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Determinants of firms innovation in Nigeria

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ABSTRACT

Nowadays with rapid changes in the business world, companies all over the globe are increasingly including innovation as one of their strategies to ensure business expansion and profitability. This study examined the determinants of a firm's innovation in Nigeria. The study utilized enterprise survey data developed by the World Bank, which were analyzed using probit and tobit regression models. The findings showed that investing in research and development (R&D), formal training, a firm's size, exporting status, competitors, location, type and sector, or activity of firms all positively drive the propensity of a firm to innovate. It was however established by the study that the firm's age and employee education negatively affect the chances of innovation. Equally it was found that almost the same factors (investing in R&D, formal training, a firm's size, type, and sector) were the significant determinants of product, process, organizational, or marketing innovation. Thus, the policy implications of the findings are that firms should make the significant factors their top priorities in their quest to boost innovation.

Introduction

The roles of innovation in the expansion of industrial activities and the general performance of an economy have long been established by economists and historians since the 19th century industrial revolution. Innovation commitment by a country and/or a firm is often conceptualized as one of the important determinants of micro level productivity gains and macro level economic growth (Cohen & Levinthal, 1990; Kuznet, 1966; Schumpeter, 1934).

The majority of business firms in less-developed countries like Nigeria are small- and medium-sized and face various challenges including limited human and financial capabilities, a poor infrastructural base, and unfavorable government policies which debilitate their innovation activities. Despite all these challenges, they are still making enormous efforts in embarking on various innovative activities despite their limited potential.

Kuznet (1966) opined that the greatest challenge to understanding the role of innovation in the growth and development of the economy has been lack of meaningful data to determine the factors influencing innovation. More recently, there has been the development of new data sources like the Enterprise Data Survey (EDS) by the World Bank. These new data sources have induced many empirical studies, especially in the developed countries, on the determinants of a firm's innovation (see Acs & Avsdretch, 1988; Artes, 2009; Cohen & Levinthal, 1990; Fabrizio, 2009). These studies have identified a vast and complex set of firm-specific, industry-specific and economy-wide factors that are found to be influencing innovation activities both in developing and developed economies. However, the extent to which these factors are influencing innovation, particularly in less developed countries like Nigeria, still remains an open question.

It was also observed from the literature that there has been little or no study done to determine a firm's ability to

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innovate using more direct measures of innovative inputs, especially in less-developed countries like Nigeria. Most of the previous empirical studies on the determinants of innovation concentrated on large firms, and therefore, empirical studies on small firms remain rare and scanty. Perhaps the conclusion to be drawn from the above studies may be misleading and inconclusive when applied to small firms. Therefore, the present study covered the above lacuna identified in the literature by analyzing the determinants of micro-, small-, medium- and large-scale firm's innovative behavior using a Nigerian dataset.

The remainder of the paper is organized as follows: Section Literature Review briefly reviews the literature on innovation and its determinants. Section Methodology of the Study discusses the econometric methodology and sources of data. Presentation of results and discussions of findings and conclusion are provided in Sections Results and Discussions and Concluding Remarks, respectively.

Literature Review

Theoretical Issues

The basic premise of most endogenous growth models is that technological progress and economic development are driven by innovative activities (see Cohen & Levinthal, 1990; Grossman & Helpman, 1994; Romer, 1990; Schumpeter, 1934). In the same vein, Schumpeter's (1934) theory posits that market power is a necessary condition for innovation. Firms should expect some forms of *ex-post* market power which prevents the limitation of the new products and processes and thereby allows them to recoup their research and development (R&D) expenses and move towards innovation. Van Dijk, Den Hertog, Menkveld, and Thurik (1997) opined that innovation will provide firms with large monopoly profits that are necessary to finance R&D and pave the way for the expansion of businesses. The Schumpeterian theory also highlighted that large firms having market power are in a better position to innovate than small firms. On the other hand, Cohen and Levinthal (1990), Romer (1990), and Van Dijk et al. (1997) stressed that small firms sometimes can be more innovative because they are most likely to benefit from the local market and from any R&D subsidy by government.

Innovation is not adopted and embraced by all individuals or firms in particular in an organization at the same period of time. Sometimes, it differs significantly due to the influence of factors like the environment and capability, among others. Adoption of new ideas is mostly caused by the interaction of some factors within or outside all forms of networking (Rogers, 1971). Zemplinerová and Hromádková (2012) discerned that there exist two major traditional theories of innovation that focused on the relationship between market structure and a firm's size, and innovation. The first is the Schumpeterian theory, which opined that large-scale or monopolist firms tend to be more innovative given their financial buoyancy, thereby ultimately become more efficient and better performing firms than small or competitive ones. Second is Arrow's (1962) theory which hypothesized, on the other hand, that competitive firms are more innovative than monopolist ones, because competitive firms are in a race to capture a market.

Again, Rogers (1971) and co-authors noted that innovation, as a new idea developed by an individual, is distinct from diffusion, which usually comes about after innovation. Conversely, Agarwal (1983) and Barnett (1953) among others have argued that innovation is not separate to diffusion in innovative process but a simultaneous process and is based on rationality not persuasion.

Empirical Studies

Generally, there are indeed several determinants of innovation that are common and vital to all firms. These include the firm's age, size, and strategic features such as orientation in foreign markets, barriers to finance innovation, level of market competition, the economic situation of the country, and research and development subsidies. Zemplinerová (2010) stated that variables which are expected to determine different components of the innovation process are so numerous that the selection of the variable is very likely to influence the results of empirical studies. Recent studies that applied modern econometric analysis report significant crowding out effects of subsidies on R&D to innovation. Again, Cerulli and Poti (2008) using Italian data found evidence of the crowding out effect between policy on R&D and innovation. Also, Mairesse and Mohnen (2005) using community innovation survey (CIS) data for French manufacturing companies, found a significant nexus between R&D and innovation output.

The size of the firm has also been found to be significant in influencing the behavior of firms with respect to innovation. In this regard, Zemplinerová and Hromádková (2012) using a dataset for the Czech Republic found a significant nexus between firm size and ability to innovate.

Competition, whether local or international, can be a driver for enhancing productivity through innovation. For instance, Lee (2009) used a World Bank survey for nine industries across seven countries. The intensity of competition was proxied by the degree of market pressure perceived by each individual firm in both local and international market and the study found that a firm's innovation habit depends primarily on its level of technological competence. Similarly, Alder (2010) using data surveyed from 40 developing and emerging economies found that firms with more advanced technology compared to their competitors have more product innovation. Another study by Artes (2009) using a Spanish dataset, found a long run influence of competition on a firm's capacity to innovate.

Consensus emerged that there is a positive nexus between productivity and firms' ability to innovate. In the case of developed economies, the CDM model has been frequently applied using data from Community Innovation Survey (CIS) data published by Eurostate. Studies such as Lööf and Heshmati (2003) applied it for Norway, Finland, and Sweden and found a positive influence of productivity on the firm's level of innovation. Another study, by Griffith, Huergo, Mairesse, and Peters (2006), found productivity to be a significant factor influencing innovation for all three European countries included in the study. There have also been studies of emerging and less-developed economies.

For instance, Vakhitova and Pavlenko (2010) using Ukrainian data, Halpem and Murakozy (2009) using a Hungarian dataset, Demijan, Jaklic, and Rojec (2005) using Slovakian data and Dotun (2015) using data for Nigeria, all obtained similar and uniform results that productivity is a significant determinant of innovation among firms.

There are numerous empirical studies that acknowledge technological capacity as a significant determinant of innovation (Cohen & Levinthal, 1990; Fabrizio, 2009; Nieto & Quevedo, 2005). For instance, Tsai (2001) found a direct nexus between a firm's internal knowledge and technological capability.

Again, the financial capability of firms has been found to be crucial in influencing a firm's innovation activity. For instance, a study of nine African countries by Lorenz (2014) found that financial constraint has a significant negative influence on a firm's innovative activities in all the countries studied. Mahendra, Zuhdi, and Muyanto (2015) found that the availability of financial resources significantly influences a firm's innovative and other related activities. According to Choi (2015), exporting firms tend to invest more on innovation. Process and product innovation will increase export market entry. The volume of empirical studies particularly for the developed economies found that export has a positive influence on a firm's innovation (see Brouwer & Kleinknecht, 1996; Porter, 1990).

Belsowics and Jakubiak (2009) examined the determinants of innovation for Polish firms and found that the size of the firm, sectors and structure have significant influence on innovative activities. Capital intensity was also found to have a significant effect on small firms but not on large firms. Market concentration had a significant influence on both large and small firms.

In another study, Bhattacharya and Bloch (2004) used data from a business longitudinal survey of the Australian economy and found that most variables, including R&D intensity, size, market structure and trade shares, were favorable activity for technological firms. Another empirical study on Singapore by Wan, Ong, and Lee (2005) using data from 71 companies, found a positive and significant influence of market size, and the presence of organizational resources, with respondents believing that innovation was important, along with a willingness to take risks and to exchange ideas on innovation.

Adeyeye, Jegede, Adekemi, and Aremu (2016) investigated the determinants of micro level firms' innovation in Nigeria using data from a Nigerian innovation survey, with the results showing that R&D intervention, investment in machinery, and market introduction have a positive influence on innovation activities. Deng, Jean, and Sinkovics (2012) using data for 998 Chinese manufacturing firms found that local competition, exports, and R&D intensity have a significant influence on innovation.

Another study by Dotun (2015) examined the determinants of innovation in SMEs in Southeastern Nigeria and found that eight factors are significant in influencing innovative activity: accessibility to foreign inputs, government support, level of education, competition, R&D subsidies, foreign celebration, and availability of patents and copyright. Knoben, van Uden, and Vermeulen (2014) using data for Kenya, Uganda, and Tanzania from the enterprise survey by the World Bank, revealed that there is a strong positive correlation between human capital and innovation. In another study for Tunisia, Choi (2015) applied a GMM model and found that firm size, age, availability of technical staff, and participation in export have significant influence on innovation. García-Villaverde, Elche, Martínez-Pérez, and Ruiz-Hortega (2017) in their study of the determinants of radical innovation in the hospitality and tourist industries in Spain used a sample of 215 firms and found that the structural dimension of social capital has a strong negative effect on radical innovation, which was slightly worsened by market dynamism.

Furthermore, Meroño-Cerdán and López-Nicolás (2017) investigated the drivers of innovation using community innovation survey data for Spain and found that reducing the response time and cost, new business processes, and external relations are significant drivers of innovation.

Similarly, in a cross country empirical study on the determinants of ICT innovation, Lee, Nam, Lee, and Son (2016) using a dataset for 40 countries spanning 1999 to 2013 found that high levels of broadband infrastructure and R&D are significant factors influencing ICT innovation. Coad, Segarra, and Teruel (2016) explored the impact of a firm's age on innovation using a Spanish dataset for 2004 to 2012 and found that young firms face larger performance benefits than old firms. Correspondingly, van Uden, Knoben, and Vermeulen (2016) studied the impact of human capital on innovation in Sub-Saharan countries and their findings indicated that the employee's school has a negative influence on firm innovation. On the other hand, the combination of training and stock time did not have a significant effect.

Božića and Mohnen (2016) studied the determinants of innovation using a Croatian community innovation survey 2010 dataset. The study revealed that service SMEs are somewhat less likely to introduce technological innovation but manufacturing and service SMEs did not defer significantly when it comes to non-technological innovation. Prokop, Stejskal, and Kuvikova (2017) using a community innovation survey for the Czech Republic, Slovakia, and Hungary, examined the drivers of innovation and their results showed that proper targeting of innovation drivers significantly influences the growth of firms in all the countries under consideration.

Methodology of the Study

Data and Measurement

The data used in this study were drawn from the Enterprise Survey conducted by the World Bank (WBES, 2015) in Nigeria between April, 2014 and February, 2015. Enterprise Surveys currently cover over 130,000 firms in 135 countries, of which 121 have been surveyed, and data were collected on each firm's experience and enterprise perception of the environment (including innovative activities) in which they operated. The Nigerian Enterprise Survey is nationally representative being obtained randomly from 2,676 business establishments, mainly from the manufacturing sector.

Estimation Strategy

To realize the principal objectives of the study, quantitative techniques were applied using binary probit regression. Binary probit regression is employed to estimate product, process, marketing, and organizational innovations given that the variables are binary dummies. Thus, the binary probit regression model can be specified as in Equation (1):

$$Pr(i = 1/X = x_i) = \theta(\beta_o + \beta_1 FCS_i + \beta_2 HCV_i + \beta_3 FIA_i + \beta_4 ICS_i + \varepsilon_i) \quad (1)$$

where, with regard to a firm i, Pr(i) is the propensity for the firm to innovate, $\Phi(\cdot)$ is the standard normal cumulative distribution function (cdf), FCS_i is a vector of individual characteristics, HCV_i is a vector of human capital variables, FIA_i is a vector of innovative activity, ICS_i is a vector of industry characteristics, and ε_i is an error term.

Tobit regression model was used to estimate the determinants of innovation using a broad measure of innovation or innovation score—the sum of dummies of product, marketing, process, and organization innovations—divided by the number of variables used. Thus, the model is specified according to Equation (2):

$$innv_i^* = \beta_o + \beta_1 FCS_i' + \beta_2 HCV_i' + \beta_3 FIA_i' + \beta_4 ICS_i' + \varepsilon_i \quad (2)$$

where $innv_i = 0$ if $innv_i^* \leq 0$ and $innv_i = innv_i^*$ if $innv_i^* > 0$. The definitions of the other variables are as specified in Equation (1).

Results and Discussions

Table in the Appendix contains the description of variables used in the study. Table 1 depicts the distribution of firms in Nigeria by their size based on the WBES dataset. The survey covered 2,676 firms in Nigeria and 52.13 percent (1,395) of them were small-scale firms.

Table 1 also indicates that about 12 percent (316) of the total firms operated at the micro scale, whereas 27.65 and 8.41 percent (740 and 225, respectively) of the total firms surveyed were medium- and large-scale firms, respectively. It is quite clear that the Nigerian business environment is dominated by small-scale firms, which is a feature of developing countries in general.

Table 2 reveals the incidence of innovation by firm type and sector, as well as the proportions of the sampled firms who were undertaking innovation in product, process, organizational structure, marketing, or R&D. Table 2 shows that firms that innovate in marketing strategies were the largest (52.4% of the total sample) followed by product innovative firms (49.8%), then process innovative firms (49.7%) and lastly organizational innovative firms (39.7%). Only 17.4 percent of the sampled firms invested in R&D. Again, this table indicates that small- and medium-scale enterprises were the most innovative.

Table 1
Distribution of Nigerian firms sampled by their size

Firm-type	Frequency	Percentage
Micro	316	11.81
Small	1,395	52.13
Medium	740	27.65
Large	225	8.41
Total	2,676	100.00

Authors' construction using WBES data

Table 2
Incidence of innovation by firm type and sector

Type of innovation	By firm type (percentage)				
	Full sample	Micro	Small	Medium	Large
Product	49.8	9.3	52.3	29.4	9.0
Process	49.7	8.2	48.1	30.4	9.5
Organizational	39.7	6.3	50.8	32.9	10.2
Marketing	52.4	9.3	51.9	30.1	8.7
R&D	17.4	6.9	45.9	29.5	17.7
	By firm sector (percentage)				
		Retail	Service (non-retail)	Manufacturing	
Product	49.8	19.5	36.7	43.8	
Process	49.7	17.1	36.1	46.8	
Organizational	39.7	18.2	38.3	43.4	
Marketing	52.4	19.8	35.4	44.8	
R&D	17.4	16.9	35.0	48.1	

Authors' construction using WBES data

However, microenterprises and large-scale firms were the least innovative. In terms of firm sector, manufacturing firms were the most innovative followed by service firms and lastly retailing firms. It could be inferred from this information that small- and medium-scale enterprises or manufacturing and service firms are the engine of innovation in Nigeria.

Table 3 contains the estimated marginal effects of the probit models on the determinants of innovation (product, process, organizational, and marketing innovation) at the firm level in Nigeria. The probit model of product innovation showed that the significant determinants of a firm's chances of introducing a new or significantly improved product were the firm's age, size, formal training, type (micro-, small-, or medium-scale enterprise), and the firm's main sector (retail and service). Model 1 indicates that a percentage rise in the age and size of a firm causes the firm to innovate a product by −3.9 and 3.3 percentage points, respectively. A firm that invests in R&D would be more likely to invent a product by 27.9 percentage point than otherwise.

Firms in the retail and service sectors are less likely to invent a product by 8.9 and 8.0 percentage points, respectively, than manufacturing firms. Firms whose employees received formal training would be more probable to innovate a product by 14.9 percentage points than otherwise. Micro-, small- and medium-scale firms are more likely to invent a product by 16.3, 14.9 and 12.3 percentage points, respectively, than large-scale firms. Model 2 in Table 4 also indicates that age, investment in R&D, size, formal training, and retail and service firms are the significant determinants of process innovation at the firm level in Nigeria.

Furthermore, a percentage rise in the age and size of a firm causes the firm to innovate a process by probabilities of −7.2 and 3.3 percentage points, respectively. A firm that

Table 3
Marginal effects of probit models on determinants of innovation

Variable	(1) Product	(2) Process	(3) Organization	(4) Marketing
Ln(age)	−0.0394*	−0.0724***	−0.0729***	−0.0775***
	(0.0214)	(0.0217)	(0.0222)	(0.0214)
Foreign ownership	0.0546	0.0299	−0.00373	0.0844*
	(0.0435)	(0.0446)	(0.0446)	(0.0437)
Export	0.0326	0.0329	0.0994***	0.109***
	(0.0363)	(0.0370)	(0.0369)	(0.0352)
Competitors	0.153	0.138	0.168	0.107
	(0.120)	(0.122)	(0.114)	(0.129)
R&D	0.279***	0.320***	0.346***	0.338***
	(0.0293)	(0.0279)	(0.0312)	(0.0256)
Ln(size)	0.0333**	0.0326**	0.0617***	0.0403***
	(0.0153)	(0.0153)	(0.0157)	(0.0155)
Employee edu	7.01e-05	−0.000260	−0.00169***	−0.000578*
	(0.000330)	(0.000331)	(0.000332)	(0.000324)
Formal training	0.149***	0.135***	0.155***	0.120***
	(0.0267)	(0.0269)	(0.0275)	(0.0267)
Micro	0.163**	−0.0333	0.0363	0.123*
	(0.0661)	(0.0738)	(0.0758)	(0.0666)
Small	0.149**	0.0628	0.128**	0.151**
	(0.0590)	(0.0598)	(0.0590)	(0.0595)
Medium	0.123**	0.0494	0.152***	0.139***
	(0.0540)	(0.0558)	(0.0560)	(0.0530)
Retail	−0.0893***	−0.150***	−0.0256	−0.0366
	(0.0330)	(0.0325)	(0.0330)	(0.0330)
Service	−0.0799***	−0.0946***	−0.0152	−0.0892***
	(0.0279)	(0.0285)	(0.0285)	(0.0283)
Pseudo R^2	0.0694	0.0924	0.1194	0.1020
Prob > chi^2	0.0000	0.0000	0.0000	0.0000
_hat	1.0740***	1.0940***	1.0001***	1.1174***
	(0.1317)	(0.1023)	(0.0617)	(0.1194)
_hatsq	−0.1162	−0.1423	−0.0080	−0.1286
	(0.1642)	(0.1117)	(0.0906)	(0.1059)
Obs Predicted	0.5397	0.5439	0.4278	0.5742
Predicted Pr(x-bar)	0.5478	0.5553	0.4252	0.5932
Observations	1,814	1,813	1,814	1,813

Robust standard errors in parentheses; ***$p < .01$, **$p < .05$, *$p < .1$

invests in R&D would be more likely to invent a process by 32.2 percentage point than otherwise. Firms whose employees received formal training would be more probable to innovate a process by 13.5 percentage points than otherwise.

The model shows that retail and service firms are less likely to invent a process than manufacturing firms by percentage points of 15.0 and 9.5, respectively. Model 3 in Table 3 also indicates that age, investment in R&D, size, export, employee education, formal training, small and medium enterprises, and retail and service firms are the significant determinants of organizational innovation at the firm level in Nigeria. Specifically, a percentage increase in the age and size of a firm causes the firm to innovate an organizational structure by probabilities of −7.3 and 6.2 percentage points, respectively.

A firm that invests in R&D would be more likely to invent an organizational structure by 34.6 percentage point than one that does not invest in R&D. Firms whose employees received formal training would be more likely to innovate an organizational structure by 15.5 percentage points than otherwise. Exporting firms are more prospective in inventing an organizational structure than those that do not export by 9.9 percentage points while firms are less likely to invent an organizational structure by 0.20 of a percentage point if the percentage of employees that completed high schools increases.

Likewise, small- and medium-scale firms are more likely to invent an organizational structure than large-scale firms by 12.8 and 15.2 percentage points, respectively. Finally, model 4 in Table 4 indicates that age, investment in R&D, size, formal training, foreign ownership, export, employee education, micro-, small-, or medium-scale firms, and service firms are the significant determinants of firms' marketing innovation. A specification test was conducted on the models in Table 3 and the results suggest that the models are correctly specified as linear since it the hat value is significant while hatsq is not significant.

Model 1 in Table 4 is a baseline model of determinants of broad innovation and it suggests that age, size, export, employee education, formal training, and R&D are significant in determining the overall innovative behavior of firms in Nigeria. While size, exports, formal training, and R&D have positive significant impacts on the probability of firms to be broadly innovative, age and employee education are less likely to result in the invention of a marketing strategy by 0.06 of a percentage point if the percentage of employees that completed high schools increases, whereas

Table 4
Tobit models on determinants of broad innovation score

Variable	(1)	(2)	(3)	(4)	(5)
Ln (age)	−0.128***	−0.122***	−0.124***	−0.119***	−0.0938***
	(0.0332)	(0.0331)	(0.0330)	(0.0332)	(0.0329)
Ln (size)	0.0685***	0.0981***	0.0864***	0.101***	0.0911***
	(0.0182)	(0.0235)	(0.0236)	(0.0237)	(0.0234)
Foreign ownership	0.0288	0.0407	0.0631	0.0406	0.0125
	(0.0653)	(0.0653)	(0.0653)	(0.0651)	(0.0641)
Export	0.139**	0.124**	0.125**	0.128**	0.115**
	(0.0555)	(0.0555)	(0.0553)	(0.0552)	(0.0548)
Employee edu.	−0.00149***	−0.00147***	−0.00128**	−0.00144***	−0.00109**
	(0.000507)	(0.000506)	(0.000508)	(0.000507)	(0.000502)
Formal training	0.282***	0.283***	0.291***	0.284***	0.271***
	(0.0430)	(0.0429)	(0.0429)	(0.0427)	(0.0421)
R&D	0.676***	0.679***	0.666***	0.681***	0.686***
	(0.0559)	(0.0559)	(0.0556)	(0.0557)	(0.0548)
Competitors	0.235	0.220	0.298	0.293	0.304*
	(0.184)	(0.183)	(0.184)	(0.183)	(0.181)
Micro		0.207*	0.195*	0.208*	0.208*
		(0.114)	(0.113)	(0.113)	(0.112)
Small		0.285***	0.265***	0.277***	0.235**
		(0.0928)	(0.0926)	(0.0925)	(0.0912)
Medium		0.244***	0.235***	0.246***	0.210**
		(0.0863)	(0.0860)	(0.0860)	(0.0845)
Food				0.0877	0.102
				(0.0666)	(0.0656)
Textiles				0.257***	0.266***
				(0.0701)	(0.0691)
Publishing				0.0629	0.0828
				(0.0788)	(0.0775)
Refined product				−0.158	−0.109
				(0.142)	(0.139)
Non-metallic				0.0476	0.0158
				(0.0574)	(0.0567)
Machines				−0.176	−0.219
				(0.193)	(0.190)
Furniture				0.212***	0.174**
				(0.0728)	(0.0718)
Transport				0.00127	0.0256
				(0.0884)	(0.0867)
NW					−0.143***
					(0.0479)
SE					−0.328***
					(0.0629)
SW					−0.169***
					(0.0575)
CRS					−0.0748
					(0.0833)
GME					0.353***
					(0.0865)
Service			−0.145***		
			(0.0429)		
Retail			−0.145***		
			(0.0507)		
Constant	0.350*	0.0345	0.0789	−0.103	−0.0393
	(0.202)	(0.232)	(0.231)	(0.233)	(0.231)
Sigma	0.723***	0.720***	0.716***	0.714***	0.698***
	(0.0212)	(0.0211)	(0.0210)	(0.0209)	(0.0204)
Pseudo R^2	0.0871	0.0902	0.0938	0.0964	0.1131
Prob > chi^2	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	1,798	1,798	1,798	1,798	1,798

Standard errors in parentheses, ***$p < .01$, **$p < .05$, *$p < .1$

firms whose employees received formal training would be more likely to innovate a marketing strategy by 12.0 percentage points than the firms whose employees did not receive formal training. Micro-, small-, and medium-scale firms are more likely to invent a marketing strategy than large-scale firms by 12.3, 15.1 and 13.9 percentage points, respectively.

Lastly, service firms are less likely to be innovative in marketing by 8.9 percentage points than manufacturing having negative effects on the overall innovative tendency of the firms. When a firm's types was controlled in model 2, it was found that the same variables were statistically significant and maintained their signs as in model 1. It was still in model 2 that micro-, small-, and medium-scale

enterprises were more broadly innovative than large-scale ones. Again, when both the firm's type and major sector were controlled in model 3, the same variables were statistically significant and maintained their signs as in models 1 and 2, but model 3 suggested that firms in the retail and other service sectors were less likely to be broadly innovative than the ones in the manufacturing sector.

Model 4 in Table 4 controls a firm's type and activities, and shows that the same variables were statistically significant and maintained their signs as in models 1, 2, and 3. The model also shows that firms involved in furniture and textiles activities were more likely to be broadly innovative than firms in other activities. Ultimately, model 5 controls a firm's type, activities, and regional differences, thereby establishing that the presence of competitors in the main market of the firm's main product make it more probable that the firm will be broadly innovative than in the absence of competitors. Over and above the significant variables in models 1, 2, 3 and 4, model 5 establishes that firms in the Northwest, Southeast and Southwest are less likely to be broadly innovative than those in the North-central zones. Firms in Gombe State are more likely to be broadly innovative than those in the North-central.

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In the analysis, R&D was found to be the major determinant of innovation which was in line with the findings of previous studies like Mairesse and Mohnen (2005) in France, Deng et al. (2012) in China, and Bhattacharya and Bloch (2004) in Australia. It is a truism that R&D paves the way for numerous scientific discoveries among firms in both developed and developing economies. The presence of competition is another important determinant of innovation at the firm level and this was consistent with the findings of Artes (2009), Lee (2009) and Alder (2010). This can be explained by the fact that for a firm to remain in the industry and make meaningful profits, innovation must be a golden priority.

Furthermore, the North-central zone of Nigeria was the most influential in innovative activities among all the regions because it is the center for the country where people with different backgrounds usually meet for businesses and other administrative activities as well being the country's capital. In the same vein, Gombe State was more innovative than North-central and other zones of the country possibly because of the concentration of bigger industries with foreign partners like the Ashaka cement factory. In addition, training, particularly in forms of seminars, workshop and conferences, is significantly important in improving a firm's knowledge and productivity, which in turn is likely to influence innovative activities (as in Knoben et al., 2014). This implies that formal education cannot necessarily influence innovative activities without appropriate training in relation to the working environment as was found in this study. Again, the size of firms is a significant determinant of innovation because most micro and small firms in their efforts to expand their activities tend to engage themselves in innovative activities contrary to old firms that mostly stick to their primitive method which can hardly influence innovation. This was also consistent with the findings of Bhattacharya and Bloch (2004), Belsowics and Jakubiak (2009), and Zemplinerová and Hromádková (2012).

Concluding Remarks

The principal objective of this study was the examination of the major determinants of a firm's innovation in Nigeria using the WBES dataset. To realize the objectives of the study, the econometric techniques of binary probit and tobit regression models were used. The study produced some stylized facts regarding innovation in Nigeria. First, it established that the major determinants of product, process, organizational, and marketing innovation were investing in R&D, a firm's size, formal training and a firm's age. Surprisingly, education and competitors were found to be not important in determining product, process, organizational, and marketing innovation. Exceptionally, the exporting status of firms was also an important factor influencing the marketing innovation of the firms. Again, microenterprises and small- and medium-scale firms were more likely to be innovative in product, process, organizational, and marketing than large-scale firms, while retail and service firms were less likely to be innovative in product, process, organizational, and marketing than manufacturing ones. Second, when broad measures covering all major forms of innovation were considered; investing in R&D, presence of competitors, formal training, a firm's size, exporting status, a firm's type and activity were found to have positive significant impacts on the firm's innovative tendency. Third, a firm's age, their employees' education and the firm's location in certain zones (Northwest, Southeast, Southwest in comparison to North-central) made the firm rather less likely to be innovative.

The policy implications of the study are that any firm that desires to be innovative in any of product, process, organizational structure, or marketing should pay much attention to R&D investment, formal training and the firm's size. Specifically, for firms to strengthen organizational innovation, they should also engage in exporting while attracting foreign investment makes firms stronger in marketing innovation. Any public policy intending to encourage firms' innovative behavior should also be directed to microenterprise and small- and medium-scale firms as well as to manufacturing firms, particularly ones involved in textiles and furniture because they are major sources of innovation.

Conflict of interest

There is no any conflict of interest among the authors.

Appendix

Description of variables

Variable	Definition
Dependent	
Product innovation	Dummy for any firm that introduces a new or significant product or service
Process innovation	Dummy for any firm that introduces new or significant process.
Organization Innovation	Dummy for any firm that introduces a new or significant organization structure.
Marketing innovation	Dummy for any firm that introduces a new or significant marketing strategy.
Broad innovation score	Sum of dummies of product, process, organization, and marketing innovation divided by four.
Explanatory	
Age	The number of years a firm has been in operation (natural logarithm)
Size	The natural logarithm of total number of firm's full-time employees
Foreign ownership	Dummy for the presence of foreign ownership
Export	Dummy for direct export by a firm
Employee education	Percentage of employees who completed high school
Formal training	Dummy for the percentage of employees who received formal training.
R&D	Dummy for any firm's expenditure on research and development
Competitors	Dummy for the presence of competitors in the main market of a given firm
Micro	Dummy for micro-scale business firm
Small	Dummy for small-scale business firm
Medium	Dummy for medium-scale business firm
Large	Dummy for large-scale business firm
Food	Dummy for any firm involved in food and tobacco activities
Textiles	Dummy for any firm involved in textiles, garments, and leather
Publishing	Dummy for any firm involved in publishing, printing, recorded media, and paper
Refined product	Dummy for any firm involved in refined petroleum products, chemical, plastics, and rubber
Non-metallic products	Dummy for any firm involved in non-metallic mineral products, basic metals, and fabricated metal products
Machines	Dummy for any firm involved in machinery and equipment, and electronics.
Furniture	Dummy for any firm involved in furniture and wood
Transport	Dummy for any firm involved in services of motor vehicle and transport
NW	Dummy for any firm that is located in northwest Nigeria
SE	Dummy for any firm that is located in southeast Nigeria
SW	Dummy for any firm that is located in southwest Nigeria
NC	Dummy for any firm that is located in north-central Nigeria
CRS	Dummy for any firm that is located in Cross River State of Nigeria
GME	Dummy for any firm that is located in Gombe State of Nigeria
Retail	Dummy for any firm whose major sector is retail
Service	Dummy for any firm whose major sector is service
Manufacturing	Dummy for any firm whose major sector is manufacturing

Authors' construction using WBES dataset

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