Kenya and Nigeria. They found evidence on the existence of complementarities between internal and external technological innovation strategies in the case of Kenya, but not in the case of Nigeria. However, organizational and marketing innovations do not appear to be complementary in innovation either in Kenya or in Nigeria.

Research Gaps

A review of the empirical literature has highlighted the benefits of innovation. However, given the diverse motives as to why firms innovate and the complex nature of innovations, it is unclear whether knowledge sources and innovative activities will have a positive effect on innovation outcome for developing countries such as Ghana. Most of the empirical evidence of the benefits of innovation were conducted in the developed countries. The evidence from developing countries is particularly rare and there could be differences in the effect of knowledge sources on innovation between the developed and the developing world. The study by Tetteh and Essegbey (2014) did not reveal the source of knowledge that lead to 66% of domestic innovations. In addition, the study by Afful and Owusu (2017) limited the scope of their study to only the manufacturing sector. A gap therefore exists for a study that involves the other sectors of the Ghanaian economy and an examination of the effect of a much wider knowledge sources that could affect innovation among firms in the country.

Chapter Summary

In sum, from the exploration of the definitions of innovation, it is clear that it is a complex concept that means different things to different people under different contexts. Knowledge is an important pre-requisite for firm level innovation; it comes from two main sources: either within or outside the boundaries of the firm. The resource-based views explain why firms look within the firm for resources or knowledge to innovate. The resource dependency theory explains why firms look for external resources to innovate. The absorptive capacity theory explains the view that external knowledge acquisition is useful if the firm has the internal knowledge base to utilise that knowledge. From the empirical literature it is clear that there are mixed results on the extent to which knowledge sources affect innovation.

CHAPTER THREE

RESEARCH METHODS

Introduction

This Chapter presents the methodology used in analysing the extent to which knowledge sources affect innovation. The chapter describes the source and type of data, the theoretical model which underpins the study, econometric models used to test the hypothesis, variables used for the study and their operationalization and how the diagnostic tests were done.

Research Design

In line with the objectives of this study, which is to analyse the effect of knowledge sources on firm level innovation in Ghana, the study adopted the positivist philosophy. Positivists believe that social reality is stable and for this reason can be observed or described from an objective viewpoint without any form of interference with the phenomena being studied (Levin, 1988). Thus, positivist philosophy provides an opportunity for the researcher to study social and economic processes in an objective manner as well as explain relationships between variables. In addition, the positivist philosophy favours the use of quantitative approaches to research as in the case of this thesis.

The quantitative approach enables the researcher to put the social and economic world into a structure of causality and effect and nullifies the value judgements and human opinions. In the case of this study, the quantitative approach allows the researcher to use quantitative instruments such as logistic regression and maximum likelihood estimation techniques on an existing data to arrive at valid and objective conclusion on the effects of knowledge sources on innovation in Ghana.

The Data Source

The data used in this study is a cross sectional data sourced from the Ghana Enterprise Survey (ES) and the Ghana Innovation Follow-up Survey (GIFS). These two datasets were merged. The Enterprise Surveys Unit of the World Bank periodically collects information on firms' experiences and enterprises perception with regard to the environment in which they operate. The data in the Ghana ES was collected between December, 2012 and July, 2014 as part of the African Enterprise Survey, an initiative of the World Bank. The population of the survey is the non-agricultural economy of Ghana. However, financial intermediation, real estate and renting activities are excluded in the survey.

Some of the key variables included in the Ghana ES dataset are age of firm, size of the firm in terms of the firms' assets and the number workers employed, type of industry, research and development (R&D) status of the firms amongst others. In all, 720 firms were sampled and interviewed using the stratified random sampling technique.

The GIFS was part of a project launched by the Enterprise Analysis unit of the World Bank in collaboration with the Department for International Development of the UK. The data for Ghana was collected between January, 2014 and August, 2014.The survey was conducted to collect firm level data on innovation and innovation related activities between 2010 and 2012 fiscal year.

A subset of business owners and top managers identified in the ES were randomly selected in order to have a final sample of 75% of the original ES respondents. In all 549 firms were successfully interviewed of which 284 were manufacturing sector firms and 265 were in the service sector.

The GIFS provides rich information on innovation variables such as: conduct of internal and external R&D, training of workers, the purchase of equipment and machinery, acquisition of intangible technologies such as patents, licenses, trademarks and other software by firms.

The unit of observation is firms in the manufacturing and service sectors of Ghana and the unit of analysis is firms that have introduced either product or process innovations.

The Theoretical Model Specification

To analyse the extent to which knowledge sources affect innovation, the study adopts a logit model as used by Lee (2004). The model predicts that some firm characteristics such as age of firm, firm size, share of export in sales, and extent of local ownership determine innovation performance. In this study knowledge sources such as internal and external R&D, training of workers, manager's years of experience, acquisition of equipment and machinery, and purchase of intangible technologies such as patents, licenses, trademarks amongst others which are proven by other researchers to influence innovation are added.

The fact that the dependent variable in this study (product or process innovation) is dichotomous is one justification for the choice of the logit model. The outcome is given 1 if the firm introduced a product innovation and 0 if otherwise. Also, the outcome is assigned 1 if the firm introduced a process innovation and 0 if otherwise.

Due to the nature of the dependent variables, linear estimation techniques such as Ordinary Least Squares or Linear Probability Model yields biased results. Linear estimation techniques may yield negative variance of the error term and the probabilities may lie outside the reasonable range of between zero and one. The logit model which uses Cumulative Distribution Frequency (CDF) to model regressions where the response variable is dichotomous, does not only guarantee that the estimated probabilities fall between the logical limits of 0 and 1 but also ensures that the relationship between the dependent and the independent variable is nonlinear.

The logit model as used in this study is specified as follows. First, the propensity for a firm to innovate is modelled as

$$Y_i = \beta X_i + U_i \qquad (1)$$

The dependent variable Y_i takes the value 1 if the firm innovates (product or process innovation) and 0 if otherwise.

X_i -the set of explanatory variables.

β -a vector of parameters to be estimated.

U_i- the error term.

The logit transformation of the probability to innovate is

$$logit(Y_i) = \alpha + \beta X_{1i} + \beta X_{2i} + \beta X_{3i} + \cdots + \beta X_{ni} \qquad (2)$$

The raw coefficients are the log of the odds (called logit). These coefficients in principle are difficult to interpret hence it is important to take the anti-log (exponent) to arrive at the odds (e^{β_i} where $i = 1,2,3....$).

The odds are determined from probabilities and range between 0 and infinity. Odds are defined as the ratio of the probability of success and the probability of failure.

$$Odds = \frac{(p_i)}{1-p_i} \quad (3)$$

Theoretically, the expected probability that Y = 1(innovation) for a given value of X as

$$P_i(Y = 1|X) = \frac{exp^{(\beta X)}}{1+exp^{(\beta X)}} \quad (4)$$

exp is the exponent function

$(\beta X) = \beta X_{1i} + \beta X_{2i} + \beta X_{3i} + \cdots + \beta X_{ni}$

The probability of not innovating $(1 - p_i)$ can also be expressed as

$$1 - p_i = \frac{1}{1+exp^{\beta X}} \quad (5)$$

The odds ratio can therefore be written as

$$\frac{p_i}{1-p_i} = \frac{exp^{\beta X}}{1+exp^{\beta X}}\left(\frac{1+exp^{\beta X}}{1}\right) = exp^{\beta X}$$

Therefore, the logits (natural logs of the odds), of the unknown binomial probabilities are modelled as a linear function of the X:

$$logit(Y_i) = Ln\left(\frac{(p_i)}{1-p_i}\right) = a_0 + \sum_{j=1}^{n} \beta_j X_{ji} \quad (6)$$

Empirical Model Specification

To analyse the effect of internal and external knowledge sources on innovation, the study models the effect of internal and external knowledge sources on innovation separately before modelling them together. This is because, although external knowledge is important for innovation, its magnitude depends on the absorptive and transformative capacity of the firm (Cohen & Levinthal 1990; Garud & Nayyar 1994; Zahra & George 2002). Modelling internal and external knowledge separately before modelling them together as adopted in this study is important for the following reason:.

1. To simulate the impact of pre-existing knowledge base on innovation before the acquisition of external knowledge; and the impact of external knowledge on innovation assuming that internal knowledge is non-existent.
2. This procedure isolates and gives a clearer picture of the separate effects of internal and external sources of knowledge on innovation from the combined effects on innovation.

Six binary logit models (each of the models are captured in the equations) below are used to examine the extent to which different knowledge sources affect innovation.

$$Product\ Innovation = \alpha + \beta_1 Int\_RD + \beta_2 Training + \beta_3 Mgt\_\ experience + \beta_4 Location + \beta_5 Sector + \beta_6 Firmsize + \beta_7 Age + e_i \quad (7)$$

$$Product\ Innovation = \alpha + \beta_1 Ext\_RD + \beta_2 Equipment + \beta_3 Intangible + \beta_4 Location + \beta_5 Sector + \beta_6 Firmsize + \beta_7 Age + e_i \quad (8)$$

$$Product\ Innovation = \alpha + \beta_1 Int\_RD + \beta_2 Training + \beta_3 Mgt\_experience + \beta_4 Ext\_RD + \beta_5 Equipment + \beta_6 Intangible + \beta_7 Int\_RD * Equipment + \beta_8 Location + \beta_9 Sector + \beta_{10} Firmsize + \beta_{11} Age + e_i \quad (9)$$

$$Process\ Innovation = \alpha + \beta_1 Int\_RD + \beta_2 Training + \beta_3 Mgt\_experience + \beta_4 Location + \beta_5 Sector + \beta_6 Firmsize + \beta_7 Age + e_i \quad (10)$$

$$Process\ Innovation = \alpha + \beta_1 Ext\_RD + \beta_2 Equipment + \beta_3 Intangible + \beta_4 Location + \beta_5 Sector + \beta_6 Firmsize + \beta_7 Age + e_i \quad (11)$$

$$Process\ Innovation = \alpha + \beta_1 Int\_RD + \beta_2 Training + \beta_3 Mgt\_experience + \beta_4 Ext\_RD + \beta_5 Equipment + \beta_6 Intangible + \beta_7 Int\_RD * Equipment + \beta_8 Location + \beta_9 Sector + \beta_{10} Firmsize + \beta_{11} Age + e_i \quad (12)$$

The effect of internal sources of knowledge on the propensity of firms to develop product innovations is modelled in equation (7). Equation (8) models the effect of external sources of knowledge on the propensity of firms to develop product innovations. In equation (9), the effect of both internal and external knowledge sources in influencing the success of product innovations is specified. The effect of internal sources of knowledge on the propensity to introduce process innovations is modelled in equation 10. Equation (11) depicts the effect of external sources of knowledge on process innovations. Finally, equation (12) shows the effect of both internal and external knowledge sources in influencing the success of process innovations.

The a priori expectations of the variables are presented in Appendix B

Measurement and operationalisation of variables

The Dependent Variables

The study focuses on product and process innovations. In this regard, the dependent variables for this study are firm's attempt to develop innovative products and processes. These are captured as dummies based on the answers to two questions in the questionnaire that seek whether the firm has introduced new or significantly improved products or processes during the period 2010-2012. For product innovations, a firm is assigned the value of 1 if it introduces significantly new products and 0 if otherwise. Similarly, for process innovations, a firm is assigned a value of 1 if it introduces a significantly new method of production or rendering services and 0 if otherwise.

Explanatory Variables

The key explanatory variables for this study include the knowledge sources. There are various knowledge sources for innovation purposes; however, based on the availability of data, the study operationalizes the sources of knowledge into two groups. The first group of explanatory variables is related to the internal source of knowledge. This consist of conduct of internal R&D, training of workers and the number of years of experience that the top manager has. The second group of explanatory variables is associated with the external source of knowledge. They include conduct of external R&D, purchase of equipment and machinery (Equipment) and purchase of intangible technology (Intangible).

The GIFS asks firms whether they conduct internal R&D between 2010 and 2012. Based on the responses, this variable takes the value 1 if the firm engages in internal R&D activities and 0 if otherwise. Similarly, firms were also asked if they provide any form of in-house training to production staff so that they can become innovative. From the responses, firms are assigned the value 1 if they train their workers and 0 if otherwise. The top manager's years of experience is a continuous variable and is measured by the number of years of experience that the top manager has. The explanatory variables for the external sources of knowledge are captured as dummies and take the value of 1 if the firm used any of these sources of knowledge between 2010 and 2012; and 0 if otherwise.

A detailed information on how each of these variables are measured is presented in Appendix A.

Control Variables

Four control variables are used in this study: firm's age, location, size of the firm and sector the firm belongs to. These variables are included to control for variation in firm's ability to innovate. The firms age is a continuous variable and is measured by the number of years the firm has being in existence. The location of firms was categorised into four regions: Accra, North (Kumasi and Tamale), Takoradi, and Tema. Firm size has three main categories. Firms that have between five (5) and nineteen (19) employees are classified as *Small*. *Medium* size firms have between twenty (20) and ninety-nine (99) employees. Firms with more than one hundred employees are categorized as *Large*. Two sectors were considered in this study: the manufacturing and the service sector. Firms are assigned a value 1 if they belong to the manufacturing sector and 2 if they belong to the service sector.

Estimation Method

This study uses the logistic cumulative probability function approach. The logistic regression allows prediction of a discrete outcome from a set of explanatory variables that may be dichotomous, discrete, continuous, or mix (Tabachnick & Fidell, 1998). In this regard, the Maximum Likelihood Estimation (MLE) techniques is adopted to estimate the logit model. This is because it is appropriate to quantify the extent to which different sources of knowledge affects firm level innovation. In addition, the maximum-likelihood estimation procedure has desirable asymptotic properties to check whether all the parameters are normal.

Diagnosis Tests

Various diagnosis and post estimation tests were performed to ensure that results are reliable. These include the heteroscedasticity test and the test for multi collinearity. Post estimation tests such as *Link test* was performed to ensure that the model is correctly specified. The *goodness of fit* test was also performed. The test interpretations were also considered in the analysis. The multi collinearity test was also performed to ensure that the independent variables are not correlated with each other. The variance inflation factor was used to detect the problem of multi collinearity or otherwise

Chapter Summary

The study sought to analyse the effect of knowledge sources on firm level innovation in Ghana. This chapter presents the methods that were used to test the various hypotheses of the study. A cross sectional data from the 2013 Ghana ES and the 2014 GIFS was merged and used in this study. The variables used and how they were measured and operationalized was also stated. Six logit models were specified to help analyse the extent to which knowledge sources affect firm level innovation in Ghana.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

This section is divided into two main parts: discussion of the descriptive statistics and discussion of the regression results. The descriptive statistics helps to explain the nature of the data and the variables that are used in this study. It delves into the distribution of some of the key variables between the manufacturing and service sectors as well as the distribution and possible implications of the different sources of knowledge on product and process innovations. The discussion of the logistics regression result help to answer the main objectives of the study.

The Descriptive Statistics

The descriptive statistics is divided into two main parts. First, the study presents the distribution of the various knowledge sources among the manufacturing and service sectors. Although this is not a main objective of this study, it will help identify the knowledge source that is predominantly used among the sectors. Second, the distribution of the knowledge sources as regards the introduction of product and process innovation by firms is also presented. to A Pearson Chi-square test was also done test the independence of the various explanatory variables in relation to our dependent variables.

Table 1: Sectors of firms used in the study

Sector	No. of Firms	Percentage
Manufacturing	284	51.73
Services	265	48.27
Total	549	100.00

Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

A total of 549 firms were used in this study. As shown in Table 1; 284 firms representing 51.73 percent were from the manufacturing sector whilst 265 firms representing 48.27 percent were from the service sector.

Figure 1 presents the distribution of product innovation status of firms between the manufacturing and service sectors of the country.

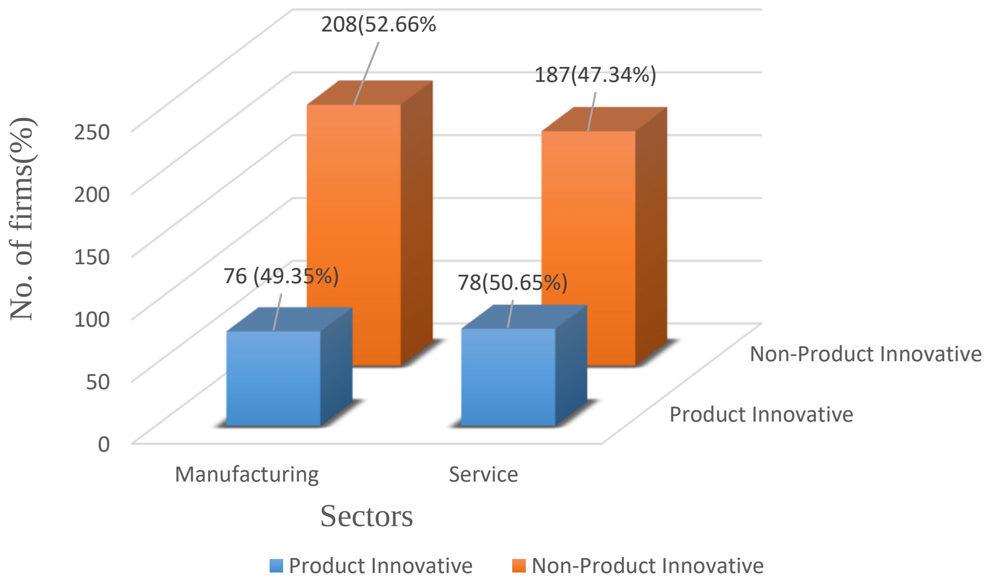

Figure 1: Product Innovation Status of the Sectors
Source: Author's own construct, 2019; from the 2013 ES and 2014 GIFS data

Out of a total of 549 firms, 154 firms representing 28.05 percent introduced new or significantly improved products or services. Of the 154 firms that develop product innovations, 76 firms representing 49.35 percent are in the manufacturing sector whilst 78 firms representing 50.65 percent are in the service sector. It can be inferred that product innovation is marginally more predominant in the service sector than in the manufacturing sector. As shown in (Appendix C), 395 firms representing 71.95 percent do not engage in product innovation. However, these firms could be engaged in other innovative activities such as marketing or organisational innovations.

The distribution of process innovation status of firms between the manufacturing and service sectors is shown in Figure 2.

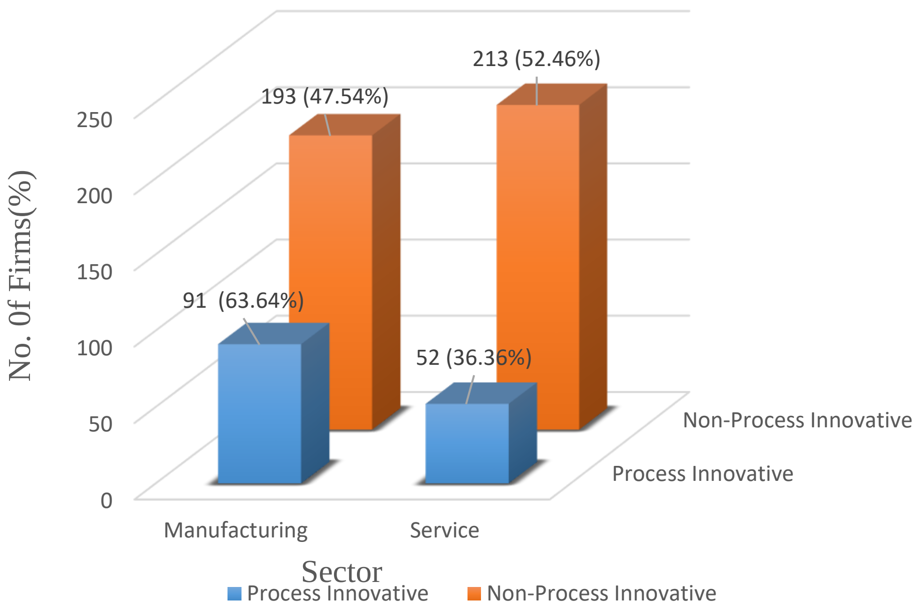

Figure 2: Process Innovation Status of the Sectors
Source: Author's construct, 2019; from the 2013 ES and 2014 GIFS data

Out of a total of 549 sampled firms, 143 representing 26.05 percent are engaged in process innovations. It is also clear from the analysis that process innovation is more pronounced in the manufacturing sector than in the service sector. Of the 143 firms that report to be process innovative, 91 firms representing 63.64 percent are in the manufacturing sector whilst 52 firms representing 36.36 percent are in the service sector. A plausible explanation for this is that innovation is more costly in the manufacturing sector than in the service sector (Baldwin, Beckstead, Gellatly, Fraumeni & Rafiquzzaman (2004). As such, manufacturing sector firms always look new methods of production that reduces their production costs. This finding however contradicts the results of Tetteh and Essegbey (2014) who used data from the second phase of the African Science, Technology and Innovation Indicator (ASTII) survey conducted in Ghana in 2012 and found process innovation to be more pronounced within the service sector firms than among firms in the manufacturing sector.

In-house R&D is important in enhancing internal capability and the absorptive capacity of firms (Belussi, Sammarra & Sedita, 2010; Hagedoorn & Wang, 2012; Oerlemans, Knoben & Pretorius, 2013). Figure 3 presents the internal R&D status of firms.

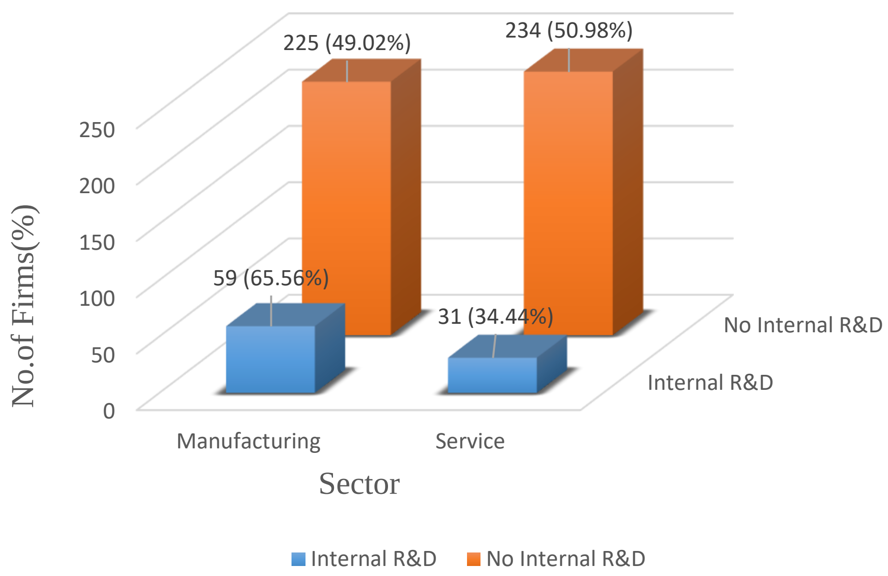

Figure 3: Internal R&D Status of Firms
Source: Author’s own construct, 2019; from the 2013 ES and 2014 GIFS data

In Figure 3, it is evident that most firms in Ghana do not conduct internal R&D. Out of a total of 549 firms, 90 firms representing 16.39 percent conduct internal R&D whilst 459 firms representing 83.61 percent do not perform internal R&D. The low rate of the performance of internal R&D could be explained by the fact that, conducting internal R&D is expensive (Dikova, 2015). Most firms in Ghana lack the necessary financial resources to employ and retain high quality research personnel.

It can also be observed from Figure 3 that internal R&D is more pronounced in the manufacturing sector than in the service sector. Out of a total of 90 firms that conduct internal R&D, 59 representing 65.56 percent are in the manufacturing sector whilst 31 firms representing 34.44 percent are in the service sector.

The third Oslo manual (OECD, 2005) defines external R&D as a creative work undertaken by other enterprises, public or private research institutions which was paid for by the establishment. The external R&D status of the firms used in this study is depicted in Figure 4.

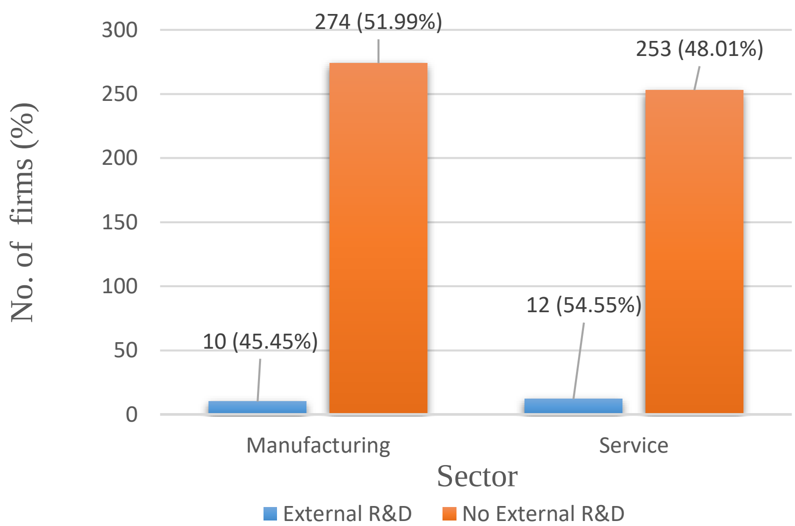

Figure 4: External R&D Status of Firms
Source: Author’s computation, 2019; from the 2013 ES and 2014GIFS data

Out of a total of 549 firms, 22 firms representing 4.01 percent conduct external R&D whilst 527 firms representing 95.99 percent do not perform external R&D. However, unlike the conduct of internal R&D, external R&D is marginally more predominant in the service sector than in the manufacturing sector. In Figure 4, out of the 22 firms that conduct external R&D, 10(45.45%) are from the manufacturing sector whilst 12(54.55%) firms are in the service sector. As shown in (Appendix D), 527 firms out of 549 did not conduct external R&D.

Providing formal training to the employees of firm specifically for the development or the introduction of innovative products or processes is also a form of innovative activity and a source of knowledge for the development of innovations (Dostie, 2014; Børing, 2017).

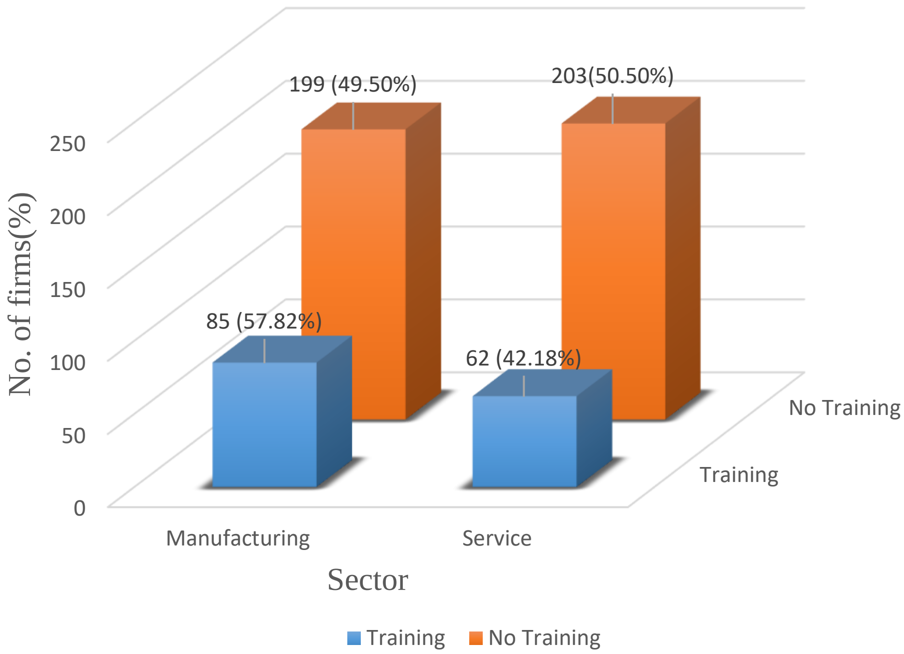

Figure 5: Training Status of Firms
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

From Figure 5, it can be observed that a high proportion of firms in Ghana do not conduct training for their employees. Out of a total of 549 firms, 147 representing 26.78 percent conduct formal training for their employees whiles 402 firms representing 73.22 percent of the sampled firms do not conduct formal training for their employees. Training of employees is more pronounced in the manufacturing sector 85(57.82%) than in the service sector 62 (42.18%). A plausible explanation for this is that the manufacturing sector usually relies on unskilled labour compared to the services sector. As such manufacturing sector firms are compelled to provide training to polish the skill their workers before deploring them for production purposes.

In Figure 6, the distribution of the purchase of equipment and machinery status of firms among the manufacturing and service sector is presented.

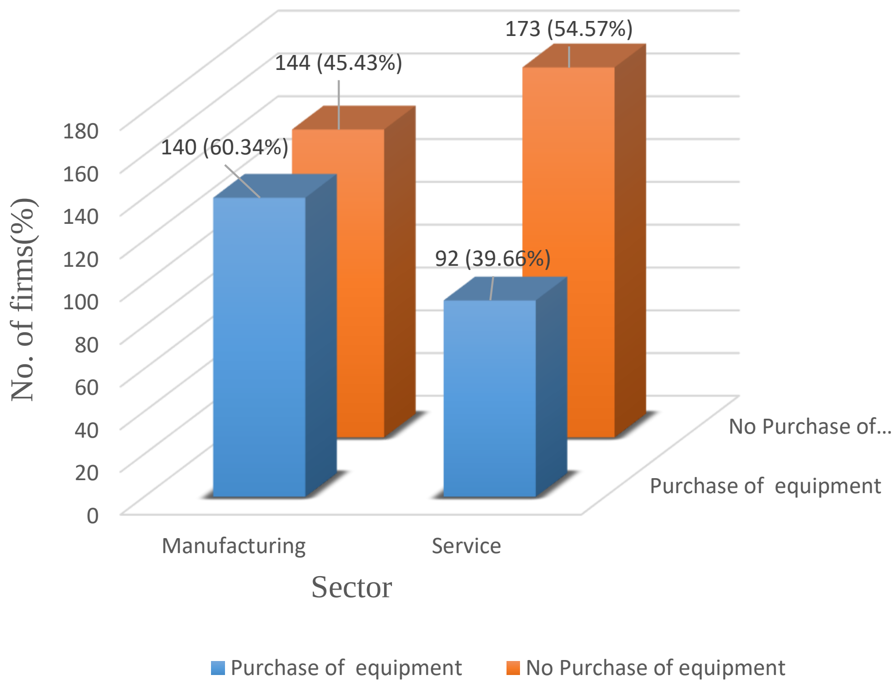

Figure 6: Purchase of Equipment Status of Firms
Source: Author’s computation, 2019; from the 2013 ES and 2014 GIFS data

Firms can also innovate through the purchase of new equipment or machinery to develop innovative products and processes. Out of a total of 549 firms, 232 firms representing 2.26 percent purchased new equipment or machinery for innovation purposes. Purchase of equipment for innovation purposes is more pronounced in the manufacturing sector than in the service sector. From figure 6, out of the 232 firms that purchased equipment, 140(60.34%) firms are in the manufacturing sector whilst 92(39.66%) firms are in the service sector. This is not surprising because manufacturing involves converting raw materials into finished products; a lot of equipment and machinery are needed to do the conversion. This also supports the views of Vega-Jurado et al. (2008) that purchase of equipment has become the main strategy of innovating in modern times.

Figure 7 indicates that acquisition of license, patents, copyrights, trademarks and other types of intangible knowledge for the purpose of innovation by firms is very low. It is almost as if the use of intangible knowledge is non-existent.

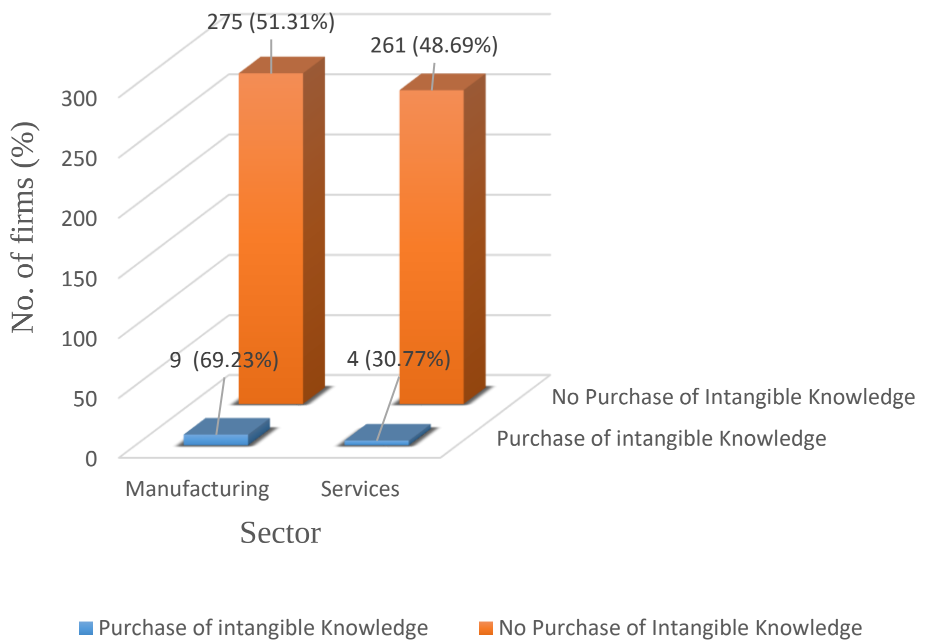

Figure 7: Purchase of Intangible Knowledge Status of Firms.
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Out of a total of 549 sampled firms, only 13 firms representing 2.37 percent purchase or use intangible technology. The purchase of intangible technology by firms is more predominant in the manufacturing sector than in the service sector. Out of the 13 firms that purchase intangible knowledge for innovation purposes, 9(69.23%) are in the manufacturing sector whilst 4(30.77%) are in the service sector.

Firm Age and Manager's Years of Experience

The mean age of the 549 sampled firms is 15.7 years. The youngest firm is 2 years old and the oldest is 77. As regards the manager's years of experience, the average is 15.9 years. The minimum years of experience is two and the maximum is 64.

Sources of Knowledge and Product Innovation Status

Internal R&D is one of the sources of knowledge for the development of product innovations (Hseih, Love, & Ganotakis, 2011; Gallié & Legros, 2012; Conte & Vivarelli, 2014). Figure 8 presents the internal R&D status of firms in relation to product innovations.

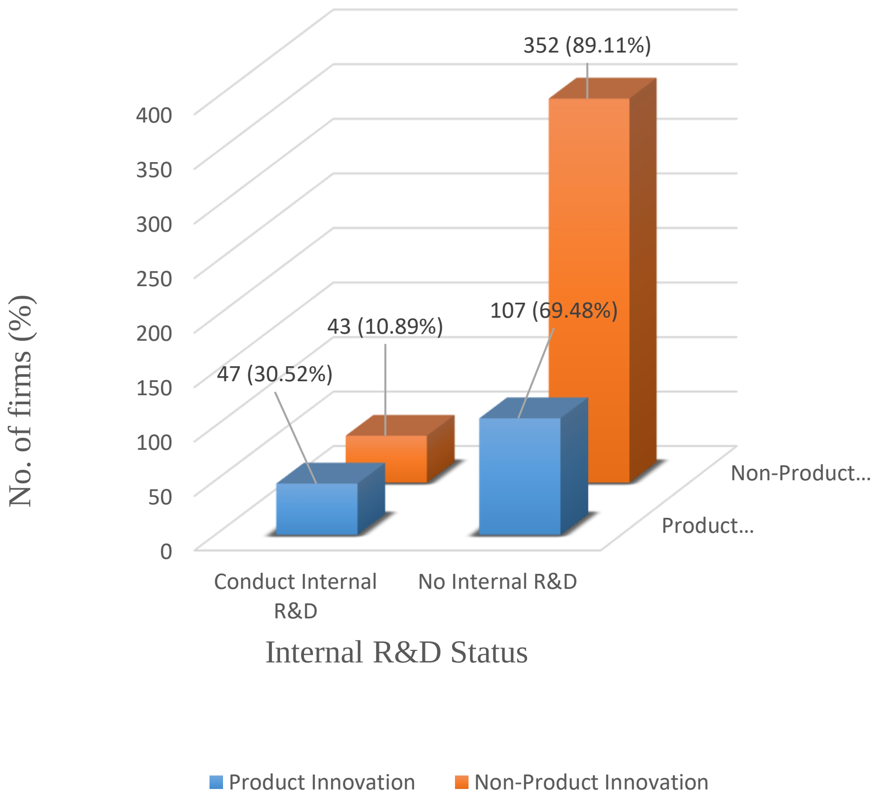

Figure 8: Internal R&D Status and Product Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

The results in Figure 8 indicate that, a high percentage of firms develop or introduce product innovations without performing internal R&D. Out of the 154 Firms that undertake product innovation, 107 firms representing 69.48 percent do not perform internal R&D whilst 47 firms representing 30.52 percent perform internal R&D. 89.11% of the non-product innovative firms also do not perform internal R&D.

Figure 9 presents the external R&D status of firms and the development of product innovations. It can be seen that firms that are product innovative but do not conduct external R&D are more than the product innovative firms that conduct external R&D.

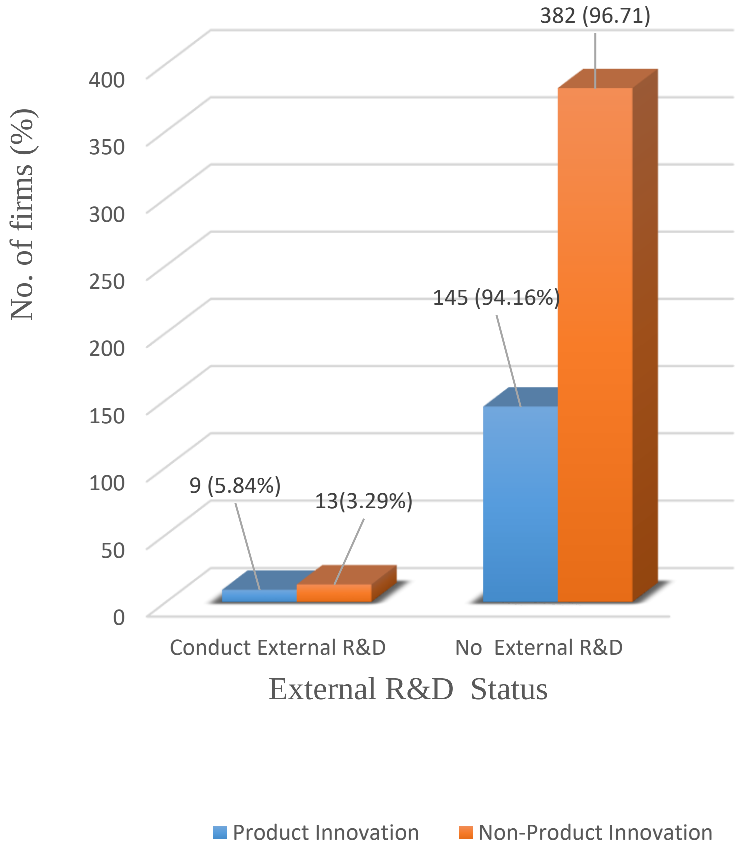

Figure 9: External R&D Status and Production Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Out of the 154 product innovative firms, nine (5.84%) conduct external R&D whilst 145(94.16%) firms do not perform external R&D. As high as 96.71% of the non-product innovative firms also do not perform external R&D. This shows the less attention that is given to the conduct of external R&D as regards the development of innovations.

Figure 10 presents the distribution between training of workers and product innovations.

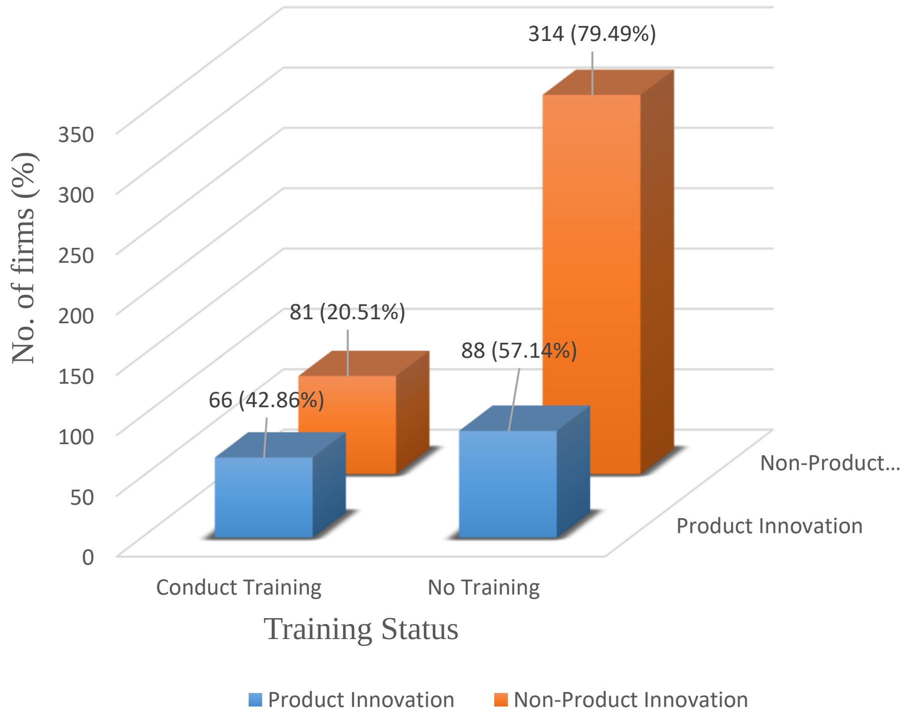

Figure 10: Training Status and Product Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Figure 10 shows that, the number of firms that develop or introduce product innovations without training their employees is higher 88(57.14%) compared to firms that develop or introduce product innovations through providing training for their employees 66(42.86%). Also out of 395 non-product innovative firms, 314 representing 79.49 percent do not train their employees whilst 81 non-product innovative firms do train their employees.

Figure 11 presents the analysis of the purchase of equipment status of firms in relation to product innovations. The results from Figure 11 shows that knowledge embodied in equipment and machinery is the predominant means of developing product innovations.

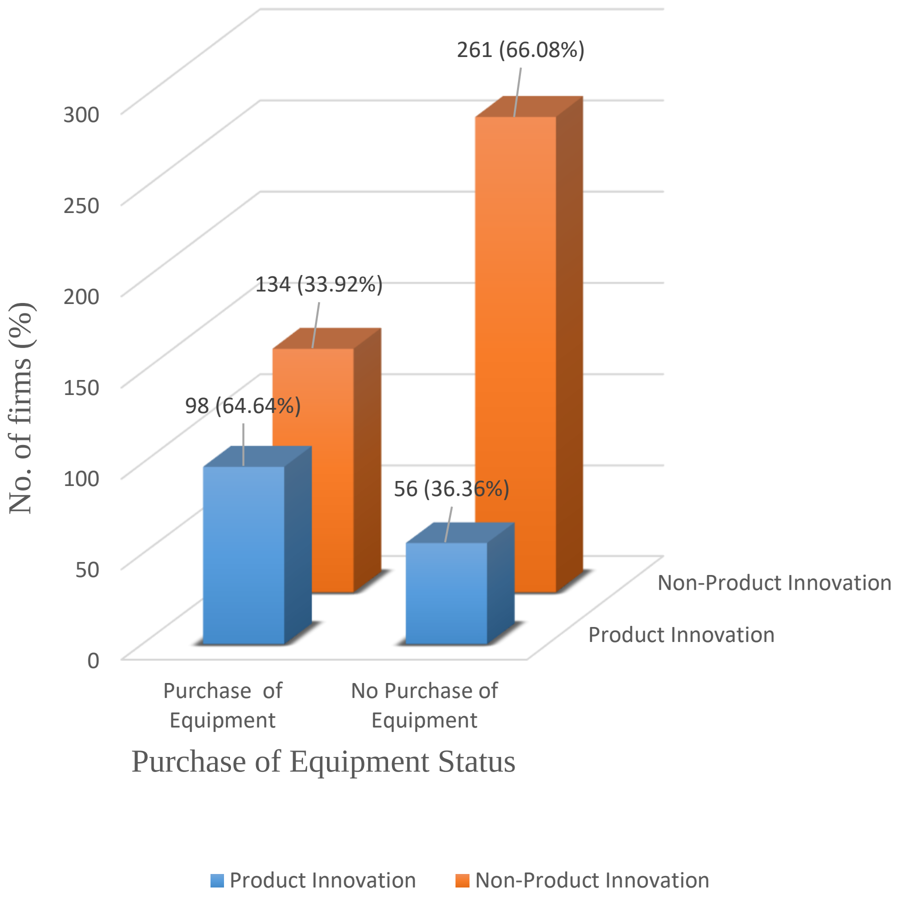

Figure 11: Purchase of Equipment Status and Product Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS

Out of 154 product innovative firms, 98 (64.64%) firms purchased equipment whilst 56(36.36%) firms developed product innovations without purchasing equipment. For the non-product innovative firms, a higher percentage (66.08%) innovated without purchasing equipment.

Figure 12 shows the purchase of intangible technology status of firms and the development of product innovations.

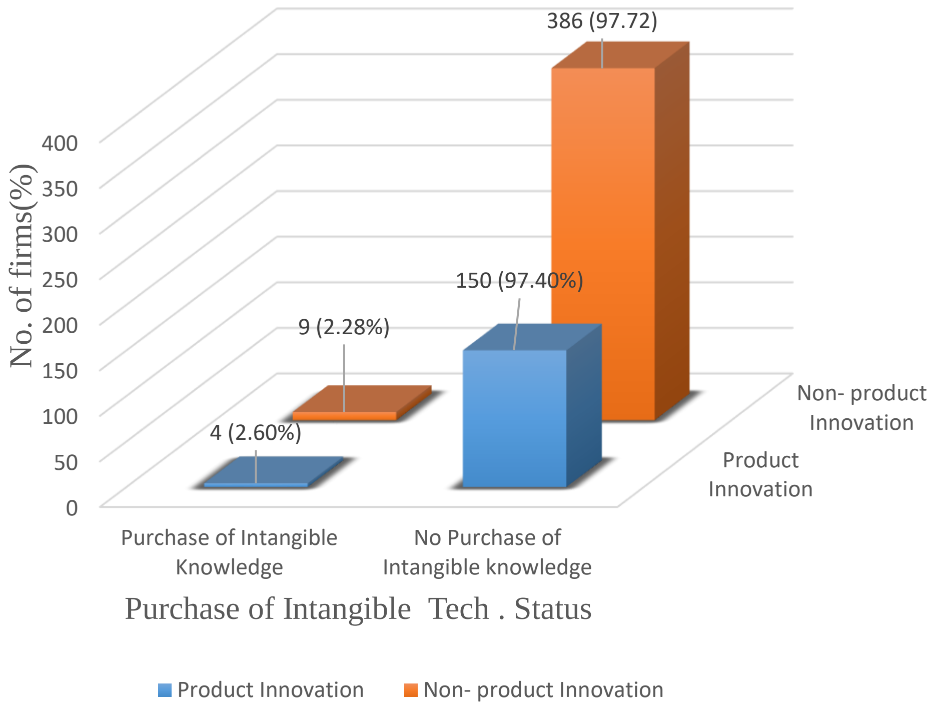

Figure 12: Purchase of Intangible Technology and Product Innovations
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Out of the 154 firms that introduce product innovations, only 4 firms representing 2.60 percent purchased intangible technology. 150 firms representing 97.40 percent product innovate without the purchase of intangible knowledge. For the non-product innovative firms 97.22 percent innovate without purchasing intangible technology.

As regards the location status of firms with respect to product innovation, four industrial clusters were used in this study: Accra, Tema, "North" and Takoradi.

The location status of firms as regards product innovation is depicted Figure 13.

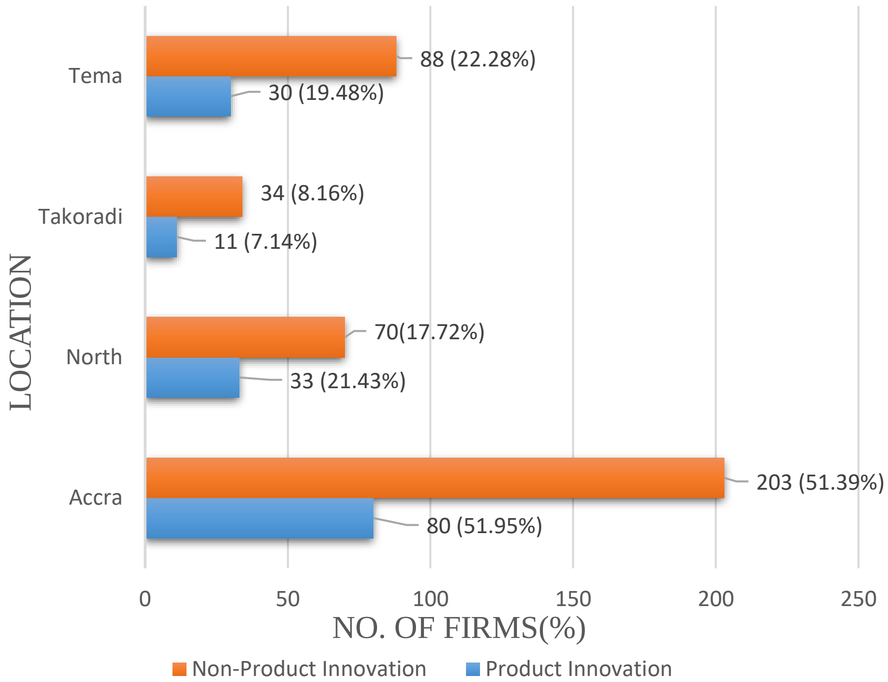

Figure 13: Location status and product Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Product innovation is more pronounced among firms located in Accra than those located in other parts of Ghana. Out of the 154 firms that engage in product innovation, 80 firms representing 51.95 percent are located in Accra. Takoradi has the least number of sampled firms that engage in product innovation. The high population and market demand in Accra compared to the other areas of the country could be the reason of the high numbers of product innovative firms in Accra. The distribution of the non-product innovative firms also follows the same pattern as that of the product innovative firms.

The distribution of product innovation status among small, medium and large scale firms are presented in Figure 14.

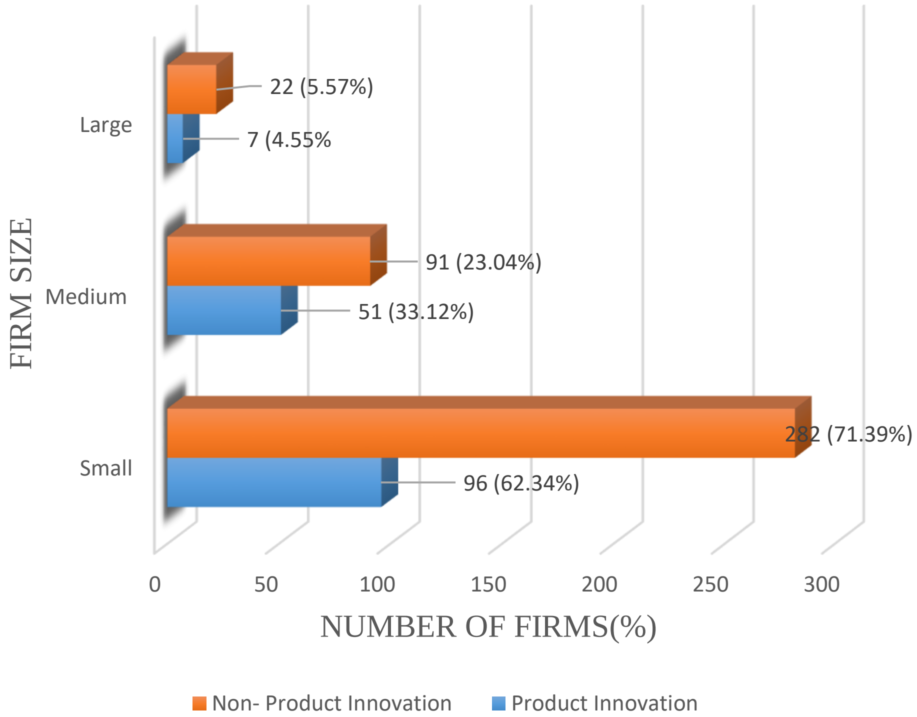

Figure 14: Firm Size and Product Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

From Figure 14, it can be observed that product innovation is more pronounced among the small size firms than among the medium and large size ones. Out of the 154 product innovative firms, 96 representing 62.34 percent are small size firms. Only seven large size firms representing 4.55 percent are product innovative. Non-product innovation is also more pronounced among small size firms than among the medium and large size firms. It can be concluded that innovation in general is more predominant among small size firms.

Sources of knowledge and Process Innovation Status

The distribution of the internal R&D status of firms in relation to process innovation is presented in Figure 15.

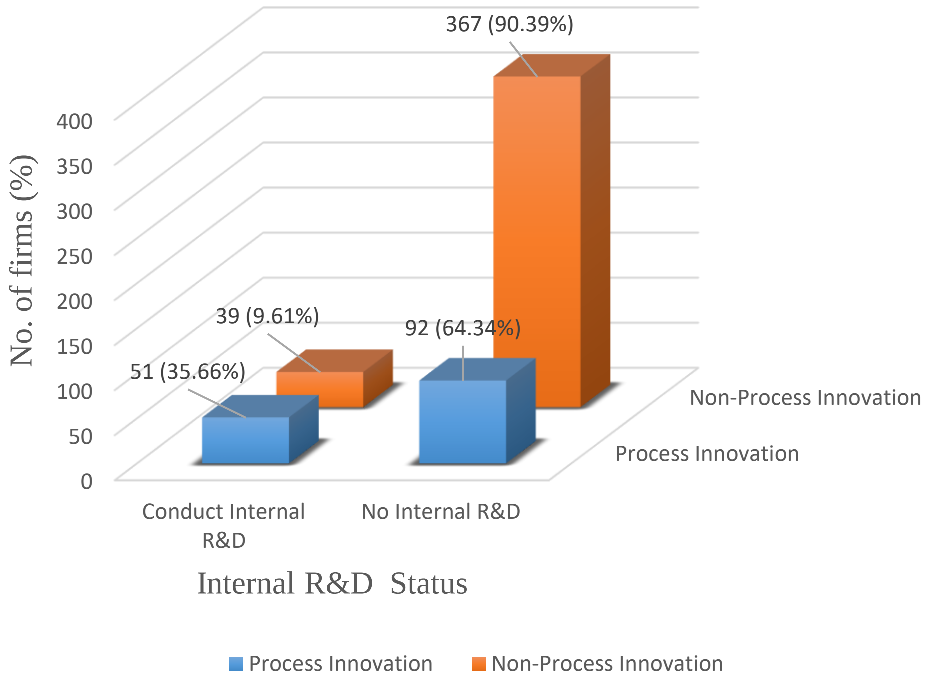

Figure 15: Internal R&D Status and Process Innovation
Source: Author's computation, 2019 based on the 2013 ES and 2014 GIFS data

Figure 15 shows that a high percentage of firms do not perform internal R&D in relation to the development of process and non-process innovations. Out of 549 sampled firms, 143 representing 26.05percent introduce process innovations. Of this, 51 firms representing 35.66 percent conduct internal R&D. The process innovations of 92 firms representing 64.34 percent are not the results of the conduct of internal R&D. This corroborates the assertions of (Naudé, Szirmai, & Goedhuys, 2011) who posits that in low income countries innovations may not be manifested through high profile breakthroughs usually measured through R&D performances but by a more incremental adoption and adaption of existing technologies.

Figure 16 shows the external R&D Status of firms and the development of Process innovations.

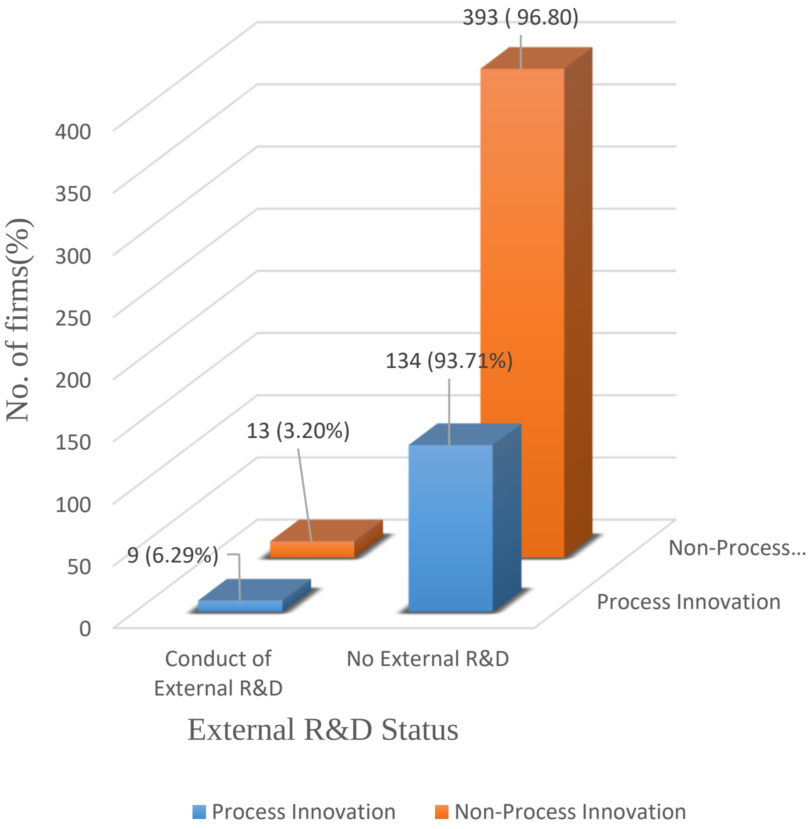

Figure 16: External R&D Status and Process Innovation
Source: Author's own computation, 2019; from the 2013 ES and 2014GIFS data

The analysis shows that the development of process innovations comes predominantly from firms that do not conduct external R&D. 143 firms out of 549 firms representing 26.05 percent report to have engaged in process innovations. Of these nine firms representing 6.29% conduct external R&D whilst 134(93.71%) firms do not perform external R&D. 96.80% of the non-process innovative firms do not perform external R&D. This again supports the view of (Naudé et al., 2011) who posits that innovations in low income countries may not come from high profile activities like conducting external R&D.

Figure 17 shows the distribution between training status of firms and the pursuit of process innovation.

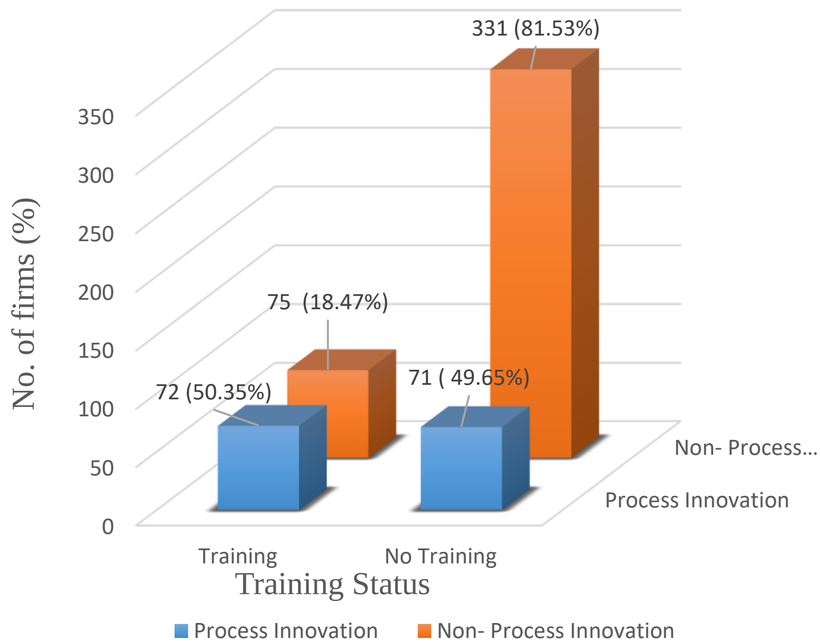

Figure 17: Training Status and Process Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Out of a total of 549 firms, 143 representing 26.05 percent have introduced process innovations. The percentage of firms that train their employees for the development or introduction of process innovations is marginally higher than those that do not train their employees. 72(50.35%) firms conduct formal training whilst 71(49.65%) do not training their workers. For the non-process innovative firms 331 representing 81.53percent do not train their workers.

The distribution of purchase of equipment status of firms with regard to process innovations are presented in Figure 18.

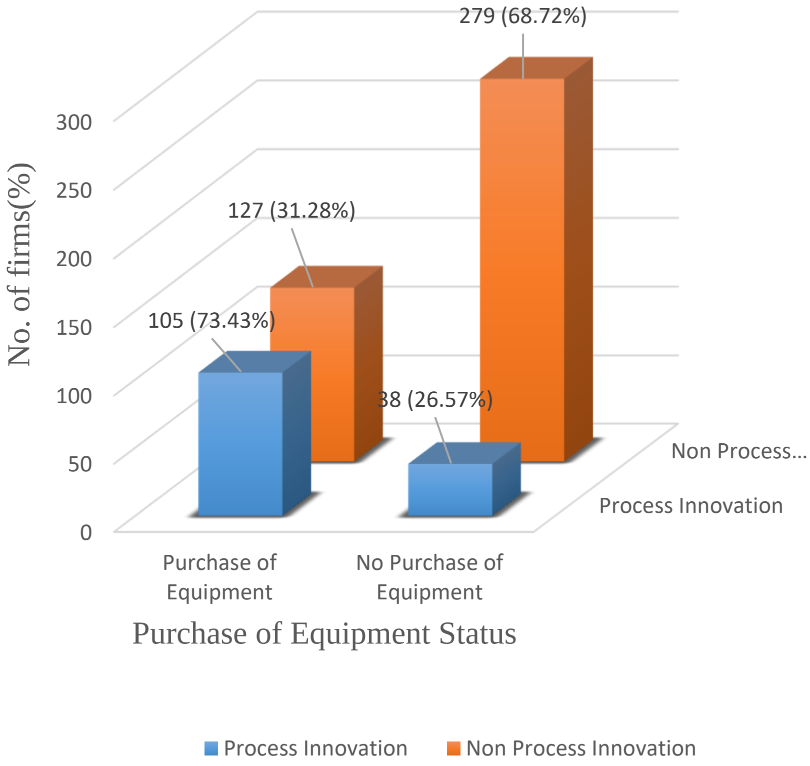

Figure 18: Purchase of Equipment Status and Process Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Firms that purchase equipment to develop process innovations are more predominant in the Country than those that do not purchase equipment. Of the 143 firms that undertook process innovations, 105(73.43%) purchased equipment whiles 38(26.57%) did not purchase equipment. Again, a higher percentage of the non-process innovative firms (68.72%) do not purchase equipment or machinery for innovation purposes.

Figure 19 shows the distribution of purchase of intangible technology status of firms and their process innovation status.

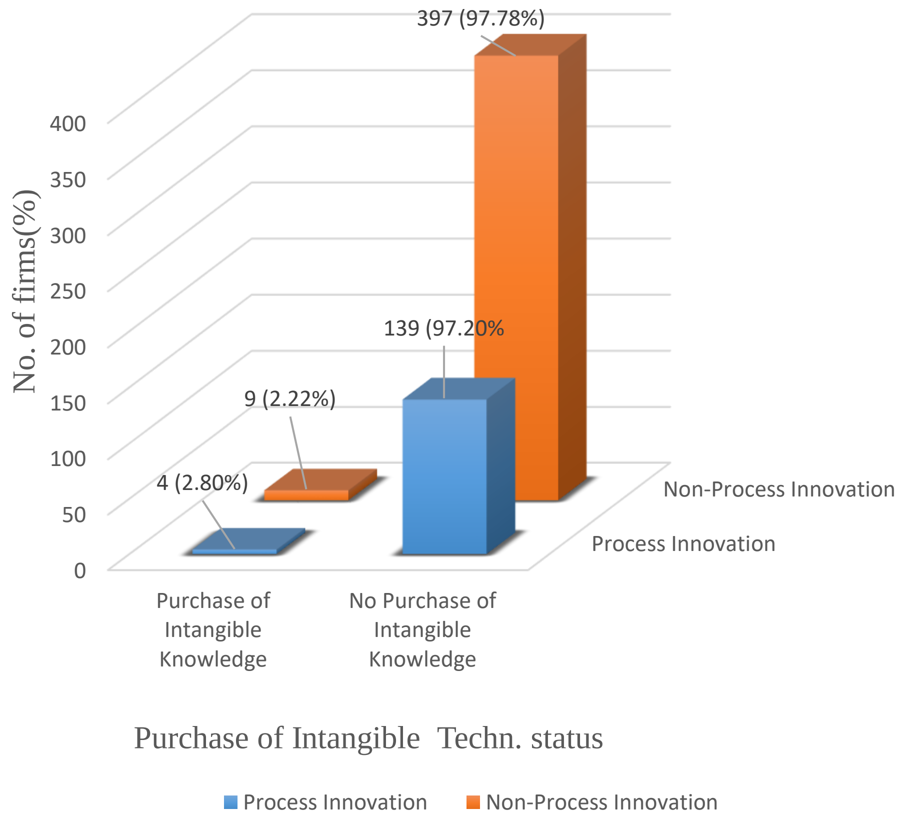

Figure 19: Purchase of Intangible Knowledge Status and Process Innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

The number of firms that introduced process innovations without purchasing intangible technology is more than those that purchase intangible technology. As shown in figure 19, out of the 143 firms that introduced process innovations 139 representing 97.20 percent introduced process innovations without purchasing intangible technology. Again, only 4 firms representing 2.80 percent process innovate by purchasing intangible knowledge. For the non-process innovative firms 97.78 percent do not purchase intangible knowledge.

Figure 20 presents the distribution of process innovation status of firms based on the location status of the firms.

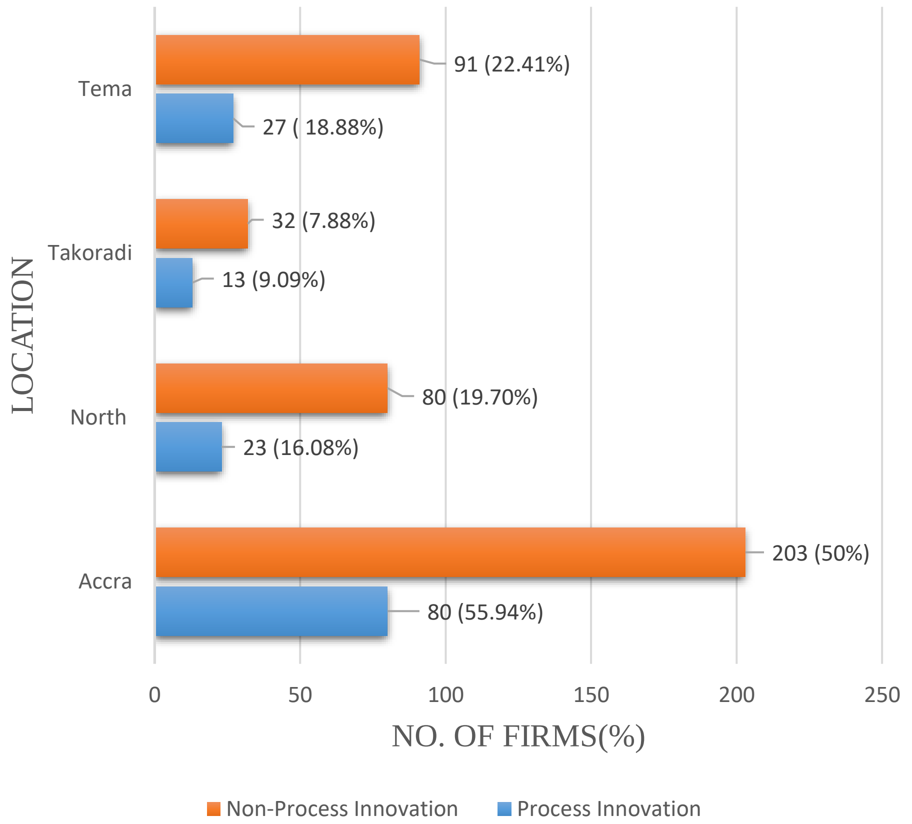

Figure 20: Location status and Process innovation
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

In Figure 20, it can be observed that process innovation is more pronounced among firms in Accra than among firms in the other parts of the country. Out of 143 process innovative firms, 80(55.94%) are located in Accra. Unlike product innovative firms, there are more firms that undertake process innovation in Tema than in the "North". The distribution of the non-process innovative firms follows the same pattern as that of the product innovative firms. The high number of process innovative firms in Accra and Tema could be as a result of the concentration of industries in these areas and so firms continually look for new and efficient ways of production so as to become competitive.

The distribution of process innovation status of firms based on the size of the firms is presented in Figure 21.

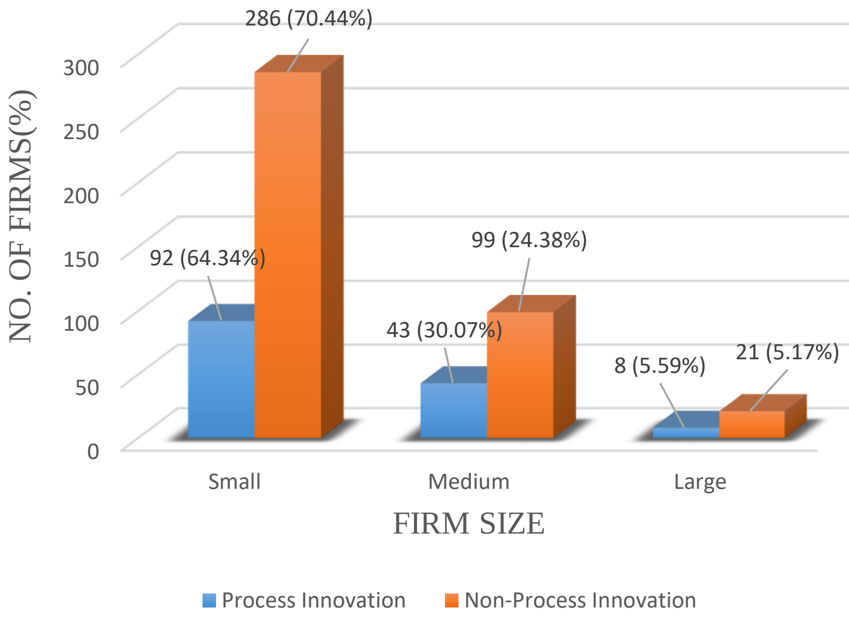

Figure 21: Firm Size and Process Innovation Status
Source: Author's computation, 2019; from the 2013 ES and 2014 GIFS data

Process innovation is more pronounced among small size firms than among medium and large sized ones. In figure 21, out of 143 process innovative firms, 92 representing 64.34 percent are small size firms. There are only eight large size firms that are process innovative. This result is not surprising because most of the firms in Ghana are small sized firms. As such it should not be surprising if there are more small size process innovative firms than the large sized ones.

Empirical Findings and Discussion of Results

This section presents and discusses the results of the various logistic regressions of the effect of knowledge sources on product and process innovations.

Logit Estimation Results for Product Innovation

Table 2 displays the logistic regression results for product innovations. Model 1in Table 2, presents the results of the effect of internal knowledge sources on product innovations. The effects of the use of external knowledge sources on product innovations are shown in Model 2 of Table 2. Model 3 in Table 2 presents the results of the joint effect internal knowledge capabilities and external knowledge on product innovation; with specific focus on the joint effect of internal R&D and purchase of equipment on product innovations.

All the three models have a Likelihood Ratio Chi-square value of 0.000. This show that overall, the models are statistically significant at 1%. In this case the null hypothesis that all the parameters besides the constant are equal to zero is rejected. This implies that the explanatory variables in the model taken together adequately explain variations in product innovations. In addition, the results of the *linktest* for each of the three models shows that the models were well specified. The three models have also passed the "Hosmer Lemeshow" *goodness of fit* test. The post estimation diagnostic results for each model are displayed in Table 2.

Table 2: Logit Estimation Results for Product Innovation

VARIABLES	Model 1 Coefficients	Model 1 Odds Ratio	Model 2 Coefficients	Model 2 Odds Ratio	Model 3 Coefficient	Model 3 Odds Ratio
Internal R&D	0.914***	2.494			0.743	2.101
	(0.274)				(0.492)	
Training	0.821***	2.274			0.605**	1.831
	(0.234)				(0.248)	
Managers experience	-0.005	0.9956			-0.000	0.999
	(0.012)				(0.0127)	
External R&D			0.369	1.446	-0.276	0.759
			(0.480)		(0.509)	
Equipment			1.244***	3.471	0.960***	2.612
			(0.209)		(0.242)	
Intangible			-0.396	0.673	-0.645	0.525
			(0.650)		(0.675)	
Internal R&D*Equipment					0.155	1.168
					(0.563)	
Location						
North	0.104	1.109	-0.0183	0.982	0.0348	1.035
	(0.268)		(0.269)		(0.277)	
Takoradi	-0.423	0.655	-0.464	0.629	-0.529	0.589
	(0.395)		(0.399)		(0.410)	
Tema	-0.053	0.948	-0.205	0.815	-0.065	0.937
	(0.263)		(0.263)		(0.270)	
Sector	0.362*	1.436	0.375*	1.455	0.486**	1.626
Service	(0.207)		(0.207)		(0.215)	
Firm Size						
Medium	0.243	1.275	0.283	1.327	0.147	1.158
	(0.227)		(0.225)		(0.235)	
Large	-0.853	0.426	-0.597	0.550	-0.948*	0.388
	(0.526)		(0.507)		(0.541)	

Table 2 continued

Age	0.023**	1.023	0.0198**	1.020	0.018	1.018
	(0.011)		(0.00)		(0.0114)	
Constant	-1.832***	0 .160	-2.026***	0.133	-2.198***	0.111
	(0.281)		(0.267)		(0.310)	
Observations	549	549	549		549	549
LR chi2	51.61		52.40		72.90	
Prob > chi2	0.0000		0.0000		0.0000	
Pseudo R2	0.079		0.0804		0.1119	
Log likelihood	-299.989		-299.59695		-289.32371	
Linktest (hatsq)	0.852		0.611		0.622	
Gof (Prob >chi2	0.2304		0.1205		0.1876	

Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Source: Author’s computation, 2019; based on the 2013 ES and 2014 GIFS data

The Effect of Internal Knowledge Sources on Product Innovation

Model 1 in Table 2 presents the effect of internal sources of knowledge on product innovations regardless of external knowledge sources. The results from Model 1 in Table 2 shows that, internal knowledge accumulated from the conduct of internal R&D and training of workers have a significant influence in the firm's decision to undertake product innovation. The age of firm and the sector a firm belongs also have a significant influence in the firm's decision to undertake product innovation.

Internal R&D has a positive and significant effect on product innovation when external knowledge is ignored. The results from Model 1 in Table 2 indicate that the odds of product innovation for firms that conduct internal R&D is 2.5 times higher than for firms that do not perform internal R&D holding all other variables constant and this difference is statistically significant at 1%.

The outcome of this study is consistent with the results of (Ganotakis & Love, 2011; Gallié & Legros, 2012; Conte & Vivarelli, 2014). They found that internal R&D has a strong and positive impact on firm's innovation output. Similarly, Osoro et al. (2016) used data from the Tanzanian Enterprise Survey and the Tanzanian Innovation Survey and found that product innovations in Tanzania are positively and significantly driven by firms internal R&D. Afful and Owusu (2017) also found that internal R&D has a positive and a significant influence on product innovation for firms in the manufacturing sector of Ghana. One explanation for the positive and significance of internal R&D on product innovation could be that internal R&D builds the internal knowledge base of the firm and this enhances the firm's technological capability to develop new products.

Training of workers also has a positive and significant effect on product innovation when internal knowledge sources are considered in isolation. The results of Model 1 of Table 2 indicates that firms that train their workers have a 2.3 times higher the odds of product innovation than the firms that do not train their workers holding all other variables constant; this is statistically significant 1%. This result is consistent with the findings of Gonzalez, Miles-Touya and Pazo (2012), who used a panel of approximately 10,000 Spanish manufacturing firms over the period 2001-2006 and found that worker training has a significant effect on firm's innovation performance. Dostie (2014) also used a 1999-2006 data from the Workplace and Employee Survey (WES) conducted by Statistics Canada and demonstrated that more training leads to more product and process innovations.

It should however be noted that Afful and Owusu (2017) did not find training of workers to significantly influence product innovation for manufacturing firms in Ghana. In this study, firms from both manufacturing and service sectors were considered; the results showed that training of workers positively and significantly influences product innovations. This result is in line with our expectation. This is because training increases the firm's stock of human capital and as such an increase in this stock through firm sponsored training might lead to more innovation.

Considering "sector" as a control variable, it was found that belonging to the service sector positively increases the chances of product innovation than firms in the manufacturing sector. From the results of the logistic regression, in Model 1 of Table 1, the odd ratio of 1.44 indicates that firms in the service sector are 1.4 times more likely to product innovate than firms in the manufacturing sector holding all other variables constant. This difference is statistically significant at 1%.

This finding is also similar to the finding of Osoro et al. (2016) who found that the chances of undertaking product innovation are higher for firms in the service sector of Tanzania than those in the manufacturing sector. In the Ghanaian case, the high chances of service sector firms to undertake product innovation than the manufacturing sector firms is not surprising. The size of the service sector is about two times more than that of the manufacturing sector (Ghana Statistical Service, 2019) which implies a higher likelihood of product innovation in the service sector.

In addition, Baldwin et al. (2004) posit that production is less costly in the service sector than in the manufacturing sector. Service sector firms therefore have less financial barriers to innovation than manufacturing sector firms. As such, the cost of product innovation is likely to be lesser in the service sector than in the manufacturing sector.

The age of a firm as a control variable also significantly influences the effect of internal knowledge sources on product innovations. The positive sign of age of the firms in Model 1 of Table 2 is an indication that older firms are more likely to product innovate than younger ones. The odds ratio suggests that as a firm advance in age the odds of product innovation is 1.02 times higher than younger firms holding all other variables constant; this difference is statistically significant at 5%.

In the findings of Afful and Owusu (2017), the age of firms is not significant in explaining product innovation for firms in the manufacturing sector. The findings of this study however is based on firms from both the manufacturing and the service sectors. The results suggest that, older firms differ more in comparison to younger firms in terms of the attributes that affect internal knowledge sources in influencing Product innovation. Some of these attributes could be remuneration and motivation of researchers, incentives for training of workers, the cost of innovating amongst others. Overall, the older firms have survived in Ghana because they are product innovative.

The number of years of experience of the manager surprisingly does not have a significant effect on product innovation. This variable was expected to have a significant influence on product innovations. This is because the manager of the firm is expected to support the innovation process by giving his knowledge related to his role as the decision maker of the innovation (Indarti, 2010). The findings of this study contradicts the findings of (Balsmeier & Czarnitzki, 2014; Li, 2017) who found that managers experience positively and significantly influence innovations. The insignificance of this variable in the case of Ghanaian firms indicates a low innovative experience of the top managers. It further highlights the fact that undertaking innovations involves a clear departure from the normal routine ways of developing products to introducing something new of which experience does not count.

The first objective of this study seeks to analyse the separate effect of internal knowledge sources on product innovations. From the results of the logistic regression it can be concluded that internal R&D and training of workers have a significant effect on product innovation. Firms that seek to develop product innovations by solely using their internal capabilities should focus on developing their internal R&D Capacity and provide more training for their workers.

The Effect of External Knowledge Sources on Product Innovations

Model 2 in Table 2 presents the effect of external knowledge sources on undertaking product innovation. The results from Model 2 in Table 2 shows that conduct of external R&D and purchase of intangible technology as external sources of knowledge do not influence product innovations. Purchase of equipment however positively and significantly influences the chances of a firm undertaking product innovations. The odd ratio of 3.47 indicates that the odds of product innovation for firms that purchase equipment is 3.5 times higher compared to firms that do not purchase equipment holding all other variables constant. This difference is statistically significant at 1%.

External source of knowledge for product innovation in Ghana thus comes from the acquisition of equipment and machines rather than the conduct of external R&D or purchase of intangible technologies such as patents or licenses. This finding is in line with the views of Szirmai, Naude and Goedhuys (2011), who posit that in low income countries innovations may not be manifested through high profile breakthroughs usually measured through R&D performances or the number of patents but by a more incremental adoption and adaption of existing technologies (Szirmai et al., 2011).

Considering “sector” as a control variable, belonging to the service’s sector positively and significantly influences the effect of external knowledge on product innovation. Belonging to the service sector positively increases the chances to product innovate than to be in the manufacturing sector. The odd ratio from the results of the logistic regression reveal that the odds to product innovate is 1.5 times higher for firms in the service sector than for those firms in the manufacturing sector holding all other variables constant. This is statistically significant at 10%

One plausible explanation for the higher chances of the services sector firms to product innovate more than the manufacturing sector firms when considering only the external knowledge sources could be due to the following: The manufacturing sector in Ghana is usually more labour intensive than the service sector. As such, less external knowledge in the form of purchase of equipment and external R&D is required for production. The services sector on the other hand usually attracts personnel who have a higher level of technological capability. As such, the use of external knowledge sources like acquiring equipment and machinery will result in higher product innovation in the service sector than in the manufacturing sector.

The second could be due to cost constraints. The cost of equipment and machinery that are used in the manufacturing sector could be more expensive than the equipment that are used in the service sector. As such innovating in the service sector is likely to be less expensive than to innovating in the manufacturing sector

Firm age as a control variable has a positive and significant effect on product innovation. The results from Model 2 in Table 2 indicate that for a unit increase in age of a firm, the odds of product innovation increases by a factor of 1.02 holding all other variables constant.

This indicates that older firms differ more than younger firms in terms of attributes that result in greater effect of external knowledge in influencing product innovations. Some of the attributes could be the cost of innovating, remuneration and motivation for innovators amongst others.

The second objective of this study is to identify the effect of external sources of knowledge on product innovation. From the logistic regression results, the study concludes that purchase of equipment or machines has a significant effect on product innovation. Firms that seek to undertake product innovation solely through external knowledge should focus on acquiring equipment or machinery.

The Joint Effect of Internal R&D and Purchase of Equipment on Product Innovation

Model 3 in Table 2 presents the logit estimation results of the effect of both internal and external sources of knowledge on product innovations. It also includes the joint effect of internal R&D and purchase of equipment on product innovation.
The Internal R&D has traditionally been acknowledged as a measure of firm's internal capability (Cohen & Levinthal, 1990; Zahra & George, 2002). In recent times purchase of machinery and equipment has also been identified as the main strategy of innovating (Vega-Jurado et al., 2008; Potters, 2009; Goedhuys & veugelers, 2012; Silva et al., 2014). In Model 1 of Table 2, internal R&D had the greatest effect on product innovation and from Model 2 in Table 2, only purchase of equipment had a significant influence on product innovations. Internal R&D is chosen as a proxy for internal sources of knowledge whiles purchase of equipment

is chosen as a proxy for external sources of knowledge. The results from Model 3 in Table 2 shows that purchase of equipment, training of workers, the sector a firm belongs to and the size of the firm have a significant effect on product innovations. Internal R&D and purchase of equipment or machinery do not have a joint significant effect on product innovations. In addition, internal R&D, manager's years of experience, external R&D, purchase of intangible technology have no significant effect on product innovations.

From Model 3 in Table 2 internal R&D and purchase of equipment jointly do not have a significant effect on product innovation. In this case, the study fails to reject the null hypothesis and concludes that jointly conducting internal R&D and purchasing of equipment have no significant effect on introducing new products among Ghanaian firms. This finding is surprising. It is also contrary to the findings of Chen et al., (2016) who found that both internal R&D and external knowledge sources such as purchase of equipment jointly have a positive and significant effect on firm's innovative performance. However, a possible explanation for this result is that, even though firms purchase equipment and conduct internal R&D, the internal R&D does not seem to be oriented toward the development of new products. The internal R&D may be geared towards meeting regulatory standards such as safety or environmental regulations, how to deal with a decrease in the demand for already existing products and services, or increasing sales.

Model 3 in Table 2 however shows the important influence of purchase of equipment and training of workers in introducing new product by firms. Firms that purchase equipment have 2.6 times higher the odds of product innovation compared to firms that did not purchase equipment holding all other variables constant. This difference is statistically significant at 1%. Also, the odds of product innovation are 1.8 times higher for firms that train their works as opposed to those that do not train their workers holding all other variables constant and this difference is statistically significant at 5%.

There is however, an indication of low absorptive capacity of firms. In other words, the internal knowledge base is less effective in utilizing external knowledge to develop product innovations. The absorptive capacity theorists emphasize that acquiring external knowledge is useful only if the firm possesses the existing base of knowledge to enable it utilise that knowledge (Cohen &Levinthal, 1990; Zahra & George, 2002). Vega-Jurado et al. (2008) also indicated that the higher the firm's internal knowledge capabilities, the higher the effects of external knowledge activities on innovation performance. From Table 2, it can be seen that the effect of purchase of equipment on innovation is higher in Model 2 than in Model 3. This indicates a low absorptive capacity of firms because the impact of an external knowledge (purchase of equipment) is low in the presence of internal knowledge.

Analysing "sector" as a control variable, it can be observed from Model 3 in Table 2, that firms that belong to the service sector have 1.6 times higher the odds of product innovation compared to firms in the manufacturing sector holding all other variables constant. This difference is statistically significant at 5%. This finding further supports the descriptive statistics that product innovation is more predominant in the service sector than in the manufacturing sector. As has already been stated, the size of the service sector is about two times larger than the manufacturing sector (Ghana Statistical Service, 2019). Product innovation is therefore more likely in the service sector compared to the manufacturing sector. Another plausible explanation of the dominance of product innovation in the services sector over the manufacturing sector could be that the cost of product innovation is less in the service sector than in the manufacturing sector (Baldwin et al, 2004).

Finally, the high significant effect of purchase of equipment on product innovation in the presence of internal R&D highlights that purchase of equipment is the main strategy for the success of product innovations. The purchase of equipment and machinery usually require some training of workers on how to use the new equipment. This could explain the positive and significant effect of training on product innovation in Model 3 of Table 2. This finding corroborates the views of Fu et al. (2010) who posit that developing countries are better off adopting external technologies than of trying to develop it on their own. It also highlights the view of the resource dependency theory that firms depend on external resources for survival, power and growth because of the lack of internal resources.

The third objective of this study sought to analyse the joint effect of internal R&D and Purchase of equipment. The Logistic regression results shows that purchase of equipment and conduct of internal R&D jointly have no significant effect on product innovation. In addition, there is an indication of low absorptive capacity among firms as the effect of external knowledge (purchase of equipment) is lower in the presence of internal knowledge (Model 3) than when the effect of external knowledge (purchase of equipment) is considered in isolation (Model 2).

Logit Estimation Results for Process Innovation

Table 3 presents the logistic regression results for the effect of knowledge sources on process innovations. Model 4 in Table 3 shows the results of the effect of internal sources of knowledge on process innovations. Model 5 in Table 3 presents the results of the effect of using external knowledge sources on process innovations. The joint effect internal knowledge capabilities and external knowledge on process innovation; with specific focus on the joint effect of internal R&D and purchase of equipment on process innovations are presented in Model 6 of Table 3.

All the three models have a Likelihood Ratio Chi-square value of 0.000. This shows that overall, the models are statistically significant at 1%. In this case the null hypothesis that all the parameters besides the constant are equal to zero can be rejected. This implies that the explanatory variables in the model taken together can adequately explain variations in product innovations. In addition, the results of the *linktest* for each of the three models shows that the models were well specified. The three models have also passed the Hosmer- Lemeshow *goodness of fit* test. The post estimation diagnostic results for each model are displayed in Table 3.

Table 3: Logit Estimation Results for Process Innovations

	Model 4		**Model 5**		**Model 6**	
VARIABLES	Coefficients	Odd Ratios	coefficients	Odd Ratios	coefficient	Odds ratio
Internal R&D	1.206***	3.339			1.127**	3.086
	(0.279)				(0.505)	
Training	1.144***	3.140			0.833***	2.301
	(0.238)				(0.258)	
Managers experience	-0.003	0.997			0.005	1.005
	(0.013)				(0.014)	
External R&D			0.621	1.861	-0.248	0.780
					(0.544)	
Equipment			1.834***	6.260	1.540***	4.665
			(0.229)		(0.267)	
Intangible			-0.414	0.661	-0.891	0.410
			(0.665)		(0.711)	
Internal R&D* Equipment					0.035	1.036
					(0.585)	
Location						
North	-0.591*	0.554	-0.781**	0.458	-0.780**	0.458
	(0.308)		(0.308)		(0.324)	
Takoradi	-0.137	0.872	-0.115	0.891	-0.209	0.812
	(0.394)		(0.393)		(0.417)	
Tema	-0.166	0.847	-0.397	0.672	-0.230	0.795
	(0.278)		(0.284)		(0.295)	
Sector	-0.597***	0.550	-0.572***	0.565	-0.497**	0.608
Services	(0.219)		(0.222)		(0.232)	
Firm Size						
Medium	0.103	1.108	0.172	1.188	-0.045	0.956
	(0.248)		(0.244)		(0.264)	
Large	-0.447	0.639	-0.0954	0.909	-0.525	0.592

Table 3 continued

	(0.521)		(0.506)		(0.546)	
Age	-0.007	0.992	-0.0104	0.990	-0.019	0.981
	(0.012)		(0.0108)		(0.013)	
Constant	-1.093***	0.335	-1.422***	0.241	-1.651***	0.192
	(0.280)		(0.268)		(0.322)	
Observations	549	549	549	549	549	549
LR chi2	82.35		92.66		127.51	
Log likelihood	-273.70585		-268.54795		-251.12385	
Prob > chi2	0.0000		0.0000		0.0000	
Linktest (hatsq)	0.511		0.256		0.366	
Gof (Prob > chi2)	0.158		0.250		0.204	
Pseudo R2	0.130		0.1471		0.203	

Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's computation, 2019; based on the 2013 ES and 2014 GIFS data

The Effect of Internal Knowledge Sources on Process Innovations

Model 4 from Table 3 presents the results of the logistic regression of the effect of internal sources of knowledge on undertaking process innovations. The results from Model 4 of Table 3 show that internal R&D and training of workers have a positive and significant influence on firm level process innovation. Firms that are located in the "North" compared to those in Accra and belonging to the service sector have a negative influence on process innovations.

As regard internal R&D, the results from Model 4 in Table 5 reveal that the odds of process innovation for firms that conduct internal R&D is 3.3 times higher than firms that do not conduct internal R&D holding all other variables constant. This difference is statistically significant at 1%.

The outcome of this study supports the results of (Ganotakis & Love, 2011; Gallié & Legros, 2012; Conte & Vivarelli, 2014). They found that internal R&D has a strong and positive impact on firm's innovation output. This indicates that internal R&D builds firm's internal capacity to efficiently introduce new methods of producing goods and rendering services.

In addition, for firms that train their workers, the odds of process innovation is 3.1 times higher than the firms that do not train their workers holding all other variables constant. This difference is statistically significant at 1%. This result in Model 4 Table 5 also corroborates the findings of Dostie (2014). He found that training of workers positively and significantly improves innovation performance. Training improves the capability and efficiency of workers to introduce new methods of producing goods and rendering services.

Comparing firms in the “North” to those in Accra, being in the north lowers the chances of the effect of internal knowledge sources on process innovation. The logistic regression results of Model 4 in Table 3 indicate that the odds of process innovation for firms located in the “North” reduces by a factor of 0.5 compared to firms located in Accra holding all others variables constant. This difference is statistically significant a 10%

A plausible explanation for this could be the effect of attributes that differ between Accra and the “North”. For example, inadequate financial institutions to support innovators, unwillingness of skilled personnel to work in some places of the “North”, low market demand for goods and services.

Considering “sector” as a control variable, it was found that belonging to the service’s sector reduces the chances of the effect of internal knowledge sources in influencing process innovations. The logistic regression results of Model 4 in Table 3 mean that the odds of firms in the service sector to undertake process innovation is 0.6 times lower than firms that are in the manufacturing sector holding all other variables constant. This difference is statistically significant at 1%.

This result indicates that the chances of process innovation are more pronounced among firms in the manufacturing sector than in the service sector. Baldwin et al. (2004) argue that the cost of production in the manufacturing sector is higher than in the service sector. It is therefore not surprising that the chances of process innovation are higher for the manufacturing sector because as Bianchini, Pellegrino and Tamagni (2018) posits, new processes are implemented primarily to drive costs down, thereby improving cost efficiency and price competitiveness.

The objective of this study sought to analyse the separate effect of internal sources of knowledge on process innovation. From the logistic regression results, it can be concluded that internal R&D and training of workers have a significant effect on process innovation. Firms that want to undertake process innovations by solely using their internal knowledge capacity and capability should focus on internal R&D provide training for their workers.

The Effect of External Knowledge Sources on Process Innovations

Model 5 of Table 3 presents the results of the effect of external knowledge sources on process innovations. Purchase of equipment positively and significantly increases the likelihood of pursuing process innovations. The results from the logistic regression in Model 5, Table 3 shows that external R&D and purchase of intangible knowledge do not influence firm level process innovations.

In model 5 of table 3, the results indicate that the odds of process innovation for firms that purchase equipment is 6.3 times higher than for firms that do not purchase equipment holding all other variables constant. This difference is statistically significant at 1% alpha level.

In the quest of firms to minimize their production cost and improve price competiveness, purchase of equipment is more common than investing in external R&D or acquiring patents. According to Tettey and Essegbey (2014), collaboration with external research institutions for the purposes of innovating is about 3% in Ghana. The result in Model 5, Table 3 also supports the view of Fu et al. (2010) that developing countries might be better off adopting external knowledge in the form of equipment instead of trying to develop it themselves because innovation is costly, risky, and path-dependent.

Firms located in the "North" compared to being located in Accra reduces the chances of influencing process innovations. The results of Model 5 in Table 3 indicate that the odds of process innovation for firms located in the "North" is 0.5 times lower than those located in Accra holding all other variables constant. This difference is statistically significant at 5%.

An explanation for this difference could be due to attributes that differ between the "North" and Accra that affect innovation. For example, unwillingness of skilled personnel and researchers to work in some places of the "North", inadequate financial institutions to support innovators, difficulty in finding equipment and machinery to purchase for innovation purposes amongst others.

Belonging to the service sector reduces the chances of the effect of external knowledge sources in influencing process innovations compared to the manufacturing sector. From the results of Model 5of table 3, the odds of process innovation for firms in the service sector reduces by a factor of 0.6 compared to firms in the manufacturing sector holding all other variables constant. This difference is statistically significant at 1%.

This result means that the chances of process innovation through the external knowledge sources is more pronounced in the manufacturing sector than in the service sector.

The Joint Effect of Internal R&D and Purchase of Equipment on Process Innovations

Model 6 of Table 3 shows the logistic regression results of the effect of using knowledge from both the internal and external sources on the likelihood of process innovations. It also includes the joint effect of the conduct of internal R&D and purchase of equipment on process innovation. The results from Model 6 of Table 3 show that internal R&D, purchase of equipment and training of workers have a positive and significant effect on process innovations. Firms belonging to the service sector and being located in the "North" compared to Accra negatively and significantly affect the chances of undertaking process innovation.

The results from Model 6 in Table 3 shows that though the coefficient of the joint effect of internal R&D and purchase of equipment is positive, it has no significant effect on process innovation. In this case the study failed to reject the null hypothesis and concludes that jointly purchasing equipment and conducting internal R&D have no significant effect on introducing process innovations. This result is surprisingly in contrast to the expectations of this study. Again, a possible explanation for this result could be that though firms purchase equipment and conduct internal R&D, the purpose of combining these activities may not be geared toward the introduction new methods of producing goods or rendering services. Rather they may be motivated by the need to comply with regulations or standards.

In spite of the insignificance of the joint effect of internal R&D and purchase of equipment on product innovations, conduct of internal R&D alone has a significant effect on process innovations. The odds of process innovation is 3.1 times higher for firms that conduct internal R&D as compared to those that do not conduct internal R&D holding all other variables constant. This difference is statistically significant at 5%. In addition, for firms that train their workers, the odds of process innovation are 2.3 times higher than for firms that do not provide training for their workers. Also, the odds of process innovation are higher by a factor of 4.7 for firms that purchase equipment compared to firms that do not purchase equipment holding all other variables constant. This difference is statistically significant at 1%.

Again, there is an indication of low absorptive capacity of firms as regards the success of process innovations. In Model 5 of Table 3, the odds of process innovation for purchase of equipment in the absence of internal knowledge capability is higher (6.2) than the odds of process innovation for purchase of equipment in the presence of internal knowledge capacity (4.7) as reported in Model 6, of Table 3. This means that the internal capability of firms is less effective in utilizing external knowledge (equipment) to pursue process innovations.

Process innovation is more pronounced in the manufacturing sector than in the service sector. The results from Model 6 in Table 3 shows that the odds of process innovation for firms in the service sector is 0.6 times lower than firms that belong to the manufacturing sector holding all other variables constant and this difference is statistically significant at 5%. Again, a plausible explanation for the dominance of process innovation in the manufacturing sector can be derived from the views of (Balwin et al., 2004; Bianchini et al., 2018). Balwin et al. (2004) argue that the cost of production in the manufacturing sector is higher than in the service sector. Bianchini et al (2018) are of the view that, new processes are implemented primarily to drive costs down, thereby improving cost efficiency and price competitiveness of firms.

The third objective of this study sought to analyse the joint effect of internal R&D and purchase of equipment on process innovation. The results are similar to that of product innovations. The logistic regression results show that purchase of equipment and conduct of internal R&D jointly have no significant effect on process innovation. In addition, there is an indication of low absorptive capacity among firms as the effect of external knowledge (purchase of equipment) is lower in the presence of internal knowledge (Model 6) than when the effect of external knowledge (purchase of equipment) is considered in isolation (Model 5).

Magnitude of Effect of Knowledge Sources on Product and Process Innovation

The analysis of the separate effects of internal sources of knowledge found internal R&D and training of workers to have a positive and significant effect on both product and process innovation. In terms of magnitude, internal R&D has a higher effect on process innovation than on product innovation. In Model 4 of Table 3, the odds of process innovation increases by a factor of 3.3 for firms that conduct internal R&D whilst in Model 1 of Table 2, the odds of product innovation increases by a factor of 2.5 for firms that conduct internal R&. Training of workers also has a higher effect on process innovation than on product innovation. In Model 4 of Table 3, the odds of process innovation are 3.1 times higher for firms that train their workers compared to those that do no training whilst in Model 1 of Table 2, the odds of product innovation is higher by a factor of 2.2 for firms that train their workers compared to those that do no training.

Purchase of equipment has a positive and significant effect on both product and process innovation when considering the separate effect of external knowledge on innovation. Purchase of equipment however has a higher effect on process innovation than on product innovation. The results from Model 5 of Table 3 show that the odds of process innovation is higher by a factor of 6.3 for firms that purchase equipment and machinery compared to those firms that do not purchase equipment or machines. On the other hand, the odds of product innovation increases by a factor of 3.5 for firms that purchase equipment compared to those firms that purchased no equipment as shown in Model 2 of table 2.

Chapter Summary

From the descriptive statistics and the logistic regressions results, the main findings of the study can be summarized as follows. Product innovation is more pronounced in the service sector whereas process innovation is more pronounced in the manufacturing sector. Internal R&D and training of workers have a significant effect on both product and process innovation when considering the separate effects of internal sources of knowledge on innovation. Purchase of equipment or machinery have a significant effect on undertaking product and process innovations when analysing the effects of external sources of knowledge regardless of internal knowledge. Purchase of equipment is the main strategy for both product and process innovation however the absorptive capacity of firms is low. The interaction of internal R&D and purchase of equipment has no significant effect on both product and process innovations.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This study sought to analyse the effects of sources of knowledge on firm level innovation in Ghana. The chapter captures the summary of findings, conclusions made from the study and thereafter gave recommendations to various stakeholders in society based on the findings and conclusions. The chapter ends with limitations of the study and also gave directions for further research.

Summary

The survival and growth of firms in the modern competitive world is increasingly associated with knowledge and innovation. Ghana has since independence initiated some measures to ensure that Ghanaian firms are innovative and competitive. To innovate, firms use knowledge from different sources. This knowledge can be generated through activities either within or outside the boundaries of the firm. However, for firms to benefit from knowledge it is important for firms to possess the capacity to utilise such knowledge to innovate. In the case of Ghana, it is unclear the extent to which knowledge from the various sources influences firm level innovation.

This study sought to examine the extent to which knowledge sources affect the propensity to introduce product and process innovation among Ghanaian firms. The study analysed the separate effects of internal and external sources of knowledge on product and process innovations. Lastly the joint effect of internal and external knowledge with specific focus on the joint effect of internal R&D and purchase of equipment on firm level product and process innovation were analysed.

Three theoretical views were explored to explain why firms use either the internal or the external sources of knowledge or to combine all these knowledge sources for innovation purposes. The resource or the knowledge-based views explain why firms decide to use the internal sources of knowledge to innovate. The resource dependency theory explains the view that firms always depend on resources for survival and due to the limited supply of internal resources firms look for external resources to innovate. The absorptive capacity theory explains the view that for firms to benefit from external knowledge they need to possess the internal capacity to utilise that knowledge.

A cross sectional data from the 2013 Ghana Enterprises Survey and the 2014 Ghana Innovation Follow-up Survey was used in this study. The dependent variables in this study are firm's attempts to introduce product or process innovation. Due to the dichotomous nature of these two dependent variables, a logistic regression model was adopted. Six logit models were specified. The Maximum Likelihood Estimation technique was used to determine the likelihood of each source of knowledge to result in product or process innovations.

The independent variables for the model for the effect of internal sources of knowledge on innovation are internal R&D, training of workers and the manager's years of experience. External R&D, purchase of equipment and purchase of intangible technology are the independent variables for the model of the effect of external sources of knowledge. The control variables for all the models are the firm's location, size, age and the sector a firm belongs.

This study has several findings. First, conduct of internal R&D and training of workers are the significant sources of internal knowledge for product and process innovation among Ghanaian firms. Internal R&D however has a higher effect on process innovation than on product innovation. Providing training of workers also has a higher effect on process innovation than on product innovation. The manager's years of experience does not influence product or process innovations.

Second, purchase of equipment is the significant source of external knowledge for both product and process innovations. In terms of the magnitude of effect, purchase of equipment has a higher effect on process innovation than on product innovation. However, its effect is lower in the presence of internal knowledge than when it is considered in isolation. This indicates low absorptive capacity of firms. Purchase of intangible technology and conduct of external R&D do not influence product or process innovation among Ghanaian firms.

Third, the interaction of internal R&D and purchase of equipment have no significant effect on both product and process innovations. Also in the presence of external knowledge, internal R&D is not significant in influencing product innovations. However, internal R&D has a significant effect on process innovation.

Fourth, for firms in the service sector the chances of undertaking product innovations are higher when internal and external knowledge are combined than when they are used in isolation. Whilst for manufacturing sector firms the chances of process innovation are higher when internal and external knowledge are jointly used than when they are considered in isolation.

Conclusions

This study set out to determine the extent to which knowledge sources affect product and process innovations among Ghanaian firms. From the analysis of data from the 2013 Ghana Enterprises Survey and the 2014 Ghana Innovation Follow-up Survey the following conclusions can be made.

First, firm level product and process innovations in Ghana are significantly influenced by purchase of equipment, internal R&D and training of workers and the sector the firm belongs.

Second, purchase of equipment and machinery is main innovation strategy for both product and process innovations. This implies that firms need to invest more in acquiring equipment and machines to develop innovative products and process.

Third, the chances of product and process innovations are higher when internal R&D and purchase of equipment are considered in isolation than when they are jointly used. Investing resources in both sources at the same time has a lower effect on innovation than when resources are concentrated on one.

Fourth, from the descriptive statistics and the logistic regression results it can be concluded that process innovation is more pronounced in the manufacturing sector than in the service sector whiles product innovation is marginally more predominant in the service sector than the manufacturing sector.

Recommendations

From the results and conclusions of this study, the following policy recommendations are suggested.

First, the Ministry of Finance should support the innovation process by granting special R&D allowance to firms or direct funding of R&D for targeted firms that because of strategic reasons can only innovate by using internal capacities and capabilities. Firms that intend to use only the internal source of innovation because of fear of losing their core competencies or competitive advantage, they should focus their resources and investments on in-house R&D and training for their workers. Since innovation is risky and has spillover effects, Firms should also provide continual training for their employees to increase the stock of knowledge embedded in them for innovation purposes.

Secondly for firms that lack internal capacity and capability and are incapable of innovating internally, they should invest their resources on the acquisition of equipment and machinery. Given the fact that most equipment and machinery are imported into the country, the Ministry of Trade and Industry should liaise with the Ministry of Finance to support the innovation system by granting tax exemption on the purchase of equipment and machines. Managers of firms should foster strategic alliances and collaborations that will ensure that they always get the best of equipment and machinery to enhance their innovation performance.

Finally, the cost of innovating in developing countries is high. Given the fact that jointly purchasing equipment and conducting internal R&D have no significant effect on product and process innovations, investing resources in both internal R&D and purchasing equipment at the same time might actually be a waste of firm's limited resources. Given the high significance of purchase of equipment on both product and process innovations, the study recommends that, firms invest in purchasing equipment and machinery and continually provide training for workers on how to use them. The Ministry of Environment, Science, Technology and Innovation should formulate a policy that compels firms to regularly train their workers especially on how to use and repair new machines. Training can improve the internal knowledge base of the firm and help raise the level of absorptive capacity of firms. In addition, the internal organisational structure of firms need to be structured such that it allows external technological alliances and collaborations.

Limitations of the Study

This study has some few limitations that need to be highlighted. First, the data used in this study is the first innovation survey conducted in Ghana that followed the guidelines outlined in the Oslo Manual. It provided information only on innovative activities between 2010 and 2012.This made it impossible to analyse the dynamics of knowledge acquisition and the sustainability of innovativeness of firms.

Second, the previous innovation history of firms was not indicated in the data. The base of innovation performance is unknown. This also prevented an analysis of innovation performance over time.

Third, a limitation of using cross sectional surveys is a potential endogeneity resulting from sampling section bias since in this study only firms that report to introduce some innovations are considered. This study however addresses this limitation by including several control variables (firm age, sector, firm size and location) to condition some of the error that is correlated with the endogenous regressors.

Areas for Further Research

The limitations of this study highlight some issues for further research. One area to explore is analysing the sustainability of innovativeness and knowledge acquisition dynamics of firms. Another area to focus on is an investigation of the alternative ways Ghanaian firms innovate apart from the traditional, formal innovative activities that were used in this study. In addition, an analysis of the joint effect of the other internal and external sources of knowledge is worth investigating.

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APPENDICES

A: Variables and their Definitions

Variable	Scale of measurement and description
Product Innovation	=1, if the firm introduced new or significantly improved product or service =0, if otherwise
Process Innovation	= 1, if the firm introduced new or significantly improved method of manufacturing products or offering services =0, if otherwise
Internal R&D	=1 if the firm conducts internal R&D =0 if otherwise
External R&D	=1 if the firm conducts external R&D =0 if otherwise
Training	=1 if the firm provide training to production staff to be innovative. =0 if otherwise
Managers Experience	the number of years of experience that the top manager has
Intangible technology	=1 if the firm purchase or license any patented or non-patented inventions or other types of knowledge =0 if otherwise
Equipment	=1 if the firm purchase new equipment or machinery to develop innovative products or services =0 if otherwise
Age	Number of years the enterprise has been in existence

Firm size	Small >=5 and <=19 employees
	Medium >=20 and <=99 employees
	Large >=100 employees
Location	Accra
	North (Kumasi and Tamale)
	Takoradi
	Tema
Sector	=1 if firm belongs to manufacturing sector
	=2 if firm belongs to the service sector

Source: Author's Construct, 2019

B: Expected Signs of Explanatory Variables

Variables	Expected sign	
	Product Innov.	Process Innov.
Internal R&D	+	+
Training of workers	+	+
Managers experience	+	+
External R&D	+	+
Purchase of equipment and Machinery	+	+
Purchase of intangible knowledge/technology	+	+
Firm Age	+	+
Firm size	+/-	+/-
Location	+/-	+/-
Sector	+	+

Source: Author's expectations, 2019

C: Sectors of Firms and their Innovation

Product Innovation Status of the Sectors

Sector	Product Innovative		Non-Product Innovative		Total
	No. of Firms	Percent	No. of Firms	Percent	
Manufacturing	76	49.35	208	52.66	284
Services	78	50.65	187	47.34	265
Total	154	100.00	395	100.00	549
Pearson chi2(1) = 0.4855 Pr = 0.486					

Source: Author,s computation, 2019 from; 2013 ES and 2014 GIFS data

Process Innovation Status of the Sectors

Sector	Process Innovative		Non-Process Innovative		Total
	No. of Firms	Percent	No. of Firms	Percent	
Manufacturing	91	63.64	193	47.54	284
Services	52	36.36	213	52.46	265
Total	143	100.00	406	100.00	549
Pearson chi2(1) = 10.9772 Pr = 0.001					

Source: Author’s computation, 2019 from; 2013 ES and 2014 GIFS data

D: Distribution of Knowledge Sources among the Sectors

Internal R&D Status of Firms

Sector	Conduct Internal R&D		No Internal R&D		Total
	No. of Firms	Percent	No. of Firms	Percent	
Manufacturing	59	65.56	225	49.02	284
Services	31	34.44	234	50.98	265
Total	90	100.00	459	100.00	549
Pearson chi2(1) = 8.2399 Pr = 0.004					

Source: Author’s computation, 2019 from; 2013 ES and 2014 GIFS data

External R&D Status of Firms

Sector	Conduct External R&D		No External R&D		Total
	No. of Firms	Percent	No. of Firms	Percent	
Manufacturing	10	45.45	274	51.99	284
Services	12	54.55	253	48.01	265
Total	22	100.00	527	100.00	549
Pearson chi2(1) = 0.3615 Pr = 0.548					

Source: Author’s computation, 2019 from; 2013 ES and 2014 GIFS data

Training Status of Firms

Sector	Conduct Training		No Training		Total
	No. of Firms	Percent	No. of Firms	Percent	
Manufacturing	85	57.82	199	49.50	284
Services	62	42.18	203	50.50	265
Total	147	100.00	402	100.00	549
Pearson chi2(1) = 2.9845 Pr = 0.084					

Source: Author’s computation, 2019 from; 2013 ES and 2014 GIFS data

Purchase of Equipment Status of Firms

Sector	Purchase Equipment		No Equipment		Total
	No. of Firms	Percent	No. of Firms	Percent	
Manufacturing	140	60.34	144	45.43	284
Services	92	39.66	173	54.57	265
Total	232	100.00	317	100.00	549
Pearson chi2(1) = 11.9408 Pr = 0.001					

Source: Authors computation, 2019 from; 2013 ES and 2014 GIFS data

Purchase of Intangible Technology Status of Firms

Sector	Intangible Tech.		No Intangible Tech.		Total
	No. of Firms	Percent	No. of Firms	Percent	
Manufacturing	9	69.23	275	51.31	284
Services	4	30.77	261	48.69	265
Total	13	100.00	536	100.00	549
Pearson chi2(1) = 1.6331 Pr = 0.201					

Source: Author’s computation, 2019; from 2013 ES and 2014 GIFS data

E: Summary Statistics of Continuous Variables

Variables	Observations	Mean	Std. Deviation	Min	Max
Age	549	15.706	10.563	2	77
Managers experience	549	15.878	9.350	2	64

Source: Author’s computation, 2019 from; 2013 ES and 2014 GIFS data

F: Knowledge Sources and Product Innovation

Internal R&D status and product Innovations

Internal R&D status	Product Innovative No. of Firms	Product Innovative Percent	Non-Product Innovative No. of Firms	Non-Product Innovative Percent	Total
Conduct Int. R&D	47	30.52	43	10.89	90
No Int. R&D	107	69.48	352	89.11	459
Total	154	100.00	395	100.00	549
Pearson chi2(1) = 31.1621 Pr = 0.000					

Source: Author’s computation, 2019 from; (2013) ES and (2014) GIFS data

External R&D Status of Firms and Product Innovations

External R&D status	Product Innovative No. of Firms	Product Innovative Percent	Non-Product Innovative No. of Firms	Non-Product Innovative Percent	Total
Conduct Ext. R&D	9	5.84	13	3.29	22
No Ext. R&D	145	94.16	382	96.71	527
Total	154	100.00	395	100.00	549
Pearson chi2(1) = 1.8774 Pr = 0.171					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data

Training Status and Product Innovation

Training status	Product Innovative No. of Firms	Product Innovative Percent	Non-Product Innovative No. of Firms	Non-Product Innovative Percent	Total
Conduct Training	66	42.86	81	20.51	147
No Training	88	57.14	314	79.49	402
Total	154	100.00	395	100.00	549
Pearson chi2(1) = 28.2315 Pr = 0.000					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data

Purchase of Equipment Status and Product Innovation

P. Equipment status	Product Innovative No. of Firms	Product Innovative Percent	Non-Product Innovative No. of Firms	Non-Product Innovative Percent	Total
P. Equip	98	64.64	134	33.92	232
No P. of Equip	56	36.36	261	66.08	317
Total	154	100.00	395	100.00	549
Pearson chi2(1) = 40.0881 Pr = 0.000					

Source: Author,s computation, 2019 from; 2013 ES and 2014 GIFS data
Note: Equip =Equipment; P = Purchase

Purchase of Intangile Technology and Product Innovations

P. of Intangible T. status	Product Innovative No. of Firms	Product Innovative Percent	Non-Product Innovative No. of Firms	Non-Product Innovative Percent	Total
P. of Intangible T	4	2.60	9	2.28	13
No P. of Intangible	150	97.40	386	97.72	536
Total	154	100.00	395	100.00	549
Pearson chi2(1) = 0.0487 Pr = 0.825					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data
Note: P = Purchase T = Technology

G: Knowledge Sources and Process Innovation

Internal R&D Status and Process Innovation

Internal R&D status	Process Innovative No. of Firms	Process Innovative Percent	Non-Process Innovative No. of Firms	Non-Process Innovative Percent	Total
Conduct Int. R&D	51	35.66	39	9.61	90
No Int. R&D	92	64.34	367	90.39	459
Total	143	100.00	406	100.00	549
Pearson chi2(1) = 52.3933 Pr = 0.000					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data

External R&D Status and Process Innovation

External R&D status	Process Innovative No. of Firms	Process Innovative Percent	Non-Process Innovative No. of Firms	Non-Process Innovative Percent	Total
Conduct Ext. R&D	9	6.29	13	3.20	22
No Ext. R&D	134	93.71	393	96.80	527
Total	143	100.00	406	100.00	549
Pearson chi2(1) = 2.6279 Pr = 0.105					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data

Training Status and Process Innovation

Training status	Process Innovative No. of Firms	Process Innovative Percent	Non-Process Innovative No. of Firms	Non-Process Innovative Percent	Total
Conduct Training	72	50.35	75	18.47	147
No Training	71	49.65	331	81.53	402
Total	143	100.00	406	100.00	549
Pearson chi2(1) = 54.8074 Pr = 0.000					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data

Purchase of Equipment Status and Process Innovations.

P. of Equip status	Process Innovative No. of Firms	Process Innovative Percent	Non-Process Innovative No. of Firms	Non-Process Innovative Percent	Total
P. Equip	105	73.43	127	31.28	232
No P. Equip	38	26.57	279	68.72	317
Total	143	100.00	406	100.00	549
Pearson chi2(1) = 76.9831 Pr = 0.000					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data

Purchase of Intangile Technology and Process Innovations

P. of intangible T. status	Process Innovative No. of Firms	Percent	Non-Process Innovative No. of Firms	Percent	Total
P. of intangible T.	4	2.80	9	2.22	13
No P. of intangible T.	139	97.20	397	97.78	536
Total	143	100.00	406	100.00	549
Pearson chi2(1) = 0.1541 Pr = 0.695					

Source: Author's computation, 2019 from; 2013 ES and 2014 GIFS data

H: POST ESTIMATION TESTS

Test for multicolinearity

Variable	VIF	1/VIF
Internal R&D	1.36	1.17
Training	1.32	1.15
Managers experience	1.35	1.16
External R&D	1.14	1.07
Equipment	1.20	1.10
Intangible	1.05	1.03
Location	1.02	1.01
Sector	1.06	1.03
Firm size	1.10	1.05
Firm age	1.45	1.20
Mean VIF	1.21	

Hosmer-Lemeshow Goodness-of-fit test and Linktest for logit model 1

Product Innov.	Coef.	Std. Err.	z	P>|z|
_hat	1.045289	.283141	3.69	0.000
_hatsq	0.0344838	0.1843496	0.19	0.852
cons	-0.0033122	0.1636116	-0.02	0.984
Goodness-of-fit-test			Prob > chi2 =	0.2304

Hosmer-Lemeshow Goodness-of-fit test and Linktest for the logit model 2

Product Innov.	Coef.	Std. Err.	z	P>|z|
_hat	1.202253	.425422	2.83	0.005
_hatsq	.1137137	.2238292	0.51	0.611
cons	.0351972	.1733084	0.20	0.839
Goodness-of-fit-test		Prob > chi2 =		0.1205

Hosmer-Lemeshow Goodness-of-fit test and Linktest for the logit model 3

Product Innov.	Coef.	Std. Err.	z	P>|z|
_hat	1.093418	0.2297565	4.76	0.000
_hatsq	0.0652902	0.1325449	0.49	0.622
cons	-0.0112068	0.1501922	-0.07	0.941
Goodness-of-fit-test		Prob > chi2	0.1876	

Hosmer-Lemeshow Goodness-of-fit test and Linktest for the logit model 4

Process Innov.	Coef.	Std. Err.	z	P>|z|
_hat	.8891724	0.2034405	4.37	0.000
_hatsq	-0.0808571	0 .12309	-0.66	0.511
cons	0.0316369	0.1596326	0.20	0.843
Goodness-of-fit-test		Prob > chi2 =	0.1580	

Hosmer-Lemeshow Goodness-of-fit test and Linktest for the logit model 5

Process Innov.	Coef.	Std. Err.	z	P>|z|
_hat	1.328116	0.3142611	4.23	0.000
_hatsq	.158485	0.1394688	1.14	0.256
cons	.0219856	0.1457526	0.15	0.880
Goodness-of-fit-test			Prob > chi2	0.2504

Hosmer-Lemeshow Goodness-of-fit test and Linktest for the logit model 6

Process Innov.	Coef.	Std. Err.	z	P>|z|
_hat	1.128756	0.1789982	6.31	0.000
_hatsq	0.0751437	0 .0830509	0.90	0.366
cons	-0.0359507	0 .1472841	-0.24	0.807
Goodness-of-fit-test			Prob > chi2	0.204