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The Intensity of Knowledge Capital Investment in Kenya: Evidence from Manufacturing and Service Sectors

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Abstract

The study investigates the extent to which firms in Kenya manufacturing and service sectors invest in knowledge capital leading to innovations. 534 firms were included in the analysis. This was the combined data from the first Kenya innovation survey data of 2012, which covered 158 firms, (2008-2011) and the second Kenya innovation survey of 2015 which covered 376 firms (2012-2014). The Crépon, Duguet, and Mairessec (CDM) (1998) model, which considers a system of four equations: innovation propensity, innovation investment, innovation output and performance equations, was used as the estimation technique. The results revealed that, a firm's decision to spend on R&D was significantly influenced by firm ownership, financial turnover and product innovativeness. A firm's R&D intensity was significantly determined by its financial turnover and ownership. A firm's activity and financial turnover were also significant in determining whether it introduced a new product in the market or not. The results of this paper suggest that a firm's financial turnover was significant in R&D decisions but R&D intensity did not significantly matter to a firm's product innovativeness. Further, a firm's level of innovativeness was a significant determinant of its productivity. In addition, the results suggest that, innovations among the Kenyan firms in the manufacturing and service sectors were heavily reliant on financial capital and were struggling to convert knowledge inputs into product output. This study thus recommends a policy that incorporates the academia and firm level innovation with national innovation systems to enhance knowledge and skill intensive innovations that are new to the world.

Keywords: innovation, R&D intensity, knowledge capital, selectivity bias, Gross domestic expenditure on research and development (GERD)

1. Introduction

Investment in knowledge capital leads to improved state of science technology and innovation of a country (Lundavall et al., 2011). Science, technology and innovation are crucial in the transformation of Kenya's economy from a factor driven economy to an innovation driven economy (MoEST & KNBS, 2012). Vivarelli (2014) asserts that achieving industrial production excellence is seen as essential to survival and economic growth of any country in this age of globalization. To meet the needs of the ever changing customer and market demands, escalating competition and the necessity to control and reduce rising costs; firms in the manufacturing and service sectors are forced to increase their innovation by adoption of new products, new marketing strategies, new process and new organizational types (Günday et al., 2011).

Kenya has incorporated investment in knowledge, innovation, research and development with its development strategy. It has done this mainly through the national policy frameworks like the industrialization policy and the Kenya Vision 2030. The Kenyan government has made attempts to improve on science, technology and innovation-related institutional framework, in a bid to complement the policy goals of Vision 2030. The government has done this through legislations, such as the National Science, Technology and Innovations Act of 2013 (MoEST & KNBS, 2012).

The Science, Technology and Innovations Act of 2013 is an institutional framework comprised of three main elements. First, the National Commission for Science, Technology and Innovation (NACOSTI) which is an autonomous government institution with the role of leading inter-agency efforts to develop policy on science, technology, and innovation across all levels of government. Second, the Kenya National Innovation Agency (KENIA), which is the implementation arm for the country's science technology and innovation agenda and policy. Third, the National Research fund which aims at mobilizing resources to develop research capacity and scientific information. This new framework, however, has not yet been fully implemented and the bulk of innovation policy remains the responsibility of the ministry of education, science and technology (MoEST & KNBS, 2012).

According to Africa Innovation Outlook II, Kenya is the leading country in Africa in terms of GERD/GDP (Gross Domestic Expenditure on Research and Experimental Development) ratio with 0.98% followed by South Africa (0.78%), Senegal (0.54%) and Egypt 0.43 % (NEPAD, 2014). GERD provides information on how much a country invests in R&D. Although Kenya is still lagging behind the world's 2010 average GERD/GDP ratio of 1.77%, it is ranked amongst countries like China, Malaysia, India, among others that are ahead of their economic peers in terms of investing in knowledge leading to innovation (Cornell and INSEAD, 2015). Kenya's R&D expenditure is channeled through higher education with more than 50% of her R&D expenditure being devoted to basic research. Kenya is among countries like Ethiopia, Ghana and South Africa that spends more than 15% on experimental development research activities. Between 2008-2014, 60% of the researches in Kenya were conducted in higher education institutions (NEPAD, 2014).

Public- private partnerships in Kenya have seen the rise of significant number of innovation hubs and incubation centers like the IBM innovation center, the Phillips innovation hub among others. These centers for innovation address a wide variety of issues like healthcare, ICT and access to electricity. The availability of underwater fiber optic cable in Kenya has reduced the price of bandwidth, enabling access to internet connection. Consequently, this has enabled the creation of innovation hubs that now offer high speed internet connection to Kenyan entrepreneurs at an affordable price. The most prominent of these include the Nai-lab and I-hub that have incubated 152 new companies and have helped to create jobs.

To provide skilled man power in the key sectors of the economy such as the industrial, manufacturing and engineering, the government came up with industry-led partnerships, with firms Linking Industry With Academia (LIWA) initiative in 2010. LIWA established 15 partnerships between Kenyan universities and major industry players such as Huawei and Safaricom. The partnerships were aimed at improving the quality of graduates by updating the curricular, training innovators and offering internship programs. A technology city which enhances technology transfers from international technopreneurs to local firms is currently being constructed under the vision 2030 flagship projects.

The study of determinants and intensity of knowledge capital investment and their influence on firm level productivity has been subject to increasing interest in past decades and especially in developing economies (Vivarelli, 2014). The greater availability of innovation and productivity micro-level data in Kenya, especially the recent 2013 community survey by the World Bank, the first National Innovation Survey (2012) and the Second Innovation Survey (2015) by Ministry of Higher Education Science and Technology (MoHEST), Ministry of Trade and Kenya National Bureau of Statistics (KNBS) data has seen very few studies in the area of innovation and productivity in Kenya. This study therefore arises out of the concern that few studies have been conducted in this area. The paper aims at empirically understanding the determinants and the intensity of knowledge capital investment among the Kenyan manufacturing and service firms leading to innovations. The rest of the paper is organized as follows: Section two briefly discusses theoretical and empirical literature. The methodology and data sources are discussed in Sections three, section four presents the empirical results; section five discusses the conclusions while section six presents the policy implications of this study.

2. Literature Review

Investment in knowledge capital leads to innovation outcomes such as the introduction of new and improved products in the market, new production processes or efficient organizational changes (OECD, 2005: Rogers, 2004). Successful innovations are likely to increase firm-level productivity by improving the capacity to transform factors of production into more and better products and increase efficiency and products value. However, achieving innovation outcomes is heavily dependent on the ability of the firm in question to transform knowledge capital into innovations, the specific sector and country context, enabling environment and policy framework in place (Lundavall et al., 2011).

Efforts by the firms to innovate are mostly indicated by the level of research and development (R&D) expenditure. Research and experimental development (R&D) comprise of efforts undertaken by the firms with the aim of increasing the stock of knowledge (Vivarelli, 2014). Firms invest in training in order to increase the available human capital. In addition, firms invest in R&D, software, copyrights, patents and licenses in order to increase their scientific or innovative capital (Szirmai, Naudé, & Goedhuys, 2011). Innovation involves investment into developing these creative assets (OECD, 2005; Miller, Dröge, & Toulouse, 1988). The growth of an economy is determined by the level of technology and innovation which, in turn, depend on the share of GDP devoted to these activities (Grossman & Helpman, 1991; Rogers, 2004). For the firms to invest in producing new ideas, they must benefit directly or indirectly from the process of research or education to justify the theoretical underpinnings of the concept of opportunity cost (Lundavall et al., 2011).

Lundavall et al. (2011) asserts that innovation system model in least developed countries follows the evolutionary innovation model. This model describes the process of self organization and the way in which public policy and organizational structures can affect the process of innovation. In evolutionary approach, aggregate innovation outcomes are as a result of an individual firm's behavior conditioned by the behavior of other firms and the institutional landscape (Szirmai, Naudé, & Goedhuys, 2011). Innovation in developing countries is a case of catch up with techology from the foreign countries and firms will rarely introduce a product which is new to the world (Vivarelli, 2014).

Tuan (2015), empirically analyzed determinants of innovation in the Vietnamese manufacturing firms using data from 118 firms. The results revealed there was a positive relationship between innovation activities and firm characteristics like communication channels, firm environment and organizational resources. De (2014) used 540 Kenyan firms and 377 Ugandan firms in investigating the determinants of innovations in Kenya and Uganda. Using a generalized linear model, De (2014) found out that financial and human capital are significant factors in determining innovations in both countries.

In a study dabbed "catching up with the technological frontier," Cirera (2015) used 549 firms from the 2013 World Bank innovation survey. The study investigated the determinants of R&D intensity and determinants of research intensity in Kenya. The results of the study indicated that the number of employees and education of the firm's manager was positively correlated with internal R&D. Further, acquisition of machinery, size, exporting and education of the firm's manager were correlated with innovations new to the Kenyan market.

In an investigation of sources of technological innovation in Chinese industries, Sun and Du (2010) found out that R&D was the most important source of technological innovation in the country. In addition, their study found no relationship between export, spillover effect and new product sales. Using a modified CDM model, Vakhitova and Pavlenko (2010) investigated the contributions of innovations to productivity of Ukrainian firms. In their study, they found that if a firm had introduced a new product in the market, it was likely to spend on R&D. They also reported a significant impact of government support to firms' innovation and productivity.

Goedhuys (2007) examined the main drivers of productivity in Tanzanians' firms. The author did not find any link between R&D, product and process innovations, licensing of technology, or training of employees, and productivity. The results suggested that Tanzanian firms faced difficulties when converting knowledge inputs into productivity improvements due to the poor enabling environment for business.

A review of empirical evidence reveals three categories of factors that influence the innovation process including firm characteristics factors for example, firm size and R&D intensity; the institutional background factors such as trade share of GDP and networking and industry specific factors like spillover effects of agglomerations (Vivarelli, 2014). Determining factors analysed by various studies depends on the scope and quality of the dataset used. There is enormous empirical literature examining the determinants and intensity of innovation in the developed economies. However, empirical evidence from developing and least developed nations is still scanty (Khan & Roy, 2011).

3. Methodology and Data Sources

3.1 Data Type and Sources

To understand the determinants of innovation and the extent of investment in knowledge by the Kenyan firms, this paper utilized firm level cross sectional data from the first and the second Innovation Survey. The data was released in 2012 and 2015 respectively by Ministry of Higher Education Science and Technology (MoHEST), ministry of trade and Kenya National Bureau of Statistics (KNBS). This paper combined data from the first Kenya innovation survey of 2012 from 158 firms conducted between 2008 and 2011 and the second Kenya innovation survey of 2015 which covered 376 firms and was conducted between 2012 and 2014. In total 534 firms were included in the analysis.

Following the available empirical literature, eleven variables which are crucial in the analysis were extracted from the two community innovation surveys as summarized in table 1. AG, which is the age of the firm, was captured as the number of years a firm has been in operation. EMPLYMNT representing the firm employment level was computed as logarithm of number of total permanent and contractual employees employed by a particular firm on average between 2008 and 2011 and 2012 and 2014. RDINTY, which is R&D intensity, was computed as Logarithm of R&D spending to employment ratio. ASSTS, which is an indication of whether a firm spent on both tangible and intangible assets or not, was recorded with a dummy that is, either a firm bought fixed assets (machinery, equipment or Software) or not. TNOVER, which is a firm's approximate financial turnover, was computed as the logarithm of the average annual turnover for the time periods surveyed. The monetary unit used was Kenya Shillings (Ksh). SKIL representing skill as a variable was computed as the ratio of skilled workers (workers with a degree or technical diploma) to total number of workers in the production unit (MoEST & KNBS, 20112; MoEST & KNBS 2015).

Table 1. Variable description

Variable	Symbol	Description
Firm age	AG	Number of years the establishment has been in existence
Employment level	EMPLYMNT	Logarithm of number of total permanent and contractual Employees
R&D intensity	RDINTY	Logarithm of R&D spending to employment ratio
Financial turnover	TNOVER	Log of average annual turnover
Assets	ASSTS	1if a firm bought fixed assets (machinery, Equipment or Software) 0 if otherwise
Skills	SKIL	Skilled production workers to total production workers Ratio
Product innovation	PDINNOV	1 if a firm introduced a new product/service into the Market 0 if otherwise
R&D spending	RDFIRM	1 if a firm spends on R&D activities 0 if otherwise
Firm activity	ACVTY	1 if a manufacturing firm 0 if otherwise
Ownership	FORGN	1 if a firm is a part of a larger group 0 if otherwise
Firm size	SIZ	1 if more than 200 employees 0 if otherwise

Note. Monetary units used are the Kenya Shillings (Ksh). Due to endogeneity these variables can be both independent or/and independent variables.

The other variable is PDINNOV, which is the product innovation, was recorded with a dummy that is, if a firm introduced a new product/service into the market or not during the survey period. This excluded simple resale of new goods purchased from other enterprises and minor changes like changes in the product appearance. From the innovation surveys, majority of the firms did not report on process innovation, marketing innovation and organizational innovation. Most of them concentrated on product innovation. Blasco (2010) appreciates the fact that variables included in the different innovation studies depend on the scope and quality of data set used. FIRMRD, representing firm spending on research and development was captured with a dummy that is, whether a firm spends on R&D or not. Firm spending on R&D included: expenditure on in-house research and experimental development, outsourced R&D, introduction of innovations into the markets and training. ACVTY is the firm activity which was recorded with a dummy. The activities of different firms were broadly classified as either manufacturing or services. FORGN, which is ownership status of the firm, was recorded with a dummy that is, whether a firm is a part of a larger group or not. A group consisted of firms under common ownership. Lastly SIZ, which is the firm size, was captured with a dummy that is whether that firm had more or less than 200 employees (MoEST & KNBS, 20112; MoEST & KNBS, 2015).

3.2 The Econometric Model

Firms make a choice on whether to use the available labor to produce goods and services or to produce ideas (innovate). Therefore, a selective group of the firms decide how much they will invest in R&D. Since not all firms in the sample will spend available labor to produce ideas (Innovate), selectivity bias is likely to occur. The Heckman estimation procedure corrects the selectivity bias by introducing the selection equation and the outcome equation. The selection equation estimates the relationship of a firm's R&D choice and its determinants by Probit regression. The outcome equation describes the influences of the explanatory variables on R&D intensity, after incorporating the selectivity problem (Waheed, 2012; Crépon, Duguet, & Mairessec, 1998).

The decision to invest in knowledge is a latent dependent variable rd_i^* for firm '*i*' which is modeled as a generalized Tobit model that expresses R&D decision as shown by equations (1) and (2). A firm's decision to carry out continuous R&D is not observed as shown by equation (1) (Blasco, 2010).

$$rd_i = \begin{cases} 1 \; if \; rd_i > 0 \\ 0 \; if \; rd_i = 0 \end{cases} \tag{1}$$

Where rd_i is the observed binary variable, which is zero for a firm that do not spend on R&D and one for a firm that spend on R&D.

$$rd_i^* = \beta X_i + u_i \quad (2)$$

Where X_i is a vector of determinants of R&D decision, β is a vector of parameters to be estimated and μ_i is a random error term. Given that a firm is classified as innovative, equation (3) has the logarithm of R&D expenditures and other innovation cost per employee as dependent variable. Firm's R&D intensity can be indicated by the amount of R&D expenditure per employee. A firm's R&D effort is described by the latent variable r_i^* (Crépon, Duguet & Mairessec, 1998).

$$r_i^* = \alpha Z_i + \epsilon_i \quad (3)$$

Where Z_i is a vector of determinants of R&D efforts, α is a vector of parameters to be estimated and $\mathcal{E}_i$ is a random error term. Knowledge outputs of the firms are mostly shown with six indicators. Four dichotomic variables are related to product, process and organizational innovation and patent applications, and two continuous variables are related to the share in the sales of new products or services new to the firm or to the market (Blasco, 2010). This paper uses product innovation (new product or service introduced by the firms to the market) as the knowledge output.

In general, the product output innovation equation is estimated using a probit regression with endogenous covariates equation (4).

$$y_i = \sigma w_i + \beta x_i + u_i \quad (4)$$

Where y_i is the innovation output which is a latent variable. $y_i = 1$ if a firm introduces a new product or service into the market, $y_i = 0$ if otherwise. w_i is R&D intensity, x_i is a vector of the other remaining determinants of knowledge production, u_i is a random error term, σ and β are parameters to be estimated. The endogenous nature of y_i and w_i is controlled with an instrumental variable.

The productivity output equation is expressed as stochastic frontier by the traditional Cobb- Douglas production function as shown by equation (5) (Waheed, 2012).

$$Q_i = f(x_i; \beta) \quad (5)$$

Where Q_i is the firm's productivity which is represented by its financial turnover. x_i is vector of independent variables and β is a vector of parameters to be estimated. To determine the impact of innovation to a firm's productivity, product innovation, PDINNOV was included as independent variable in the stochastic frontier function.

4. Empirical Results and Discussion

4.1 Correlation Analysis

Correlation analysis test results, shown by Table 2, revealed statistically significant positive correlation between financial turnover and firm ownership, firm size, product innovation, firm activity, firm age and employment level.

There was also a statistically significant positive correlation between product innovation and financial turnover and firm size. However product innovation was negatively correlated with the firm age. R&D intensity was significantly negatively correlated with firm age and size.

Table 2. Correlation analysis test

	AG	EMPLY	RDINTY	TNOVER	SKIL	PDINNOV	ACTVTY	FORGN	SIZ
AG	1								
EMPLY	0.1984*	1							
	(0)								
RDINTY	-0.1648*	-0.0530	1						
	(0.046)	(0.4994)							
TNOVER	0.2929*	0.4127*	0.1248	1					
	(0)	(0)	(0.1268)						
SKIL	-0.1726*	-0.0104	0.0714	-0.0664	1				
	(0.0024)	(0.8441)	(0.4108)	(0.2498)					
PDINNOV	-0.0516*	0.0874	0.03	0.2236*	0.0274	1			
	(0.2931)	(0.0548)	(0.7174)	(0)	(0.6169)				
ACTVITY	0.0953*	-0.1105*	-0.0701	0.1049*	-0.1511*	0.0756	1		
	(0.0418)	(0.0111)	(0.3712)	(0.0302)	(0.004)	(0.0948)			
FORGN	0.1896*	0.0666	0.0002	0.2005*	0.1416*	0.0221	-0.0404	1	
	(0.0001)	(0.1308)	(0.9977)	(0)	(0.0076)	(0.6292)	(0.3564)		
SIZ	0.2502*	0.4803*	-0.1833*	0.5142*	-0.1084*	0.1422*	-0.0210	0.1951*	1
	(0)	(0)	(0.0184)	(0)	(0.0395)	(0.0017)	(0.6299)	(0)	

Note. *indicates statistical significance at 5% significance level, the figures in the brackets are the p – values.

The results were comparable with other studies conducted in Kenya. For instance Cirera (2015) found that innovation activities were positively correlated with the number of employees, manager's education and firm size.

4.2 Regression Results

Regression estimation process involves estimation of two equations that is, the selection equation (equation 2) and the outcome equation (equation 3). The results are as shown by table 3 .The Heckman selection model requires at least one variable of the selection equation be excluded in the outcome equation. This restriction is necessary to avoid collinearity between the mills ratio and other explanatory variables used in the outcome equation (Wooldridge, 2015). This paper excludes PDINNOV from the outcome equation since a firm spending on research and development is correlated with product innovation. Removing PDINNOV helps in reducing collinearity between the mills ratio and other explanatory variables used in the outcome equation.

Apart from being useful in the control for selectivity problem, the Heckman selection enables us to empirically analyze the determinants of the R&D decision (column (3) of Table 3) and the influence of these determinants on the subsequent R&D expenditure per employee (column (2) of Table 3) (Waheed, 2012). The Wald test of the overall PROB > CHI significance and the significance of *λ (lambda)* provides empirical significance to the use of the Heckman selection model. In addition, the significance of the model indicates that the featured firm characteristics are significant determinants to explain both types of R&D activities which include R&D decisions and expenditure.

Table 3. Heckman selection model

	Independent		Dependent Outcome(RDINTY)	Selection(FIRMRD)
	AG		0.0048	-0.0029
			(0.0066)	(0.0047)
	EMP		-0.0004*	-0.0001
			(0.0001)	(0.0001)
	TNOVER		0.4159*	0.0967*
			(0.0637)	(0.0238)
	SKIL		0.6263	-0.0202
			(0.4956)	(0.4162)
	SIZ		-0.2251	0.3861
			(0.3032)	(0.2140)
	PDINNOV			0.6811*
				(0.1797)
	ACTIVTY		0.1507	0.1133
			(0.2265)	(0.1728)
	FORGN		0.5953*	0.5216*
			(0.2753)	(0.1982)
MILLS	LAMBDA	0.6687	(0.2289)	
	RHO	0.96045		
	SIGMA	1.2168		PROB>CHI = 0.0

Note. * indicate variables significant at 5% significant level. The robust standard errors are reported by the terms in the brackets

The results revealed TNOVER, FORGN and PDINNOV were statistically significant in explaining a firm's decision to spend on R&D. There was a positive relationship between a firm's financial turnover and R&D spending decisions. This suggest that, increasing financial turnover would increase the likelihood of a firm to spend on R&D. Firm ownership had a positive impact on firm's R&D spending meaning that if a firm was part of a larger group (if the firm was a subsidiary of other company)there is increased chances of it spending on R&D. The results also revealed that if a firm had introduced a new product into the market, that particular firm was likely to spend on R&D. However, firm age, employment level, skills, firm size and firm activity did not significantly influence a firm's decision to spend on R&D.

After selection, the outcome was that a firm spends on R&D. RDINTY, research and development intensity, is the amount of money spent per employee by the firms. Employment level, firm turnover and ownership significantly determined R&D intensity. There was a positive relationship between firm turnover and R&D intensity, implying that as the firm's financial turnover increases, R&D intensity increases. Firm ownership had a positive impact to R&D intensity, implying that if a firm was a part of a larger group, it was likely to spend more money for R&D. There was an inverse relationship between the number of employees in a particular firm and R&D intensity, indicating that intensity would decrease as the number of employees increase. Firm age, skills, firm size and firm activity did not significantly influence firms R&D intensity. Table 4 shows the results of the probit regression, where R&D intensity has been included as an explanatory factor to observe the effect of R&D on firms' innovation output (product innovation).

To control for the endogenous nature of R&D intensity in the PDINNOV equation, this paper used an instrumental variable for RDINTY. To serve as an instrument, the predicted values of RDINTY obtained from the Heckman selection model in Table 3 were used. RDFIRM included in the Heckman procedure was excluded to avoid the Probit equation with an endogenous Regressor (RDINTY) being unidentified (Wooldridge, 2015). Use of lagged values of RDINTY as a measure to control endogeneity was not possible since the data set used was not panel data. Robust standard errors are used as a result of using predicted values as explanatory variables (Baltagi, 2014).

Table 4. Probit regression with selection

Independent Variables	PDINNOV
AG	-0.0049
	-0.008
EMP	0.0001
	-0.0002
RDINTY	-0.2356
	-0.196
TNOVER	0.2181*
	-0.1147
SKIL	0.2775
	-0.5669
SIZ	0.6683
	-0.2106
ACTVTY	0.6248*
	-0.3229
OWNSHP	-0.007
	-0.436

Note. * indicate variables significant at 5% significant level. The terms in the brackets are robust standard errors.

The results shown in table 4 reveal that a firm's activity was significant in increasing the probability that a firm would introduce a new product into the market. Manufacturing activity increased the likelihood that a firm would introduce a new product into the market. This implies that, comparing the manufacturing sector and the service sector, the manufacturing sector had more innovating firms. Günday et al. (2011) explains this by arguing that innovation in manufacturing industry is more radical and has a stronger impact on performance than that in the service sector. A firm's financial turnover also increased the chances of product innovation. R&D spending per employee (intensity) did not have any significant impact to production innovation by firms. Lundavall et al. (2011) asserts that, R&D spending is an input in the innovation process and identifying the conditions under which R&D spending investment can result to innovation is crucial. Identification of conditions where R&D leads to innovation is particularly important in the context of less developed countries where institutional factors may play an important role in firms' performance. In some developing countries with industrialization policies, governments often choose some industries for instance, the manufacturing industry for development and induce investments in these areas (Vivarelli, 2014). In addition to R&D intensity, firm age, employment level, skills, firm size and ownership did not matter significantly in the process of product innovation.

The results of this study are consistent with other studies conducted in Kenya. For example, Cirera (2015) found no link between knowledge capital investment and product innovation in Kenya. Further, Goedhuys (2007) who examined the main drivers of productivity in Tanzanians' firms and found no link between R&D, product and process innovations, licensing of technology, or training of employees, and productivity. However, it contradicts a study conducted by De (2014) that found that human and financial capital was significant in the innovation process.

The final equation in the system of equation is the productivity equation (equation 5) with its estimates shown by Table 5. Financial turnover was the dependent variable used to denote the productivity of a firm. Product innovation was included as an independent variable in the stochastic frontier to determine its impact on the firm productivity. Other independent variables in this estimation include firms spending on assets and R&D intensity.

Table 5. Estimates of the stochastic frontier model the productivity equation

TNOVER	Coefficient.	Std. Err.	z	P>z
RDINTY	0.0881*	0.0136	6.44	0.0000
PDINNOV	0.4672*	0.0869	5.38	0.0000
ASSTS	0.2234*	0.0583	5.97	0.0000
Constant	8.7653	0.0369	237.03	0.000
lambda	1.2705	0.1119		

Note. * denotes statistical significance at 5% significance level.

The estimates of the productivity equation, revealed a significant relationship between financial turnover and R&D intensity, product innovation and firm's spending on assets. The results revealed a very strong positive impact of product innovation on the firm productivity. This suggests that product innovation had increasing returns to scale implying that, the firms in the manufacturing and service sectors would really reap positive financial turnovers from their product innovations. Buying of fixed assets had a fairly significant impact on a firm's financial turnover. R&D intensity had a very small margin of change to firm productivity.

5. Conclusion

The determinants of R&D and innovation and their effects on productivity at the firm level have not been supported sufficiently by empirical work in developing nations like Kenya. A survey of literature reveals that innovation is a key input in the production process. However, successful innovations are heavily dependent on the ability of the firm, institutional and country specific factors, enabling environment and policy framework (Lundavall et al., 2011). This study considered a total of 534 firms and a system of equations as the estimation methodology to investigate the intensity of knowledge capital investment in Kenya. Correlation analysis revealed statistically significant positive correlation between firm product innovation and financial turnover and firm size. R&D intensity was significantly negatively correlated with firm age and size.

Regression estimation results suggest that between 2008 and 2014, a firm's decision to spend on R&D was significantly influenced by firm ownership, financial turnover and product innovativeness. Firm R&D intensity was significantly determined by a firm's financial turnover and ownership. Firm activity and financial turnover were also significant in determining whether a firm introduced a new product in the market or not. The attempt to investigate the impact of firm innovativeness to firm productivity revealed that, innovation was a significant input in the process of production. The paper concludes that a firm financial turnover was significant in R&D decisions but R&D intensity (R&D spending per employee) did not matter to firm product innovativeness. Firm age and other variables relating to human capital (skills, size and employment level) did not increase the intensity and the probability that a firm would introduce a new product in the market. These results suggest that Kenya as a developing country heavily relied on financial capital for innovations to take place and was struggling to convert knowledge inputs into product outputs.

6. Policy Implications

The results of this study revealed that R&D intensity, skills, employment level did not significantly impact R&D activities (spending intensity and product innovation) for the time period under study. The results suggest that, innovations in the Kenyan firms in the manufacturing and service sectors relied heavily on financial capital and were still struggling to convert human capital into product output. A policy that incorporates the academia, firm level innovation with national innovation systems that enhances knowledge and skill intensive innovations that are new to the world is thus recommended.

The results also indicate that financial turnover had a significant impact in influencing R&D activities in Kenya. Innovations in developing countries require better innovation systems and the weaker the systems the less innovation there is (Szirmai, Naudé, & Goedhuys, 2011). For this reason, heavy government spending on the knowledge base in Kenya is recommended. It can be done by increasing experimental development research, protection of property intellectual rights and increasing state subsidies to support innovation strategies in Kenya.

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