Tanzanian Economic Review, Vol. 4 Nos. 1 & 2, 2014: 73–90

Factors Affecting Engagement and Commercialization Of Innovation Activities of Firms in Tanzania

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Abstract

This paper analyses the commercialization of innovations in Tanzania, using firm level data. Specifically, it assesses the relative importance of firm, innovation and environmental level factors in commercialization, and how innovation is linked with commercialization. The analysis reveals that firm investment in internal research and development significantly impact both product innovation and commercialization of innovations in Tanzania, implying internal knowledge base is the main link between innovation and commercialization of innovations. Commercialization of innovations in Tanzania is influenced by cooperation with domestic and foreign firms, investment in research and development, and purchase of intangible technology with cooperation with domestic firms having the largest impact on commercialization, followed by investment in research and development. Knowledge acquisition and firm cooperation with other firms have greater impact on commercialization when undertaken by firms with histories of doing so in the past than when undertaken by firms for the first time.

1. Introduction

Innovation translates ideas or inventions into goods or services. Innovation basically involves generation, exploitation and manipulation of new forms of knowledge by firms to create new products or services (Schulze & Hoegl, 2008; Katila & Chen, 2008). Innovation is however only relevant if it the products or services it creates have economic value that attract consumers.

Economic value is realized when technologies and techniques arising from ideas or inventions are diffused and adapted. Realization of economic value from ideas or inventions arises from packaging technologies and techniques in forms that can easily be adapted by users. Such packaging is what is termed commercialization. Commercialization is the process of converting technologies and techniques emanating from innovation into viable products of high quality that can adequately be manufactured cost effectively. Commercialization ensures innovations meet performance, reliability and economic requirements. This implies that successful innovation manifests itself in commercialized products that add value to consumers and firms (Balachandra et al, 2010). Thus, commercialization involves converting innovations produced in research conditions into a product or process that will gain market acceptance and adoption, building from industrialization process that has been undertaken.

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Sullivan (2003) writes that industrialization is a process of social and economic change that transforms a human group from an agrarian society into an industrial one. On the other hand, the Tanzania Development Vision 2025 states, "It is envisioned that Tanzania will have graduated from a least developed country to a middle income country by the year 2025 with a high level of human development. The economy will have been transformed from a low productivity agricultural economy to a semi industrial one" (pg. 2). By the Vision, the country is supposed to transform from a least developed country dominated by low productivity agriculture to an industrial middle income country by 2025. In this context, the words 'industrial economy' are used imply lifting up a least developed country to a middle income one.

Since commercialization entails converting ideas and inventions into viable products demanded by the market, its success positively impacts firm output, sales and growth. Successful commercialization enables firms to enhance market penetration, dominance and exploitation of new markets, which enhances economic performance and leads to growth (Datta, 2011; Zahra & Neilson, 2002; Cohen & Levinthal, 1990).

Although there are many innovations, not all are successful. In fact only a very low proportion of raw ideas culminate into successful commercial products (Stevens & Burley, 1997). Low success rates of commercialization of innovations may be due to not only technical issues but also flaws in the commercialization process. Despite the low success of commercialization of innovations, it is an important aspect of growth because it is the avenue through which innovations are made relevant to facilitate growth through employment, economic growth and economic development (Schumpeter, 1912). In the light of this, commercialization of innovations is therefore an important element of economic growth and development, and is pursued by many innovative firms despite low success rates.

Given the significance of commercialization of innovations to economic growth and development, and the low rate of success rate of commercialization of innovation, adequate understanding of commercialization with respect to factors driving it is necessary. Thus, the objective of this paper is to identify factors determining commercialization of innovations Tanzania. Specifically, it analyses the relative importance of firm, innovation and environmental level factors for commercialization; and how innovation is linked with commercialization.

The remainder of the paper is structured as follows. Section two describes the relationship between innovation and commercialization. Section three presents the methodology of the study; describing the data, variables, and empirical specification. Section four presents the results, and section five concludes the study.

2. Innovations and Commercialization

As innovation entails translation of ideas or inventions into products with economic value to meet market demands, it is incomplete until the innovative products resulting from innovation are accepted and adapted by the market.

Market acceptance and adaption of innovative products is the core of commercialization, which is the final piece of the innovation puzzle. Innovation and commercialization are, therefore, closely linked: the former is a prerequisite for the latter, while the latter completes the former.

The close link between innovation and commercialization has led many studies to assume they go hand in hand where commercialization is assumed as long as innovation has taken place (Vega-Jurado et al., 2008; Burgelman et al., 2006; Dahlin & Behrens, 2005; Portelli & Narula, 2006; Danielson & Mjema, 1994; Chandler, 1977). Although innovation is a necessary condition for commercialization by leading to development of new products, it is not a sufficient condition for market success, which depends on other factors that differ from those driven by innovation.

Meaning?

Other studies have separated innovation and commercialization in recognition of the fact that they are not determined by the same factors (Bogers & West, 2012; Nerker & Shane, 2007; Baldwin & von Hippel, 2011; Dahlander & Gann, 2010; Chesbrough, 2006). Since commercialization is the culmination of innovation, it is a function of all the stages preceding it. Various scholars (Datta et al., 2012; Balachandra et al., 2010; McCoy et al., 2009; Andrew & Sirkin, 2003, Nerker & Shane, 2007; Jolly, 1997; Corkindale, 2010; Sigel et. al, 1995) describe commercialization as consisting of stages preceding and following market adaption of innovative products such as investigation, development and commercial phases. Määttänen (2012) defines different phases of technology commercialization as idea generation, technology development, seeking market opportunities, market promotion, and sustaining commercialization. These involve planning, basic and applied research, design, engineering and manufacturing, market strategy and business planning, pre-launch and test-marketing, and value assessment.

Datta et al. (2012) uses a firm-level model to analyze commercialization, focusing on innovation sourcing, assessment of viability, governance, external networks, absorptive capacity, and micro- and macro-level factors as determinants of commercialization. Innovation sourcing involves being aware of sources of ideas and being willing and able to use them; viability involves determining how innovations impact patents and tactical business decisions on whether to continue with an innovation project or discontinue it. Governance involves the form of structure required for commercialization with respect to ownership of technology in the process of commercialization. External networks involve firm access to critical resources, knowledge, and capabilities. Absorptive capacity involves the ability of a firm to absorb scientific or technological information. Micro-level factors involves the previous experience of managers in bringing innovations to market, which may impact their decisions on subsequent commercialization; while macro-level factors involve the nature of the environment in which a firm operates with regard to being dynamic, munificent or complex.

Given commercialization entails stages preceding and following market adaption of an innovative product, it is thus a function of technical, market and business

factors. The technical side of commercialization involves innovation and factors affecting it. Innovation entails translating ideas into useful output; and is determined by knowledge acquisition, which can be internal or external.

Internal knowledge involves development or acquisition of knowledge within a firm's boundaries through in-house knowledge dissemination and research and development, and internal education and training. External knowledge, on the other hand, involves introduction of new knowledge from sources outside a firm via external research and development, and purchase of equipment or intangible technology. However, the existence of an adequate knowledge base is necessary for a firm to successfully utilize acquired knowledge to innovate (Cohen & Levinthal, 1990; Garud & Nayyar, 1994; Zahra & George, 2002).

Various studies examining the link between sources of knowledge and innovation have found that internal knowledge and external knowledge complement each other as the latter can enhance a firm's capacity to generate the former, while the former can enhance a firm's capacity to adequately utilize the latter in innovation (Beneito, 2003; Lundvall, 1988; Cohen & Levinthal, 1990; Edquist, 2004; Lowe & Taylor, 1998; Portelli & Narula, 2006; Szogs, 2004; Mahemba & De Bruijn, 2003). Since innovation is a necessary condition for commercialization, knowledge acquisition is one of the factors that can determine the commercialization of innovations by ensuring products are adequately developed in a manner that enhances their chances of penetrating the market.

Once a product is developed it has to be diffused and adopted by consumers in the market. This entails marketing the product to convince people of its usefulness. Nerker and Shane (2007), McCoy et al. (2009) and Moore (1991) consider successful commercialization as the sale of an innovative product not only to innovative product enthusiasts who are easy to convince (but make up a small share of a market), but also to innovative product pragmatists who are difficult to convince (but make up a large share of the market). Successful commercialization is thus not just mere sale of an innovative product in a market, but rather widespread sale; implying wide adaption of the product. Marketing involves disseminating information in a targeted manner about a new product to demystify with regards to function, cost, and advantages over existing products in order to make it more acceptable to pragmatists who form a large segment of any market.

It is common for many firms to develop innovations without considering profiting from such innovations; implying non-prioritization of commercialization from the onset. Products are however useless until they are commercialized; implying it is necessary to carry out business models for commercializing of new innovations. A business model links technical decisions and economic outcomes with alignment of choice of an innovation and its commercialization strategy with a firm's business model leading to profit (Chesbrough, 2006; Chesbrough, 2003).

Apart from examining commercialization from the technical, market, and business perspectives, other studies have examined commercialization strategy with regards to cooperating or competing with incumbents firms in the market (Gans & Stern, 2003; McCoy et al., 2009; Gans et al., 2002; Marx et al., 2014; Hsu, 2006). These studies found out that commercialization strategy is determined by market environment, uncertainty about an innovation's future value, incumbent's integration costs, friction, and access to complementary assets. Various studies have grouped factors influencing the decision of firms to commercialize into environmental-level, firm-level and innovation-level factors (Teece, 1986; Arora et al., 2001; West & Bogers, 2014; Chesbrough, 2003; Herzog & Leker, 2010; Baldwin & von Hippel, 2011).

Environmental-level factors are strength of appropriability mechanisms that make commercialization profitable, availability of markets for technology, institutional framework facilitating knowledge accumulation, and industry structure. Firm-level factors are the availability of complementary assets (manufacturing, distribution, marketing, sales, and support capabilities), internal knowledge base, knowledge acquisition, and corporate culture. Innovation-level factors pertain to the alignment of an innovation to a firm's business model, the nature of a firm's product, communication costs, and absorptive capacity.

Literature on innovation and commercialization indicate the existence of a variety of factors that impact commercialization in different directions and magnitudes. Such factors can however be grouped in various ways (Baldwin & von Hippel, 2011; Dahlander & Gann, 2010; Chesbrough, 2006; Määttänen, 2012; Herzog & Leker, 2010; West & Bogers, 2014). This paper analyses factors influencing commercialization of innovations in Tanzania by grouping factors that can impact commercialization into environmental-level, firm-level, and innovation level factors in line with West and Bogers (2014), Baldwin & von Hippel (2011), Herzog and Leker (2010), Chesbrough (2003), and Arora et al. (2001).

3. Data and Methodology

3.1 Data

This study employs data from the World Bank, namely the Tanzania Enterprise Survey (ES) of 2013, and an Innovation Follow-up Survey conducted in 2014. The former provides a wide range of firm-level variables, including information on recruitment, training and R&D practices within a firm. The innovation follow-up survey provides evidence on the nature, role and determinants of innovation in Tanzania. It furthermore provides data on commercialization and commercialization-related variables. Specifically, it contains information on the innovation output, innovation-related activities, commercialization and commercialization-related activities such as sales of innovative products, product innovation, process innovation, organizational innovation, and marketing innovation for Tanzanian firms.

3.2 Variables

Dependent Variables

Although the study focuses on identifying factors determining commercialization of product innovations in Tanzania, it must be noted that innovation is a necessary condition for commercialization. The study thus also explores the factors determining product innovation in Tanzania. Therefore, the study has two dependent variables: one for commercialization, and the other for product innovation.

As commercialization of innovations entails converting ideas and inventions into viable products demanded by the market, commercialization must be related to sales of innovative products. Given this, the dependent variable is a percentage of a firm's total sales represented by sales from its main innovative product or service (COMM). The fact that COMM is only observable for some values of the percentage of sales of innovative products ranging between 1 and 100 percent implies that it is a censored variable.

Innovation is a process rather than an instantaneous event, and therefore should not just consider actions that have led to the development of innovative products, but also attempts to develop innovative products as such attempts put ideas in practice. In the light of this, the dependent variable for product innovation is a firm's attempts to develop innovative products (PROD), which is a dummy variable.

Independent Variables

There are two sets of independent variables: those that can influence commercialization; and those that can influence product innovation. Independent variables that can influence commercialization are the sector of economy a firm belongs to (SECTOR), i.e., a manufacturing dummy; cost reducing motive for engaging in innovation (MCOST) that indicates there is demand in the market for low cost products; a firm's cooperation with domestic firms (CODF); and a firm's cooperation with foreign firms (COFF), which are environmental factors.

Other independent variables influencing commercialization are changes undertaken by a firm in the promotion of its products or services (PROMOTE); knowledge acquisition through purchase of equipment, machinery or software (PEQP), and purchase of intangible technology (PINT); a firm's application for a patent (PATENT); the year of establishment of a firm (YEAR), which are firm-level factors. Firm funding of internal research and development (IRD) is an innovation-level factor indicating a firm's absorptive capacity. SECTOR, MCOST, CODF, COFF, PROMOTE, PEQP, PINT, PATENT, and IRD are all dummy variables, while YEAR is a continuous variable.

There are various knowledge sources embodying different types of knowledge. Knoben and Oerlemans (2010) distinguish between various knowledge sources embodying different types of knowledge as a firm's internal knowledge, external business knowledge, external technological knowledge, and external codified knowledge. With regard to this classification, independent variables that can influence product innovation are classified as: firm internal knowledge (firm

funding of internal research and development (IRD)); external technological knowledge (firm funding of external research and development (ERD), firm purchase of equipment, machinery or software (PEQP) and purchase of intangible technology (PINT)); business knowledge (recruitment of staff for innovation purposes (RECRUIT) and staff training (TRAIN)).

Apart from variables pertaining to firm internal, external technological and business knowledge, other independent variables for the study pertain to motives for pursuing innovation (cost reducing motive for engaging in innovation (MCOST), and market share enhancement motive for engaging in innovation (MSHARE), the sector of the economy a firm belongs to (SECTOR), i.e., a manufacturing dummy; and the year of establishment of a firm (YEAR), which controls for variation in the ability of different firms to innovate as pursuit of innovative activities requires a firm be established for some time. IRD, ERD, PEQP, PINT, RECRUIT, TRAIN, SECTOR, MCOST, and MSHARE are all dummy variables, while YEAR is a continuous variable.

3.3 Empirical Specification

The commercialization variable (COMM) can take values between 1% and 100%, although not all values in this range are observed; implying COMM is censored from below and above. Observed values of COMM, therefore, consist of a combination of unobserved values of COMM, and observed values arising as a result of censoring. Since we cannot observe all the values for COMM between 1% and 100%, we run a Tobit model to identify the factor determining commercialization of innovations in Tanzania.

The Tobit model is given as,

$$COMM_i^* = \beta + \alpha X_i + \varepsilon_i \; i = 1,2, \dots \dots, n$$

$$COMM_i = \begin{cases} COMM_i^*, \text{ if } COMM_i^* > 0 \\ 0 \text{ if } COMM_i^* \leq 0 \end{cases}$$

Given that we observe commercialization of innovations if a firm's total sales represented by sales from its main innovative product or service exceeds zero, we use the following empirical model to identify factors affecting commercialization of innovations in Tanzania.

$$COMM = \alpha_0 + SECTOR + \alpha_2 MCOST + \alpha_3 CODF + \alpha_4 COFF + \alpha_5 PROMOTE + \alpha_6 PEQP + \alpha_7 PINT + \alpha_8 PATENT + \alpha_9 YEAR + \alpha_{10} IRD \quad (1)$$

Model (1) can identify factors determining commercialization of innovations in Tanzania, as well as those determining the relative importance of environmental, firm, and innovation factors in commercialization of innovations.

In the case of product innovation (PROD), we employ a binary logit model to analyse factors influencing product innovation in Tanzania since it is a categorical variable. The empirical model for analysing product innovation is:

$$PROD = \beta_0 + \beta_1 ERD + \beta_2 PEQP + \beta_3 PINT + \beta_4 IRD + \beta_5 TRAIN + \beta_6 RECRUIT + \beta_7 MCOST + \beta_8 MSHARE + \beta_9 YEAR + \beta_{10} SECTOT \quad (2)$$

Model (2) can show the extent to which internal and external knowledge impacts innovation, as well as how they interact with each other to affect innovation. Since Model (2) has some common independent variables with Model (1), it enables us to determine the extent to which product innovation plays a role in commercialization of innovations in Tanzania.

4. Results

4.1 Descriptive Statistics

A discussion of features characterizing the data used for the study is necessary before discussing the empirical results to identify patterns in the data. Tables 1 and 2 summarise statistics of the variables used in Models (1) and (2), respectively, and their correlation coefficients.

Table 1 shows most of the firms in the sample were established in 2010 or 2011, and have thus had adequate time to at least attempt to develop new product innovations; and thus have high likelihood of commercializing their products. Furthermore, innovative products account for just over a third of total sales of innovative firms, indicating a satisfactory rate of commercialization of innovations. A third of firms cooperate with foreign firms, which is more than twice as much as a firm's cooperation with domestic firms. Only one out of seven firms undertook changes to the way they promote their products, indicating a weakness in innovation promotion, which may hinder commercialization. Just over a fifth of firms fund internal R&D activities, with almost twice acquiring knowledge through purchase of equipment, machinery or software, and almost a fifth through purchase of intangible technology.

Table 1: Descriptive Statistics and Correlation Coefficients Of Variables Used in the Model (2)

	Mean	SD	COMM	SECTOR	MCOST	CODF	COFF	PROMOTE	PEQP	PINT	PATENT	YEAR	IRD
COMM	36.30	24.88											
SECTOR	0.501	0.500	0.010										
MCOST	0.270	0.446	-0.130	-0.135									
CODF	0.150	0.362	0.534	-0.400	-0.080								
COFF	-0.333	1.732	0.042	0.1800	0.240	-0.470							
PROMOTE	0.136	0.343	0.234	-0.203	-0.080	0.413	0.082						
PEQP	0.400	0.500	0.190	0.170	0.230	0.080	-0.240	0.080					
PINT	0.170	0.403	0.043	0.1502	0.010	0.070	-0.411	-0.200	0.190				
PATENT	0.103	0.261	-0.021	-0.220	0.240	0.081	-0.040	0.081	-0.240	0.100			
YEAR	2.191	0.767	-0.300	0.112	0.040	0.370	-0.400	0.210	-0.040	-0.050	0.200		
IRD	0.223	0.417	0.360	0.160	0.300	-0.150	0.070	-0.150	0.430	-0.170	0.070	0.200	

Most of the firms in the sample were established in 2010 or 2011, and have thus had adequate time to at least attempt to develop new product innovations. About half of the sampled firms are involved in manufacturing. Table 2 reveals that only about a fifth of the sampled firms undertake or attempt product innovation; with firms investing about seven times more in internal knowledge and business

knowledge than in external knowledge. Firms invest more in external technological knowledge via purchase of equipment, machinery or software and tangible technology than in business knowledge through staff recruitment and training. Market factors are important considerations for firms in making innovation decisions. Over half of the firms regard increased market share as a reason for undertaking product innovation. For more than a quarter of the firms, decreased costs are the reason for undertaking product innovation.

Table 2: Descriptive Statistics and Correlation Coefficients of Variables Used in the Model (2)

	Mean	SD	PROD	IRD	TRAIN	RECRUIT	ERD	PEQP	PINT	MCOST	MSHARE	YEAR	SECTOR
PROD	0.214	0.410											
IRD	0.223	0.417	0.403										
TRAIN	0.250	0.434	0.132	0.359									
RECRUIT	0.225	0.420	0.114	0.271	0.143								
ERD	0.035	0.184	0.149	0.439	0.173	0.219							
PEQP	0.400	0.490	0.326	0.429	0.511	0.084	0.258						
PINT	0.158	0.365	0.139	0.190	0.242	0.208	0.209	0.270					
MCOST	0.270	0.446	0.159	-0.099	0.015	-0.024	-0.148	-0.118	-0.040				
MSHARE	0.551	0.446	0.035	0.183	0.263	-0.109	0.122	0.311	0.236	-0.062			
YEAR	2.191	0.767	-0.312	-0.069	-0.073	-0.148	-0.131	-0.088	-0.138	-0.080	-0.019		
SECTOR	0.501	0.500	-0.350	0.011	0.048	-0.121	-0.080	-0.027	-0.043	-0.229	0.204	0.195	

The correlation coefficients in Table 1 reveal cooperation with domestic firms (CODF) and firm investment in internal R&D (IRD) to have the greatest correlation with commercialization of innovations, indicating internal knowledge base and local cooperation may play significant roles in the commercialization of innovations in Tanzania, consistent with Goedhuys' study findings (2005). Change in the methods of promoting products (PROMOTE), and the purchase of equipment, machinery or software are also important in influencing commercialization. Internal R&D is significantly correlated with the purchase of equipment, machinery or software, indicating that external knowledge enhances internal knowledge base, which in turn enhances commercialization of innovations through the development of high quality products demanded by markets.

The correlation coefficients in Table 2 reveal a far higher correlation between product innovation and internal research and development compared to product innovation and external research and development. This may hint at a greater impact of internal knowledge than external knowledge on product innovation. Product innovation has higher correlation with external technological knowledge than with business knowledge, indicating that firms may have a preference for buying technology over investing in internal research and development to produce them. There is significant correlation between internal knowledge (IRD) and external knowledge (ERD and PEQP); as well as a significant correlation between business knowledge (TRAINING) and external research and development (ERD). This may indicate a complementarity between internal knowledge and external knowledge in impacting product innovation (Mohnen & Roller, 2005; Cassiman & Veugelers, 2006).

4.2 Regression Analysis

Table 4 shows the Tobit model and logit model estimation results for Model (1) and Model (2), respectively. The probability of the likelihood Chi-square values for both models indicates the models fit significantly better than models without regressors. Pseudo R^2 values for both models are sufficiently high, further indicating changes in commercialization and product innovation significantly result from changes in their explanatory variables.

Table 4: Tobit and Logit Estimation Results for Commercialization And Product innovation

Model (1)				Model (2)				
COMM	**Coeff**	**SE**	**t-Value**	**PROD**	**Coeff**	**SE**	**Z-Value**	**dy/dx**
SECTOR	8.911	5.506578	1.62	ERD	-1.61	1.542	-1.05	-0.35
MCOST	-5.484	5.325407	-1.03	PEQP	1.43	0.727	1.98	0.34
CODF	51.06	8.521371	5.99	PINT	0.45	0.744	0.60	0.11
COFF	6.662	2.12757	3.13	IRD	3.52	1.101	3.20	0.62
PROMOTE	-2.174	8.034377	-0.27	TRAIN	-1.11	0.856	-1.30	-0.27
PEQP	-1.336	6.697877	-0.20	RECRUIT	-0.55	0.768	-0.70	-0.13
PINT	14.61	7.00254	2.09	MCOST	-0.811	0.639	-1.27	-0.20
PATENT	-4.401	13.64282	-0.32	MSHARE	0.021	0.647	0.03	0.01
YEAR	2.804	4.647925	0.60	YEAR	-1.03	0.402	-2.59	0.26
IRD	31.40	9.321118	3.37	SECTOR	-1.88	0.639	-2.95	-0.44
LR chi2 (10) = 31.84				LR chi2 (10) = 44.07				
Prob > chi2 = 0.0004				Prob > chi2 = 0.0000				
Log likelihood = -94.372468				Log likelihood = -39.647363				
Pseudo R2 = 0.1444				Pseudo R2 = 0.3573				

4.3 Factors Impacting Product Innovation

Innovation is a necessary condition for commercialization as it influences commercialization by determining the quality and worthiness of products seeking acceptance in the market. The fact that innovation is such an important aspect of commercialization necessitates identifying factors that influence product innovation and their interactions before analysing commercialization of innovations.

Estimation results of Model (2) in Table 4 shows that purchase of machinery, equipment or software, age of firm, sector firm belongs, and investment in internal research and development influence a firm's decision to undertake product innovation. Therefore, external knowledge acquisition in Tanzania is more driven by the purchase of machinery, equipment or software rather than financing external research and development, or purchasing intangible technology. Purchasing machinery, equipment or software is more common than investing in external research and development probably because of low levels of technological capability that constrain firms' capacities to undertake adequate internal research and development. This finding is consistent with Portelli and Narula (2006) and Szogs (2004).

Model 2 shows the older a firm, the higher the likelihood of it undertaking product innovation with younger firms being less likely to undertake product innovation. This indicates younger firms start out producing products already existing in the market before attempting product innovation. This is because product innovation requires adequate internal technological capacity acquired through internal research and development, training and recruitment (Cassiman & Veugelers, 2006).

Belonging to the manufacturing sector reduces the probability of a firm undertaking product innovation by about a third. This may be because the service sector is significantly larger than the manufacturing sector in Tanzania, resulting in a higher likelihood of product innovation occurring in the service sector than in the manufacturing sector; as well as the fact that service sector firms usually require less capital than manufacturing firms because production in the service sector tends to be less costly than in the manufacturing sector.

Investment in internal research and development has the largest impact on a firm's decision to undertake product innovation, while internal knowledge development through staff training and recruitment do not influence product innovation. Internal knowledge is thus sourced through internal development of knowledge rather than internal development of processes and skills. Firms may prefer to generate knowledge through funding internal research and development than through training and staff recruitment because output of internal research and development tends to be more sustainable than knowledge generated through training and staff recruitment; as knowledge obtained from staff training and recruitment may be depleted or totally lost in the face of employee turnover.

Since internal and external knowledge sources can influence innovation in their own ways, and are thus important for innovation, it is necessary to examine the extent they affect each other in innovation processes. Fig. 1 shows the impact on product innovation resulting from the interaction of purchase of machinery, equipment or software, and firm investment in internal research and development.

Figure 1: ***Predictive Margins of PEQP and IRD at 95% C.I.***

Fig.1 shows that the effect of the purchase of machinery, equipment or software increases on a firm's decision to undertake product innovation depends on whether a firm undertakes internal research and development. The figure shows increased purchase of machinery, equipment or software increases the impact of internal research and development on product innovation and vice-versa, implying that external knowledge in the form of purchase of machinery, equipment or software enhances the capacity of internal knowledge to influence product innovation. The purchase of machinery, equipment or software, on the other hand, has greater impact on product innovation the greater the internal knowledge base emanating from firm investment in internal research and development, i.e., external knowledge is more effective given adequate absorptive capacity (Cassiman & Veugelers, 2006; Portelli & Narula, 2003; Cohen & Levinthal, 1990).

4.4 Factors Impacting Commercialization of Innovations

Table 4 reveals that firm investment in internal research and development, firm cooperation with domestic firms, firm cooperation with foreign firms, and purchase of intangible technology significantly impact commercialization of innovations in Tanzania. The predicted value of commercialization is 31.4 times higher when a firm invests in internal research and development. Investment in internal research and development enhances a firm's internal knowledge base, which increases a firm's capacity to absorb external knowledge, resulting in higher marginal productivity of external knowledge in innovation.

Higher internal knowledge base emanating from greater investment in internal research and development makes a firm more attractive to other firms with regards to links as such firms have more to offer. Significant firm investment in internal research and development thus prepares a solid foundation for a firm to develop greater external links and greater capacity to acquire and utilize external knowledge sources (Edquist, 2004; Lowe & Taylor, 1998). Such links enhance a firm's capacity in various activities such as research, production, marketing, and distribution, and thereby enhance not just the quality of a firm's innovative products but also its marketing and distribution capacity, which is crucial for successful commercialization.

The predicted value of commercialization is 14.61 times higher when a firm purchases intangible technology. The purchase of intangible technology increases the likelihood to commercialize innovations probably because most firms purchasing intangible technology have adequate commercialization capabilities, which they take advantage of once they utilize intangible technology to develop innovative products. The purchase of intangible technology indicates adequate commercialization capabilities of firms, and thereby enhances commercialization of innovations (Braunerhjelm & Svensson, 2010; Cohen et al., 2000).

Cooperation with other firms significantly influences commercialization of innovations in Tanzania, with cooperation with domestic firms (CODF) having a far larger impact on commercialization of innovations than cooperation with

foreign firms (COFF). The predicted value of commercialization, which has the greatest impact on commercialization of innovations amongst all the regressors, is 51.06 times higher when a firm cooperates with other domestic firms; compared to only being 6.6 times higher when it cooperates with a foreign firm. This indicates domestic links are more important than foreign links for firms in commercialization of innovations.

The relative importance of domestic cooperation over foreign cooperation in commercialization of innovations reveals that cooperation with domestic firms leads to greater benefits with respect to building commercialization capabilities. Such capabilities are determined by such things as marketing, distribution, and sales capacities in which domestic firms are better by virtue of being more conversant than foreign firms in the domestic market. This is consistent with Marx et al. (2014), Datta et al. (2012) and Gans and Stern (2003) who identified complementary assets such as manufacturing, distribution, marketing, sales, and support capabilities as being crucial for commercialization.

The effect of the regressors that significantly affect commercialization of innovations may differ depending on the initial value of a regressor. Therefore, we need to determine the impact of a regressor on commercialization at different values of the regressor. We do this by estimating the means of the marginal effects on the expected value of commercialization conditional on the different values of IRD, PINT, CODF and COFF.

Table 5 shows the estimated means of marginal effects on the expected value of commercialization given different value of the significant regressors.

Table 5: Estimated Means of Marginal Effects on Commercialization

	0	1
IRD	22.81661	29.96204
PINT	10.42632	13.59196
CODF	34.95555	46.43436
COFF	5.11733	5.730032

Table 5 reveals that investment in internal research and development, and purchase of intangible technology have greater impact on commercialization when a firm already has a history of investing in internal research and development and purchasing intangible technology rather than when a firm is doing so for the first time. The impact of cooperation with domestic firms and foreign firms on commercialization is greater when firms are already cooperating with domestic and foreign firms than when a firm is cooperating with domestic and foreign firms for the first time. The difference between the impact of cooperating with a firm with and without a history of cooperation is far greater for cooperation with domestic firms than for cooperation with foreign firms.

Investment in internal research and development, purchase of intangible technology, and cooperation with domestic and foreign firms enhances internal knowledge base and commercialization capabilities. Therefore, the fact that investment in internal research and development, purchase of intangible technology, and cooperation with domestic and foreign firms has greater impact on commercialization when firms have histories of doing so in the past indicates development of internal knowledge base and commercialization capabilities are important factors for commercialization. However, the development of commercialization capabilities via cooperation with domestic firms, which leads to enhanced marketing, distribution and sales capacities impact commercialization more than development of internal knowledge base via investment in internal research and development.

Given the specific objectives of this paper of determining the relative importance of firm, innovation and environmental level factors for commercialization and the extent to which innovation is linked with commercialization, Tables 4 and 5 reveal that environmental, firm and innovation factors all impact commercialization of innovation in Tanzania. However, cooperation with domestic firms, an environmental factor, has the greatest impact on commercialization; followed by investment in research and development (innovation-level factor), and purchase of intangible technology (firm-level factor).

On the link between innovation and commercialization, investment in internal research and development is the only variable that significantly impacts both product innovation and commercialization, implying that development of internal knowledge base is the main link between innovation and commercialization of innovations. This emanates from the fact that adequate internal knowledge base leads to the development of quality products that have high likelihood of meeting market needs.

5. Conclusion

Analysis of commercialization of innovations must take into account the fact that innovation is a necessary condition for commercialization, and therefore must analyse it before proceeding to analyse commercialization. The purchase of equipment, machinery or software is the main external source of knowledge in Tanzania, while firm investment in external research and development does not influence product innovation. Investment in internal research and development is the main source of internal knowledge in Tanzanian firms, while business knowledge and codified knowledge do not influence a firm's decision to undertake product innovation.

External knowledge complements internal knowledge in product innovation, implying that the more developed a firm's internal knowledge base, the more effective is external knowledge sourcing in facilitating product innovation.

Commercialization of innovations in Tanzania is influenced by cooperation with domestic and foreign firms, investment in research and development, and purchase of intangible technology; which are environmental-level, innovation-level, and firm-level factors respectively.

Investment in internal research and development, purchase of intangible technology, and cooperation with domestic and foreign firms has greater impact on commercialization when firms have histories of doing so in the past. This implies that more developed internal knowledge base and commercialization capabilities impact commercialization of innovations more than less developed ones. Cooperation with domestic firms has the largest impact on commercialization, followed by investment in research and development. Thus, commercialization capabilities obtained through cooperation with domestic firms impact commercialization of innovations more than internal knowledge base.

With regards to the link between innovation and commercialization, investment in internal research and development is the only variable that significantly impacts both product innovation and commercialization. Since investment in internal research and development is an important element of internal knowledge base, development of internal knowledge base is the main link between innovation and commercialization of innovations.

This study had several limitations. First, data used for the paper only provided information on firms established between 2010 and 2012, making it impossible to analyse the sustainability and dynamics of commercialization. Second, the data used lacked information on firms prior commercialization history that is needed to capture the evolution of commercialization over time. Third, the data lacked sufficient information on managerial aspects of decision-making, which can play a significant role in commercialization.

Given the limitations of the study, there are several areas for future research. One of the area can focus on analysing commercialization behaviour of firms over a longer period of time to analyse sustainability and dynamics of commercialization. Analysis of the evolution of commercialization over time and its impact on subsequent commercialization is another area for future research. Another area for future research is the analysis of commercialization by specific characteristics such as sectors, size of firms, and managerial characteristics in order to determine the impact of such factors on commercialization of innovations.

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