NETWORK FOR SOCIOECONOMIC RESEARCH AND ADVANCEMENT

WORKING PAPER

July, 2017

NESRA

nesra/wp/17/006

Types and drivers of innovation in the manufacturing sector of Ghana

Benedict Afful Jr
E-mail: benedictaffuljr@ucc.edu.gh

Gideon Owusu
E-mail: gideon.owusu@uni-jena.de

Types and drivers of innovation in the manufacturing sector of Ghana

Benedict Afful Jr [a c 1]
E-mail: benedictaffuljr@ucc.edu.gh

Gideon Owusu [b]
E-mail: gideon.owusu@uni-jena.de

[a] Department of Economics, University of Cape Coast, Cape Coast, Ghana
[b]Faculty of Economics, Friedrich-Schiller-Universität Jena, Jena, Germany
[c] Network for Socioeconomic Research and Advancement (NESRA), Accra, Ghana

Abstract
The study sought to identify the type and drivers of innovation with special reference to the manufacturing sector of Ghana. This study employed Probit regression model on the 2013 Ghana Enterprise Survey and the 2014 Ghana Innovation Follow-Up Survey. The results showed that market innovation is the predominant type of innovation among the manufacturing firms in Ghana. Product innovation and process innovation were found to be driven by internal R&D. It was also discovered that organisational innovation is positively driven by the age of the firm, training of production staff and internally installed internet. We further found that female top managers, internal R&D, training of production staff and internally installed internet drive market innovation. In order to aid the innovation activities, government should subsidize internal R&D activities and companies should engage in constant training of production staff in the manufacturing firms.

Keywords *– Innovation, R&D, Manufacturing, Technological, Ghana*

[1] Corresponding author: benedictaffuljr@ucc.edu.gh

1. Introduction

Economic growth, employment, the creation of value, wealth creation, competitiveness and high corporate performance among others, are the advantages that a firm and the nation gain from innovation. The ability to innovate technology seems to represent the highest degree of development of an industrial society (Halty, 1979). However, Wolf (2007) found that most African countries are under-developed because the capacity to innovate is quite low in those countries. It is usually believed that innovation holds the key to prosperity for firms, industries and countries. In view of this, many researchers, policy-makers, governments, firms, industries and other big institutions all over the world try to promote innovation at all levels.

Further, several researchers have looked at the determinants of innovation in the area of manufacturing. For instance, Lee (2004) analysed the determinants of innovation in the Malaysian manufacturing sector (food processing, apparel and textiles, woodwork, etc.) using firm-level data. Wignaraja (2008) additionally examined the links among ownership, innovation and exporting in electronics firms in three late industrialising East Asian countries (China, Thailand and the Philippines), drawing on recent trends in applied international trade, innovation and learning. Even though, there is considerable experience accumulated in the field of innovation policy in developed/OECD countries, much of which is not directly applicable to developing countries because of the nature of the challenges the latter are facing.

After gaining independence in 1957, Ghana has put in place many policies, structures, and institutions to encourage the development of science and technology. Due to this, governments of Ghana have provided means (National Board for Small Scale Industries, Ghana Regional Appropriate Technology Service, President's Special Initiative among others) to help develop science and technology in the micro, small and medium scale industries.

The surfacing of AGOA and other trade agreement between Ghana and her neighbouring countries, the United States and other giants from the West, offers good opportunities for the manufacturing firms in Ghana to expand their production due to a large market. This could lead to other indirect opportunities like increase employment, increase in tax revenue, varieties of goods and access to bigger and better market. However, the opportunities available to the firms in Ghana are under great stress since they are going to be faced with serious internal and international competition and the only way firms are going to succeed is to innovate. Innovation is therefore critical in the development of the individual, the household, firm and the nation as a whole (Abereijo et al., 2007). It is however surprising that this subject matter has not yet been given a serious look at in Ghana. Therefore, the determinants of innovation in the manufacturing firms in Ghana ought to be looked at.

The study, therefore, will help determine the drivers of innovation among manufacturing firms in some selected areas. This will help provide information that will enable manufacturing firms to understand the inputs of innovation and thereby adjust their operations accordingly. It will help to identify innovative options that would serve as an input for policy makers in formulating innovation policy in the industry, and also help the Association of manufacturing firms and MOFA in designing appropriate policy on innovation.

Therefore, the objectives of the study are: to identify the various types of innovation undertaken in the manufacturing sector of Ghana; to determine the effect of firm's size on innovation; to find out if training of production staff can stimulate innovation, and to investigate whether internal R&D can stimulate innovation.

This rest of the paper is organised as follows. Section two provides the literature review. Section three describes the research methodology that includes the source of data and analytical techniques. Section four presents the empirical results. Finally, the conclusions and recommendations are presented in Section five.

2. Literature Review

This section is divided into two, thus the theoretical and empirical literature review to help us gain better grounding for our work and also get an empirical support of our findings.

2.1 Theoretical literature

Innovation is basically, the introduction of new goods or new methods of production; the opening of a new market; conquest of a new source of supply of raw materials or half-manufacture goods; and implementation of a new form of organisation (Godin, 2008). In general, innovation is the first commercialization of newly generated ideas that result from the invention (Fagerberg & Verspagen, 2009). By its definition, all forms of innovation must contain a degree of novelty. OECD (2005) identifies three types of novelty such that, innovation can be "new to the firm", "new to the market" or "new to the world". Innovation "new to a firm" may have already been implemented by other firms. Through diffusion processes, a firm implements innovation of other firms. An innovation is new to the market if a firm is first to introduce the innovation to the market. Innovation can be new to the world when a firm is first to introduce the innovation to all markets and industries.

Innovation can be classified according to "type". Using the definition of Schumpeter, five types of innovation can be distinguished. They include new products, a new method of production, new sources of supply, exploitation of new markets and new ways to organise business. Economists normally focus on the first two; "product innovation" and "process innovation". Product innovation is the occurrence of new or improved goods and services whereas process innovation consists of improvements in how production is done. Process innovation aims at effectiveness and efficiency of the internal organisational processes towards production and distribution of goods and services to the consumer. Organisational innovation consists of new ways to organise production and distribution; as well as, arrangements across firms such as the re-organisation of entire industries. Market innovation consists of the use of an existing product in new ways and sometimes for a different segment of customers.

The process of innovation is explained by two models. The first model is the "Linear model" which was introduced by Schumpeter in the year 1912. The model is linear because there are defined stages that innovation is assumed to go through (Fagerberg & Mowery, 2009). The stages consist of research, development, production, marketing or diffusion and application. The invention takes place at the research stage whereas innovation takes place at the development stage. A marketable product is produced at the production stage and market success is achieved at the marketing or diffusion stage. Effects of the innovated product on the user and the society are observable at the application stage. The model means that "science leads to technology and technology satisfy market needs" (Edquist & Hommen, 1999). Thus, there is a smooth, uni-directional flow from basic scientific research to commercial applications. It makes a generalisation in regards to the source of innovation. It assumes that all innovation stems from scientific breakthroughs (Fagerberg & Mowery, 2009). Because of the uni-directional flow of the model, there is no feedback from the several later stages of the innovation process to the initial stage of research. Also, there is no feedback between any of the other stages. Though this model is very simplistic, it is consistent with the neoclassical economic theory of "market failure". Therefore, the need for government to support industrial R&D (Edquist & Hommen, 1999).

The "Chain-linked model" was developed by Klein and Rosenberg in the year 1986 to explain the possible feedbacks that exist between the various stages of the innovation process. Firms normally innovate for commercial purposes; as a result, the starting point towards innovation is making a review and (re)combination of existing knowledge. Firms only invest in research (science) when a review and a (re)combination of existing knowledge becomes futile. Often, the experience of users is the most relevant source of innovation and not necessarily science. Thus, the initial step in most innovations is not research. Moreover, the model posits that shortcomings and failures that occur at various stages of the innovation process may lead to a reconsideration of earlier steps. Consequently, such reconsideration may lead to totally new innovations (Fagerberg & Mowery, 2009). Therefore, innovation processes are in most cases non-linear.

2.2 Empirical literature

The fulcrum of literature shows that there are two sources of innovation which are ‘demand-pull’ and ‘science-push’ theories of innovation. In any case, the sources of innovation are able to produce two types of innovations (process and product/service) which have clear economic implications. On one hand, a product innovation corresponds to the creation of a new production function (Kamien & Schwartz, 1982), which includes the likelihood to discriminate an existing product (Beath et al., 1987; Vickers, 1986). On the other hand, a process innovation can be viewed as an outward shift of an existing supply function, which corresponds to lower variable costs in the production of an existing product or service, and is, therefore, a productivity increase (Beath et al., 1987; Dasgupta & Stiglitz, 1980).

Kumar and Saqib (1994) studied firm size, opportunities for adaptation and in-house R&D activity in developing countries using the case of Indian manufacturing as a proxy. Using a sample of 291 Indian manufacturing firms, they employed Probit and Tobit models to analyse the determinants of the probability of undertaking R&D. Their empirical findings suggest that there is a positive relationship between firm size and undertaking R&D. They, therefore, concluded that the probability of undertaking R&D increases when firm size is increasing. Some studies from the developed economies claim that innovation output is negatively related to firm size (Hansen, 1992; Stock et al., 2002). However, innovation literature from the developing economies generally describes a positive relationship between firm size and innovation output (Mel, McKenzie, & Woodruff, 2009; Miguel Benavente, 2006).

Segarra-Blasco (2010) studied innovation and productivity in manufacturing and service firms in Catalonia using a regional approach. The determinants of research and development were analysed in the research. The empirical analysis revealed that in Catalonia, high-tech knowledge-intensive services (KIS) play a strategic role in promoting innovation in both manufacturing and service industries. Moreover, their empirical results show that new firms are likely to create a greater R&D intensity than incumbent firms. Hansen (1992) by using a National Science Foundation (NSF) dataset, discovered that firm age is inversely related to innovation, whereas Radas and Božić (2009) demonstrated that it has no influence on both product and process innovation of the Croatian firms.

Dachs et al. (2008), by using the CIS of five European countries, were unable to find a relationship between foreign ownership and innovation expenditure, except for Norway where they found a negative relationship. They also found that foreign ownership increases firm's innovation output, except in the case of Austria. However, for developing countries, Braga and Willmore (1991) demonstrated a positive influence of foreign ownership on five different input and output innovation activities; nevertheless, the relationship was insignificant for R&D expenditure. Pla-Barber and Alegre (2007) established a direct relationship between innovation outcomes and export intensity for the French bio-technology industry. For 43 developing countries, Seker (2011)found that firms' external trade has a significant effect on their innovativeness.

Leiponen (2005) asserted that a highly educated workforce has a positive impact on its innovative activities. Radas and Božić (2009) found a positive relationship between employees' education levels and radical product innovation; nevertheless, they were unable to find any relationship between education and process innovation. Hage and Aiken (1967) argued that knowledge depth, as measured by the extent of professional training, is positively correlated with innovation. Swan & Newell (1995) also revealed that on-the-job training is positively associated with innovation. Later studies, by Du and Girma (2007) did a similar thing and found that training is positively related to innovation.

3. Methodology

3.1 Source of Data and Data

The data used for this study was sourced from the Ghana 2013 enterprise survey (ES) and Ghana innovation follow-up survey (to the Ghana 2013 enterprise survey) conducted in Ghana in 2014. In 2011, the Enterprise Analysis Unit in collaboration with DFID launched the Ghana Innovation Follow-up Survey (GIFS). The main aim of the survey is a follow-up survey to the standard Enterprise Survey (ES) and re-visits firms already interviewed during the ES to collect firm-level data on innovation and innovation-related activities.

It must be noted that the Innovation Follow-up Survey was tailored along the Enterprise Survey global methodology to collect data on product innovation, process innovation, organisational innovation, and marketing innovation. The survey was administered to a subset of ES respondents randomly selected in order to have a final sample of 75% of the original ES. In all, 549 (284 manufacturing and 265 services) firms were successfully interviewed and 4 firms declined to participate in the survey. The survey fell between January 2014 and August 2014 with the primary respondent being the business owners and top managers.

For the purposes of this study, we made use of only the 284 manufacturing firms in the dataset (see Appendix 1 for the details). The data were processed and analysed using STATA version 13 to generate the results. The unit of analysis was the firm.

3.2 Methods and model

Model specification

In accordance with the stated objectives and the research questions raised, the researchers followed the conventional practice of using a discrete and limited dependent variable model. To examine the determinants of manufacturing firms' ability to innovate in Ghana, the bivariate probit was employed. The fact that the dependent variables are dichotomous one is justifiable in using any binary model. We adopted the probit model partly because of its ability to resolve the problem of heteroscedasticity (Asante et al., 2011). The propensity of a manufacturing firm to innovate is modelled as:

$$y_i^* = X_i^{'}\beta + \mu_i \qquad (1)$$

Where

$$y_i = \begin{cases} 1 & \text{if } y^* > 0 \text{ i.e. firm i innovatives} \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$

X_i is the set of explanatory variables and µ the error term.

Given the assumption of normality, the probability that y_i^* is less than or equal to y_i can be computed from the normal cumulative normal distribution (Akinola & Owombo, 2012) as:

$$P_i = P\left(Y = \frac{1}{X}\right) \qquad (3)$$

$$P_i = P\left(y_i^* < y_i\right) \qquad (4)$$

$$P_i = P\left(Z_i < \beta_0 + \beta_j X_{ij}\right) = \mathrm{F}\left(Y_i\right) \qquad (5)$$

$$P\left(Y = \frac{1}{X}\right) = F\left(X\beta\right) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{X\beta} e^{\frac{-(X\beta)^2}{2}} dx \qquad (6)$$

where y_i^* is the critical or threshold level of the index, such that if y_i exceeds y_i^*, the firm innovate, otherwise the firm does not. $P\left(Y = \frac{1}{X}\right)$ is taken as the probability that the firm innovate given the values of the explanatory variables X, and Z_i is a random variable normally distributed with mean zero and unit variance, $Z_i \sim N(0, \sigma^2)$.

The explanatory variables were selected based on empirical literature and intuition. The set of explanatory variables hypothesized to influence firms' decision to innovate includes age of the firm (*Agef*), size of the firm (*Sizef*), top manager is female (*Topmf*), international recognized quality certificate (*IRQC*), internal R&D (*InRD*), external R&D (*ExED*), trained production staff (*Trdps*), and internal internet (*Innet*). The full empirical model for the determinants of innovation in the manufacturing sector of Ghana can be explicitly expressed as:

$$Innov = \beta_0 + \beta_1 Agef + \beta_2 Sizef + \beta_3 Topmf + \beta_4 IRQC + \beta_5 InRD + \beta_6 ExRD$$
$$+\beta_7 Trdps + \beta_8 Innet + \beta_9 InRD * Innet + \beta_{10} InRD * ExRD + \varepsilon \qquad (7)$$

Where the measurements of the variables and their a priori expectations in the probit model (equation 7) are presented in Table 1.

Table 1: Operationalization of variables

Variable	Measurement	Expected sign
Innovation (Innov)	=1, if the firm has any form of innovation; =0, if otherwise	
Product innovation (PTinnov)	=1, if the firm has a significant change in product; =0, if otherwise	
Process innovation (PRinnov)	=1, if the firm has a significant change in the method of production; =0, if otherwise	
Organisational innovation (ORinnov)	=1, if the firm has a significant change in the management and institutional structure; =0, if otherwise	
Market innovation (MTinnov)	=1, if the firm has a significant change in the channels of distribution and advertising; =0, if otherwise	
Age of the firm	=Number of years the enterprise has been in existence	+
Firm size	=Number of full-time employee	+/-
Gender	=1, if the top manager is a female; =0, if otherwise	-
Int. Recognised quality cert.	Yes=1; No=0	+
Internal R&D	Yes=1; No=0	+
External R&D	Yes=1; No=0	+
Training of production worker	=Percentage of permanent full-time production employees received formal training	+
Internally stalled internet	Yes=1; No=0	+

4. Results and Discussions

This section is divided into two parts that are the descriptive statistics and the regression results. We used the descriptive statistics to explain the possible trends and the implications of these trends. In other to address our research questions, a probit model was estimated to help us determine the various drivers of innovation in the Ghanaian manufacturing industry.

Descriptive statistics of the study

As can be seen from Table 2, the majority (79.23%) of the manufacturing firms were engaged in innovation whiles few (20.77%) were non-innovative. Thus, many manufacturing firms have embraced the new ways of doing business whiles few other are comfortable or have not figured out how to bring change to the firms.

Table 2: Innovation status

Firm status	Number of firms	Percentage
Innovative	225	79.23
Non-innovative	59	20.77
Total	284	100.00

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data

Our findings confirm the results of Tetteh and Essegbey (2014), who found that innovation is more prevalent in the manufacturing sector of Ghana. However, Tetteh and Essegbey (2014) and other researchers on innovation in the manufacturing sector in Ghana said little about the composition of this innovation prevalent. Table 3, therefore, presents the percentage of innovative firms that are engaged in the various types of innovations in the manufacturing sector.

Table 3: Types of innovation

Innovation type	Number of firms	Percentage
Product innovation	76	33.78
Process innovation	91	40.44
Organizational innovation	52	23.11
Market innovation	200	88.89
Total	225	100.00

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data
NB: Multiple responses

It can be inferred from Table 3 that out of the 225 innovative firms used in the sample, 88.89 percent had market innovation only or with some other form of innovation. This makes market innovation the most prominent innovation type practised by Ghanaian manufacturing firms. It is not surprising that more of the manufacturing firms are engaged in market innovation. The possible reasons could be that it is cheaper to market innovate or because the firms' products are being exported to different parts of the world/markets and therefore must look attractive to all.

Table 4: Types of Market Innovation

Type of market innovation	Number of firms	Percentage
Packaging	94	47.00
Branding, logo, name, or trademark	44	22.00
Products' appearance, excluding packaging or branding	111	55.50
Advertising methods	57	28.50
Promotion of the product or service	74	37.00
Sales channels or sales points	76	38.00
Discount schemes	87	43.50
Pricing strategies, excluding discount schemes	102	51.00
Payment schemes	93	46.50
Customer loyalty rewards	92	46.00
Total	**200**	**100.00**

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data

Taking a critical look at the market innovation, it was discovered in Table 4 that Ghanaian manufacturing firms usually embark on pricing strategies (excluding discount schemes), packing and products' appearance (excluding packaging or branding). However, the Ghanaian manufacturing firms are highly involved in products' appearance (excluding packaging or branding) followed by pricing strategies (excluding discount schemes) and packing. It is also evident from Table 4 that about 47 percent of firms observed in the study changed their product appearance between 2010 and 2012. However, branding, logo, name or trademark, as well as advertising methods, are the bottom two types of market innovations recorded by the manufacturing firms in Ghana with a representation of 22 percent and 28.50 percent respectively.

Table 5: Number of innovations firms engaged in

Number of innovation firm engaged in	Number of firms	Percentage
1	102	45.33
2	71	31.56
3	33	14.67
4	19	8.44
Total	225	100.00

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data

It is evident from Table 5 that majority (45.33% which translates into 102 firms) of the innovated firms engaged in one type of innovation whiles few (8.44%) firms innovated in all the four folds of innovation. See Appendix 2 for the full details.

Table 6: Descriptive statistics of the explanatory variables

Variable			Frequency	Percentage
Female top manager			44	15.49
International recognition quality certificate			28	9.86
Internal R&D			59	20.77
External R&D			10	3.52
Training of production staff			85	29.93
Internally installed internet			156	54.93
Internal R&D and use of internally installed internet			45	15.85
Internal R&D and external R&D			7	2.46
	Mean	**Std. Dev.**	**Min**	**Max**
Age of the firm	14.79225	11.90195	0	75
Firm size	10.61972	33.13293	1	500

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data

The results in Table 6 shows the statistical breakdown of the explanatory variables considered in the research. Among the number of firms studied in the research, 44 (15.49%) have their top managers to be females; this is a clear indication that majority of manufacturing firms in Ghana have their top notch personal to be males. It can be noticed in Table 6 above that many Ghanaian manufacturing firms do not have International recognition quality certificate. Only 28 (9.86%) firms involved in the study have International recognition.

The study identified 59 (20.77%) firms who are involved in internal R&D. The study indicates that 10 firms under the study employ externally-generated R&D. This represents a meagre 3.52 percent of the firms under the study. Surprisingly, only 2.46 percent of the entire sample size are engaged in both internal and external R&D.

It can also be observed that 85 (29.93%) firms considered in the researchers trained their production staff within the study period. This shows how manufacturing firms give less attention to the training of production staffs. This practice is likely to have a toll on the firms' ability to innovate in product or process.

It is evident from Table 6 that major (54.93%) of the manufacturing firms have internet connections in their organisations. One would have thought these internet connections could have encouraged the firms to do more of the internal research. However, only 45 of these firms uses the internally installed internet for research.

As it can be seen from Table 6, the mean age of a manufacturing firm in Ghana is about 15 years with the maximum age of 75 years. The average number of people employed in a manufacturing firm in Ghana is 10 workers with a maximum employment going as high as 500 persons.

Table 7: Probit Estimates of drivers of innovations in the manufacturing sector of Ghana

Variable	Product innovation		Process innovation		Organization innovation		Market innovation		Any form of innovation	
	Coeff.	Marginal effect	Coeff.	Marginal effect	Coeff.	Marginal effect	Coeff.	Marginal effect	Coeff.	Marginal effect
Age of the firm	0.0018	0.0006	-0.0126*	-0.0044	0.0176**	0.0040	-0.0055	-0.0018	-0.0070	-0.0014
	(0.0074)		(0.0077)		(0.0076)		(0.0073)		(0.0081)	
Firms size	-(0.0010)	-.0003	0.0001	0.0005	0.0022	0.0005	0.0088	0.0028	0.0096	0.0019
	(0.0032)		(0.0025)		(0.0024)		(0.0074)		(0.0091)	
Female top manager	0.5287**	0.1882	-0.1438	-0.0487	0.1005	0.0234	0.5571**	0.1536	0.6660**	0.0986
	(0.2247)		(0.2360)		(0.2668)		(0.2530)		(0.2953)	
International recognition	0.3412	0.1195	-0.0283	-0.0098	-0.0962	-0.0207	0.0708	0.0222	0.3250	0.0543
quality certificate	(0.2829)		(0.2895)		(0.3260)		(0.3082)		(0.3823)	
Internal R&D	1.5114***	0.5413	1.1388***	0.4242	0.5451	0.1431	0.8057*	0.2134	4.9904	0.4386
	(0.3981)		(0.3843)		(0.4428)		(0.4501)		(207.4528)	
External R&D	5.6067	0.7989	-0.0784	-0.0268	0.4036	0.1087	4.1750	0.3027	4.2762	0.1490
	(167.2127)		(0.7843)		(0.7856)		(209.667)		(441.9821)	
Training of production staff	0.3042	0.1024	0.6674***	0.2432	0.5162***	0.1288	0.6513***	0.1883	0.6162**	0.1047
	(0.1964)		(0.1886)		(0.2092)		(0.2213)		(0.2600)	
Internal installed internet	0.2441	0.0786	0.2518	0.0870	0.7823***	0.1694	0.4847***	0.1567	0.6994***	0.1438
	(0.1990)		(0.1900)		(0.2453)		(0.1831)		(0.2003)	
Internal R&D and external	-6.5028	-0.3157	-0.2978	-0.0952	-0.9591	-0.1249	-4.4409	-0.7801	-4.9517	-0.9053
R&D	(167.2138)		(0.9654)		(0.9913)		(209.668)		(441.9826)	
Internal R&D and use of	-1.0522**	-0.2544	-0.4084	-0.1305	-0.1733	-0.0365	-0.6688	-0.2391	-4.9379	-0.9743
internal installed internet	(0.4651)		(0.4528)		(0.5047)		(0.5343)		(207.4531)	
Constant	-1.1819***		-0.8111		-2.0227***		-0.0028		0.2061	
	(0.1837)		(0.1739)		(0.2413)		(0.1660)		(0.1772)	
Number of observation	284		284		284		284		284	
Likelihood Ratio X^2	44.79***		49.01***		46.90***		38.45***		44.31***	
Log Likelihood	-142.5701		-153.6152		-111.7489		-153.2327		-122.9575	
Pseudo R^2	0.1358		0.1376		0.1735		0.1115		0.1527	
Hosmer-Lemeshaw Prob>X^2	0.3991		0.2654		0.0565		0.1496		0.4816	
Specification Linktest (hatsq)	0.0960 (0.2980)		-0.1915 (0.2820)		0.0700 (0.2076)		-0.1500 (0.0922)		-0.1079 (0.1179)	

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data

The probit model was used to estimate the drivers of innovation in the Ghanaian manufacturing sub-sector. The likelihood ratio test indicates that the appropriate model does not contains only a constant (intercept) term but other explanatory variables. The Pseudo R-squared values indicate that 13.58 percent, 13.76 percent, 17.35 percent, 11.15 percent and 15.27 percent of the variations in the product innovation, process innovation, organisational innovation, market innovation and general innovation respectively are explained by the independent variables. The specification linktest scores show that the models are correctly specified and it's only by chance that additional explanatory variables can be found. It was also found that the age of the firm, female top manager, internal R&D, training of production staff, internally installed internet, and internal R&D with the use of internally installed internet are important discriminants among innovative and non-innovative manufacturing firms in Ghana.

Our results indicate that the age of the firm can influence both process and organisational innovation. It is interesting to see the age of the firm influencing process innovation negatively whiles it affects organisational innovation positively. From Table 7, it is clear that a unit increase in the age of a firm result in a decrease in the probability to process innovate. On the other hand, a unit increase in the age of the firm increases the probability of the firm engaging in organisational innovation. This means that a firm is more likely to be innovative in its management and institutional structure as it ages but less likely to process innovate. Studies by Hansen (1992) and Huergo and Jaumandreu (2004) supports the negative effect of the age of the firm on process innovation. Sørensen and Stuart (2000) also support the positive relationship between firm's age and organisational innovation.

The presence of a female top manager in a manufacturing firm has a significantly positive effect on innovation output (product and market innovation). This indicates that firms with female top managers are more likely to innovate, compared to those with male top managers. Due to the marketing skills of females, firms that have female top managers stands a better chance of getting different ways of marketing their produce. Also, females are known of being selective and more observant than men, they are likely to think of different types of product which can be a good source of product innovation.

Internal R&D is positively related to product innovation, process innovation, and market innovation. Our results suggest that firms that pursue internal R&D are 54, 42 and 21 percent more likely to product innovate, process innovates and market innovates respectively as compared to those that do not pursue internal R&D. Our finding supports the view that internal R&D plays a major role in increasing firms' innovation performance (Conte & Vivarelli, 2014; Garcia-Quevedo et al., 2014; Hall & Bagchi-Sen, 2002; Karlsson et al., 2015). Similarly, Artz et al. (2010), Mairesse and Mohnen (2005), Ganotakis and Love (2011), and Gallié and Legros (2012) revealed that internal R&D has a strong and positive impact on firms' innovation output. As shown in Table 7, internal R&D seems to have a greater effect on product innovation, process innovation, and market innovation as compared to the other variables. This means that internal R&D allow firms to fully capture the benefits of outsourced technology sources, evaluate and recognise external sources that they can integrate and use (Cohen & Levinthal, 1990; Escribano et al., 2009) to achieve of increase innovative outputs.

The regression results show that the percentage of the permanent full-time production staffs formally trained matters a lot in process innovation, organisational innovation, market innovation and innovation in general but does not matter in product innovation. As shown in Table 7, the higher the percentage of production staff with formal training the higher the probability to process innovate, organisational innovate, market innovate and innovation in general. This result is in line with our expectation and intuitively right. A Large proportion of production staff with formal training gives the firm a larger base of resources with a better understanding of how things work in the organisation or industry, the structure of the organisation and even where to get the needed raw materials for production. This is likely to bring a lot of innovations to the firm especially in the area of process innovation, organisational innovation and market innovation as suggested by our results.

The probability of a firm to organisational innovate, market innovate and innovate in general were positively influenced by the internally installed internet. Firms that have internally installed internet are more likely to innovate (organisational innovation, market innovation and general innovation) relative to those who have not the internally installed internet. The probability to organisational innovate, market innovate and innovate in general by firms that had internally installed internet were 17, 16 and 14 respectively higher than those without internally installed internet. Firms with internally internet connections are able to search for new markets and trends of organisational arrangements for adoption.

Finally, the interactive term, internal R&D and use of the internally installed internet was negatively associated with the probability of product innovate. The marginal effect indicates that the probability of product innovate by internal R&D using the internally installed internet was 25 lower than internal R&D without the using internally installed internet. Firms that embarked on internal R&D via internally installed internet turns not to be paying attention to the R&D but may be browsing or doing their own works. The implication of our result is that internally installed internet alone is not enough for internal R&D to produce product innovation but rather a factor to help reduce the likelihood of producing product innovation.

5. Conclusion and Recommendations

Innovation is a key factor in addressing most of the unfavourable competitions that local manufacturing firms face from their foreign rivals. The predominant type of innovation among the manufacturing firms was found to be market innovation followed by process innovation, product innovation and organisational innovation. Econometrically, the age of the firm, female top manager, internal R&D, training of production staff, internally installed internet, and internal R&D via the internally installed internet are important discriminants among innovative and non-innovative manufacturing firms in Ghana. In other words, these are the factors that create the needed innovations in the Ghanaian manufacturing sub-sector. The study found that firms with a female top manager, internal R&D, and firms that run their internal R&D with internally installed internet are more likely to create product innovation. Process innovation, on the other hand, is driven by young firms, internal R&D, and training of large proportion of production staff. It was also evident that increase in the age of the firm, training of production staff and the use of internally installed internet engender organisational innovation. Market innovation and innovation, in general, were found to be positively driven by a female top manager, training of high proportion of production staffs, and internally installed internet but internal R&D influenced only market innovation.

Therefore, for a manufacturing firm to be competitive and survival on the market, the firm must undertake innovation which will translate into a reduction of it's per unit cost of production. Given that the cost of internal R&D is high, the government can subsidise R&D of the firms via fiscal incentives such as the reduction of the firm's tax burden related to internal R&D. Such incentives include special exemption of wage for R&D employees, tax credits on internal R&D, special R&D allowance and accelerated depreciation schemes for investments made into R&D activities. An alternative to the fiscal incentive could be a directing funding of R&D by the government for targeted firms.

Moreover, training of production staff is essential for the innovativeness of a firm, thus, on the job training should be encouraged by manufacturing firms. Again, regulators, directors and managers of the manufacturing firms are encouraged to make females to be part of their top managers, embark on internal R&D, and use their internally installed internet for their R&D activities. Further research should be undertaken to know the regional distribution of innovative firms in Ghana; hence, finding regional specific factors that influence firms to undertake innovation. In addition, such a research can help to identify the necessary policies that the government can adopt to support networks among actors of innovation within and between the ten regions of the country. Additional cooperative activities around issues such as training and technological development can be developed via networks.

6. Acknowledgements

We wish to thank The World Bank and DFID for ensuring the implementation of the 2013 Ghana Enterprise Survey and the 2014 Ghana Innovation Follow-Up Survey.

7. References

Abereijo, I. O., Ilori, M. O., Taiwo, K. A., & Adegbite, S. A. (2007). Assessment of the capabilities for innovation by small and medium industry in Nigeria. *African Journal of Business Management*, *1*(8).

Akinola, A., & Owombo, P. (2012). Economic analysis of adoption of mulching technology in yam production in Osun State, Nigeria. *International Journal of Agriculture and Forestry*, *2*(1), 1–6.

Artz, K. W., Norman, P. M., Hatfield, D. E., & Cardinal, L. B. (2010). A longitudinal study of the impact of R&D, patents, and product innovation on firm performance. *Journal of Product Innovation Management*, *27*(5), 725–740.

Asante, B. O., Afari-Sefa, V., & Sarpong, D. B. (2011). Determinants of small-scale farmers decision to join farmer based organisations in Ghana. *African Journal of Agricultural Research*, *6*(10), 2273–2279.

Beath, J., Katsoulacos, Y., & Ulph, D. (1987). Sequential product innovation and industry evolution. *The Economic Journal*, *97*, 32–43.

Braga, H., & Willmore, L. (1991). Technological imports and technological effort: an analysis of their determinants in Brazilian firms. *The Journal of Industrial Economics*, 421–432.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 128–152.

Conte, A., & Vivarelli, M. (2014). Succeeding in innovation: key insights on the role of R&D and technological acquisition drawn from company data. *Empirical Economics*, *47*(4), 1317–1340.

Dachs, B., Ebersberger, B., & Lööf, H. (2008). The innovative performance of foreign-owned enterprises in small open economies. *The Journal of Technology Transfer*, *33*(4), 393–406.

Dasgupta, P., & Stiglitz, J. (1980). Industrial structure and the nature of the innovative activity. *The Economic Journal*, *90*(358), 266–293.

Du, J., & Girma, S. (2007). Finance and firm export in China. *Kyklos*, *60*(1), 37–54.

Edquist, C., & Hommen, L. (1999). Systems of innovation: theory and policy for the demand side1. *Technology in Society*, *21*(1), 63–79.

Escribano, A., Fosfuri, A., & Tribó, J. A. (2009). Managing external knowledge flows: The moderating role of absorptive capacity. *Research Policy*, *38*(1), 96–105.

Fagerberg, J., & Mowery, D. C. (2009). *Innovation: A Guide to the Literature*: Oxford University Press. Retrieved from //www.oxfordhandbooks.com/10.1093/oxfordhb/9780199286805.001.0001/oxfordhb-9780199286805-e-1

Fagerberg, J., & Verspagen, B. (2009). Innovation studies—The emerging structure of a new scientific field. *Research Policy*, *38*(2), 218–233.

Gallié, E.-P., & Legros, D. (2012). French firms' strategies for protecting their intellectual property. *Research Policy*, *41*(4), 780–794.

Ganotakis, P., & Love, J. H. (2011). R&D, product innovation, and exporting: evidence from UK new technology-based firms. *Oxford Economic Papers*, *63*(2), 279–306.

Garcia-Quevedo, J., Pellegrino, G., & Vivarelli, M. (2014). R&D drivers and age: Are young firms different? *Research Policy*, *43*(9), 1544–1556.

Godin, B. (2008). In the shadow of Schumpeter: W. Rupert Maclaurin and the study of technological innovation. *Minerva*, *46*(3), 343–360.

Hage, J., & Aiken, M. (1967). Relationship of centralization to other structural properties. *Administrative Science Quarterly*, 72–92.

Hall, L. A., & Bagchi-Sen, S. (2002). A study of R&D, innovation, and business performance in the Canadian biotechnology industry. *Technovation*, *22*(4), 231–244.

Halty, C. M. (1979). *Technological Development Strategies for Development Countries: A review for Policy Makers*: Montreal, IRP.

Hansen, J. A. (1992). Innovation, firm size, and firm age. *Small Business Economics*, *4*(1), 37–44.

Huergo, E., & Jaumandreu, J. (2004). How does probability of innovation change with firm age? *Small Business Economics*, *22*(3), 193–207.

Kamien, M. I., & Schwartz, N. L. (1982). *Market structure and innovation*: Cambridge University Press.

Karlsson, C., Tavassoli, S., & others. (2015). Innovation Strategies and Firm Performance. *Centre of Excellence for Science and Innovation Studies Working Paper Series*, *401*.

Kumar, N., & Saqib, M. (1994). *Firm size, opportunities for adaptation, and in-house R&D activity in developing countries: the case of Indian manufacturing*: United Nations University.

Lee, C. (2004). The determinants of innovation in the Malaysian manufacturing sector: an econometric analysis at the firm level. *ASEAN Economic Bulletin*, 319–329.

Leiponen, A. (2005). Organisation of knowledge and innovation: the case of Finnish business services. *Industry & Innovation*, *12*(2), 185–203.

Mairesse, J., & Mohnen, P. (2005). *The importance of R&D for innovation: a reassessment using French survey data*: Springer.

Mel, S. de, McKenzie, D. J., & Woodruff, C. M. (2009). Innovative firms or innovative owners? Determinants of innovation in micro, small, and medium enterprises.

Miguel Benavente, J. (2006). The role of research and innovation in promoting productivity in Chile. *Economics of Innovation and New Technology*, *15*(4-5), 301–315.

OECD/Eurostat. (2005). Oslo Manual: Guidelines for collecting and interpreting innovation data. Advance online publication. https://doi.org/10.1787/9789264013100-en

Pla-Barber, J., & Alegre, J. (2007). Analysing the link between export intensity, innovation and firm size in a science-based industry. *International Business Review*, *16*(3), 275–293.

Radas, S., & Božić, L. (2009). The antecedents of SME innovativeness in an emerging transition economy. *Technovation*, *29*(6), 438–450.

Segarra-Blasco, A. (2010). Innovation and productivity in manufacturing and service firms in Catalonia: a regional approach. *Economics of Innovation and New Technology*, *19*(3), 233–258.

Seker, M. (2011). *Importing, Exporting, and Innovation in Developing Countries*. MPRA Paper. Retrieved from University Library of Munich, Germany website: http://EconPapers.repec.org/RePEc:pra:mprapa:29904

Sørensen, J. B., & Stuart, T. E. (2000). Ageing, obsolescence, and organisational innovation. *Administrative Science Quarterly*, *45*(1), 81–112.

Stock, G. N., Greis, N. P., & Fischer, W. A. (2002). Firm size and dynamic technological innovation. *Technovation*, *22*(9), 537–549.

Swan, J. A., & Newell, S. (1995). The role of professional associations in technology diffusion. *Organisation Studies*, *16*(5), 847–874.

Tetteh, E. K., & Essegbey, G. O. (2014). Firm-level innovation: The case of Ghanaian firms. *European Journal of Business and Innovation Research*, *2*(2), 1–18.

Vickers, J. (1986). The evolution of market structure when there is a sequence of innovations. *The Journal of Industrial Economics*, 1–12.

Wignaraja, G. (2008). *FDI and Innovation as Drivers of Export Behaviour: Firm-level Evidence from East Asia*. MERIT Working Papers (No. 061). Retrieved from United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT) website: http://EconPapers.repec.org/RePEc:unm:unumer:2008061

Wolf, S. (2007). *Encouraging innovation for productivity growth in Africa*: African Trade Policy Centre, Economic Commission for Africa.

Appendix 1

ISIC	Type of firm	OECD Product classification	Product innovation	Process innovation	Organizational innovation	Market innovation	Any form of innovation	Observations	Percentage
15	Food	Low-Tech	9	10	8	30	35	**40**	**14.08**
17	Textiles	Low-Tech	3	1	0	4	6	**6**	**2.11**
18	Garments	Low-Tech	4	5	1	14	14	**15**	**5.28**
19	Leather	Low-Tech	2	1	0	4	4	**4**	**1.41**
20	Wood	Low-Tech	2	6	3	10	13	**20**	**7.04**
21	Paper	Low-Tech	0	1	1	2	2	**2**	**0.70**
22	Publishing, printing, and Recorded Media	Low-Tech	9	18	11	35	37	**44**	**15.49**
23	Refined petroleum product	Medium-High-Tech	0	1	0	1	1	**1**	**0.35**
24	Chemicals	Low-Medium-Tech	11	11	9	18	19	**24**	**8.45**
25	Plastics & Rubber	Low-Medium-Tech	4	5	5	11	11	**15**	**5.28**
26	Non-metallic mineral products	Medium-High-Tech	2	2	0	7	7	**10**	**3.52**
27	Basic metals	Low-Medium-Tech	3	2	2	7	10	**16**	**5.63**
28	Fabricated metal products	Low-Medium-Tech	12	11	4	26	32	**46**	**16.20**
29	Machinery and equipment	Medium-High-Tech	1	0	0	2	2	**3**	**1.06**
31&32	Electronics	High-Tech	0	0	0	3	3	**3**	**1.06**
33	Precision instruments	High-Tech	0	1	0	1	1	**1**	**0.35**
35	Transport machines	Medium-High-Tech	0	1	0	1	1	**1**	**0.35**
36	Furniture	Low-Tech	10	12	5	15	17	**22**	**7.75**
37	Recycling	Low-Tech	1	1	1	1	1	**1**	**0.35**
45	Construction	NA	0	0	0	2	2	**2**	**0.70**
	Others	NA	3	2	2	6	7	**8**	**2.81**
	Total		**76**	**91**	**52**	**200**	**225**	**284**	**100.00**

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data

Appendix 2

	Product innovation	Process innovation	Organizational innovation	Market innovation
Product innovation	9	4	0	19
Process innovation	4	5	0	33
Organizational innovation	0	0	7	15
Market innovation	19	33	15	81
Process & organisational innovation	0	na	na	8
Process and market innovation	22	na	8	na
Organizational & market innovation	3	8	na	na
Product & organisational innovation	na	0	na	3
Product and market innovation	na	22	3	na
Product and process innovation	na	na	0	22
All	19	19	19	19
Total	**76**	**91**	**52**	**200**

Source: Authors' own calculations based on 2013 ES and 2014 GIFS data