INNOVATION AND PRODUCTIVITY IN KENYA’S MANUFACTURING FIRMS

BY

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DECLARATION

This research paper is my original work and has not been presented for any degree award in any institution.

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This research paper has been submitted for examination with my approval as the university supervisor.

Signature……………………………….… Date……………………...................

Prof. Anthony Wambugu

DEDICATION

To my husband Joash Kosiba and my children: Aldora, Liam, & the twins Malkiel and Matisse. Your support has been invaluable.

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I thank Professor Anthony Wambugu, my supervisor for the guidance he accorded me during the research work. My family which has played a pivotal role in supporting me all through the journey. I extend my sincere gratitude to my friends and classmates more so Gideon Sifuna, Pheobe Gor, Socrates Majune and Josphat Machagua for their constant follow up on the process. Above all, I thank God whose grace has been sufficient thus far.

ABSTRACT

In recent times, technological change and innovations have proven to be major economic growth engines. Given the changing needs of customers and pursuit of sustainable productivity growth, creative inventions and innovations are the most important components of firm survival and economic growth. A renewed emphasis is laid on attaining quality innovations that will consequently boost productivity. Kenya's economic blue print, Vision 2030, envisages highly industrialised economy in order to attain high economic growth rates. This is only possible if productivity is boosted to not only enable the firms compete favourably in the global value chain but also to generate quality employment within the economy. An important element to improving productivity is to increase innovation activities at firm level. This study's main objective was to determine the nature of the innovation –productivity link in Kenya's manufacturing sector. Specifically, it examined the determinants of innovative efforts and the impact of innovation activities on labour productivity of a firm. The study linked innovation and productivity through a structural framework that enabled innovation inputs (knowledge capital investment) be associated with innovation output, finally innovation output with productivity. A cross-sectional data at firm-level was used from the Enterprise survey (2018) done by the World Bank. Ordinary Least Squares estimation method was employed for the analysis of the study's two objectives. Results indicate that firm's size, export status and access to finance are determinants of innovation input (knowledge capital investment). Process innovation and product innovation were found to have no significant impact on a firm's productivity. Policy implications drawn from the findings is that firms should endeavour to improve the quality of their products and processes to meet the ever changing customer needs and compete favourably in the global market. Collaboration with academic institutions and private research institutions is important for diffusion of information on innovations. Relatively younger firms face cost setback for innovative activities, it is therefore crucial that the government offer support programs that will ease individual finance burden of investing in knowledge capital. The support program may be in form of subsidies granted to firms with high quality but costly projects.

ACRONYMS AND ABBREVIATIONS

AGOA-	African Growth and Opportunity Act
BOP-	Balance of payments
CDM-	Crépon, Duguet, and Mairesse
GDP-	Gross Domestic Program
KNBS-	Kenya National Bureau of Statistics
R&D-	Research and Development
SAP-	Structural Adjustment Programs
STI-	Science, Technology and Innovation
WBES-	World Bank Enterprise Survey.

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CHAPTER ONE
INTRODUCTION

1.1Background

Innovations are the most important components of business survival and economic growth in the modern competitive global markets (Ngo and O'cass, 2013). In recent times, technological change through innovations has proven to be major economic growth engines. This is so given the observations made particularly in the developed economies with high income levels and open borders. The firm's high productivity and the capacity to supply not only new but also significantly improved products raises the level of competitiveness of these high-income economies. In order to achieve the said high productivity and superior quality products, continuous improvement of factors of production, institutions re-focusing and firms restructuring is paramount. Essentially, innovation is the introduction or significant improvement of products and production methods; new and /or upgraded and differentiated products; changes in management practises within the organisation as well as improved working conditions.

The concept of productivity can be summarized as the output quantity produced by utilizing a given input level. In this broad definition, efficiency in production does not arise. However, it is assumed that the firm whose productivity is measured is efficient when it is able to utilize the least possible input levels to produce a certain output quantity, conditioned on technology status, characteristics that are specific to a firm such as its size, other endowments and the business environment that the firm operates in. A lot of literature has emerged explaining the link between productivity and innovation activities e.g. WulongGu et al. (2004); Cirera et al. (2016); Nyeadi et al. (2018).

Despite the attempts made in handling this issue at aggregate level, the main innovative decision units are firms. Consequently, innovation activities and the impact on firm-productivity can be varied among firms. Hence, to study innovation- productivity link, it is important a firm is taken as the observation unit. For advanced countries, the issue of innovation and productivity is far from being a concern, but for developing regions, it is of importance since, innovation is a costly activity for such developing countries due to scarcity of resources.

In light of manufacturing firms, (Eshlaghy and Maatofia, 2011) posits that innovation forms a central component of corporate activities in that it allows a firm to use new and productive processes in the manufacturing, ultimately responding to the ever-changing needs of the customer. The firm thus attains a positive reputation from its customers hence gains from sustained competitive advantage and superior productivity. Innovations are believed to diffuse across industries and sectors as competition and globalisation come to play, ultimately, the overall productivity of the economy rises.

1.1.1 Manufacturing Sector in Kenya

Dating back from independence, Kenya's manufacturing sector has undergone various policy changes subjected under different regimes. Like any other developing economy, Kenya, in her earlier post-independence years, pursued import substitution as an industrial strategy geared towards direct support the industry and for tariff protection. The objectives of this strategy were anchored on rapid industry growth, encouraging local firms to participate in the sector, increasing productivity, to ease the pressures originating from the Balance of Payments (BOP) and creating high-income employment.

It is also noted that this strategy was somewhat a carryover from the policies of colonial regimes. The strategy yielded mixed results hence call for changes. Despite this, the strategy persisted in to late 1970's. The government introduced yet another strategy in the 1980's known as the Structural Adjustment Programme (SAP) with an aim of strengthening industry competitiveness and reducing excess industrial sector's capacity among others. This came in to address the distortions that had been created by the initial strategy. Besides this, a major policy restructuring through a sessional paper was initiated with an aim of the distortions of the previous policies (Kenya's republic 1986)

In the 2000's period, Sector policy reforms have been explicitly outlined in Kenya's three blueprints targeting general performance and productivity of the Kenya's industrial sector (Bigstenet al.,2010). For instance, the Vision 2030 envisions a robust, competitive and diversified manufacturing sector. The government has continued to support the sector through initiatives such as Africa Growth and Opportunity Act (AGOA), which allows Kenya's to export textiles and other classified products to the United States of America (USA) without quota restrictions.

It can be perceived that, Kenya's Industrial policies have not been consistent enough, therefore, such policies have often been unstable which is detrimental for a steady industrial growth and development. Consequently, Kenyan manufacturing sector has suffered poor productivity growth. In addition, the performance of the industry can be attributed to inefficiency in operations of the firms, as they end up spending more resources on services that would have been cost effectively supplied through outsourcing.

Less research and development and innovations in Kenya also contributes to this dismal performance. Despite the dismal performance, the government of Kenya has renewed its commitment on achieving industrial sector growth through Kenya Industrial Transformation Programme. This effort will see the sector's contribution to GDP rise to a contribution of 15 per cent by the year 2022. The table below shows the GDP contribution and employment of three main sectors in the economy.

Table 1: GDP contribution and employment trend for Agriculture, Manufacturing and services

	Value addition (% of GDP)			Employment		
Period	Agriculture	Manufacturing	Services	Agriculture	Manufacturing	Services
2006-2010	22.3	12.2	49.6	60.4	6.8	32.8
2010-2014	26.6	10.8	47.7	59.3	7.1	33.7
2014-2017	32	8.9	44.5	58.3	7.4	34.4
2018	34.2	7.7	42.7	57.8	7.5	34.6

Source: WDI database (2019

1.1.2 Kenya's Innovation Policy Landscape

Kenya has witnessed steady growth in the development and application of Science, Technology and Innovation (ST&I) on socio-economic development since pre-independence era (Ndakala et al., 2017). However, the innovation phenomenon still remains subject of discussion in any growth and development policy agenda.

Kenya’s innovation policy framework before 2013, was characterised by highly disintegrated Institutional arrangements, marked absence of a robust coordinating institutions which ensures government efforts in innovation areas are harmonised with its envisioned growth (Cirera et al., 2016). In order to propel innovation agenda to greater heights of economic growth, Kenya’s blue Print-Vision 2030 brings out the role of innovation focusing on priority sectors’ growth. The Medium Term Plan of the period (2008-2012) outlines institutional arrangements for harmonising productivity with innovation and technology.

Coordinating Science Technology and Innovation (STI) institutions through an act of parliament, STI act 2013 was birthed in attempt to further improve on the institutional framework. The policy framework brought along three key institutional elements in the area of innovation to ensure institutionalized linkages and mobilizing resources for research capacity and scientific information. Despite having made strides, Kenya’s STI institutional framework is still perceived to be at a young stage thus only certain programs cushion the transfer of technology or intangible (Muzi et al.,2016).

1.2 Problem Statement

Vision 2030 envisions a robust, competitive and diversified manufacturing sector that fosters industrialization of the economy. Given the forward and backward linkage that the sector has in the economy, it’s performance should be a major concern to government and sector’s stakeholders.

Stylized facts on Kenya’s manufacturing sector indicates a steady decline in the sector’s contribution to GDP and lower sector’s employment. The government initiatives aimed at improving the sectors performance has often been met with mixed results as the sector still grapple with dismal value added growth. Scholars and researchers have extensively acknowledged the role of innovation towards increasing productivity. Kenya’s manufacturing sector can become globally competitive and produce high quality employment only by increasing productivity. A critical component to growing productivity is enhancing investments in innovation activities at the level of a firm. However, very little is known on the nature of the relationship between innovation activities and firm’s productivity among developing countries in general, particularly Kenya (Muzi and Cirera,2016).

1.3 Research Questions

a) What are the determinants firm's innovative efforts?
b) What is the impact of innovation on firm's productivity?

1.4 Objectives of Research

14.1 Main Objective

The main objective of this study was to examine the relationship of innovation activities and firm productivity in Kenya's manufacturing sector.

1.4.2 Specific Objectives

a) To examine the determinants of firm's innovative efforts.
b) To establish the impact of innovation on firm productivity.
c) To derive policy implications based on the nature of innovation-productivity relationship.

1.5 The Significance of the Study

Majority of literature on innovation-productivity nexus have been in developed economies context. Basically, such studies have very limited application in developing countries' context especially Africa (Kenya included). This is so because of the distinctive dissimilarities in the development stages between the developed and developing economies. Innovations in Africa at large are regarded as incremental and not radical (Cirera &Muzi, 2016). Therefore, studying this relationship in the Kenya's context adds to literature existing on innovation –productivity link among developing economies.

(Ganna et al., 2010) empirically established that only sound government policies breed positive effects of innovation on productivity. The study thus provides new insights based on innovation-productivity link in Kenya that is essential in formulating most appropriate evidence based industrialization policies. The beneficiaries of the insights include the relevant government ministry, manufacturing sector 's stakeholders, the current and potential manufacturers.

1.6 Study Organization

Given the introduction, chapter two that follows examines existing literature reviewed. Chapter three discusses the methodology applied, chapter 4 presents and discuss the empirical findings. Chapter five focus on conclusion and suggestions of policies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Literature Review

Several theories have examined the output -innovation/ technological advancement relationship. Among them is the Solow-Swan (1956) growth model, emphasized that the rate of technological innovation is augmented with labour productivity exogenously for growth of the economy in the long run. In the model, the factor inputs are linked by an aggregate production function. Neo-classical theory hence assumes that the technological progress rate is explained by a scientific process different from economic forces. Therefore, growth rate in the long-run is determined outside economic system. Since the Solow-Swan model assumes technical progress to be exogenous, it does not provide a channel through which economic factors influence the long run output growth rate through technical progress.

Endogenous growth models by (Frankel (1962); Romer (1990) and Aghion et al. (1992) emerged to critique the neoclassical view point by underscoring technology shocks as being endogenous in the analysis that pursues to clarify the economic decisions essential for the knowledge accumulation. Thus, indicating ways through which the technology progress is influenced by various economic agents given their decisions on innovation within the production boundaries.

The AK model (Frankel, 1962) was the initial version of endogenous growth models. This model aggregates all the capital inputs i.e. physical and human then subjected this to a technological progress. For instance, AK model, demonstrates that aggregate production function is able to show a constant return to scale with more capital accumulation, part of which are intellectual in nature thus offsetting the characteristics of diminishing marginal product of capital described in neoclassical models.

AK model is criticized on the ground that it does not provide a clear distinction between physical, human and intellectual capital. Consequently, innovation-based growth models (Romer, 1990, Aghion et al., 1992) thereafter emerged, recognizing the difference between intellectual capital and the other two. Furthermore, these models lay emphasis on intellectual property as a source of technological progress.

The ‘Schumpeterian’ theory developed by Segerstrom et al. (1990); Corriveau (1991); Helpman (1991) is innovation- based theory which is fundamentally different from other innovation-based models such as that developed by Romer, (1990) in two folds. First, emphasis is laid on the fact that the technological progress creates losses and gains at the same time. This happens when old skills, markets, products and processes are rendered obsolete and replaced with new and /or improved ones to gain efficiency. Secondly, growth is assumed to be in intervals as the technological shocks influence the production each time a decision made to innovate.

The main focus of the Schumpeterian theory is innovations that significantly improve quality that consequently renders vintage products obsolete thus ‘creatively destroys’ the old products (Schumpeter,1942). The aggregate output in this theory is a function of a combination of intermediate products-both new and improved. Schumpeter’s theory underscores improved quality product resulting from research and development activities. The complexity in the products is as a result of technological advances; therefore, the society must endeavour to increase their expenditures on research and development so that more innovations are carried out. Also, research and development expenditure is anticipated to increase productivity levels by cutting down the production cost i.e. process innovation and expanding the product variety through new and quality upgraded products- known as product innovation.

In summary, the theoretical underpinnings of the endogenous theory of growth shows that economic output is correlated with new and significantly improved products flow (Romer,1990) and (Howitt,1998). In addition, the Schumpeterian theory focuses on critical role played by research and development towards output growth. The growth theory predicts that total factor productivity differs with intensity of research (Madsen, 2007).

Regarding the relationship between firm specific characteristics that determine its innovative efforts, there is a dearth of growth theories that give analysis on the determinants of innovative activities. However, Schumpeterian theory, 1942, links firm size and its capacity to innovate which has distinct effects for the expected relationship. The theory asserts that monopoly profits generated from the market dominance of a firm is enough financial resource for innovation. This eventually leads to a more efficient production and improved productivity.

Thus, large firms are the main engine of growth. In addition to the firm characteristics, the sectoral conditions are varied, therefore the evolutionary theorists' asserts that these sectoral differences are to be incorporated as a core element in analysis of the innovation-productivity link.

2.2 Empirical Literature

This section identifies gap in the existing empirical studies reviewed.

2.2.1 Determinants of a Firm's Innovative Efforts

Firm's innovative efforts as measured by firm's expenditures on R&D and machinery and equipment, is fundamental in any innovation-productivity discourse. Industrial economics literature asserts that firm's innovative efforts can mainly be explained by industry specific characteristics in which a firm operates. Furthermore, characteristics specific to the firm such as size and age affects firm's ability to invest in R&D. (Liu, 2017).

Majority of empirical studies indicate a positive link between the firm's size and research and development (Scherer, 1980). Contrary, some studies have revealed a negative link between the two (Audretsch et al., 1988). Zemplinerová and Hromádková (2012) revealed a significant link between size of the firm and the innovative efforts in Czech Republic. Generally, large firms have been found to enjoy comparative advantage when it comes to investment in knowledge capital which may be costly for individual start-ups. (Cohen et al.1987). (Huergo et al.,2004) expected older firms to have capacity for innovation than relatively younger firms.

Ownership status is identified to influence the innovative efforts of a firm. Kwon (2018) confirmed that indeed ownership status is a predictor of firm's innovative efforts. Similarly, David et al. (2006) revealed that foreign owned firms invest more in R&D as well as physical capital among Japanese listed manufacturing firms. On the contrary, Kumar et al. (2005) found foreign ownership status not significant.

Exporting or importing firms usually have need for R&D than locally oriented firms. It is based on the fact that exports enhance R&D returns on investment through the big size of the market (Zimmerman, 1987). Furthermore, exporting firms need to meet the ever changing global value chain. Empirical evidence indicates a positive association between R&D intensity and export orientation of a firm (Braga et al.,1991; Kumar et al. 1996; Goldaret al.,1998; Rao et al.,1994). Therefore, empirical studies exhibit inconclusive findings on factors determining firm's innovative efforts regarding their magnitude and sign of association.

2.2.2 Measures of Innovation Inputs and Outputs

In examining that part of productivity growth unexplained by labour and capital, earlier studies had put efforts in establishing the economic measurement of returns to innovation. Due to the broad nature and scope of innovation activities, it made its measurement difficult (Rogers, 1998). Towards this end, numerous research has been pooled together as a matter of discussions consequently raising many analytical issues for the subsequent research the first being done by Griliches, (1979).

Griliches, (1979), addressed the measurement of innovation in a study of the innovation determinants. The study observed that a share of the growth in output was attributed to "technical change" rather than to capital and labour input (Hall, 2011). Griliches recognised two measures of this technical change for reasons of limited data available i.e. R&D expenditures and patent statistics. One weakness of this measure is that R&D is only an input oriented view of innovation therefore do not clearly show innovation success. Patent statistics on the other hand, is an invention success measure, it can thus be considered a partial measure of innovation. Given the changing industrial structures of the economies, the single indicator approach of measuring innovation no longer holds because it doesn't capture innovation completely as it leaves out other non-research and development innovation inputs (Bernstein, 2002 and Tang et al., 2004). Based on this limitation, subsequent research work was birthed to take care potential bias that comes with earlier research findings.

Studies (Sassenou et al., 1989; Crépon et al., 1993; Hall, B.H., Grifith et al., 2006; Lotti et al., 2011; Pierre Mohnen et al., 2013) have attempted to expanded the scope of innovations measures to include non-R&D activities. For example, empirical studies by (Cunéo et al,1985; Sassenou et al.,1989; and Crépon et al.,1993) revealed that both R&D and non R&D have equal returns to investments. On the contrary, Klette, (1994) reported a variation in the productivity performance among the firms. The study revealed that firms with non-R&D activities have lower productivity, this leaves a gap of finding the appropriate scope of measures of inputs to be included in the knowledge capital function.

Regarding the output view of innovation, (Muzi et al.2016; Nyaedi et al.,2018) differentiates types of innovation outputs that bring about heterogeneous impacts on firms' productivity. Therefore, appreciating these modes of innovation has come up only recently given the availability of data at firm level from innovation surveys. Many earlier studies used traditional measures of innovative activities such as patent counts, sales from innovative activities (Griliches, 1979; Crépon et al., 1998; Bloom et al., 2002; Balasubramanian et al., 2011). The major limitation of measuring innovation output using patents statistics only is the fact that some innovations occur without being patented. On this ground, others have changed to direct measures of innovative outputs of firms by use of dummy variables for product, process, organisational and market innovations example of such studies being Griffith et al., (2006) and Gana et al. (2010).

2.2.3 Measures of productivity

The empirical evidence on productivity and innovation relationship is heterogeneous among firms, productivity measures and across innovation types. For instance, some literature uses labour productivity measures such as value added per labour input (Mohnen et al., 2010; Bezerra et al., 2011) or sales per labour input (Cirera et al., 2016), others used total factor productivity growth (Chudnovsky et al., 2006; Loof and Heshmati, 2006; Cassiman et al., 2010).

Proponents of productivity of labour (Carvalho et al.,2016; López et al.,2006), mention the advantage of this measure being its computational simplicity and availability of data. However, opponents (Loof and Heshmati, 2006; Cassiman et al., 2010) have criticized it for creating instability in establishing the productivity gains from efficiently utilized materials in an enterprise. Secondly, the measure is sensitive to production functions any changes made by companies. For instance, if the company reduces employees' numbers but maintained the efficiency in production, this will show increased productivity. It is in this sense that some studies have use of the Total Factor Productivity as the measure. The TPF is considers productivities of each input, therefore appropriate instrument for measuring technical change. The challenge that comes with Total Factor Productivity measure is the difficulty in measures of inputs of production. In this regard, there is no uniformity in productivity measurement mechanism therefore leaving it open for further studies.

2.2.4 Methodological Approaches to Innovation-Productivity Link

A critical issue in the analysis of the innovation-productivity nexus is methodological approach to be applied. Review of early literature Griliches (1995) revealed that R&D and productivity link were examined Cobb-Douglas production function framework. This was criticized based on neglect of ‘knowledge production function’ as noted earlier by Pakes &Griliches, (1984). The knowledge production function connects innovation inputs to outputs. In order to deal with the limitations of earlier empirical framework, more recent studies employ other frameworks. The main one is a three-step- recursive framework by Crépon, Duguet, and Mairesse (1998). It is the first framework to integrate empirically innovation inputs to innovation outputs (Crespi and Zuniga, 2010). The three-step model links a firm’s decision to engage in R&D, innovation inputs to outputs, and output to firm’s productivity (Mazlina et al., 2015).

Although many studies employ the framework in their studies, the empirical evidence reveals inconclusive findings. While some studies have showed a positive impact of innovation on productivity of a firm (Mohnen et al. (2013) and Nyeadi et al. (2018). Other studies revealed negative effect of innovation output (Janz et al. (2004); Duguet, (2006); Klomp et al. (2006); Raffo et al. (2008).

(Hall, Lotti and Mairesse, 2009) found a positive impact of process and product innovation outcomes on productivity of Italian manufacturing sector. Similarly, (Griffith et al., 2006) examined the impact in four countries (UK, Germany, Spain and France). The study revealed a positive effect of innovation activities on productivity across the four countries. Furthermore, Arza et al. (2010), found a positive link in Argentine manufacturing firms. Contrary to these findings, Lee (2011), Berger (2009) and Jefferson et al., (2006) found negative impact of innovation activities on firm productivity.

Studies such Mohnen (1992); (Goedhuys and Sleuwaegen, 1999). Bernstein (2002) and Muzi et al. (2016) revealed insignificant innovation impact on productivity of firms. Going by the existing findings, it can be deduced that “empirical findings are inconclusive on firm level innovation- productivity relationship. Thus, the recommendation to raise the number of studies on this phenomenon as suggested by (Lee, 2011; Mwaura,2012) still stands.

One main limitation of the traditional CDM framework is that there is potential selectivity bias (Cirera et al.,2016). Only research and development is included as input to knowledge production function. Therefore, only firms with expenditures on R&D are considered in the measures. Further modifications have been made by subsequent scholars to correct for the potential bias in the model (Griffith et al. (2006). Another critical element is correcting for potential endogeneity problem in the innovation-productivity analysis. scholars in the literature, have commonly corrected the endogeneity problem by instrumenting the endogenous regressors (Ramadani et al. (2013); Abazi-Aliliet et al. (2017); Exposito et al., 2018). Apart from the CDM framework, other scholars have used different approaches to examine the innovation-productivity link. Several studies (Wulong et al., 2004; Nyeadi et al., 2018) and (Lee, 1978; Adamchik et al., 2000; Ohnemus, 2007; Fazlıog˘lu et al., 2016) employ innovation index and endogenous switching methods respectively.

2.3 Literature Overview

The theoretical literature underscores the important role of research and development towards growth in output. The growth theory shows that productivity varies proportionately with research intensity (Madsen,2007). Empirical literature reveals inconclusive findings regarding the determinants of innovative effort, for example, some literature finds characteristic specific to a firm such as size influence innovation efforts (Scherer, 1980; Hromádková, 2012), others have found a negative effect of firm size on firm’s innovative effort (Audretsch et al., 1988). The mixed findings on the magnitude and direction of the relationship between firm size and innovative efforts warrant more research. Generally, being an export oriented firms are empirically established to have a positive effect on firm innovative effort contrary to mixed results on foreign ownership and firm’s innovative effort.

To date, the bulk of empirical literature have broadly established positive innovation-productivity link for European firms and those other developed economies, evidence for developing countries is limited and/or mixed for some that exists. Studies whose focus has been on innovation and productivity in the developing economies include Enos (1992), and Lall (1992), Arza et al. (2010), el elj Moez et al. (2014), Goedhuys et al. (2008), Muzi et al. (2016), Nyeadi et al. (2018) among others, have revealed mixed findings. This implies that there is a gap to be addressed, especially for developing countries.

With the identified gaps, the study aims at empirically examining the innovation-productivity relationship in Kenya’s manufacturing firms by employing (Crépon, Duguet, and Mairesse,1998).).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Theoretical Framework

The Model

Three main equations are described indicating the three important sectors of the economy;

The final goods sector production function is given as;

$$\boldsymbol{Y_i = f(AX_iZ_i)} \quad \ldots \quad \mathbf{1}$$

Where;

Y_i - final goods output

A- Productivity parameter with each new and improved intermediate goods

X_i- Intermediate goods from the intermediate sector

Z_i- Labour input

i- Firm

The sector is assumed to be competitive with a constant labor supply. The intermediate goods sector is monopolised and trades the products to the final product industries at a price that is equal to their marginal products.

$$X_i = f(I_iL_i) \quad \ldots \quad 2$$

Where;

X_i- Intermediate goods from the intermediate sector

L_i- Labour input flow

I_i Innovation from Research and Development sector

The research and development sector which results into a probability flow of innovations.

$$I_i = \mu R_i(N_i) \quad \ldots \quad 3$$

I_i- Innovation flow as a result of research and development intensity.

$\mu(R_i)$- Arrival rate of innovation conditional on the R&D intensity (N_i).

The arrival rate depends on current flow of research as new research emerge with time. The model posits that each innovation process results into new quality intermediate goods which intern raises the productivity parameter (A) in the production of the final goods. In summary the model shows that innovations raise productivity forever as new and more efficient intermediate goods are utilised in the production process. Stock of knowledge is also added with each innovation done.

3.2 Empirical Framework

This study follows the empirical framework as per (Crépon, Duguet, and Mairesse,1998). The framework known as CDM, provides a connection of the innovation activities and productivity. The framework links innovation inputs to innovation outputs then to productivity in a structured manner. Basically the framework has three main equations i.e. the innovation inputs (firm's decision to innovate), Innovation and Productivity equations. The study follows the framework as modified by Griffith et al., (2006). Machinery and Equipment, Research and Development are included as inputs to innovation. The equation is specified as follows;

$$N_i = \alpha X_i + \mu > 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

Where;

N_i=Total knowledge capital (R&D, Machinery equipment)

α=The coefficient vector of determinants of innovative efforts

X_i= Independent variables influencing the investment in knowledge capital.

μ=The error term

The explanatory variables are characteristics of the firm such firm size, firm age, and ownership status, demand factors such as export status dummy, technology push factors proxy by mobile money as the set of explanatory variables that determines innovative efforts.

The innovation equation links knowledge capital to innovation outcomes.

Equation:

$$I_{i1}=\Upsilon \mathbf{N_i}+\varphi X_{i1} +e_1\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5a$$

$$I_{i2} =\Upsilon \mathbf{N_i} +\varphi X_{i2} +e_2\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5b$$

Where;

I_{i1} and I_{i2} =Product innovation and Process innovation respectively

N_i=Knowledge capital

X_i=other explanatory variables affecting product and process innovation.

ϒ=Coefficient of Knowledge investment capital expenditures

φ= coefficient vector of independent variables for each innovation equation.

e =Error term

The final step in the CDM framework which links innovation output and firm productivity.

The productivity function is estimated using a production function given as;

$$Y=f\ (K, L, \mathbf{I_i})\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where;

Y= Output

K=Physical capital input

L=Labour input

I_i=Innovation

Dividing equation (6) by labour r the labour productivity equation is:

$Y/L=f(K/L, \mathbf{I_i}) + \varphi(X_{i3}) + e_2$……………….. ……………………………………7

Where;

Y/L= Productivity of labour

K/L=Capital intensity

X_{i3} =Other explanatory variables affecting productivity

e_2 =Error term

φ =Coefficient vector of other explanatory variables

3.3 Econometric specification and estimation technique

Total knowledge capital investment equation

$KIC=\alpha_0 + \alpha_1 SIZE + \alpha_2 AGE + \alpha_3 FOR + \alpha_4 EXP + \alpha_5 MOB + \alpha_6 FA + e$ …………….8

Where;

KIC= Total expenditure on R&D and machinery and Equipment

SIZE= Firm size

AGE= Firm age

FOR= Foreign Ownership

EXP= Export status

FA= Access to finance obstacle, instrumental variable in KIC equation

KIC equation is estimated using OLS.

The innovation equation;

$PROD= \varphi_0 + \varphi_1 KIC + \varphi_2 CAPI + \varphi_3 SIZE + \varphi_4 AGE + \varphi_5 FOR + \varphi_6 EXP + \varphi_7 TR + \varphi_8 ED + \varphi_9 Res. + u_1$…………………………………………………………………….…………9a

$PROC= \varphi_0 + \varphi_1 KIC + \varphi_2 CAPI + \varphi_3 SIZE + \varphi_4 AGE + \varphi_5 FOR + \varphi_6 EXP + \varphi_7 TR + \varphi_8 Ed + \varphi_9 Res + u_2$ …………………………………………………………………….….9b

Where;

PROD= Product innovation

PROC=Process innovation

KIC=Total expenditure on Machinery and Equipment and R&D

CAPI=Physical Capital intensity

SIZE= Firm size

AGE=Firm Age

Res. =Residuals obtained from KIC equation

Ed=Lack of skilled manpower, instrumental variable in the innovation equation.

The innovation equations are simultaneously estimated using maximum likelihood estimation method. This technique allows estimation of different innovation outcomes simultaneously while correcting for potential correlation.

Productivity equation

$PR=\varphi_0 + \varphi_1 PROD + \varphi_3 CAPI + \varphi_5 SIZE + \varphi_6 Res + u_3$……………………………….10a

$PR=\varphi_0 + \varphi_2 PROC + \varphi_3 CAPI + \varphi_5 SIZE + \varphi_6 Res + u_4$………………………………….10b

Where; PR=Productivity (Sales per Labour)

PROD=Product Innovation

PROC=Process Innovation

Size=Firm size

Res=Residuals obtained from innovation equation.

The productivity equation is estimated using the OLS method for each equation.

3.4 Description and measurements, predicted signs of variables

variables	Description	Measurements from the data source	Predicted sign
Knowledge capital investment function			
KIC	Total expenditures on R&D,Machinery and Equipme	R&D expenditures Machinery and Equipment Expenditures	Positive on innovation
Innovation Equation			
PROD	Product innovation	Value"1" if a firm introduces new or significantly improved products,"0" if otherwise	Positive/Negative/No effect on productivity
PROC	Process innovation	Value"1" if a firm introduces new or significantly improved process,"0"if otherwise.	Positive/Negative/No effect on productivity
Demand pull factors			
EXP	Export status-Whether the firm is a direct or indirect exporter	Value of "1", if a firm is a direct or indirect exporter, "0" if otherwise.	Positive
Factors of technology push			
MOB	Mobile money use in the current firm financial operation	Value of "1", if a firm uses mobile money for its operation, "0" if otherwise.	Positive
Characteristics of the firm			
SIZE	Firm size	Measure firm with 20 and above employees taking value of "1", "0" if otherwise.	Positive/Negative
AGE	Age of the firm	The difference between the year of the survey and the year the firm began its operations.	Negative
FOR	Foreign ownership	If the firm has atleast 10 percent foreign ownership.	Positive
FA	Access to finance obstacle	Value of "1",if the Access to finance is an obstacle,"0" if otherwise.	Negative
Ed.	Lack of Skilled manpower	Value of "1" if firm lacks manpower."0" otherwise	Negative
TR	Formal training for developing	"1" if the firm offers employee training,"0 if otherwise	Positive
CAPI	Capital intensity	Capital to labour ratio	Positive

3.5 Data types and Data Sources

Cross-sectional data used in this study is extracted from Enterprise Survey by the world Bank. Kenya's enterprise survey data was recently released in February 2019. This wave of the survey contains firm level information on various aspects of the business environment and investment climate, and with fairly detailed module on innovation. Data collection was done between May 2018 to January 2019 with a three-year information sought on innovation activities. An original sample of 625 firms on manufacturing, retail and service sectors. The survey used a random stratified sampling design to come up with the sample.

CHAPTER FOUR
PRESENTATION AND DISCUSSION OF RESULTS

4.1Introduction

Chapter 4 describes the diagnostics tests and study results. Findings of each regression model are discussed to achieve the study's objectives.

4.2 Descriptive statistics

Table 3 presents the descriptive statistics which shows the statistical properties of the variables included in the study. These properties include the mean which is the average value of each variable. The standard deviation shows how the variable observations vary from the mean value. The maximum and minimum values which measure spread of variables.

Table 2: Summary Statistics

The difference in the number of observations among the variables was due to missing values.

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
KIC (million)	310	30.49372	134.6703	0.015	3000
SIZE	746	.5348525	.4991185	0	1
Age	746	22.02681	18.1089	0	124
FOR	746	.1313673	.3380282	0	1
EXP	746	.1434316	.3507476	0	1
MOB	746	.6863271	.4642964	0	1
FA	746	.0991957	.2991252	0	1
PROD	746	.4490617	.4977322	0	1
PROC	746	.2399464	.427337	0	1
CAPI	240	376159.7	772708.2	1190.476	6250000
TR	746	.4450402	.4973037	0	1
Ed	746	.6313673	.4827577	0	1

Note: FOR-Foreign ownership; EXP-Export status; MOB-Use of mobile money; FA-Access to finance obstacle; PROD-Product innovation; PROC-Process innovation; CAPI-Capital intensity; TR-Formal training; and ED- Lack of skilled manpower.

Knowledge Capital Investment (KIC) which is the sum of expenditure on Research and Development, and Machinery and Equipment. This variable was converted into millions of Kenya shillings. The mean expenditure on KIC is about Kshs. 30.49372 million with a standard deviation of Kshs. 134.6703. Capital intensity had a mean value of 376159.7 with a standard deviation of 772708.2. The mean value of firm age was 22.0 and standard deviation was 18.1089. Foreign ownership (FOR) had the least mean and standard deviation.

The maximum and minimum columns show the highest achievable observations and least achievable observations respectively. KIC had the maximum value of Ksh. 3.0 billion and minimum value of Ksh.0.015 million, Capital intensity had a maximum value 1190.476and a minimum 6250000.The maximum and minimum observations for the age is 124 and 0 respectively. One firm in the dataset began its operation in 1894 thereby making it the oldest observed firm.

4.3 Estimation tests and Regression results

First is the total knowledge capital investment equation then the innovation equations (product and process) lastly the productivity equation. Under each model, diagnostic tests are carried out and discussed, and the model results.

4.3.1 The total knowledge capital investment model

Multicollinearity exist when independent variables are closely related to each other and this may cause inaccurate results. Therefore, it was important to check for the same using the variance integrating factor. The decision rule is that a mean value of the VIF greater than 10.0 is an indication of the presence of Multicollinearity while value less than 10.0 indicates the absence of Multicollinearity (Greene, 2018)

Table 3: Multicollinearity test results for knowledge capital investment model

Variable	VIF	1/VIF
MOB	1.43	0.698424
SIZE	1.43	0.700925
Age	1.16	0.863914
EXP	1.12	0.894742
FOR	1.11	0.900427
FA	1.10	0.908436
Mean VIF	1.22	

Results from Table 3 show that the mean value of VIF was low with 1.22 which indicates that there was no Multicollinearity. Hence, the estimated model does not suffer from Multicollinearity.

This study employed the Breusch–Pagan to test for heteroscedasticity in the total knowledge capital investment model. The p value from was found to be 0.0000 which was significant at 5 percent level of significance concluding that the variance is not constant, hence heteroscedasticity is present. To address this problem, robust standard errors (Greene, 2018) were used.

4.4. Regression Results

Three regression models were estimated as discussed in chapter three: First is the total knowledge capital investment equation, then innovation and lastly productivity equation.

4.4.1 The total knowledge capital investment results

Table 4 shows results of the total knowledge function. KIC is the sum of expenditure on Research & Development, and Equipment and Machinery.

Table 4: Results of the knowledge capital investment function regression results

	(1) KIC_million
SIZE	28.17^{***}
	(8.365)
Age	0.535
	(0.560)
FOR	28.64
	(27.68)
EXP	33.60^{**}
	(14.79)
MOB	5.063
	(15.08)
FA	-17.78^{**}
	(8.497)
Constant	-15.67
	(17.43)
Observations	310
Adjusted R^2	0.062

Note: Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

The results indicate that size is statistically significant. On average, larger firms are likely to invest more in knowledge capital than smaller ones. The result is similar to Zemplinerová and Hromádková (2012) and Crepon et al. (1998) findings. This indicates that large firms enjoy comparative advantage when it comes to investment in knowledge capital such as R&D which are costly for start-ups. The results also show that export status of a firm determines the innovative efforts of a firm. If the firm increases its export activities, investment in knowledge capital increases.

Exporting firms have higher affinity to put more efforts towards coming up with ideas that will enable them compete favourable in the global market. Firm Age, Foreign ownership and use of mobile money have positive relationship with investment in knowledge capital but not significance.

Firm access to finance indicates a significant inhibitor to investment in knowledge capital. From the regression results, a unit increase of finance access obstacle, reduces firm's investment in knowledge capital. This indicates an inverse relationship between the two variables.

4.4.2 The innovation equation

Table 5: Multicollinearity test

Variable	VIF	1/VIF
Residual	13.08	0.076481
Age	8.81	0.113461
CAPI	3.39	0.295085
SIZE	3.26	0.306945
FOR	3.25	0.307424
KIC_million	1.97	0.508194
EXP	1.82	0.549171
TR	1.50	0.665277
Ed	1.17	0.852092
Mean VIF	4.25	

Table 5 shows low VIF mean value of 4.25 indicating absence of Multicollinearity.

4.4.3 Knowledge function probit model results

Table 6: Probit model Results of the knowledge function

	(1) PROD	(2) PROC
KIC_million	0.000302***	-0.000429***
	(0.0000232)	(0.0000186)
CAPI	0.595e-08***	0.000000210***
	(3.28e-09)	(3.12e-09)
SIZE	0.537***	0.673***
	(0.00682)	(0.00694)
Age	0.00902***	0.00560***
	(0.000128)	(0.000123)
FOR	0.383***	-0.176***
	(0.00531)	(0.00506)
EXP	0.503***	0.724***
	(0.00654)	(0.00675)
TR	0.700***	1.002***
	(0.00368)	(0.00396)
ED	0.135***	-0.0668***
	(0.00383)	(0.00387)
Residuals	-0.0157***	-0.0220***
	(0.000172)	(0.000180)
Constant	-0.417***	-1.104***
	(0.00453)	(0.00488)
Observations	310	310
LR Chi2(9)	25.39	29.97
Prob>Chi2	0.0026	0.0004
Pseudo R^2	0.0621	0.0729

Note: Standard errors in parentheses. *p< 0.10, **p< 0.05, ***p< 0.01, the residuals from KIC equation. Instrumental variable: Lack of skilled manpower and training, Access to finance obstacle.

The table 6 presents the result of determinants product and process innovation respectively. The two columns on the table represent each innovation type. Findings is that investment in knowledge capital is highly significant. This means that an increase in knowledge capital investment, increases the probability of a firm to introduce new/or and significantly improved product. On the contrary, an increase in knowledge capital investment, reduces the likelihood of process innovation. It indicates that firms which invest in knowledge capital are likely to increase their product innovation though this is contrary to process innovation whose probability reduces with each increase in knowledge capital investment. The results differ slightly from the findings of Mairesse et al. (2008) that had investment in knowledge capital positively influencing both product and process.

To avoid endogeneity problem in the innovation equations, the residuals obtained from the KIC equation were incorporated in each innovation equation. An F-test was done to establish the relevance of the instrumental variable (Finance access obstacle) that had been used. Hansen J test was done to test for the validity of the instrument. Capital intensity is positively associated with product and process innovation. An increase in firm's capital intensity, on average, increases the likelihood of a firm's product and process innovation. In addition, the results indicate that increase in size of a firm, increases the probability of coming up with product innovation and process innovation, similar to the findings of Scherer (1980) and Ayyagari et al. (2012).

Age of the firm equally predict the probability of a firm to innovate, from the results, age of a firm positively influences the likelihood of a firm to innovate. It is an indicator that large firms are more likely to innovate than small firms. The results are contrary to the findings of Ayyagari et al., (2012) whose results indicated an inverse relationship.

Foreign ownership status of the firm positively relates with product innovation. The study's findings show that an increase in foreign ownership status of the firm leads to an increase probability of product innovations. On the contrary, the probability of process innovation is inhibited by the firm's ownership status. This could probably be due to the fact that there is direct transfer of knowledge and technologies for the firm's operating locally from their headquarters in foreign space particularly the multinational firms (Cantwell et al., 2003).

This study also examined the connection of a firm being a direct or indirect exporter and the two innovation types. The result shows that either being a direct or indirect exporter increases the probability of introducing a new product and process respectively for every increase in export activities. Firms which are foreign market oriented tend to innovate more so as to remain relevant and competitive in global market. This is because competition is more intensive in the foreign market than the local one, therefore making innovation an important activity to the firms with foreign market orientation. The result supports the previous findings of Alena et al. (2012).

Training is an important and positive predictor of product innovation and process innovations. An increase of employee training increases the likelihood of firm to have product and process innovation respectively. This result is similar to the findings of Vermeulen et al. (2014). Lack of skilled manpower the leads to the reduction in the chances of a firm to introduce new or improved production processes. The coefficients of the residuals indicate a negative relationship with both product and process innovation.

4.4.4 Results of the productivity equation

Table 7: Multicollinearity (Product Innovation)

Variable	VIF	1/VIF
Residual	1.14	0.876821
SIZE	1.13	0.883776
PROD	1.02	0.976773
CAPI	1.02	0.979581
Mean VIF	1.08	

Results from Table 7 show that the mean value of VIF was low with 1.08 which indicates that there was no Multicollinearity.

4.4.5 Multicollinearity (Process Innovation)

Table 8: Multicollinearity (Process Innovation)

Variable	VIF	1/VIF
Residual	1.14	0.877567
SIZE	1.14	0.880913
CAPI	1.03	0.973396
PROC	1.02	0.977214
Mean VIF	1.08	

Results from Table 9 show that the mean value of VIF was low with 1.08 which indicates that there was no Multicollinearity. Hence, the estimated model will not suffer from Multicollinearity.

4.4.5 Productivity model regression results

Table 9: Results of the productivity Model

The table below shows the results of the productivity equation.

	(1) log_PR	(2) log_PR
PROD	0.237 (0.182)	
log_CAPI	0.293*** (0.0497)	0.305*** (0.0504)
SIZE	0.125 (0.257)	0.166 (0.258)
Residuals	0.0150*** (0.00442)	0.0150*** (0.00444)
PROC		-0.0988 (0.177)
Constant	10.53*** (0.576)	10.56*** (0.577)
Observations	290	290
Adjusted R^2	0.200	0.196

Note: Standard errors in parentheses. $^{*}p< 0.10$, $^{**}p< 0.05$, $^{***}p< 0.01$, residuals from the innovation equation.

Table 9 shows the results of productivity equation for each innovation type as independent variables. The labour productivity equation is in two folds and simultaneously analysed for each type of innovation outcome. The study examined the nature of relationship between innovation and productivity. First column of the table indicates the impact of product innovation while the second column shows impact of process innovation.

In order to correct for endogeneity problem in the equation, it was important to test for the presence of endogeneity. The problem was corrected by using residuals obtained from the innovation equation. Test for validity of instrumental variables used in the innovation equation (Lack of skilled manpower and Training of employees) was done. Sargan and Basman test was done to test, the p values from the test were 0.53 and 0.60 for product and process innovation respectively indicating valid instruments. Both product and process innovation have no significant effect on labour productivity. It is important to note that innovation in Kenya’s manufacturing firms is more of incremental rather than radical in nature. The finding is similar to that of Muzi et al. (2016) and Goedhuys et al. (2008), contrary to the findings of Nyaedi et al. (2018).

The study also analysed the relationship between capital intensity and labour productivity, results shows highly significant capital intensity. The respective first and second productivity models show that a 1 percent increase in capital intensity, increases labour productivity by 0.293 percent and 0.305 percent at 1 percent level of significance *ceteris paribus*. Results indicate that the size of the firm does not matter on labour productivity of a firm. The residuals have a positive relationship with labour productivity of the firm.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Summary

Findings of the determinants of knowledge capital investment indicated that the firm size and export status determined firm's innovative efforts. However, access to finance is an inhibitor to firms' innovative efforts. It is interesting to note that foreign ownership seems to have less linkage to the investments in knowledge capital. Firm age appears to be less binding when it comes to investment in knowledge capital as reported in some of the literature.

In as much as firms do invest in knowledge capital, it does not imply direct innovation outcomes. It is thus crucial to examine the second stage of understanding innovation-productivity link. The second step of analysis focussed on the role of knowledge capital in specific innovation outcome. The results indicate that indeed investment in knowledge capital positively influence both the product and process innovation. Moreover, market orientation of a firm, firm age and training employees specifically for development of new products were found to be significant with a positive direction for both process and product innovation. Interestingly, results on firm foreign ownership status and lack of skilled manpower were heterogeneous across the two innovation outcomes.

The last stage involves examining the impact of innovation on productivity. The main results show that both product innovation and process innovation have no effect on labour productivity which is generally consistent with some literature such Muzi et al. (2016) and Goedhuys et al., (2008). Capital intensity was found to be positively related with labour productivity.

5.2 Conclusion

The Kenya's Vision 2030 envisages an increasing economic development rate of the Kenya's economy. In order to achieve the vision of a highly industrialised economy, firm level productivity has to be substantially improved. Study noted that innovation activities of the firms in the Kenya's context is incremental rather than radical. This means that the innovation activities being carried out are minor improvements to already existing products or /and processes.

It is therefore important for the firms to put more efforts on improving the quality of their products and/or processes to meet the ever changing customer needs and compete favourably in the global value chain. In as much as, the study had a limitation in using the cross section data which is not robust enough to establish the causality of innovation activities on labour productivity, it has provided some useful insights on the innovation –productivity link by giving a snapshot of innovation activities and productivity in Kenya’s manufacturing sector. Main conclusion of this study is that both product and process innovation do not significantly impact on productivity.

5.3 Policy Implications

The global innovation index 2019 shows a slight improvement in Kenya’s global ranking from 78th country in 2018 to 77th country in 2019. First, statistics indicate that innovation outputs in Kenya are more common than peers (the developing countries) i.e. equal investment innovation activities and GDP per capita. This reflects a disparity between innovation inputs and outputs in relative terms. Therefore, the need for investment in knowledge capital that would increase the chances of introducing new and improved firm products and processes.

Second, for innovation output to be realised from the innovation inputs, there is greater need for enough absorptive capacity at the firm level. The results indicate that training of employees has a strong link with the innovation outputs. This study recommends strong support for appropriate on job training policies that ensures skilled labour force at firm level.

Third, in order to improve the capacity of a firm to transform innovation outputs into gains in productivity. There’s need to address the information asymmetries emanating from firms’ lack of sufficient resources for proper research and to innovate, uncertainty arising due to anticipated innovation failure as well as poor quality innovations.

Information asymmetry can further be exaggerated by failures in policy coordination at national level in which the individual cost of radical and incremental innovation are so costly particularly to the small and medium enterprises. Therefore, there is need for programs that target innovation and productivity by enhancing firm’s research and innovation potentials at lower cost.

In addition, programs that support financing of knowledge capital investments (R&D) is recommended in order to boost innovation outcomes. Gradual but Partial subsidies to high quality innovation projects have been internationally recommended to effectively support R&D than tax exemptions.

Fourth, it is important to enhance collaboration among the academic institutions and the firms where the innovation outputs are required such as manufacturing. The research work done at academic institutions and other private firms should be shared with the stakeholders within the manufacturing sector. The recommended collaboration between academic institutions, firms as well as private sector can have a strong positive effect on the quality of innovation activities.

Fifth, the current innovation coordinating institution is considered embryonic therefore exhibiting a gap in the policy framework. It is important to firm up the policy framework at the institutional level to better coordinate innovation activities and evaluate policies that will better enhance collaboration and dialogue among the stakeholders in the country.

5.4 Areas for Future Research

The study used a cross-sectional data to determine the impact of innovation and productivity, measuring the magnitude of innovation activities on productivity requires the use of panel data. Thus, the results should be treated with caution.

In light of panel data availability, a recommendation for future studies that examines how innovation outcome in the current period influences the probability of innovation in subsequent periods i.e. "if success breeds success/failure breeds failure". This will offer insights on the spill over effects of expenditure on research and development that is rare in literature.

Finally, given the availability of updated data in this area, it is important to carry out more research in the innovation-productivity link to examine innovation patterns and trends over time for the better understanding of innovation-productivity link and economic development.

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