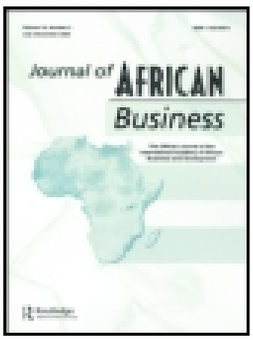

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R&D, Human Capital and Export Behavior of Manufacturing and Service Firms in Ghana

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ABSTRACT

The paper carries out a detailed analysis of the effects of R&D and human capital as well as their interactions with innovation on export behavior of manufacturing and service firms in Ghana using a dataset of 720 firms that merges the Enterprise, Innovative Capability and the Innovation Follow-up Surveys respectively for Ghana. Using a bivariate probit regression, the results show that R&D and human capital (employees' education, slack time and formal training) are positive and significantly related to the propensity for firms to export in Ghana. The cross derivatives (differences) for the interaction terms (R&D and innovation, and education and innovation) also showed that these interaction terms have positive effects on the likelihood for firms to export but are significant only for a negligibly small fraction of the sample. Thus, there is no much statistically significant evidence in support of the mediation role of innovation in the relationship between R&D/education and the export behavior.

KEYWORDS

R&D; human capital; innovation; export behavior; firms; Ghana

Introduction

Governments often pursue policies designed to promote exports. The economic reasoning for encouraging firms to export is based on the view that exporting enhances efficiency, domestic innovation and economic growth (Gourlay & Seaton, 2004). The export capacity of a firm has often been regarded as an indicator of competitiveness and success, with the justification that an exporting firm tends to be more productive than a non-exporter (Smith, Madsen, & Dilling-Hansen, 2002). Recently, exporters and non-exporters have been differentiated based on their respective willingness to invest in intangibles, including R&D and human capital. Specifically, Aw, Roberts, and Winston (2007) identified investment in R&D and adoption of technology as important factors explaining the higher productivity of exporters compared to non-exporters. Also, Wagner (2011) identified human capital as a relevant factor explaining the differences in productivity between exporters and non-exporters. In addition, Alvarez and Lopez (2005) and Bernard, Redding, and Schott (2007) argued that exporters are mostly more productive and larger than non-exporters. The fundamental problem is that non-exporters are different from exporters in a variety of (un)observable ways.

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Observations made over the years uncover that, the same macroeconomic conditions are being experienced by firms but surprisingly, they respond and perform differently in their export activities. This means that, there exist some relevant firm-specific characteristics and capabilities that might be causing this phenomenon (Dueñas-Caparas, 2007). The resource-based view of the firm (RBV) has been accepted as the main paradigm explaining this issue since the mid-1980s (Collis, 1991). The RBV considers firms as bodies with unique bundles of resources (both tangible and intangible) that affect their export activities. This has moved the concentration of recent research toward determining the factors that explain export behavior and performance at the firm-level (Van Dijk, 2002).

In developing countries, participation in export markets is often regarded as a prerequisite for economic growth. This has made exporting one of the most important economic issues in the region. It is therefore not surprising that export capacity in developing countries increased by 4.7% in 2011(Wto, 2011). One can therefore pose an analogous question at the firm-level – do R&D and human capital cause a firm to export? This question may be difficult to answer when one observes the correlation between exports and specifically, R&D in existing datasets. This is because R&D may be the consequence (and not the cause) of export behavior (Zhao & Li, 1997). It may also be easy to imagine ways in which R&D and human capital could be correlated with innovation, that directly influence exports. For example, an innovative firm may be more aggressive in conducting R&D (or having a high stock of human capital) and also be more aggressive in participating in the export market (Badri, Yahyavi, & Pourebrahim, 2015). This leads us to the second question – do R&D activities and human capital (educational level of employees) of a firm affect export activity indirectly through innovation?

Generally, it has been shown that, one of the main reasons why many countries in Africa are under-developed is that, firms lack innovative ideas that will enhance their participation in the export market (Goedhuys & Sleuwaegen, 2010). According to Teal (1999) and Robson and Freel (2008), firms in Ghana are least represented in the export market. It is recently that Ghana has given relevance to export-led growth policies. Among these is the promotion of the manufacturing of value-added export products (Adjasi, 2006). Boosting socio-economic development through the manufacturing of value-added exports has been the main goal of Ghana (Mahmoud, 2010). Surprisingly, this cannot be achieve if we fail to recognize the effects of firm-specific capabilities (i.e. human capital, R&D) on export behavior of firms in Ghana.

Export behavior and performance has been widely researched and has gained attention globally. However, since export behavior and performance has both micro and macro foundations, the generalization of findings from studies at the country-level to the firm-level may not be appropriate. Most studies investigating the effects of human capital and R&D on exports are mostly focused on the developed world (see Munch & Skaksen, 2008; Contractor & Mudambi, 2008; Wagner, 2011). Therefore, this study seeks to extend the literature to an under-researched context (Ghana) to investigate these relationships. Specifically, this paper is motivated by two main objectives: first, to examine whether human capital and R&D affect the export behavior of firms and second, to investigate whether innovation mediates the relationship between R&D, human capital and export behavior. In doing this, the study contributes to the

extant literature on firm export behavior by offering new insights into the interplay between R&D and export behavior of African firms, particularly firms in Ghana. This would in turn assist in developing innovative ways for achieving firm growth which is an important channel for reducing poverty in Africa.

Using a unique dataset of 720 firms that combines the Ghana 2013 Enterprise Survey, the Ghana 2013 Innovative Capability Survey and the Ghana 2013 Innovation Follow-up Survey and with reference to similar studies by Girma, Görg, and Hanley (2008) and Aw et al. (2007), the paper employs robust estimation techniques to carry out the analysis. Specifically, we estimate a bivariate probit model that accounts for endogeneity through the simultaneous estimations of the two decisions (export and R&D). Finally, we disaggregate the firms into manufacturing and service firms to provide a detailed evaluation of the results from these sub-samples. The findings of the study showed that human capital and R&D are positive and significantly associated with the propensity for firms to export in Ghana. The interactions between R&D and innovation, as well as education and innovation also had positive effects on the likelihood to export for all firms. However, after computing the cross derivatives (differences) as specified by Ai and Norton (2003), these interactions terms are significant only for a negligibly small fraction of the sample. Thus, there is no much statistically significant evidence in support of the mediation role of innovation in the relationship between R&D/education and export behavior.

The rest of the paper is organized as follows. The next section presents the theoretical framework followed by the empirical evidence. Section 3 discusses the data and the modeling strategy employed in the study. Section 4 presents the discussion of results and section 5 presents the conclusion of the study.

Literature review

Theoretical review

For the past decades, the conceptualization of export performance research has mainly relied on the resource-based view of the firm (RBV) (Francis & Collins-Dodd, 2000). This study therefore employs the resource-based view as the main theoretical underpinning to assess how firms use their resources and capabilities to expand their export capacities to enhance firm survival, competitiveness and performance (Barney, 1991).

The resource-based view (RBV) was proposed from the writings of Penrose (1959). Over the years, there have been a lot of extensions to this theory by many authors (Barney, 1991; Teece, 1996). Among the various versions of the RBV discussed in the literature are: the resource scarcity theory (Castrogiovanni, Combs, & Justis, 2006), dynamic capability theory (Teece, 1996), resource exchange theory (Zacharakis, 1997) and resource dependency theory (Pfeffer and Salancik, 2003).

The resource-based view (RBV) proposes a theory that relies on different aspects of a firm's resources and capabilities used to explain its export activity (Morgan-Thomas & Bridgewater, 2004). A firm, from this theory, is regarded as a body consisting of an inimitable bundle of tangible and intangible resources (i.e. assets, knowledge, processes, and capabilities among others) that makes it more effective and efficient (Barney, 1991). The RBV shows that, the important factors that explain the export performance of

a firm are its capabilities (technology, human resources, formal training and employee expertise) and internal organizational resources. This makes it difficult for other firms to copy its activities (Collis, 1991).

Consequently, literature on export performance argues that, the main factors that explain the export performance of a firm are its capabilities (i.e. R&D, human capital and innovation). Other factors like, firm size, capital intensity, firm age and foreign affiliation are also identified to affect exports. Recently, the literature has proposed a more profound measure of human capital that argues that, human capital does not only comprise employees' education (Nohria & Gulati, 1996). Employee slack time (see Bourgeois, 1981) and formal training (see Knight & Yorke, 2003) are argued to be other important measures of human capital. Drawing from the resource-based view, the proposed conceptual model is presented in Figure 1

The conceptual framework in Figure 1 shows the effects of firm capabilities and characteristics on export participation. Innovation may mediate the association between firm capabilities (i.e. R&D and human capital) and export participation. However, the export behavior of a firm can have a positive effect on its R&D (Girma et al., 2008) – a term known as 'learning-by-exporting effect'. This effect is theoretically demonstrated by many researchers (see Aw et al., 2007; Girma et al., 2008) who opined that exports positively affect the investment in R&D by firms.

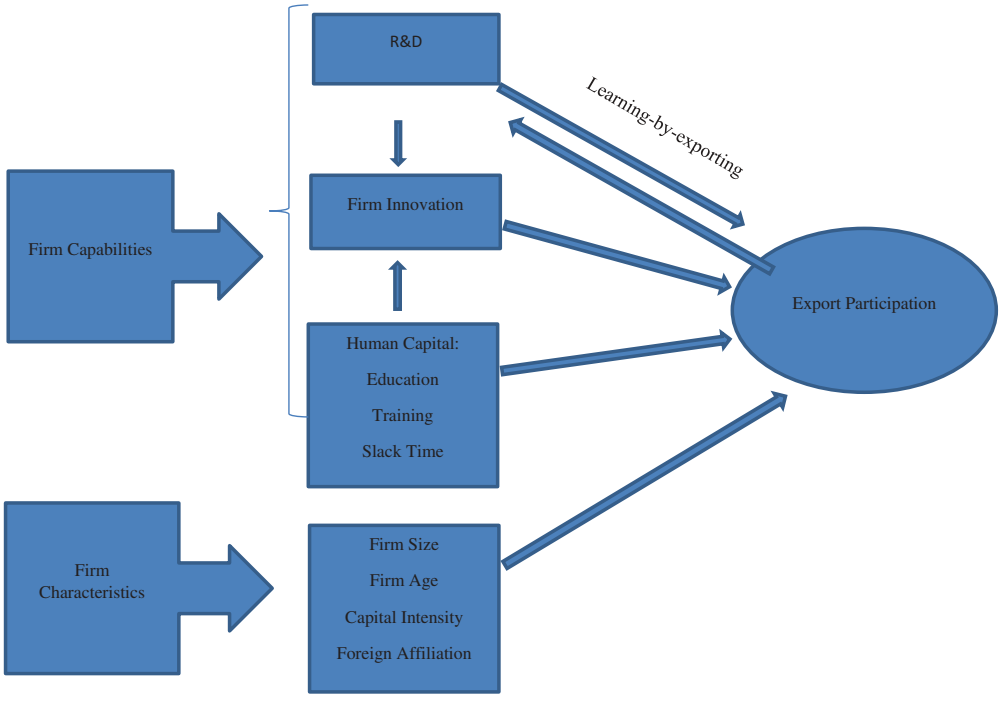

Figure 1. Conceptual model.

Source: Developed by Author's based on the Resource-Based View of the firm.

Empirical evidence

Over the years, exports, R&D and human capital have gained the interest of many researchers. But the understanding of the relationships between these factors still remains limited. Most studies have examined the relationship between innovation capability (R&D and human capital) of firms and their likelihood to engage in exports (see Lefebvre, Lefebvre, & Bourgault, 1998; Teal, Rankin, & Söderbom, 2006; Contractor & Mudambi, 2008; Harris & Moffat, 2012; Danquah & Amankwah-Amoah, 2017; Danquah, 2018). However, the empirical evidence on the roles of R&D and human capital in explaining export performance seems to be mixed. Specifically, most studies find negative or no correlation between R&D (or human capital) and exports (see Lefebvre et al., 1998; Ramstetter, 1999; Becchetti and Rossi, 2000); while others point to a positive and significant effect of R&D (or human capital) on exports (see Ito & Pucik, 1993; Smith et al., 2002; Aw et al., 2007; Munch & Skaksen, 2008; Wagner, 2011).

One of the first studies was by Hirsch and Bijaoui (1985), who assessed export performance of 111 Israeli firms. They showed that expenditure on R&D has a positive and significant effect on export growth and that innovative firms are more likely to engage in export activities. Ito and Pucik (1993) confirmed these results in their study on a sample of 266 Japanese manufacturing firms. They found that R&D intensity has a positive effect on the export share of these firms. However, when firm size is controlled for, the effect becomes insignificant. In contrast, the work of Lefebvre et al. (1998) and Becchetti and Rossi (2000) on Canadian and Italian firms respectively, showed that the export performance of a firm is not affected by its R&D intensity.

Lefebvre et al. (1998) using a dataset of Canadian firms examined the determinants of export growth among these firms. They found that a firm's export growth does not depend on its R&D intensity. They rather opined that, firm export growth depends on various technological variables including the proportion of employees with scientific and technical backgrounds and joint R&D projects with other firms. Becchetti and Rossi (2000) confirm this in their study on Italian firms. They assert that the propensity to export or the export intensity of a firm does not depend on its R&D intensity but on other factors such as human capital and managerial expertise.

In addition, the study of Roper and Love (2002) investigates the export behavior of manufacturing firms in German and UK. The likelihood of a manufacturing firm to export in both countries was positively associated with innovation. They concluded that, the role of innovation is indeed one of the facilitators of firm export performance in both countries. In the context of Africa, Teal et al. (2006) study manufacturing firms in five African countries – Kenya, Ghana, Nigeria, Tanzania and South Africa- and assessed the main causes of their poor export performance. They found that, firm size and human capital are robust drivers of the export decision of a manufacturing firm. Also, Aw et al. (2007) examined the relationship between firm export and R&D using a large sample of firms in Taiwan. The results from their bivariate probit regression suggest a positive and significant causal relationship between export and R&D. The findings of Girma et al. (2008) on Irish and UK firms confirm this relationship. They employed the same methodology of bivariate probit regression by Aw et al. (2007) and found positive and significant causal relationship export and R&D. Aw et al. (2007) and

Girma et al. (2008) concluded that R&D and export activity depend on each other and they both increase the profitability of firms in the future.

Moreover, the work of Contractor and Mudambi (2008), Schneider, Gunther, and Brandenbury (2010) and Wagner (2011), established that the initial schooling level of employees is positively associated with export growth. In particular, Contractor and Mudambi (2008) investigates the role of human capital on firm-level exports from a rich dataset of 25 countries from 1989 to 2003. Their findings suggest that, human capital has a positive and significant impact on the exports of goods and services in these selected countries, whilst Schneider et al. (2010), argued that, it is very important for a firm to have a better understanding of the relation between human capital and innovation as better trained employees will provide firms with more innovative output and hence, export growth. Furthermore, Wagner (2011) in his study on German-manufacturing firms finds human capital to have a positive and significant impact on exports.

We note, however that, the extant empirical studies have looked at the direct relationships between human capital, R&D and export behavior without examining the possible mediating effect innovation can have. As explained with regards to the Resource-Based View (RBV) of the firm, export participation can be predicted by human capital and R&D as well as their (i.e. human capital and R&D) interactions with innovation, hence the need for this study in Ghana to explore these relationships as well.

Modeling strategy and data

Modeling strategy

The paper is specifically motivated by two research objectives:

(1) To examine whether human capital and R&D affect the export behavior of firms.
(2) To investigate whether innovation mediates the relationship between R&D, human capital and export behavior of firms.

To achieve these two research objectives we employ a robust empirical estimation technique in this context at the aggregate firm-level (all firms) as well as the disaggregate firm-level (services and manufacturing). Based on these two research objectives, we adopt a modified version of the model of Van Dijk (2002), which was employed to investigate the determinants of export participation among Indonesian manufacturing firms. We model the export participation or behavior of a firm as a function of human capital, R&D, innovation, firm characteristics and sector dummy. The dependent variable (Export behavior) is a binary variable (whether a firm exports or not). Following from this, we specify a probit model of the form:

$$Pr(EXP_i = 1|Z_i) = Pr(EXP_i = 1|R\&D_i, HCAP_i,\ FMINNO_i,\ ITR_i, FMC_i,\ SECT_i) \quad (1)$$

Where, EXP_i is the dependent variable (Dichotomous) and Z_i represents the vector of explanatory variables (i.e. R&D, human capital (HCAP), innovation (FMINNO),

interaction terms (ITR), firm characteristics (FMC) and sector type (SECT) of the firm). Equation 1 can be re-specified as:

$$Pr(EXP_i = 1|Z_i) = \Phi(\beta_0 + R\&D_i\beta 1 + +EDUC_i\beta_2 + SLAC_i\beta_3 + \ TRAIN_i\beta_4 + FMINNO_i\beta_5 + \ R\&DFMINNO\beta_6 + EDUCFMINNO\beta_7 + SIZE_i\beta_8 + AGE_i\beta_9 + FORAF_i\beta_{10} + CAPI_i\beta_{11} + SECT_i\beta 12) \quad (2)$$

Where, Φ is a cumulative standard normal distribution function. EXP is a dummy variable (taking a value 1 if a firm exports and 0 otherwise) measuring export behavior. R&D (dummy) denotes research and development; human capital is measured by education (EDUC), formal training (TRAIN) and slack time (SLAC). FMINNO (dummy) represents firm innovation. R&DFMINNO and EDUCFMINNO represent the interaction for R&D and innovation, and education and innovation, respectively. Firm characteristics comprise the size of a firm (SIZE), the age of the firm (AGE), foreign affiliation (FORAF), capital intensity (CAPI) and sector dummy (SECT) representing the sector type of a firm (services or manufacturing).

Moreover, with reference to Girma et al. (2008) and Aw et al. (2007), we suspect an endogeneity between exports and R&D, given that R&D predict exports and exports also acting as a predictor of R&D. Since the variable (R&D) we suspect to be endogenous is a dummy variable, we resort to the use of a bivariate probit regression. Failing to account for the possible endogeneity may lead to bias estimates of our regression parameters in the empirical model. Hence, we specify the bivariate probit model as:

$$EXP_i^* = \beta X_i + \delta R\&D_i + \varepsilon_i$$

$$R\&D_i^* = \gamma Y_i + \mu_i \quad (3)$$

$$E\ (\varepsilon_i) = E\ (\mu_i) = 0;\ Var\ (\varepsilon_i) = Var\ (\mu_i) = 1;\ Cov\ (\varepsilon_i, \mu_i) = \rho$$

Where, $EXP^* = 1\{EXP^*>0\}$ *and* $R\&D^* = 1\ \{R\&D^*>0\}$.

The model is identified in its functional form. Rho (ρ) measures the degree of correlation between the error terms of the structural equations. If Rho (ε_i, μ_i) is significantly different from zero, it means that the errors are correlated and hence there is endogeneity.

With regards to the estimation and interpretation of the interaction terms (that is R&DFMINNO and EDUCFMINNO) in our model, Ai and Norton (2003), Norton, Wang, and Ai (2004) and Greene (2010) have shown that the marginal effect of a change in two variables is more complicated in nonlinear models than in linear models. They indicate that the interaction effect cannot be evaluated simply by looking at the sign, magnitude, or statistical significance of the coefficient on the interaction term in the case of a nonlinear model, but through the computation of cross derivatives (differences). Therefore in this paper, we use the cross derivative (difference) method through the use of the "*inteff*" after probit command to compute the correct marginal effect of a change in two interacted variables within a probit model, as well as the correct statistical significance (using the graphs of the interaction effects).

Description and source of data

Description of data

The empirical model measures the firm's export behavior (EXP) by considering the export propensity of the firm. It is a dummy variable that shows whether a firm has exported (direct and indirect export) during the considered period or not. The unobserved variable is therefore a dichotomous variable which takes on two values, '1′ if a firm is engaged in export activity and '0′ otherwise. Firm Innovation (FMINNO) was coded as a binary variable, based on whether respondents reported that their firm has introduced a new product or service into the market (takes the value of '1') or otherwise ('0'). This definition relates more closely to that of Miller (1983) concept of the firm being first with proactive new products and services, and to traditional measures such as counting the number of innovations. It is argued that many firms decide to develop product innovations to construct barriers to imitation and to obtain the first-mover advantage. This is based on the notion that product innovation allows the firm to develop valuable competitive advantage (Monreal-Pérez, Aragón-Sánchez, & Sánchez-Marín, 2012). R&D is a dummy variable which is measured based on whether respondents reported that their firm has invested in research and development or not during the considered period (Aw et al., 2007). Therefore this binary variable which takes on two values, '1' if a firm conducts R&D and '0' if it conducts no R&D. There are three human capital measures used in this paper- education (EDUC), formal training (TRAIN) and slack time of employees (SLAC). Education is measured as a continuous measure of the number of permanent employees who have completed at least Senior High School. Formal training is also measured as a dummy variable that takes the value 1 if the firm conducts formal training and 0 if it does not. Finally, slack time is a dummy variable that takes the value 1 if the firm gives time to employees to develop new ideas, and 0 if it does not.

With respect to the control variables, the study used the age, size, foreign affiliation, capital intensity of the firm and the sectoral dummies as the control variables. Firm age is measured as the number of years that the firm has stayed in business; firm size as the total number of permanent full time employees in the firm; foreign affiliation as a dummy variable denoting whether a firm has a foreign affiliation or not; capital intensity as the stock of capital available to a firm; and sectoral dummies that account for the variations that may exist among firms in different sectors (services being the reference category).

Source of data

The data for the study are sourced from three datasets. These datasets are merged to bring out a comprehensive analysis of the relationship between firm performance, innovation and the capabilities of firms in Ghana. Specifically, these data are from the Ghana 2013 Enterprise Survey (ES), the Ghana 2013 Innovation Capability Survey (ICS) and the Ghana 2013 Innovation Follow-up Survey (IFS).

The Enterprise Survey (ES) is a survey at the firm-level conducted by the World Bank, which comprises both manufacturing and service firms. This survey was carried out in Ghana in 2007 and 2013. The study uses the 2013 data that comprises 720 manufacturing and service firms. The follow-up survey to the ES is the IFS. Firms that were already interviewed during the ES are revisited to obtain information on innovation and innovation-related activities. This data comprises 549 service and manufacturing firms. Finally, the Innovation Capability Survey (ICS) revisits firms (only manufacturing) that were interviewed in the IFS to obtain

more information on innovation and innovation-related activities. The data comprise 201 manufacturing firms. All these firms were part of the IFS and the ES.

Discussion of empirical results

First, we discuss the results from the test for endogeneity between exports and R&D both at the aggregate level (all firms) and the disaggregate level (service and manufacturing firms) (see Table 1). The estimated value of ρ is observed to be significantly different from zero in all the samples. This shows the presence of endogeneity in our models. This is consistent with the findings of Aw et al. (2007), who suggest that export activity and R&D depend on each other and both influence the profitability a firm in the future. Failing to account for the presence of endogeneity in the models may result in bias estimates in our regressions.

Consequently, having established that there is endogeneity between export and R&D, we estimate a bivariate probit regression in order to account for the endogeneity. Tables 2 and 3 and 4 present the estimated results for Eqn. (3), which report the coefficient estimates of the bivariate probit conditional mean function for all firms in the model as well as for manufacturing and services respectively. Following the specification by Ai and Norton (2003), Norton et al. (2004) and Greene (2010), these coefficients estimates are reported because of the existence of interaction terms in our regression model. The cross derivative (difference) method through the use of the '*inteff*' after probit command is employed to compute the correct marginal effect of a change in two interacted variables within a probit model, as well as the correct statistical significance (using the graphs of the interaction effects) (see Ai & Norton, 2003; Norton et al., 2004; Greene, 2010). It is worth noting that we carried out the '*inteff*' after probit command and not after the bivariate probit command. This is because the computation of the interaction effects cannot be fitted after estimating a bivariate probit model. As a result, we run the '*inteff*' after probit command following from the similarities in the coefficients and significance levels of the probit and bivariate probit estimates. This caveat is therefore important in explaining the interaction effects. Also, the regressions were carried out with reference to sectoral dummies. This is driven by the view that manufacturing firms are mostly known to engage in export activities while the activities of the service firms are mostly home-based. We begin by discussing the results for all firms and for the disaggregate firms (manufacturing and service firms) respectively.

From the estimation results in Table 2, Model 1 portrays the baseline regression, which shows that, the relationship between R&D, human capital (proxied by employee's education, formal training and slack time) and the propensity of the firm to export are

Table 1. Endogeneity test between exports and R&D (From the Bivariate Probit Model).

	Aggregate level (All firms)		Disaggregated level (Manufacturing firms)		Disaggregated level (Service firms)	
Correlations between disturbance terms	Coefficient	Linearized SE	Coefficient	Linearized SE	Coefficient	Linearized SE
Rho (ρ)	0.1101807**	0.0944016	0.2793266**	0.1223014	0.2642036*	0.1799782
Observations	259		142		117	

***p < 0.01 **p < 0.5 *p < 0.1

Table 2. Bivariate probit estimates: dependent variable – export behavior (Full Sample).

	Model 1	Model 2	Model 3	Model 4	Model 5
	Full Sample (All Firms)				
VARIABLES	Biprobit (EXPORT)	Biprobit (EXPORT)	Biprobit (EXPORT)	Biprobit (EXPORT)	Biprobit (EXPORT)
Independent Variables:					
R&D	0.152*	0.245**	0.174**	0.318**	0.275**
	(0.215)	(0.163)	(0.156)	(0.271)	(0.149)
EDUC	0.036**	0.064***	0.087**	0.096***	0.098**
	(0.022)	(0.014)	(0.043)	(0.034)	(0.015)
SLAC	0.204**	0.218***	0.104***	0.236**	0.117***
	(0.130)	(0.202)	(0.069)	(0.174)	(0.102)
TRAIN	0.173**	0.150***	0.142**	0.246**	0.149***
	(0.125)	(0.102)	(0.135)	(0.164)	(0.102)
FMINNO		0.142**	0.252**	0.184*	0.173*
		(0.111)	(0.219)	(0.127)	(0.158)
R&DFMINNO			0.047**		0.051*
			(0.018)		(0.022)
EDUCFMINNO				0.050**	0.093**
				(0.016)	(0.027)
SIZE		0.295**			0.297**
		(0.126)			(0.129)
AGE		−0.118			−0.119
		(0.129)			(0.130)
FORAF		0.274			0.127*
		(0.234)			(0.114)
CAPI		0.032			0.139**
		(0.072)			(0.074)
SECT		0.120***			0.169**
		(0.105)			(0.110)
Constant	−1.931***	−2.978***	−2.180***	−1.503***	−2.843***
	(0.174)	(0.678)	(0.428)	(0.279)	(0.689)
Rho (ρ)					0.110**
					(0.094)
Prob>Chi2	0.000	0.000	0.000	0.000	0.000
Observations	671	259	338	338	259

Robust standard errors in parentheses, ***p < 0.01, **p < 0.05, *p < 0.1

positive and statistically significant. This relationship still holds when the control variables (firm size, age, capital intensity, foreign affiliation and innovation) are added in Model 2. In Models 3 and 4 we augment the baseline model (Model 1) with the interaction terms – R&D and innovation (R&DFMINNO); and human capital and innovation (EDUCFMINNO) respectively. The R&D and human capital variables continue to exert positive relationships on our dependent variable (export behavior). Also, the interaction terms are positive and statistically significant. In Model 5, we run the combined effect of all the variables (R&D, human capital, integration terms and the controls). The role of R&D, human capital and the interaction term are still positive and statistically significant on our dependent variable.

Consequently, we replicate models 3 and 4 using a probit regression and the 'inteff' after probit command (cross derivatives method) to obtain correct marginal effects and correct statistical significance of our interaction terms, since the magnitude, signs and statistical significance of the interaction effect may vary by observation (Ai & Norton, 2003) (see Tables 5 and 6 and their corresponding graphs). Tables 5 and 6 and the graphs (see Figures 2–5) report that the interaction effects are positive but their

Table 3. Bivariate probit estimates: dependent variable- export behavior- (Manufacturing Firms).

	Model 1	Model 2	Model 3	Model 4	Model 5
	Sub-Sample (Manufacturing firms)				
VARIABLES	Biprobit EXPORT	Biprobit EXPORT	Biprobit EXPORT	Biprobit EXPORT	Biprobit EXPORT
Independent Variables:					
R&D	0.427**	0.407**	0.196**	0.209**	0.258***
	(0.378)	(0.362)	(0.179)	(0.116)	(0.129)
EDUC	0.095**	0.076*	0.040**	0.053*	0.093**
	(0.022)	(0.046)	(0.013)	(0.025)	(0.059)
SLAC	0.289***	0.261**	0.143**	0.177**	0.213***
	(0.211)	(0.220)	(0.078)	(0.095)	(0.134)
TRAIN	0.148*	0.225**	0.244**	0.131*	0.113**
	(0.101)	(0.179)	(0.214)	(0.119)	(0.099)
FMINNO		0.194**	0.147**	0.107**	0.152**
		(0.151)	(0.116)	(0.039)	(0.089)
R&DFMINNO			0.097**		0.082**
			(0.052)		(0.064)
EDUCFMINNO				0.074	0.048
				(0.081)	(0.017)
SIZE		0.297**			0.280**
		(0.159)			(0.171)
AGE		−0.089			−0.081
		(0.162)			(0.156)
FORAF		0.572**			0.177*
		(0.291)			(0.096)
CAPI		0.123*			0.130*
		(0.080)			(0.081)
				(0.081)	(0.017)
Constant	−1.354***	−1.196***	−1.277***	−1.405***	−1.196***
	(0.189)	(0.804)	(0.291)	(0.371)	(0.878)
Rho (ρ)					0.279**
					(0.122)
Prob>Chi2	0.000	0.000	0.000	0.000	0.000
Observations	349	142	183	183	142

Robust standard errors in parentheses, ***p < 0.01, **p < 0.05, *p < 0.1

statistical significance vary by observation in the sample. From the graphs, the concave line drawn for references shows the incorrect marginal effect.

The discussions above show that the R&D variable has the expected positive and significant relationship on the likelihood of the firm to export. This is in line with the findings of Aw et al. (2007), who stressed that R&D has a positive influence on the export behavior of a firm. In addition, education has a positive and significant influence on a firm's probability to export. This confirms the findings of Teal et al. (2006) for firms in Sub-Saharan Africa, who argued that skilled workers within a firm are expected to be creative and process information faster than unskilled workers, hence, impacts positively on exports. But the size of the effect is very small. Furthermore, we establish a very strong support for the positive effect of formal training (TRAIN) on export participation. The size of the effect of this variable is larger than the education variable. Thus investing in formal training by a firm increases its likelihood of exporting. The same conclusion holds for those firms that give slack time to employees to work on new and creative ideas. It shows that the size of this effect is even more profound than the formal training variable. Therefore, granting employees some time to develop new ideas increases the likelihood of a firm to export.

Table 4. Bivariate probit estimates: dependent variable- export behavior- (Service Firms).

	Model 1	Model 2	Model 3	Model 4	Model 5
	Sub-Sample (Service Firms)				
VARIABLES	Biprobit (EXPORT)	Biprobit (EXPORT)	Biprobit (EXPORT)	Biprobit (EXPORT)	Biprobit (EXPORT)
Independent Variables:					
R&D	0.096*	0.118**	0.069*	0.056**	0.138**
	(0.045)	(0.055)	(0.023)	(0.037)	(0.114)
EDUC	0.059***	0.071**	0.046**	0.021***	0.049**
	(0.033)	(0.061)	(0.018)	(0.016)	(0.035)
SLAC	0.119**	0.234**	0.149**	0.185**	0.176**
	(0.073)	(0.178)	(0.125)	(0.144)	(0.150)
TRAIN	0.164**	0.113**	0.242**	0.130*	0.118**
	(0.123)	(0.101)	(0.187	(0.105)	(0.111)
FMINNO		0.065*	0.061*	0.103**	0.092*
		(0.022)	(0.011)	(0.071)	(0.081)
R&DFMINNO			0.063**		0.105**
			(0.036)		(0.059)
EDUCFMINNO				0.074**	0.097**
				(0.029)	(0.012)
SIZE		0.217**			0.126***
		(0.198)			(0.104)
AGE		−0.131			−0.118
		(0.270)			(0.267)
FORAF		0.122*			0.087**
		(0.064)			(0.039)
CAPI		0.087**			0.056*
		(0.029)			(0.013)
Constant	−1.477***	−5.529***	−2.849***	−2.982***	−5.419***
	(0.307)	(1.325)	(0.513)	(0.746)	(1.392)
Rho (ρ)					0.264*
					(0.180)
Prob>Chi2	0.000	0.000	0.000	0.000	0.000
Observations	322	117	155	155	117

Robust standard errors in parentheses, ***p < 0.01, **p < 0.05, *p < 0.1

Also, we find support for the hypothesis that the interactions – R&D and innovation; and education and innovation- exert positive influence on the firms' propensity to export (as confirmed by Tables 5 and 6 and Figures 2 and 4). For many observations (in both cases) with a predicted probability value of being engaged in exporting greater than 0.2, the interaction effect is positive, not negative (see Figures 2 and 4). This is in line with the findings of Harris and Moffat (2012) and Wagner (2002) for British Dutch firms respectively. This shows that firms that innovate and invest in R&D or have more educated employees are more likely to export compared to firms that do not. However, the statistical significance of the interaction terms vary by observation (i.e. some being significant and others not significant) based on the computation of the cross derivative (difference) after probit regression (see Figures 2 and 5). Therefore, a clear conclusion cannot be drawn on the significance of the interaction terms (that is R&DFMINNO and EDUCFMINNO) in our model. Finally, the sectoral dummy variable (SECT) is significantly positive in our estimations. It is mostly argued that manufacturing firms are heavily engaged in export activities while the activities of the service firms are mostly home-based. The results show that manufacturing firms are more likely to engage in export activities compared to service firms.

Table 5. Estimated interaction effect between R&D and innovation in model 3 (All firms).

Variable	Mean	Std. Dev.	Min.	Max.
Interaction effect	0.007266	0.003743	0.003043	0.0093374
Standard error	0.0012039	0.0006482	0.0001538	0.0023396
z-ratio	2.2678610	0.0808037	1.1976808	3.7475622

Table 6. Estimated interaction effect between education and innovation in model 4 (All firms).

Variable	Mean	Std. Dev	Min.	Max.
Interaction effect	0.006720	0.0062110	0.001772	0.0073460
Standard error	0.0012093	0.0006328	0.000198	0.0023411
z-ratio	5.5569338	0.5332835	1.756896	6.5212511

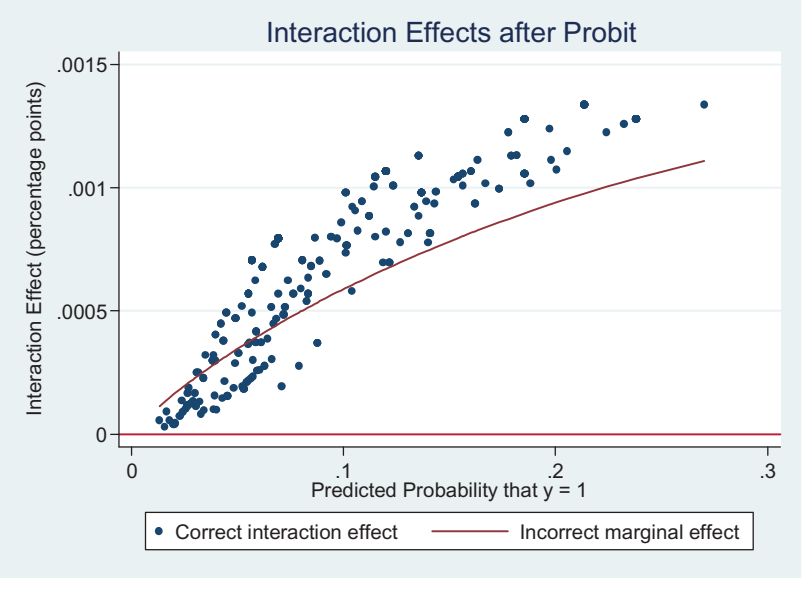

Figure 2. Interaction effects after probit between R&D and innovation in model 3 (All firms).

In Tables 3 and 4, firms are disaggregated into manufacturing and service firms. Across manufacturing and service firms, the coefficients estimates of the bivariate probit regression indicate that R&D and human capital have positive and significant association with the export propensity of firms. These results clearly show that these variables are good predictors of the export activity of a firm in Ghana. From Tables 3 and 4, we replicate the models in Table 2, but this time based on the disaggregate firms – manufacturing and service firms, respectively. The role of R&D, human capital and the interaction terms (except the interaction of education and innovation among manufacturing firms) is positive and statistically significant on our dependent variable (export behavior).

Based on the results from the cross derivatives (differences) after probit, the interaction terms – human capital and innovation (EDUCFMINNO); and R&D and innovation (R&DFMINNO) – across manufacturing and service firms, exert positive influence

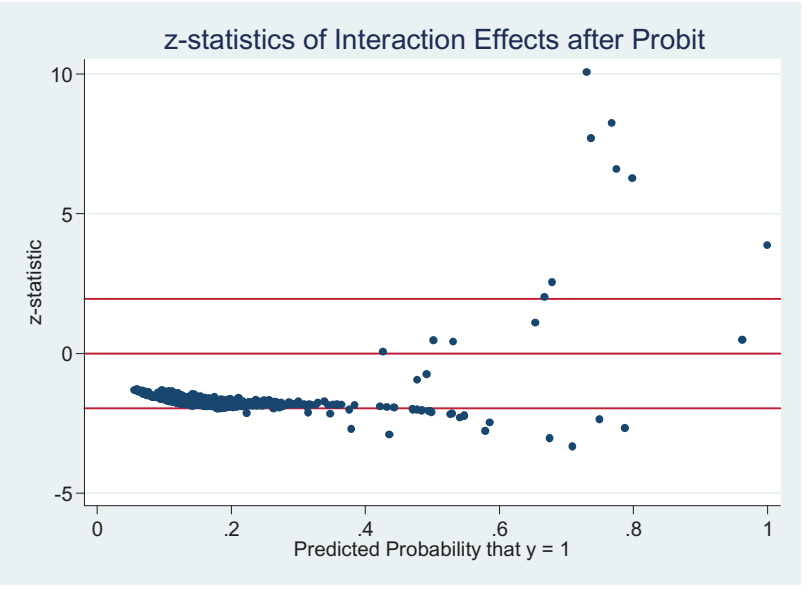

Figure 3. z- statistics of Interaction effects after probit between R&D and innovation in model 3 (All firms).

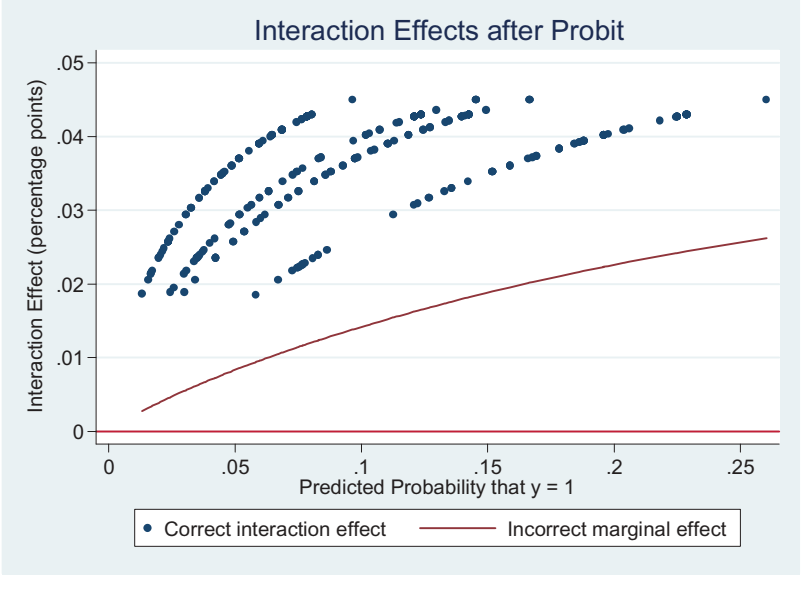

Figure 4. Interaction effects after probit between education and innovation in model 4 (All firms).

on our dependent variable as confirmed by Table 7, 8 for manufacturing and Tables 9 and 10 for services and their corresponding graphs. For many observations (in both manufacturing and services) with a predicted probability value of being engaged in exporting greater than 0.2, the interaction effect is positive, not negative (see Figures 6 and 7 for manufacturing and Figures 8 and 9 for services). Also, the statistical

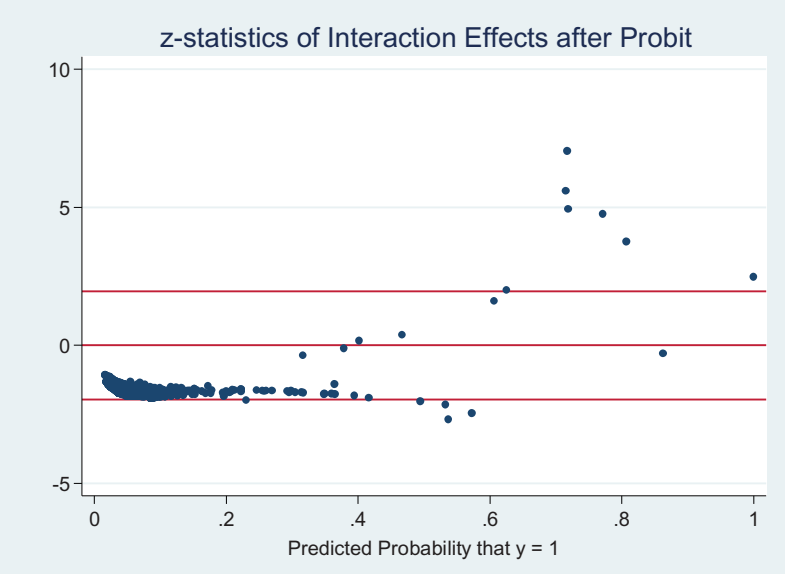

Figure 5. z- statistics of Interaction effects after probit between education and innovation in model 4 (All firms).

Table 7. Estimated interaction effect between R&D and innovation in model 3 (Manufacturing).

Variable	Mean	Std. Dev.	Min.	Max.
Interaction effect	0.002695	0.0011925	0.0011006	0.0034795
Standard error	0.0009429	0.0002747	0.0005442	0.002084
z-ratio	2.855265	0.8923571	1.10669	3.718657

Table 8. Estimated interaction effect between education and innovation in model 4 (Manufacturing).

Variable	Mean	Std. Dev.	Min.	Max.
Interaction effect	0.0515143	0.0140117	0.0228384	0.0697432
Standard error	0.1019217	0.0329435	0.0396146	0.1507532
z-ratio	0.5057117	0.0329078	0.4626319	0.5765152

Table 9. Estimated interaction effect between R&D and innovation in model 3 (Services).

Variable	Mean	Std. Dev.	Min.	Max.
Interaction effect	0.0028775	0.0012842	−0.0064838	0.0044637
Standard error	0.0009263	0.0002934	0.0005669	0.002174
z-ratio	3.1064449	1.042319	1.752313	5.582067

Table 10. Estimated interaction effect between education and innovation in model 4 (Services).

Variable	Mean	Std. Dev.	Min.	Max.
Interaction effect	0.016563	0.004297	0.0044691	0.0213694
Standard error	0.007947	0.032608	0.0119366	0.1160906
z-ratio	2.0841827	0.111889	0.1179269	0.4737453

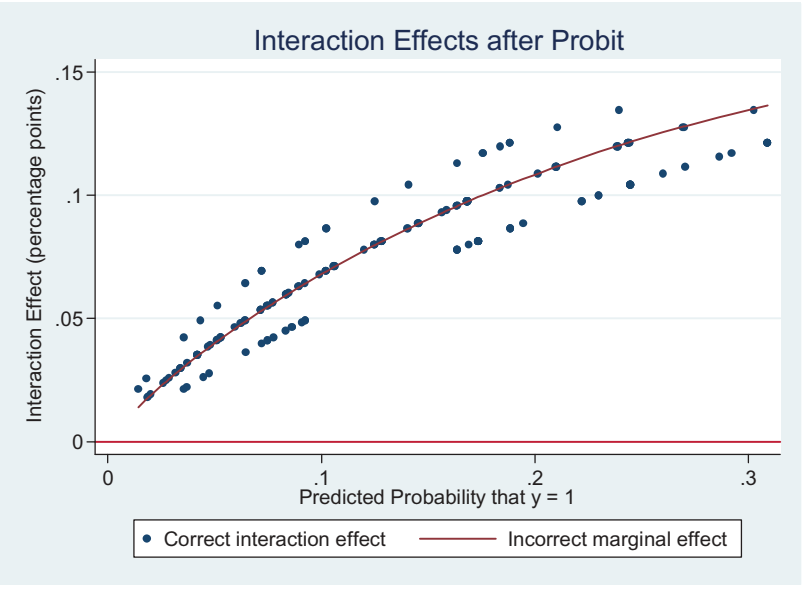

Figure 6. Interaction effects after probit between R&D and innovation in model 3 (Manufacturing).

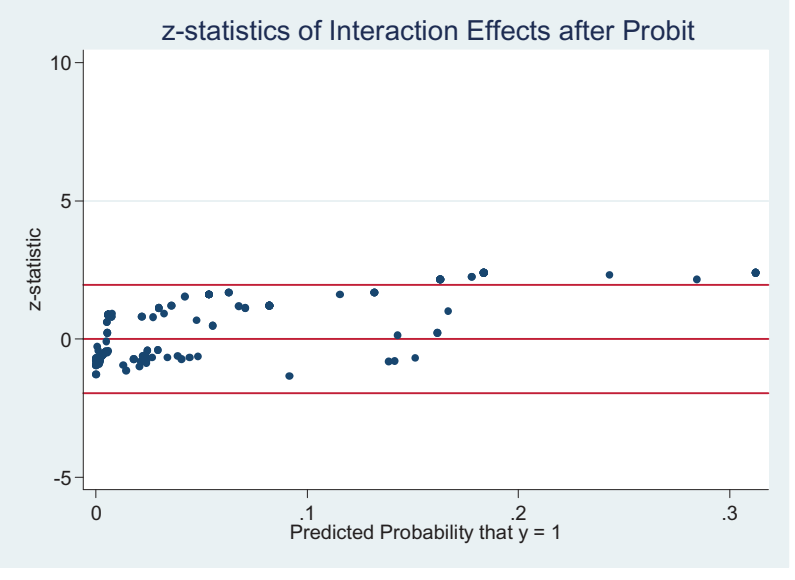

Figure 7. z- statistics of Interaction effects after probit between R&D and innovation in model 3 (Manufacturing).

significance of the interaction terms for both manufacturing and services vary by observation (i.e. significant for some observations and non significant for other sections of observations) (see Figures 10 and 11 for manufacturing and Figures 12 and 13 for services). This implies that, a general conclusion cannot be drawn on the statistical significance of the interaction terms in our manufacturing and service models.

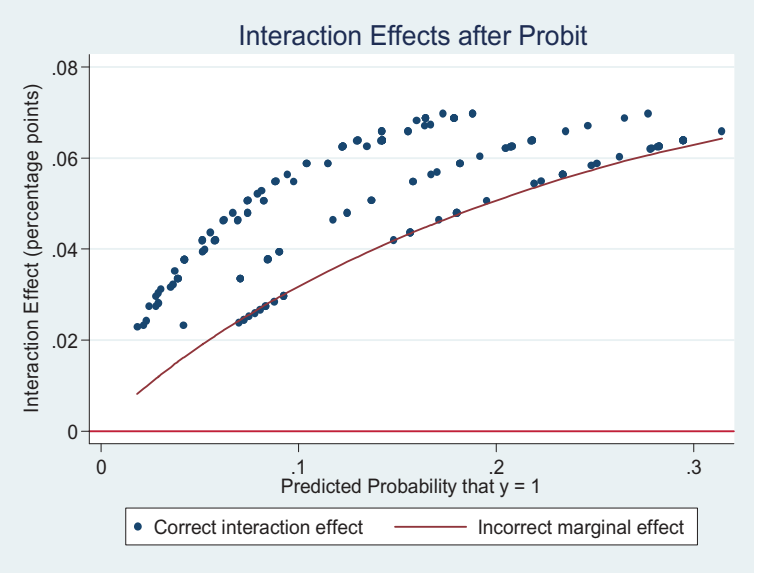

Figure 8. Interaction effects after probit between education and innovation in model 4 (Manufacturing).

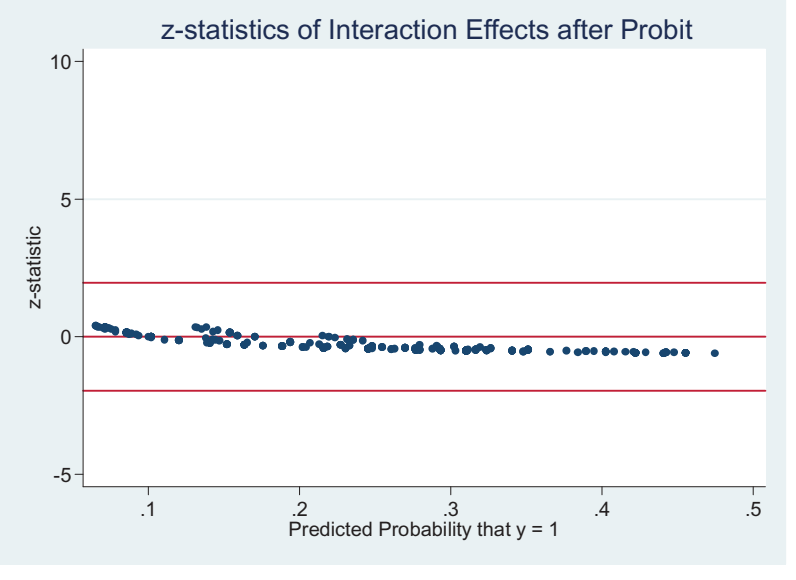

Figure 9. z- statistics of Interaction effects after probit between education and innovation in model 4 (Manufacturing).

With regards to the overall results from the control variables in Tables 2 and 3 and 4, firm size has a positive effect on the probability to export, while firm age has no effect. Foreign affiliation, capital intensity and innovation have the expected positive effects. Firm size is observed to exert the greatest positive effect on export behavior among the control variables. It implies that size is relatively an important driver of the export

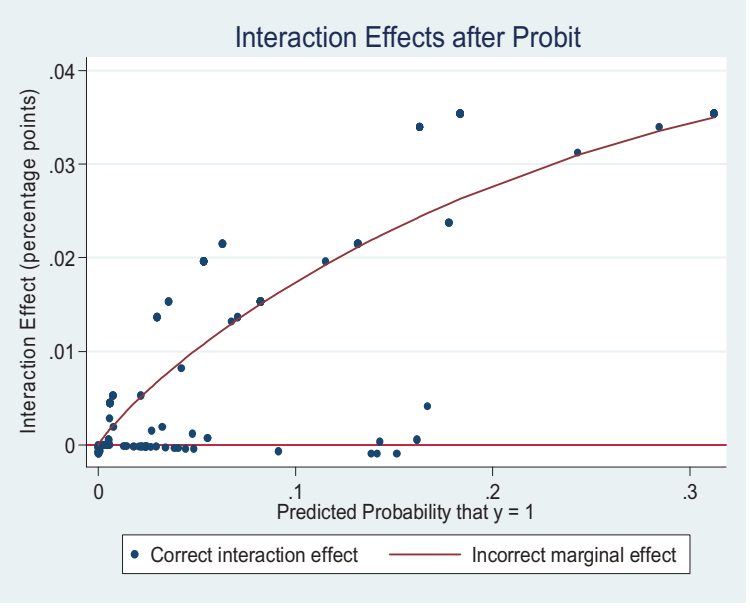

Figure 10. Interaction effects after probit between R&D and innovation in model 3 (Services).

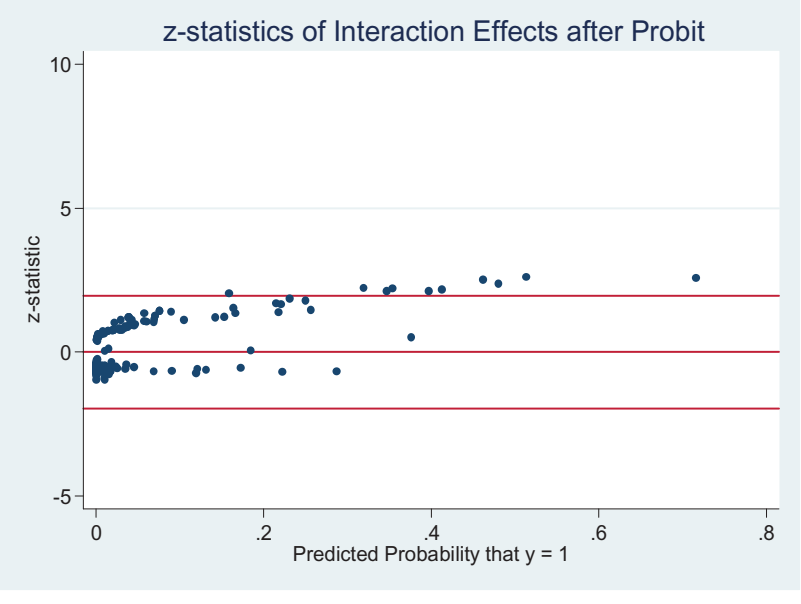

Figure 11. z- statistics of Interaction effects after probit between R&D and innovation in model 3 (Services).

decision of firms. This confirms the findings of Sarpong and Wolf (2008), who found a positive effect of firm size on export performance of firms in Ghana. This means that large firms are more likely to export compared to small firms (Teal et al., 2006), and that firm age is not a predictor of firm export participation in Ghana. Foreign affiliation

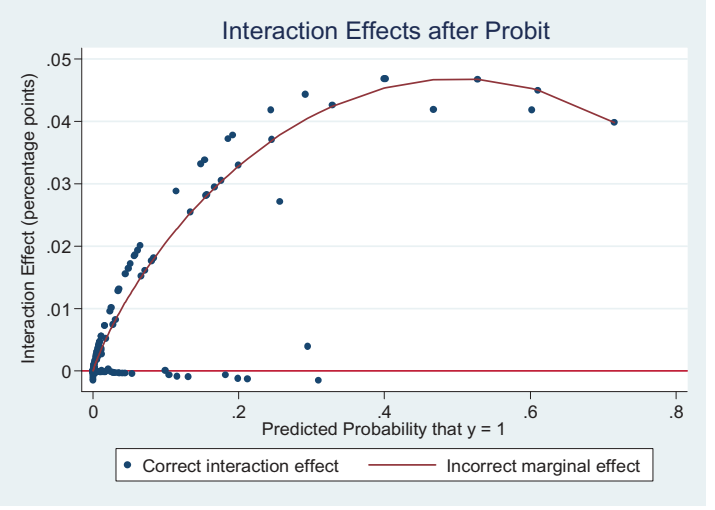

Figure 12. Interaction effects after probit between education and innovation in model 4 (Services).

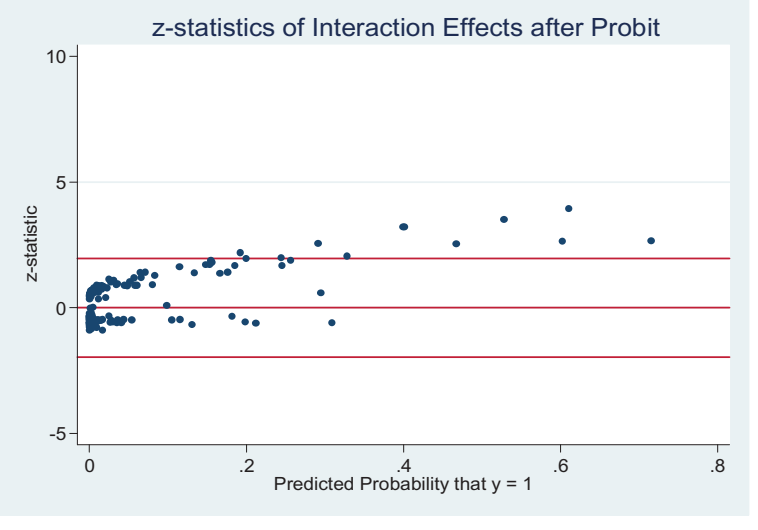

Figure 13. z- statistics of Interaction effects after probit between education and innovation in model 4 (Services).

and capital intensity have the expected positive effects. This implies that firms that have foreign stakes and use sophisticated capital participate fully in the export market than those that are wholly domestically owned and use less sophisticated capital.

Conclusion

Using a merged dataset on the 2013 Ghana Enterprise Survey, the Innovation Follow-up Survey and the Innovative Capability Survey, this paper employed the bivariate probit regression approach to model the effects of R&D and human capital as well as

their interactions with innovation on export behavior of manufacturing and service firms in Ghana. Human capital and R&D in general, are found to have positive and significant influence on the propensity of the firm to export (see Aw et al., 2007; Teal et al., 2006; Wagner, 2011). Also, the interactions – R&D and innovation; and education and innovation – exert positive effects for all firms and in the manufacturing and service firm models as well (see Harris & Moffat, 2012 and Wagner, 2000). However, after computing the cross derivatives (differences) as specified by Ai and Norton (2003), these interaction terms are significant only for a negligibly small fraction of the sample. Therefore, there is no much statistically significant evidence in support of the mediation role of innovation in the relationship between R&D/education and export behavior. These results opine the roles of R&D, human capital in boosting innovation and exports among firms in Ghana. The best explanation of the variation in the significance of the interactions may be due to the lower levels of education of the production workers and lower spending on R&D across firms in Ghana (see Danquah & Ouattara, 2014; Sarpong & Wolf, 2008; Teal, 1999).

The study also uncovered some interesting findings as well. For instance, the relationship between the educational level of employees and the likelihood for the firm to export was small compared to that of slack time and formal training on export. This means that firm-specific practices are beneficial for export participation in Ghana. Generally, our analyses showed that human capital and R&D play crucial roles in increasing export activities of firms in Ghana.

This study makes substantial contributions to the limited literature on R&D, human capital and export behavior in Ghana, a country under-represented in the existing literature. The study subsequently offers valuable insights to the role of R&D and human capital in understanding the export behavior of firms in Ghana. The findings of the study suggest that the lower levels of R&D and skilled workers by firms may have detrimental implications for export growth and economic growth in Ghana. To some extent, the lower levels of R&D and skilled workers by firms may somewhat explain the failure of technological (innovation) and economic convergence in Ghana.

On the policy implications of the study, policymakers, who would like to enhance export at the firm-level, should encourage investments in slack time and formal training. Giving tax advantages or subsidies to firms that introduce these will be beneficial. Government also needs to establish a fund for R&D activities to boost innovation, productivity and the performance of firms. Specifically, policies on the promotion of

innovation and exports should be implemented and carried out together rather than implementing separate policies for each activity. Moreover, policy makers need to implement export-promotion policies that are industry-specific.

Disclosure statement

No potential conflict of interest was reported by the authors.

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