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Foreign Direct Investment and Technological Upgrading among Manufacturing Firms in Ghana

Abena D. Oduro
Agyapomaa Gyeke-Dako
Priscilla Twumasi Baffour
F. Ebo Turkson

We investigate whether foreign owned firms are more likely than domestic firms to introduce new products and processes. This issue is particularly relevant given the importance that policy in Ghana places on the link between FDI and innovation. The majority of manufacturing firms that innovate tend to simultaneously introduce new products and new processes. Using a bivariate probit model we find that wholly-owned and partially-owned foreign firms are more likely than domestic firms to introduce new products, however partially-owned foreign firms are more likely than domestic firms to process innovate whilst there is no difference between wholly owned and domestic firms in the probability of process innovation. In addition we find a positive relationship between research and development and both process and product innovation.

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Abena D. Oduro

Department of Economics and Centre for Social Policy Studies, University of Ghana

Agyapomaa Gyeke-Dako

Department of Finance, UGBS, University of Ghana

Priscilla Twumasi Baffour

Department of Economics, University of Ghana

F. Ebo Turkson

Department of Economics, University of Ghana

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1. Introduction

Foreign direct investment (FDI) has become increasingly important to Ghana's economy. In the 1980s and early 1990s net FDI inflows were less than 1 percent of gross domestic product (GDP). The ratio averaged 2.2 percent between 1993 and 2005, rising to an average of 7.7 percent between 2006 and 2014 (World Bank, 2016). The stock of inward FDI is estimated to have risen from US$319 million in 1990 to US$23,205 million in 2014 (UNCTAD, 2015). In policy documents such as the first poverty reduction strategy paper for the period 2003-2005, FDI is considered important for a number of reasons including being a vehicle for the transfer of technology (International Monetary Fund, 2003). The Ghana Shared Growth and Development Strategy for the period 2010-2013 identified technology and innovation as the bases that would provide the impetus for structural economic transformation by 2020 (Government of Ghana, 2010). The Ghana Shared Growth and Development Strategy recognised the importance of foreign direct investment as a channel for technology transfer. Indeed it stated that '…if FDI should be beneficial to Ghana, one of the basic principles is that it must promote the transfer of technology' (Government of Ghana 2010, p. 26).

There are several channels whereby FDI can lead to innovation in the host country. The first is through the introduction of new products and/or processes by the foreign affiliate. Second, the presence of a foreign firm in an industry can generate spillover effects that will either encourage or force domestic firms to innovate if they want to remain competitive (Javorcik, 2008). Workers employed by foreign firms may either set up their own businesses or else transfer knowledge when they are employed by other firms in the industry. The focus of this paper is on the first channel. The objective of the paper is to investigate whether foreign owned firms are more likely than domestic firms to introduce new products and processes. This question is particularly important given the importance that policy in Ghana places on the link between FDI and innovation. The study of factors associated with innovation in

developing countries is only beginning to gain some momentum. One such study on Ghana investigates entrepreneurs' characteristics and innovation (Robson et al, 2009). The focus of that study by design excludes an analysis of the link between FDI and innovation. The present paper contributes to the literature on the determinants of innovation in developing countries and Africa in particular. It departs from the previous study by Robson et al, (2009) by focusing only on product innovation (the introduction of new products) and process innovation (the introduction of new methods of production) by manufacturing firms and does not place a limit on the size of firms sampled.

We find that FDI is positively associated with product and process innovation among manufacturing firms in Ghana. Wholly-owned and partially-owned foreign firms (i.e. joint ventures) are more likely than domestic firms to introduce new products, however partially-owned firms are more likely than domestic firms to process innovate whilst there is no difference between wholly owned and domestic firms in the probability of process innovation. The paper is structured as follows. Section 2 presents information on the investment framework in Ghana. Section 3 reviews the literature on the determinants of innovation. Section 4 presents a description of the sample and the variables used in the study. Section 5 documents the empirical model. Section 6 presents the results and Section 7 concludes.

2. The Investment Framework in Ghana

Several legal instruments provide the regulatory framework for the activities of foreign companies in Ghana. These include the Ghana Investment Act of 2013 (Act 865)[1], the Technology Transfer Regulations of 1992 (LI 1547) and the Free Zones Act of 1995 (Act 504). The Ghana Investment Act of 2013 replaces the Ghana Investment Promotion Centre Act of 1994 (Act 478). The new Act increases the scope of activities that exclude foreign participation and has increased the minimum capital requirements of the foreign investor. Both the Ghana Investment Promotion Centre Act of 1994 and the Ghana Investment Act of 2013 contain a provision guaranteeing against expropriation and provide for the unconditional transfer of dividends or net profits, loan servicing and fees and charges related

[1] It does not cover investment in the mining sector.

to technology transfer agreements. In Act 865, the unconditional transfers are subject to the Foreign Exchange Act of 2006 (Act 723). Immigrant quotas are provided for. The automatic maximum number of expatriates who can be employed is determined by the value of the paid capital. The minimum paid-up capital has been raised from US$10,000 to US$50,000 and allows for an initial automatic maximum immigrant quota of one person.

Investors are not obligated to enter into technology transfer agreements. However, technology transfer agreements must adhere to the guidelines set out in the Regulations of 1992 which specify what can and cannot be included in an agreement (Government of Ghana, 1992). For example, Section 4(k) of the Regulations states that 'clauses which restrict R&D (research and development) activities of the transferee to improve and adapt the licensed technology or restrict the transferee access to continue improvements in techniques and processes related to the licensed technology' are not enforceable. Technology transfer regulations must include a clause to provide training for the effective utilisation of the technology.

3. Literature Review

One reason why foreign direct investment occurs is because firms have an advantage – technology, organisational and managerial skills- over local firms that allows them to compete successfully in foreign markets. This is one reason why it is expected that firms with foreign capital ownership are more likely than local firms to innovate. The case study of two state owned firms in Tanzania, Tanzania Breweries Limited and Tanzania Cigarette Company Limited, taken over by foreign investors is a good illustration of this (Portelli & Narula, 2006). New production systems and methods similar to those employed in the parent companies were introduced after the acquisition. New products were introduced and ISO certification was introduced in one of the companies. Another reason firms with foreign participation are more likely to innovate is because they are more attractive than domestic firms to lenders and are therefore less likely to face credit constraints that can hamper investing in innovation activities (Harrison & McMillan, 2003).

There is mixed empirical evidence on the relationship between foreign direct investment and innovation. In a study on the determinants of innovation among firms in Egypt, Jordan, Syria

and Tunisa, (El Elj & Abassi, 2014) do not find that foreign ownership (as measured by the share of foreign capital) is associated with product innovation. Girma, Gong, & Gorg (2008) find a positive relationship between foreign direct investment and product innovation among firms in China. They suggest that this may be due to either lower financial constraints or the introduction of new technology. Using a sample of manufacturing firms in Australia (Rogers, 2004) finds a negative relationship between foreign ownership and the probability of innovation. Foreign direct investment is not a significant correlate of innovation among non-manufacturing firms. Among non-manufacturing firms employing between 20 and 99 employees, however, there is a positive relationship between foreign direct investment and innovation. Ownership structure of FDI may matter. Firms that are wholly-owned may be more likely to receive technology transfer than firms that are partially-owned. On the other hand, foreign firms may choose to wholly acquire domestic firms that are near the technological frontier and therefore do not require much in the way of technological upgrading. Partially-owned firms may be further away from the frontier so there may be more upgrading after acquisition by the foreign firm. Almeida & Fernandes (2008) find for a sample of firms from 43 developing countries that minority foreign ownership is positively associated with process innovation. Majority foreign owned firms are significantly less likely to adopt new technology. They suggest that this is probably because of the transfer of mature technologies by multinational firms to their majority-owned subsidiaries.

In addition to foreign ownership the literature identifies several other variables associated with the decision to innovate. One of the early hypothesis is on the relationship between firm size and innovation. Schumpeter argued that there is a positive relationship between firm size and innovation. This positive relationship is expected because large firms can benefit from economies of scale. The high fixed costs of research and development can be spread over large production and sales (Cohen & Klepper, 1996). Other advantages of size are that many projects can be undertaken at the same time thus reducing the risks associated with R&D. Large firms are less likely to be credit constrained and will have access to a broader knowledge and human skills base than small firms. However, large firms may be subject to more bureaucratic controls which may limit their capacity to innovate or ability to respond to market changes. Small firms may be faster at recognising opportunities and finally, incremental benefits of innovation may be smaller for larger firms if size is positively associated with market power (Ahuja, Lampert, & Tandon, 2008). Empirical studies reveal a

mix of relationships between firm size and innovation. Many studies find a positive relationship ((Elj & Abassi, 2014; Tavassoli, 2015; Murro, 2013; Martinez-Ros, 2000**;** Rogers, 2004; Almeida & Fernandes, 2008; de Mel, McKenzie & Woodruff, 2009; Robson et al, 2009). Smit, Abreu, & de Groot (2015) find that firm size is negatively associated with product innovation and positively associated with services and process innovations. Du, Love, & Roper (2007) using data from manufacturing firms in Ireland and Northern Ireland find that firm size differentiates between innovating and non-innovating firms (it has a positive effect) but does not differentiate between product and process innovation.

The age of the firm has sometimes been found to be a significant determinant of innovation. Younger firms are more likely to innovate because older firms may be more set in their ways and have routines that are not flexible enough to encourage innovation. On the other hand, older firms may have the advantage because of experience through accumulated learning. Almeida & Fernandes (2008) find that older firms are less likely to innovate whilst Du, Love, & Roper (2007) find that older firms are more likely to perform only product innovation. Among firms in Ghana, Robson et al (2009) do not find a significant relationship between firm age and innovation.

The ability of firms to assess, evaluate and utilise new information for the purposes of innovation is determined by their absorptive capacity (Cohen & Levinthal, 1990). Absorptive capacity is measured using different indicators such as training (Elj & Abassi, 2014; Smit, Abreu, & de Groot, 2015; Moreira, Silva, Simoes, & Sousa, 2012), the proportion of the workforce with university education (Tavassoli, 2015; Murro, 2013) or secondary education (Almeida & Fernandes, 2008) and experience of management (Elj & Abassi, 2014). Most studies find absorptive capacity is important for explaining the probability that a firm will innovate. Some studies find absorptive capacity is a significant correlate of one type of innovation but not another. Thus Murro (2013) finds a positive relationship for product innovation and not process innovation and Moreira, Silva, Simoes, & Sousa (2012) find that the provision of training by the firm is not associated with the likelihood of marketing innovation.

Research and development is an input into the innovation process. However, since it does not always result in an innovation occurrence it cannot be used as a measure of innovation. Several studies find a positive relationship between research and development and innovation

(Smit, Abreu, & de Groot, 2015; Moreira, Silva, Simoes, & Sousa, 2012; Almeida & Fernandes, 2008; Rogers, 2004; Girma, Gong, & Gorg, 2008).

It is expected that firms that export are more likely to innovate (Elj & Abassi, 2014; Martinez-Ros, 2000; Almeida & Fernandes, 2008). Exporting firms are exposed to competition and will innovate in order to stay competitive and maintain market shares. They are also more likely to have access to foreign technology and can benefit from economies of scale. However the causal relationship can run from innovation to exporting- innovative firms can self-select into exporting (Roper & Love, 2002; Cassiman, Golovko, & Martinez-Ros, 2010).

The innovation activity is an investment that will require firms to utilise retained earnings and/or loans to finance the undertaking. Firms that are not financially constrained are more likely to invest in innovation activities that will increase their profits. The evidence on the importance of access to finance for innovation is mixed. de Mel, McKenzie, & Woodruff (2009) find a positive relationship between having received a bank loan and product, process and marketing innovation respectively. Almeida & Fernandes (2008) find a positive relationship with process innovation. On the other hand Elj & Abassi (2014) do not find that use of loans or access to lines of credit are significantly associated with product innovation. Bank financing may be used for product and not process innovation because the former may require more investment and thus higher costs. Second, process innovation is more likely to be shrouded in secrecy and firms may want to reduce the risk of information spillovers from the banks to their competitors (Herrera & Minetti, 2007).

4. Description of the data

Data for this paper is from a survey of 428 firms that was conducted between July and September 2015 by a team of researchers in the Department of Economics, University of Ghana. At the time of the survey the only available census of firms was the Industrial Census of 2003. This was considered inappropriate for a sampling frame because it does not cover the services sector and it is more than a decade old. A sampling frame was therefore constructed using membership of the Association of Ghana Industries and the list of registered and unregistered firms with the National Board for Small Scale Industries. A total

of 600 firms were initially selected, based on a stratified random sample across industry, size and location. Firms in the Northern Region, Upper East Region and Upper West Region were not included in the survey since very few of the membership are in those regions. Including them in the survey would have increased the unit cost of data collection.[2]

The questionnaire was administered through face to face interviews and included modules on technology and innovation, exporting, investment, production, the labour force and access to finance. Data was collected for 2013 and 2014. In addition to the quantitative survey, case study information was collected from 9 firms in the sample. The reason for conducting the case studies was to collect more in depth information on innovation activities within the firms. In this paper we work with a sample of 344 manufacturing firms. Table 1 presents the definition of all variables used for the analysis.

Table 1 Description of Variables

Variable Name	Definition
Product innovation	Dummy variable equal to 1 if the firm introduced a new or improved product or service
Process innovation	Dummy variable equal to 1 if the firm introduced a new or significantly improved method of production
Firm size	
Micro	Dummy variable equal to 1 if the firm employs less than 5 workers in 2014
Small	Dummy variable equal to 1 if the firm employs 5-19 workers in 2014
Medium	Dummy variable equal to 1 if the firm employs 20-49 workers in 2014
Large	Dummy variable equal to 1 if the firm employs 50 or more workers in 2014
Firm age	Age of the firm in 2014
High skilled workers	Share of workforce comprising engineers, scientists, accountants and tertiary degree holders
Training	Dummy variable equal to 1 if firm trains workers in 2014
Research	Dummy variable equal to 1 if firm undertook research in 2014
Website	Dummy variable equal to 1 if firm has active website
Certification	Dummy variable equal to 1 if firm has ISO certification
Exporter	Dummy variable equal to 1 if firm exported in 2013
Wholly owned foreign firm	Dummy variable equal to 1 if 100 percent foreign ownership

[2] This survey is not unusual in not collecting data from all the 10 administrative regions in Ghana. The World Bank Enterprise Survey only collected data from three regions. This survey covered a wider geographical area.

Partially owned foreign firm	Dummy variable equal to 1 if foreign ownership is greater than 0% and less than 100%
Loan	Dummy variable equal to 1 if firm received loan from formal financial institution in 2014
Food and beverages	Dummy variable equal to 1 if firm in food or beverages sectors
Textiles, Garments, Leather	Dummy variable equal to 1 if firm is in textile, garments or leather sector
Wood processing & furniture	Dummy variable equal to 1 if firm is in wood processing or furniture sector
Publishing	Dummy variable equal to 1 if firm is in publishing sector
Chemicals	Dummy variable equal to 1 if firm is in chemicals sector
Non-metallic	Dummy variable equal to 1 if firm is in non-metallic sector
Basic metals	Dummy variable equal to 1 if firm is in basic metals sector
Manufacture of equipment	Dummy variable equal to 1 if firm manufactures equipment

Source: Field Survey, 2015

The technology and innovation module of the questionnaire contains a series of questions on the introduction of new or significantly improved products or services and the introduction of new methods of producing or offering services. A firm is classified as having undertaken product or process innovation if it responded in the affirmative to either of these

Table 2 Descriptive Statistics

Variable Name	Mean	Standard Deviation	Number of Observations
Any innovation	48.5		344
Product innovation	41.3		344
Process innovation	38.4		344
Only product innovation	10.2		344
Only process innovation	7.3		344
Both product and process innovation	31.1		344
Firm size			
Micro	30.5		344
Small	33.7		344
Medium	18.3		344
Large	17.4		344
Firm age in years	17.0	13.39	344
High skilled workers	22.4	0.24	344
Training	29.4		344
Research	20.9		344
Website	31.7		344
Certification	14.8		344
Exporter	14.5		344

Share of foreign ownership		
Wholly owned foreign firm	8.4	344
Partially owned foreign firm	4.9	344
No foreign ownership	86.6	344
Loan	31.7	344
Industry		
Food and beverages	35.5	344
Textiles, Garments, Leather	18.3	344
Wood processing & furniture	7.6	344
Publishing	5.2	344
Chemicals	16.6	344
Non-metallic	3.2	344
Basic metals	10.2	344
Manufacture of equipment	3.5	344

Source: Field Survey, 2015.

Note: The number of observations is the number of firms which had non-missing observations for all variables.

questions. The definitions of product and process innovation employed in this paper are guided by the definitions provided in the Oslo Manual ((OECD, 2005). We do not differentiate between novel and incremental innovation. It is recognised that developing countries such as Ghana make progress towards the technological frontier incrementally through the introduction of products and processes that may be new to the firm but not to the industry. Table 2 presents descriptive statistics on the variables.

The innovation rate among manufacturing firms is high at about 49 percent. A slightly higher share of firms (41%) introduced new products compared to 38 percent that reported introducing new processes. Most innovating firms introduced both new products and processes. About 31 percent of firms sampled undertook both process and product innovation, whilst 10 percent and 7 percent of firms respectively introduced either new products or new processes. The high incidence of firms involved simultaneously in product and process innovation suggests that the two innovation types are related and should not be considered in isolation.

About 33 percent of firms are small in size employing a minimum of five and a maximum of 19 workers whilst 30 percent are micro firms employing less than 5 workers. The remaining firms are almost equally distributed between the medium and large size categories

Firms with foreign ownership comprise about thirteen percent of the sample. Wholly owned firms comprise about 8 percent of the sample whilst firms with some foreign ownership comprise about 5 percent. About 14 percent of firms produce some of their output for export.

About 29 percent of firms provide training to their workers. This includes on the job training and the participation of workers in training programmes provided by other firms and organisations. With respect to indicators of technological capability, 21 percent of firms conduct research and development that is either in-house or contracted with other companies. About 32 percent of firms have active websites.

Firms in the food and beverages sectors and the textiles and garments sectors account for about 50 percent of the sample of firms.

Table 3 presents information on the characteristics of firms that innovated in 2014 and those that did not. Innovating firms are those that introduced new products and/or processes in 2014. Firms that innovate are larger, have a smaller proportion of skilled workers, provide training to their workers and are more likely to undertake research and development and own a website. Innovating firms are more likely to export and to have received a loan. There are also significant differences in the sectors of operation of the two categories of firms.

Table 3: Comparing Innovating and Non-innovating firms

Variable Name	Innovator	Non-innovator	p-value
Firm size			0.095
Micro	25.2	35.6	
Small	34.1	33.3	
Medium	19.2	17.5	
Large	21.6	13.6	
Firm age in years	17.3	16.6	0.627
High skilled workers	18.9	25.6	0.010
Training	35.9	23.2	0.009
Research	29.9	12.2	0.000

Website	41.3	22.6	0.000
Certification	16.8	13.0	0.325
Exporter	18.6	10.7	0.040
Share of foreign ownership			0.079
Wholly owned foreign firm	10.2	6.8	
Partially owned foreign firm	7.2	2.8	
No foreign ownership	82.6	90.4	
Loan	38.9	24.9	0.005
Industry			0.001
Food and beverages	46.9	23.4	
Textiles, Garments, Leather	14.1	22.8	
Wood processing & furniture	6.2	9.0	
Publishing	4.0	6.6	
Chemicals	11.3	22.2	
Non-metallic	2.8	3.6	
Basic metals	11.3	9.0	
Manufacture of equipment	3.4	3.6	

Source: Field Survey, 2015.

5. Empirical Model

Firms will embark on innovation expenditures and activities if they expect that profits post the innovation , π_i^*, will exceed what will pertain if the innovation does not happen. Expected profits π_i^* is not observed. What is observed is whether the firm innovates.

$$I_{ij} = \begin{cases} 1 \; if \; and \; only \; if \; \pi_i^* > 0 \\ 0 \; otherwise \end{cases}$$

I is the innovation dummy which takes the value of 1 if firm *i* reports that it has introduced innovation of type j and zero otherwise. π_i^* is not observed, however we assume it takes the following form:

$$\pi_i^* = \beta x_i + \varepsilon_i$$

where β is the vector of coefficients, x_i is the vector of explanatory variables and ε_i is the error term.

The explanatory variables used in the model are informed by the literature and are listed and defined in Table 1. In addition to foreign ownership which is our variable of interest, we

control for firm size, age of the firm, the share of highly skilled workers in the workforce, training, conduct of research and development, ownership of an active website, ISO certification, export status of the firm, receipt of a loan and the industry the firm operates in. Foreign ownership is introduced into the model by differentiating between wholly-owned and partially owned firms. The dummy variable for a wholly-owned firm takes the value of 1 if foreign ownership is 100 percent and takes a value of zero otherwise. The dummy variable for partially-owned firms takes a value of 1 if foreign ownership is less than 100 percent and equal to or greater than 10 percent. Industry dummies are introduced to control for the external context in which the firms operate such as competition and technological differences across industries.

Product and process innovation are different activities and tend to be modelled separately. The factors associated with process and product innovation are not found to be the same (Martinez-Roos, 2000; Rouvenin, 2002; Du and Roper, 2007). Product innovation involves the introduction of new or differentiated products that allow firms to increase their market share whilst process innovation aims at reducing costs (Martinez-Roos, 2000). The search for technological competitiveness may motivate the decision to embark on product innovation whilst process innovations may be motivated by the desire to be price competitive (Vaona & Pianta, 2008).

In this study the majority of firms that innovate (61%) introduce both new products and new processes. This suggests that the decisions to introduce new products or services and to introduce new methods of production are interrelated. Previous work that recognises the possibility that product and process innovation may be interrelated introduce a lagged product innovation variable in the process innovation regression model and a lagged process innovation variable in the product innovation regression model and find that process innovation affects the probability of product innovation and vice versa (Martinez-Roos, 2000). Another approach that has been employed to capture the interrelatedness of the two types of innovation is use of the bivariate probit model. Rouvenin (2007) investigates the relationship between the two types of innovation using a bivariate probit regression and finds a significant correlation between the errors of the two probit equations.

The joint occurrence of product and process innovation among the majority of innovating firms suggests that the error terms of the equations for product and process innovation will not be independent. A bivariate probit is therefore employed in this paper.

We are not able to describe the relationship between the dependent and explanatory variables as causal because the data is a cross-section. We recognise the possibility of endogenous explanatory variables but do not have appropriate instruments to address this. We address the possible self-selection of innovating firms into exporting by using the export status of the firm in the previous period as an explanatory variable.

6. Results and discussion

The results of the bivariate probit regression model for product and process innovation are reported in Table 4. Foreign ownership in Ghana is positively associated with both product and process innovation. However, the nature of the relationship is different between the two types of innovation. Wholly-owned firms and joint ventures are positively associated with product innovation whilst joint ventures only are positively associated with process innovation. This finding that highlights the relevance of the structure of foreign ownership to different innovation types is similar to the results of Almedia and Fernandes (2008). Their cross-country study on process innovation in 43 developing countries finds that foreign firms with minority ownership are more likely to undertake process innovation and majority and wholly-owned foreign firms are less likely to do same. They argue that this is because minority owned firms are less likely to receive mature technologies that do not require adaptation. To develop their reasoning further it is possible that the ownership structure of joint ventures allows for a wider range of choice of technology. Under the technology transfer regulations of 1992, agreements that contain clauses that forbid the use of complementary technologies, require the consent of the transferor before any modifications to products and processes can be made and that require that equipment, raw materials and parts must be procured from the transferor are not applicable or enforceable. The Regulations of 1992 provide the space for joint ventures to adapt technologies and be less constrained in their choice of technologies. Products must be designed to satisfy domestic preferences. It is

thus not unexpected that both wholly-owned firms and joint ventures are involved in product innovation.

There is a positive relationship between firms' involvement in formal research and development that is conducted in-house or with other companies and product and process innovation. Maintaining an active website is introduced as a control variable to capture the technological disposition of the firm and its desire to be visible and competitive. It is positively associated with product but not process innovation. New products have to be marketed if the expected increase in revenues and profits are to be realised. Technologically competent firms will embrace the internet as one of several routes to reach the targeted customers.

Access to finance from formal institutions such as banks, savings and loans, microfinance institutions, credit unions and government agencies has a positive and significant effect on product innovation. Although the coefficient of the access to finance variable is positively signed it is not statistically significant in the process innovation model. Studies on the link between access to finance and innovation suggests that firms are less likely to utilise external resources to finance process innovation since it may involve sharing information on the innovation with lenders which could be leaked to competitors.

Process innovation is positively associated with age of the firm. There is no significant relationship between age of the firm and product innovation.

Contrary to the univariate analysis which found significant differences in the firm size of innovating and non-innovating firms, the size of the firm has no effect on the probability of either product or process innovation. Introducing other control variables such as research and development renders the firm size variables insignificant. There is a positive association between firm size and spending on R & D. Whilst only 7.4 percent of micro firms spend on R&D, the proportion of firms that invest in R&D rises to 14 percent among small firms, 25 percent among medium firms and 46 percent among large firms. Large firms are much more likely to undertake research and development. This may explain why there is no independent size effect.

Table 4. Determinants of Product and Process Innovation

	Product Innovation		Process Innovation	
	Coefficient		Coefficient	
Small (5-19)	0.219		0.186	
	(0.193)		(0.188)	
Medium (20-49)	0.141		-0.114	
	(0.241)		(0.238)	
Large (>50)	-0.028		-0.352	
	(0.304)		(0.306)	
Age of Firm (in logs)	0.078		0.132	*
	(0.079)		(0.078)	
High skilled workers	-0.821	**	-0.771	
	(0.367)		(0.353)	**
Training	-0.096		0.050	
	(0.187)		(0.178)	
Research	0.759	***	0.754	***
	(0.203)		(0.202)	
Website	0.365	*	0.154	
	(0.196)		(0.195)	
Exporter	0.104		0.176	
	(0.212)		(0.210)	
Partially owned foreign firm	0.618	*	0.747	**
	(0.350)		(0.362)	
Wholly owned foreign firm	0.564	*	0.432	
	(0.297)		(0.297)	
Received loan	0.381	**	0.073	
	(0.156)		(0.156)	
International Certification	-0.278		0.026	
	(0.240)		(0.234)	
Constant	-1.181	***	-1.086	***
	(0.252)		0.246	
Sector Dummies	Yes		Yes	
Rho		1.236		
		(0.141)***		
Wald chi square		84.72		
Number of Observations		344		

Notes: Values in parentheses are standard errors. *, **, *** indicate significance at 10%, 5% and 1% confidence levels respectively. All variables are defined in Table 1.

ISO certification is included in both models to capture firm heterogeneity as well as being an indicator of the extent to which a firm keeps up with international standards. It is expected that the activities undertaken to implement the requirements of the certification can create the incentive for firms to introduce new products or processes. However we do not find that ISO certification is associated with either process or product innovation. The variable, though not statistically significant has a negative coefficient in the product innovation model and a positively signed coefficient in the process innovation model. The insignificance of this variable may be because firms may have acquired the certification but may not have adopted the practices required by the standard (Manders, de Vries, & Blind, 2016). Further research is required to unpack the relationship between ISO certification and innovation.

Firms that export are no more likely than firms that do not to introduce new products or processes although the coefficient of the export status variable is positively signed in both models.

One indicator of the absorptive capacity of the firm, i.e. whether workers receive training does not discriminate between innovating and non-innovating firms in either model. A second indicator, the proportion of highly skilled workers in the workforce is significantly associated with both product and process innovation, but has an unexpected negative sign.

The set of factors associated with the probability of product and process innovation are not the same. This finding is consistent with the findings of other studies. The significant and positive coefficient of correlation indicates that product and process innovation are inter-related. It is not possible from the data available to determine which precedes the other. It is not entirely unexpected that the two types of innovation are not independent of one another in a country that has a low level of technology. The introduction of products with new characteristics may require that firms must introduce new equipment and machines.

7. Conclusion

Manufacturing firms in Ghana do not shy away from innovation. Just under half of the firms sampled across a large number of industries had introduced a new product or process in 2014. Despite this, Ghana is still a distance away from the technological frontier. A positive relationship has been established between FDI and product and process innovation among

manufacturing firms in Ghana suggesting that this may be an important route to move Ghana towards the technological frontier. The finding that FDI in the form of joint ventures are more likely to engage in process innovations, whilst there is no difference between wholly owned and domestic firms in the probability of process innovation highlights the importance of the effective implementation and enforcement of the technology transfer regulations.

Research and development has emerged as a robust correlate of both product and process innovation. Only a fifth of firms invest in formal research and development and about 44 percent of them are large firms employing more than 50 workers. Although firm size is not associated with the likelihood of innovation the robust relationship between firm size and R&D on the one hand and the relationship between R&D and innovation on the other suggests that an enabling environment that encourages the establishment of large firms and the growth of firms from small to medium to large will increase the incidence and pace of innovation among manufacturing firms. An example of a policy geared towards promoting the establishment of large foreign firms is the raising of the minimum capital requirement for immigration quotas in the Ghana Investment Act of 2013 (Act 865).

Having an active website is important for product innovation. Policies that will promote internet coverage and access will be important measures to facilitate innovation, particularly product innovation among firms.

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