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ABSTRACT

This paper aims at investigating the various factors driving technological and non-technological innovations in the manufacturing and service sectors in Ghana. We argue that numerous previous studies have shown that digitalization, firms' collaborations, access to finance, engaging in research and development and certain firm characteristic such as age, size and ownership influence firms' aptitude and incentives to be innovative. However, in the context of developing countries like Ghana, we do not know whether these same determinants also have positive effects on stimulating innovations at the firm-level. Using a sample of 549 firms sourced from the World Bank Enterprises Survey conducted between 2007 and 2013, this study finds that the adoption of digitalization promotes non-technological (organizational) innovations than technological innovations. We also find that firms' innovation collaboration with consultants and universities rather exert no impact on technological and non-technological innovations. Our finding show that internal R&D enhance technological innovations and not nontechnological innovations. The main practical implications of the study are that attempts to boosting firm-level and developing countries innovation potentials should mainly focus on improving internal R&D and innovation support activities, expanding access to finance, and upgrading Information and Communication Technology (ICT) infrastructure to enhance digitalization.

KEYWORDS: Technological innovation, non-technological innovation, innovation collaboration; digitalization, research and development, R&D funding, Ghana

Introduction

Firms rely on innovations to generate and utilize new ideas, knowledge, and business models to develop novel products and services with an ultimate aim of achieving sustainable competitive advantages (**Odei & Stejskal, 2020**). Innovation is driven by several factors such as availability of skilled human capital, access to finance, engaging in research and development and favorable business environment among others (**Osabutey, Williams, & Debrah, 2014**). The adoption of innovation increase productivity and gives firms the competitive advantage over market rivals (**Mehrotra & Velamuri, 2021**). Hence, innovation is a key strategic determinant for a firm's competitiveness in emerging economies (**Agarwal & Wu, 2015**). However, the innovation processes vary from firm-level based on the firm's characteristics, level of technological knowledge, corporate strategies (**Bahl, Lahiri, & Mukherjee, 2021**). According to **Rogers** (**2003**), innovation can be classified into two main categories

using new product and processes. Similarly, **González-Blanco**, **Coca-Pérez**, and **Guisado-González** (**2019**) also introduced a new dimension that classifies innovation into two categories, i.e. technological, and non-technological. Technological innovations can be classified to consist of product or process innovations, whilst non-technological encompasses marketing or organizational innovations (**González-Blanco et al., 2019**).

Considerably, there is sufficient evidence that some factors play a significant role in innovation among firms' growth and competitiveness, whereas, at the firm level, innovation can be attributed to the performance of employees and how they embrace change across emerging economies (**Grant, 1991**). Innovative firms are classified as competent when they continuously embrace change of any sort in society and have qualified and competent employees to develop new products and services. Studies conducted by **Osabutey et al.** (**2014**) in Ghana discovered that some determinants contributing to industrial innovation could be attributed to in-house training, foreign direct investment, and technology transfer. Similar studies by **March-Chorda**, **Gunasekaran**, and **Lloria-Aramburo** (**2002**) on small and medium enterprises in Valencia identified that major determinant of product development was the use of modern technology, but the cost of its implementation discouraged firms commitment to new product development, whereas market uncertainties limited firms attitude toward innovation.

Despite the important role innovation play on firms and countries development, there exist a large innovation and technology gap between the developed and developing countries. Countries in Sub-Sahara Africa are repeatedly far from the technology frontiers (**You, Dal Bianco**, **Lin, & Amankwah-Amoah**, **2019**). The innovation landscape especially in African economies is hampered by a range of constraints such as lower level of technological adoption, poor infrastructure, difficulties in accumulating human and physical capital, weak managerial competences, and weak government capacity. The combination of these factors serves as a great hindrance to innovation and explains why African countries continuously lag the developed economies in terms of innovations (**Oduro, 2020**). Notwithstanding these challenges, African countries have strived to increase their technological advancement in the past few years, though this is progressing at a steady pace (**Myovella**, **Karacuka**, **& Haucap**, **2020**; **Woldai**, **2020**). However, existing literature have some caveats that do not give get a better understanding of the innovation ecosystem in African countries. For instance, previous research conducted in West African countries (see **Karakara & Osabuohien**, **2020**; **Olurinola et al.**, **2021**), ignored some key determinants such as innovation collaboration, the role of human capital and innovation funding that have been proven to impact firms' innovation. Subsequently, previous research has just focused on the manufacturing sector while ignoring other important sectors such as the service sector that stand a better chance of benefiting from innovation (**Osei**, **Yunfei**, **Appienti**, **& Forkuoh**, **2016**; **Fu**, **Mohnen & Zanello**, **2018**; **Adu-Danso & Abbey**, **2022**). Furthermore, it can be seen from the literature reviewed that there has been the paucity of studies that have attempted to analyze technological and non-technological dimensions of innovations across developing African economies especially in Ghana.

This paper aims at filling these gaps in innovation research by assessing the various determinants affecting technological and non-technological specifically in Ghana. This paper is novel because we have shown that though the extent of digitalization and adoption of ICT is low in Ghana, it has potential to impact on both technological and non-technological innovations. This study offers a new insight on human capital and its impact on firms' innovation. We have shown that new employees are a great source of innovations. In this paper we argue that hiring new employees that are skilled have great potential to induce innovations because they come in with new knowledge and ideas that can complement the existing knowledge stock leading to fresh ideas and processes. These two vital determinants of innovations have not been included in previous analysis of innovation in the African

economies. Our results therefore contribute to the growing literature on innovation, human capital, and digitalization adoption in developing countries.

The paper is organized as follows: Section one introduces the paper; section two reviews literature on the concepts of technological and non-technological and the various factors promoting them. Section three presents the methodology, sources of data and measures, section four presents the results and discussion in relation to the literature. Section five concludes the paper with suggestions for future research and policy recommendations.

Theoretical background and hypotheses developments

Innovation is not a spontaneous action by a firm, but rather requires resources and human capabilities to embrace it simultaneously. Firms can acquire new knowledge and ideas that can impact their technological and non-technological innovations from within and outside their confines (**Odei & Stejskal, 2018**). New knowledge and ideas can be generated internally within firms using their own resources or externally through the open innovation search. Hence, the open innovation and Resource-Based View (RBV) theories are the main theoretical foundations of this study. First, the open innovation theory opined that diverse knowledge sources can be used by firms to produce new and significantly improved products or processes (**Chesbrough, 2012**). Open innovations therefore require firms to partner with external agents such as universities, other firms, consultants, governments to enable them access to vital resources needed to improve and sustain competitive advantage over market rivals (**Hervas-Oliver**, **Sempere-Ripoll, & Boronat-Moll**, **2021**). Firms' collaborations allow them to access new knowledge from different partners that can be used to complement internal knowledge generated with firms. Second is the RBV theory which postulates that owning strategic resources positions firms better to improve and maintain competitive advantages over competitors (**Barney, Ketchen, & Wright, 2021**). Firms can exploit on these strategic resources at their disposal to be innovative and competitive. RBV theory integrates the firm heterogeneity notion that emphasis on ownership of key resources and the aptitude to manage and utilize these resources effectively and efficiently (Nair & Bhattacharyya, 2019). Strategic resources at firms' disposal encompasses of usual factors of production, human capital, knowledge, firm attributes, capabilities, social interactions (**David-West, Iheanachor, & Kelikume, 2018**). Knowledge is recognized as one of firms most significant strategic resources propelling productivity, competitiveness, and sustainable performance (**Pereira & Bamel, 2021**).

Technological innovation is classified into product and process innovation. Technological innovations broadly encompass any actions and activities embarked on by firms that meaningfully lead to technological transformations that delivers economic benefits to firms (**Hervas-Oliver et al.**, **2021**). Technological innovations are explicitly associated with the growth and usage of new technologies (**Geldes**, **Felzensztein, & Palacios-Fenech**, **2017**). According to **Acosta-Prado** (**2020**), technological innovation is a single process that involves series of technological activities within an organization using both internal and external funding. These processes are mostly adopted by firms to introduce new production methods to ensure that firms' raw materials are turned into finished goods. A study by **Quaye** and **Mensah** (**2019**), assessed the dynamic mechanism of technological innovation among SMEs in Ghana and discovered that the main drivers of technological innovation consist of six important factors, namely, market demand, competent workforce, the benefit drive, companies' strategies, keen competition, and public policy.

Technological innovation involves a series of activities like applying new technologies, adopting new production methods, new management strategies, improving the old production methods, exploring

new markets, and generating profit. It can be deduced that technological innovation involves research and development, production processes, effective management decision, and greater sales output. In short, it is a process of sharing new ideas and applying them for greater outputs. The importance of technological innovation is the surgency of new methods of production and commercializing. Product innovation is the only way in which firms can strengthen their competitive advantage and compete on the market. It is affirmed that the promotion of sustainable development of companies through technological innovation can be discovered through the application of information technology to stimulate industrialization. Technological innovation paves the way for industrial competitiveness and restructuring in old firms, thereby improving organizational structure to promote firm's collaboration. Nontechnological innovation refers to innovation activities that do not have technological motives (**Cornejo-Caňamares**, **Medrano, & Olarte-Pascual**, **2021**). Non-technological innovation is relevant for a firm's innovation activities that complement technological innovation, and it can again be defined as introducing the firm's organizational structure and new marketing system (**Schmidt & Rammer**, **2007**). Non-technological innovation is characterized by the application of advanced management practices, the adoption of relevant organizational structures and the implementation of new corporate strategies (**Ab Rahman, Ismail, & Rajiani**, **2018**). The implementation of technological and nontechnological are often determined by several factors such as social and legal framework, institutional and support mechanism (**Geldes et al., 2017**).

Globally, several studies have shown that numerous factors affect firms' innovation outcomes. These factors can be categorized as those that are internal within the firm and those that are external. The internal factors include firms' characteristics such as size and age (**Audretsch, Coad**, **& Segarra**, **2014**). Others are strategic decisions undertaken by firms such as domestic and international markets and inadequate funding for innovation, keen market competition, collaboration, economic situation and public subsidy on research and development (**Tian**, **Wang**, **Xie**, **Jiao, & Jiao**, **2019**). Firms' willingness and capability to innovate depends on different characteristics, new firms are often perceived to be the main drivers of innovation. In general, while such firms make an essential contribution to developing new product and processes, however they are not necessarily more innovative than existing firms. This is because new firms adopt the best approaches to capitalize on the local and foreign market to be successful and therefore grow to become bigger firm. Innovative start-ups that are not successful in the market often run out of funds and exit the market. In addition, not all new firms are innovative start-ups because some adopt an innovation after series of successful business operations. A similarly positive correlation exists between a company's size and age and their propensity to adopt a new product or process innovation that can be observed in advanced economies compared to developing economies. According to **Shields** (**2015**) economies of scale may also partly explain the positive correlation between a company's age or size and innovation. The development of new products and services often involves fixed costs and massive investment, which may be easier for larger firms to bear. These larger firms can adopt the best technology and are likely to utilize the services of R&D personnel. Larger firms may also be involved in more innovative activities and have a higher success rate than smaller firms. Surprisingly, new firms are less likely to introduce marketing and organizational innovation to reflect that bigger firms tend to have resource personnel focusing on marketing techniques and developing new approaches to marketing (**Gimenez-Fernandez**, **Sandulli, & Bogers, 2020**).

Consensus emerged that there is a positive relationship between firms' collaboration and ability of to innovate. The open innovation literature classifies this as vertical cooperation where firms can cooperation with customers and suppliers and horizontal cooperation where firms can collaborate with their competitors (**Radicic, Pugh, & Douglas**, **2020**). Consultants also represent a very important medium of knowledge transfer and firms can benefit from their expert advice and this has been proven

to impact firms' innovation (see **Odei, Odei, & Anderson**, **2020**). Though external consultants' role in innovations has been proven by the above recent study, they have received limited attention by innovation scholars. Beyond these horizontal and vertical cooperation, firms can also collaborate with knowledge providers such as universities and other public research organizations that are known to provide the greatest knowledge base comparative to any other collaborative partner (**Fernandes & Ferreira, 2013**). Firms' formal collaborations with universities are naturally expected to yield innovative outcomes, generate business opportunities and novel knowledge for industries (**Abdulai**, **Murphy**, **& Thomas**, **2020**). Despite the above-mentioned economic benefits of university-industry collaboration, a study by **Amankwah-Amoah** (**2016**) found that firm's collaboration with knowledge providers in Ghana is low due to the lack of mutual trust and confidence between these social institutions. Based on the above, we expect that firms will engage more in vertical and horizontal collaboration with market partners than these knowledge institutions. In agreement with the open innovation theory, these vertical and horizontal cooperation with market partners result in new knowledge and expertise that can positively impact firms' innovations. We therefore propose our first hypothesis as.

Hypothesis 1*: Firms' collaborations with other firms are more likely to enhance process and marketing innovations.*

Innovation support activity is a broader term that covers several tasks firms undertake to support innovation. Innovation activities in firms is well-defined as all activities embarked upon by firms to add value to their final products and services. These innovation support activities facilitate an efficient and successful development of new product and process. Innovation activities refer to all technological, scientific, and organizational roles undertaken with the intentions to further implement innovations. Innovation activities are essential for firms to deepen and broaden their scope of knowledge by blending new ideas from research activities and disseminating knowledge across firms to boost technological and non-technological innovation (**Lei**, **Khamkhoutlavong**, **& Le**, **2021**). An example of such innovation support activities is undertaking formal in-house training, mentoring and other carrier development programs. The capacity of companies can well be enhanced through sharing of information and employee training to boost productivity. This is because innovation requires the integration of human capital capabilities with new knowledge absorption (**Osabutey & Jin**, **2016**). A recent study by **Gyamfi** and **Stejskal** (**2021**) found out that internal innovative activities positively impact firms' innovation performance. In agreement with the above-mentioned study and the resource-based view theory, we believe that these innovation support activities will generate new knowledge that becomes a strategic asset that could have the potential to stimulate technological and non-technological innovations. We provide the second hypothesis as.

Hypothesis 2*: Innovation support activities are positively related to technological and nontechnological innovations.*

According to the resource-based view theory, skilled human capital is a vital strategic asset for firms as they have improved absorptive capabilities that have direct effects on innovation performance (**David-West et al.**, 2018). New employees are important when it comes to stimulating firms' innovations especially when they are skilled and experienced. These new employees can infuse new knowledge and ideas into their new companies, this can help to generate new products and process. Since labor is highly mobile, they carry their ideas and knowledge into their new workplaces. These new skilled and competent pool of new skilled personnel could help transformed firms with expert advice and new ideas to improve upon new product and process innovations. System effect refers to economic mode of production in which the same method of doing things does not bring change and new employees could bring in new these desired changes (**Pazaitis, De Filippi, & Kostakis, 2017**). In

line with the resource-based view theory, new skilled employees become important strategic assets available to firms when employed, their skills and expertise positions firms that employ them competitively. We summarize the idea that new employees could be a great source of new knowledge and innovations needed to revive stagnations and deficiencies in ideas and knowledge within firms. From this we provide the hypothesis as.

Hypothesis 3*: New employees are more likely to impact technological innovations than non-technological innovations.*

Firms can spend and undertake R&D to help prop the development of innovative products. Firms can carry out this R&D internally when they have the capabilities. Although firms can have the necessary capabilities to undertake internal R&D for new products or process's introduction, they may decide to acquire the remaining missing knowledge from external sources. They can collaborate with other external partners such as higher education and public/private research institutions, suppliers, customers from both national and international countries. Research and development activities carried out by firms help to produce new knowledge that can be useful in resolving scientific or technical problems that significantly impact innovations. The introduction of new products and processes requires specific input research and development. Internal R&D is a precondition for innovation but not an end in itself. Both internal and external R&D promote technological innovation as companies heavily invest in laboratory research, which could lead to discovering effective ways of applying innovative technology for higher profit margins (**Farkas, 2017**). Some firms contract the services of R&D consultants from other institutions and this process therefore requires heavy injection of capital, whiles others rely on in house training. However, most developing, and emerging economies combine in-house R&D, and few experts are contracted because of the high price demanded for consultancy services. Numerous studies have shown that internal R&D increases the prospects of introducing new products and processes withing firms (**Anzola-Román**, **Bayona-Sáez, & García-Marco**, **2018**; **Mata & Woerter**, **2013**). In agreement with the resource-based view theory, internal R&D results in new knowledge that constitutes an important strategic asset to firms that undertake it. We therefore summarize that firms in Ghana will likely conduct internal R&D in comparison to external R&D to promote technological innovations. We propose that.

Hypothesis 4*: Internal R&D is likely to promote technological innovations and not nontechnological innovations.*

Increasing adoption and use of digital technologies help companies to enhance their innovation performance and business scope (**Senyo, Effah, & Osabutey**, **2021**). Digitalization can be defined as the system-level reorganization of countries, institutions, and firms through digital technologies diffusion. The embedded utilization of information and communication technologies and digital technologies allow companies to accomplish success by optimizing resource usage, reduced costs, raise employee efficiency and productivity. This also allows firms to constantly and rapidly interact with customers to know their needs to solicit feedback on their satisfactory or dissatisfaction with products. This process helps firms to implement and incorporate customers view in the production process that tend to improve products and processes. Over the years digitalization has enable firms gain substantial change because they can transact their daily business activities with ease (**Cerf, 2008**). Companies can use e-mails to interact with their customers and suppliers, when they are connected to the internet. The current coronavirus pandemic has pushed firms to adopt more digital technologies in their transaction with clients as physical contacts have been reduced. A study conducted by **Karakara** and **Osabuohien** (**2020**) in West African firms concluded that firms that use e-mails, mobile phones, and website to communicate with their clients or suppliers have more prospects to introduce innovative products or processes as well as organizational or marketing innovations. Based on the

results of the study and the resource-based view theory, we summarize the idea that when Ghanaian firms adopt and use digital technologies it becomes part of their strategic assets that can facilitate their technological and non-technological innovations. We, therefore, propose that.

Hypothesis 5*: Adoption and usage of digitalization could positively contribute to driving both technological and non-technological innovations in Ghanaian firms*

Funding has been found to be a crucial factor influencing a firm's innovative activity. Without requisite funding firms may repudiate new products and process development. Studies on funding by **Shankar** (**2020**) discovered that financial constraint has been a negative factor influencing firm's innovative activities in African economies. Similar studies by **Adu-Danso** and **Abbey** (2022) found that funding enhance technological innovation among manufacturing firms in sub-Sahara African economies. However, the volume of studies conducted in developed economies found that most of the firms across Europe are supported by the European Union funding (**Bassi & Dias**, **2020**). According to studies conducted by **Choi** (**2017**), internal funding and other external factors affect different components of innovation process that makes the selection of variables for empirical studies as well as determining productivity very complex. A recent study has found some discrepancies between funding R&D and innovation outcomes using complex econometric models (see **De Blasio**, **Fantino**, & **Pellegrini, 2015**).

This raises the question of whether access to financial credit has helped companies to innovate in developing economies. There are often high interest rates and high collateral demands that affects the overall access to funds for innovations across the African region (**Appiah**, **Possumah**, **Ahmat**, **& Sanusi**, **2019**). From the above narrative, we therefore predict that firms in Ghana will be unable to have access to reliable external funding from private and governmental sources. The only viable financial option they have is to plow back their profits and reinvest in their operations. We therefore propose that these expected events will reduce access to external funding and that firms are most likely to depend on their own funding. We therefore propose that access to internal funding is more likely to stimulate technological and non-technological innovations, which is in line with the resource-based view theory that views access to funds as an asset to firms. We therefore hypothesis that.

Hypothesis 6*: Firms own funding are more likely to stimulate technological and nontechnological innovations than other funding sources.*

Firms' preparedness and capabilities to innovate depend on various internal characteristics such as size, ownership, and age. The age of a firm can have impact on innovation potentials, for instance young and small firms are believed to be key drivers of innovation. Young firms can make imperative decisions and contribution to new products development. The size of a firm can also influence its decisions to compete in internationalize and benefit from foreign markets benefits, collaborations, and competitions. Large, matured firms stand a great chance to be more innovative because of their "largeness" due to their long existence and they can learn from long periods of try and errors. A study of by **Coad et al**., (**2016**) confirmed that larger and matured firms are more probable to introduce technological innovations than SMEs and young firms.

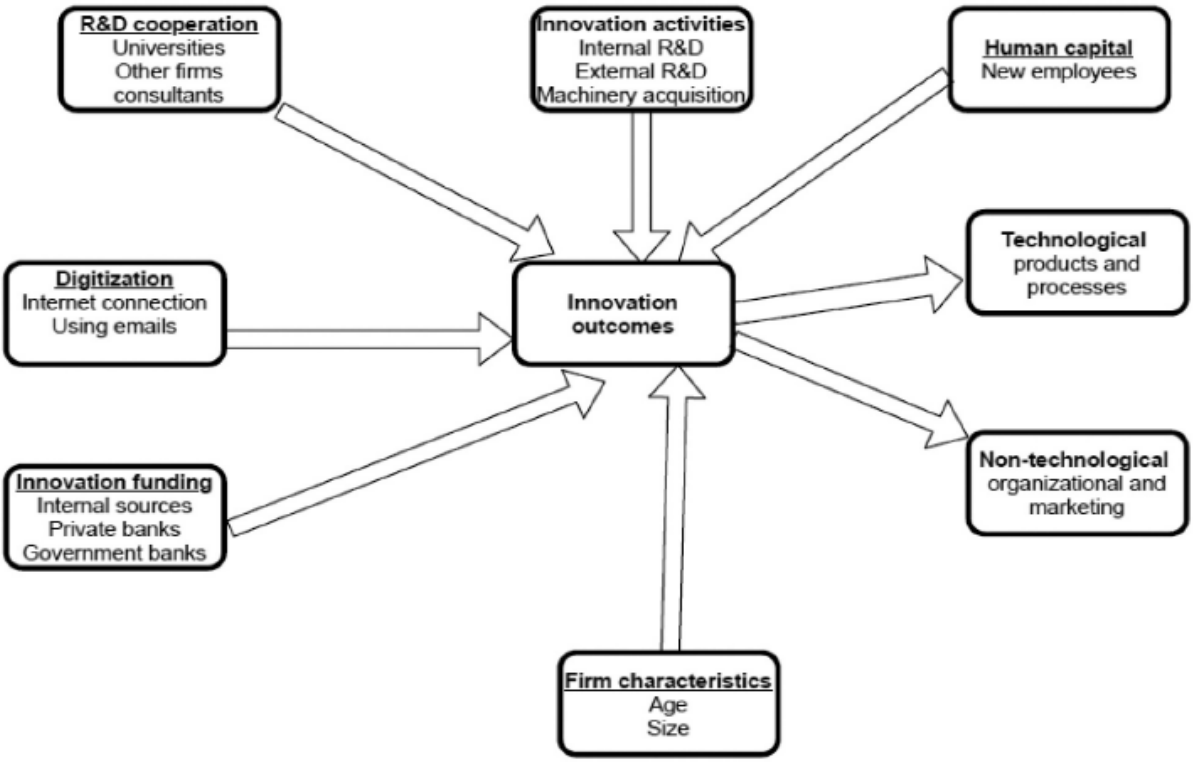

Figure 1. Conceptual Framework. Source: Author's own elaboration

Similarly, large, and older firms are also likely to be non-technological innovators when compare with SMEs and young firms. Numerous studies (see **Hervas-Oliver et al.**, **2021**) have concluded that SMEs are less probable to introduce both technological and non-technological innovations when compared with large firms.

Figure 1 summarizes and maps the relationships between the variables stated in our hypotheses. We test our various hypotheses by collecting data from 549 firms consisting of 286 firms in the manufacturing sector and 263 firms from the service sector across Ghana. The process continued by creating a representative sectoral sample of randomly selected firms from these two vital sectors. Our sample contains 52.09% of observations from the manufacturing sector and 47.91% from the service sector. We used own regression model stated in equation 1 below to examine these hypothesized relationships to test of they will be accepted or rejected.

Data and measures

Data for our empirical analysis is based on a sample of 549 industries in the manufacturing and service sector in Ghana. This panel data were sourced from the World Bank Enterprise Survey on Ghana conducted between 2007 and 2013. As of the time of writing this paper, this is the latest dataset from this survey for Ghana. The Enterprise Survey is a firm-level survey of a representative sample of an economy's private sector that covers an extensive range of business milieu topics such as market structures, access to finance, innovation and technology, infrastructure, business-government relations, competitions, and performance measures. The survey also provides data on firm characteristics such as size, ownership, age among others. These properties of the data allow us to understand firm-level innovations in countries. The Enterprise Surveys uses the stratified random sampling technique for the data collection. Firms have been selected based on industrial classification

to reflect the distribution of economic activities into manufacturing and service industries. Several studies have used this dataset to analyze firm-level innovation see for instance the recent study by (**Storz**, **ten Brink**, & **Zou**, **2021**).

To analyze the factors driving technological and non-technological innovations in Ghana' manufacturing and service sectors, we used the panel ordinary least square (OLS) regression methodology. The OLS allows the residuals to be treated as a continuous quantity and this enabled us to estimate how much innovation outputs changes when any of the covariate changes (**Hutcheson, 2011**). We are aware that the OLS can be contaminated with issues of endogeneity which can undermine the expected outcomes. We continue with analysis to deal with endogeneity separately and the result of one test is provided in the **Appendix 1**. All endogeneity results can be provided on request. We check for potential endogeneity in our models with the Dubin Chi test and Hausman F-test. These results show that the OLS results are consistent and suitable for our analysis. We provide the below general model for the OLS regression:

$$Y = \beta_0 + \Sigma_{j=1..p}\beta_j X_j + \beta_j P_{i+}\varepsilon_i \qquad (1)$$

From the formula, Y is firms innovation outcomes, β_0, is the intercept of the model, X_j corresponds to the j^{th} explanatory variables of innovation funding, innovation collaborations ($j = 1$ to ρ), P_i denotes control variables on firm-level characteristics likely to influence innovation outcomes. and ei is the error term.

Dependent variables

We identified innovative firms as those that are successful in generate commercially new improved products or services. The four dependent variables used in the empirical models are all conform to the measures used by the World Bank Enterprise Survey. We classified these four measures into two groups consisting of technological and nontechnological innovations. For the technological innovations, we measure if the firm has introduced newly improved product and process within the three-year period of the survey. The non-technological innovations measure if the firm has introduced marketing and organizational innovations within the three-year period. Product innovation simply denotes the aptitude of firms to introduce a significantly novel and improved goods or services that are entirely new to the establishment (**Odei & Stejskal**, **2020**). Process innovation means the application of innovative or significantly improved methods that decrease the unit costs of production or delivery (**March-Chorda et al**., **2002**). Organizational innovation refers to firms' capacity to implement and use new organizational approaches in decision-making, business activities, and external relations (**Geldes et al., 2017**). Marketing innovation means firms' ability to significantly transform their product packaging designs, and product advertisement occasionally (**Quaye & Mensah**, **2019**).

Independent variables

We select variables that have been widely used to analyze firms' innovations. The variables on finance sought to ascertain the sources of funding and the characteristics of financial transactions for firms' operations. Access to finance has been proven to impact firms' innovation performances positively (**Kijkasiwat & Phuensane**, **2020**), we included three dummy variables to indicate whether a firm used

their own internal funding from their profits or retained earnings, whether they borrowed from private financial institutions and whether they borrowed from government financial institutions. Firms research and development collaboration has also been shown to influence firms' innovations (**Kafouros**, **Love**, **Ganotakis**, **& Konara**, **2020**). We also added four dummy variables if these firms developed new products and services through collaborations with universities, other firms, engaged the services of consultants and if they had vertical cooperation with customers and suppliers (**Radicic et al., 2020**). Digitalization and the use of ICT can also affect firms' innovations and it can help to improve their products, process marketing and organizational activities (**Karakara & Osabuohien**, **2020**). We included a dummy variable 1 if the firm has internet connections, 0 if they don't, and also 1 if the firm used e-mails to communicate with their clients or suppliers and 0 if otherwise. Employing skilled employees can influence firms' innovations and they are proven to have higher absorptive capacities (**Aldieri**, **Makkonen**, **& Vinci**, **2021**). This was also a dummy variable 1 if the firms learned from new employees and 0 otherwise. The other remaining variables focused on firms' innovation activities. A binary variable to specify whether firms developed or altered a product and executed an ideas inhouse from internal R&D. We also believe that if these firm do not have the capacities for internal R&D, they may outsource this, based on this, we also included a binary variable, 1 if the firm engaged in external R&D and 0 if they did not. Purchasing new equipment can affect firms' innovation outcomes, so we included another dummy variable, 1 for if the firms purchased new equipment and 0 when they didn't procure any. Lastly, we included a variable on innovation support activities such as improvement in production processes, changing accounting procedures among others (**Pellegrino & Piva**, **2020**). The innovation support variable was also binary with 1 signifying if the firm introduced these activities and 0 other wise.

Control variables

We control for a certain firm-level characteristics that have been proven to influence innovations. We control for firm size a composite measure of total number of employees. Firms with between 5-19 workers are classified as small, those with 20-99 workers are medium, and large firm have more than 100 employees (**Petruzzelli, Ardito**, **& Savino**, **2018**). The age of firms plays vital role in firm-level innovations, it can influence the propensity to introduce novel products or processes (**Pellegrino & Piva**, **2020**), we measure firm' age by the year the firm was established.

Results

Tables 1-3 present statistical tests for the hypotheses developed in Section 2 above. We find statistical backing for our hypotheses. The results show that there is a statistically significant relationship between marketing and process innovations and firms' linkages with other domestic firms. This relationship was well-established in all sectors ($\beta = 0.024$, $p < 0.01$, $\beta = 0.117$, $p < 0.001$) and for the service sector ($\beta = 0.019$, $p < 0.05$, $\beta = 0.126$, $p < 0.05$). These results mean that our hypothesis 1 is supported for all sectors and the service sector. We also found a positive and statistically significant correlation between firms' linkage with domestic academic institutions and organization innovations ($\beta = 0.033$, $p < 0.05$). We also found enough evidence to support our hypothesis 2. Innovation support activities positively enhance technological innovations across all sectors. Lastly, we find that firms linkages with clients and customers positively enhance organizational innovations across all sectors combined ($\beta = 0.925$, $p < 0.001$), and for the manufacturing sector ($\beta = 0.956$, $p < 0.001$).

We also find that new employees in firms is positively associated with technological innovations. The results mean that our hypothesis 3 is fully supported for both all sectors and the manufacturing sectors. However, the results partially support our hypothesis in the service sector where they positively impact only process innovation ($\beta = 0.199$, $p < 0.001$). Also, our results point to a positive and statistically significant association between engaging in internal R&D and technological innovations for all sectors ($\beta = 0.098$, $p < 0.05$, $\beta = 0.167$, $p < 0.001$). However, for the manufacturing sector, engaging in internal R&D positively enhance process innovations $\beta = 0.131$, $p < 0.05$). This means our hypothesis 4 is fully supported across all sectors and partially supported for the manufacturing sector. We find no evidence of external R&D enhancing both technological and non-technological innovations across all sectors.

Table 1. Drivers of Innovation across All Sectors.

	Technological innovations		Non-technological innovations	
Variables	Product	Process	Organizational	Marketing
Coop. universities	−0.014(0.094)	−0.024(0.113)*	−0.045(0.085)	0.267(0.513)
Coop. other firms	−0.073(0.005)***	0.024(0.009)**	−0.016(0.010)	0.117(0.032)***
Coop. consultants	0.028(0.095)	−0.272(0.115)**	0.068(0.088)	−0.416(0.535)
Coop. suppliers/clients	−0.070(0.012)***	−0.089(0.014)***	0.925(0.078)***	0.085(0.095)
Innovation support	0.255(0.060) ***	0.389(0.059)***	0.142(0.127)	0.191(0.357)
New employees	0.065(0.011)***	0.092(0.014)***	0.029(0.078)	−0.090(0.010)
Internal R&D	0.098(0.060)*	0.167(0.056)***	−0.047(0.082)	−0.018(0.284)
External R&D	−0.069(0.062)	−0.198(0.057)***	0.073(0.094)	0.408(0.320)
Machinery acquisition	0.055(0.028)*	0.070(0.034)*	−0.228(0.053)***	0.258(0.207)
Internal funding	0.049(0.018)**	0.062(0.019)***	−0.010(0.046)	0.328(0.123)**
Funding private banks	−0.007(0.036)	−0.055(0.027)*	0.073(0.063)	−0.287(0.159)*
Funding government	−0.049(0.032)	−0.020(0.017)	−0.049(0.050)	−0.014(0.010)
Internet connections	−0.096(0.021)***	−0.007(0.048)	0.201(0.043)***	−0.701(0.147)***
E-Mail- clients support	−0.015(0.004)***	−0.007(0.006)	0.030(0.011)**	−0.074(0.028)**
Constant	0.816(0.332)***	1.683(0.145)***	−0.301(0.277)	1.048(0.978)
Control variables				
SMEs	0.068(0.043)	0.011(0.041)	−0.099(0.132)	−0.690(0.345)*
Large firms	0.057(0.075)	0.053(0.057)	0.034(0.089)	0.494(0.277)*
Age (years)	−0.001(0.001)	−0.001(0.001)***	−9.540(0.001)	−0.004(0.002)*
Model fit summary				
Obs.	549	549	549	549
RMSE	0.412	0.373	1.106	2.602
Prob > F	0.000***	0.000***	0.000***	0.000***
R^2	0.237	0.306	0.926	0.050

Authors' elaboration

**0.05, **0.01, ***0.001 significance level. Robust standard errors in brackets.*

Hypothesis 5 suggests that digitalization does contribute to driving both technological and non-technological innovations. Our results fully support hypothesis 5 for nontechnological innovations across all sectors. However, the results mean that we accept hypothesis 5 partially for technological innovations for the manufacturing sector. Across all sectors, digitalization exerted positive impacts on organizational innovations ($\beta = 0.201$, $p < 0.001$, $\beta = 0.030$, $p < 0.01$). Also, for the manufacturing sector, the results confirmed the positive correlation on organizational innovation ($\beta = 0.156$, $p < 0.001$, $\beta = 0.031$, $p < 0.01$). On the contrary, in the manufacturing sector, internet connection positively impacted process innovations and was likely to increase process innovations by 5%.

Table 2. Drivers of Innovations in the Manufacturing Sector.

	Technological innovations		Non-technological innovations	
Variables	Product	Process	Organizational	Marketing
Coop. universities	0.022(0.120)	0.166(0.181)	−0.015(0.092)	0.410(0.594)
Coop. other firms	−0.088(0.159)	0.195(0.198)	−0.064(0.149)	0.183(0.841)
Coop. consultants	0.008(0.0971)	−0.376(0.131)**	0.095(0.104)	−0.758(0.725)
Coop. suppliers/clients	−0.062(0.013)***	−0.066(0.013)***	0.956(0.063)***	−0.032(0.067)
Innovation support	0.257(0.082)***	0.449(0.072)***	0.006(0.077)	−0.309(0.307)
New employees	0.068(0.013)***	0.079(0.013)***	0.026(0.060)	−0.085(0.078)
Internal R&D	0.081(0.082)	0.131(0.073)*	0.038(0.067)	−0.016(0.347)
External R&D	−0.082(0.084)	−0.166(0.076)*	−0.053(0.069)	0.185(0.371)
Machinery acquisition	0.070(0.027)**	0.054(0.037)	−0.143(0.025)***	0.482(0.190)**
Internal funding	0.059(0.020)***	0.046(0.020)**	0.016(0.027)	0.243(0.098)**
Funding private banks	0.109(0.093)	0.052(0.074)	0.039(0.071)	0.261(0.346)
Funding government	−0.168(0.094)*	−0.119(0.074)	−0.042(0.072)	−0.418(0.348)
Internet connections	−0.083(0.017)***	0.051(0.029)*	0.156(0.019)***	−0.685(0.110)***
E-Mail- clients support	−0.008(0.005)*	−0.001(0.006)	0.031(0.012)**	−0.042(0.027)
Constant	1.311(0.124)***	1.390(0.135)***	0.223(0.187)	0.971(1.041)
Control variables				
SMEs	0.127(0.056)*	0.052(0.057)	−0.198(0.150)	0.142(0.312)
Large firms	0.101(0.074)	0.189(0.045)***	−0.057(0.116)	0.642(0.244)**
Age (years)	−0.002(0.005)***	−0.003(0.004)***	4.950(0.009)	−0.001(0.002)
Model fit summary				
Obs.	284	284	284	284
RMSE	0.400	0.374	0.633	2.120
Prob > F	0.000***	0.000***	0.000***	0.000***
R^2	0.280	0.402	0.974	0.081

Authors' elaboration

**0.05, **0.01, ***0.001 significance level. Robust standard errors in brackets.*

Table 3. Drivers of Innovation in the Service Sector.

	Technological innovations		Non-technological innovations	
Variables	Product	Process	Organizational	Marketing
Coop. universities	0.012(0.010)	−0.022(0.015)	0.033(0.020)*	−0.120(0.110)
Coop. other firms	−0.077(0.007)	0.019(0.009)*	−0.041(0.021)*	0.126(0.055)*
Coop. consultants	-	-	-	-
Coop. suppliers/clients	−0.086(0.122)	−0.206(0.095)*	0.526(0.618)	0.683(0.922)
Innovation support	0.280(0.092)***	0.323(0.094)***	0.361(0.261)	1.046(0.725)
New employees	0.070(0.120)	0.199(0.093)*	0.399(0.612)	−0.624(0.920)
Internal R&D	0.154(0.094)	0.129(0.0100)	−0.003(0.141)	0.094(0.618)
External R&D	−0.095(0.093)	−0.146(0.099)	0.022(0.167)	0.502(0.621)
Machinery acquisition	0.073(0.079)	0.081(0.070)	−0.416(0.231)*	0.131(0.545)
Own funding	0.067(0.060)	0.156(0.047)***	−0.157(0.183)	1.039(0.370)**
Funding private banks	−0.050(0.062)	−0.148(0.050)***	0.177(0.174)	−0.994(0.386)**
Funding government	−0.026(0.021)	−0.009(0.014)	−0.029(0.036)	0.009(0.095)
Internet connections	−0.140(0.083)*	−0.064(0.072)	0.389(0.272)	−0.749(0.566)
E-Mail- clients support	−0.022(0.010)*	0.012(0.008)	0.043(0.034)	−0.107(0.070)
Constant	0.271(0.184)	1.913(0.198)***	−1.169(0.572)*	2.083(1.583)
Control variables				
SMEs	−0.002(0.068)	−0.042(0.060)	−0.016(0.241)	−1.649(0.635)**
Large firms	0.039(0.116)	−0.084(0.092)	0.060(0.177)	0.471(0.483)
Age (years)	0.001(0.006)*	−0.003(0.006)***	0.007(0.001)	−0.002(0.004)***
Model fit summary				
Obs.	263	263	263	263
RMSE	0.419	0.360	1.459	2.946
Prob > F	0.000***	0.000***	0.000***	0.000***
R^2	0.261	0.231	0.883	0.119

Authors' elaboration

**0.05, **0.01, ***0.001 significance level. Robust standard errors in brackets.*

Our hypothesis 6 is also supported, we find a positive and statistically significant correlation between own funding and technological and non-technological innovations across all sectors. The hypothesis is fully supported for technological innovations across all sectors and the manufacturing sector but partially for non-technological innovations. But partially supported for non-technological innovations. The results, however, show that it enhances technological innovation between 4% and 6%. Surprisingly, all the remaining sources of funding did not influence technological and non-technological innovations across all sectors. Other results such as machinery acquisition proved to be a significant determinant driving innovations across sectors. Across all sectors, machinery acquisition is likely to increase product innovations by 5% while process innovations by 7%. For the manufacturing sector, it was likely to increase product innovations by 7% and marketing innovations by 48%.

Finally, our results on the control variables show that across all sectors these carefully selected firm characteristics such as firm size and age were not probable to influence technological and non-technological innovation. Size and age produce negative impact on process innovations (β = -0.001, p < 0.001, β = -0.004, p < 0.05). Contrariwise, the results show large firms were probable to be organizational innovators (β = 0.494, p < 0.05). For the manufacturing sector, these firm characteristics demonstrated to impact on innovations. SMEs were likely to be product innovators (β = 0.127, p < 0.05). SMEs in Ghana' manufacturing sector are more probably to develop new products that are new to the market. Large firms were probable to be process and organizational innovators (β = 0.189, p < 0.001, β = 0.642, p < 0.01). In the service sector, age demonstrated to positively influence product innovations marginally β = 0.001, p < 0.05). Studies by **Quaye** and **Mensah** (**2019**) established a non-significant positive nexus between process and product innovations and SMEs' performance, implying that SMEs in Ghana are not likely to be innovators. Donkor, **Donkor**, **Kankam-Kwarteng**, and **Aidoo** (**2018**) also find that firm age has no significant relationship with innovation performances.

Discussions

Our results have affirmed the importance of firms' open innovation collaboration with external partners positively stimulate innovation. Across all the model specifications, it can be witnessed that this collaboration did not significantly stimulate innovations. Among all the collaborating partners considered, only vertical cooperation with customers and suppliers, was likely to improve organizational innovations by 93% across all sectors combined and 96% for the manufacturing sector. Surprisingly, we find that firms linkages with knowledge institutions were not a significant determinant of innovation. Our results of the insignificant results for universities boosting innovation contradicts a related study by **Abdulai et al.** (**2020**) who found that formal linkages of businesses and universities in Ghana foster knowledge transfer to these firms which is the much-needed catalyst for innovations. Ghanaian universities might not have well-embraced their third mission of carrying economically viable research that can be adopted and commercialized by Ghanaian businesses. The significant role played by linkages with suppliers and clients is not surprising because suppliers provide access to professional knowledge that firms can rely on to improve their organizational processes (**Kafouros et al.**, **2020**). Firms' linkages with consultants also did not stimulate innovations, these collaborations rather negatively reduced the likelihood of contributing to process and new product development across all sectors and the manufacturing sector. In the manufacturing sector, it reduces process innovations by 38%. Ghanaian businesses do not rely on consultants because consultancy services and contract comprise high transaction costs, consultants benefit at the expense of firms' innovation.

Our results have demonstrated the benefits of carrying out innovation support activities within firms. This proved effective in promoting technological innovations across all sectors. Firms aiming to be innovative undertake certain innovation activities such regular employee training activities, innovation management among others. There are no doubt innovation support activities contributed positively to technological innovations because it develops the skills and knowledge of employees. The investment in new knowledge can contribute to the creation of technologically new and enhanced products or processes. Our results confirm to a similar conclusion by **Ndemezo** and **Kayitana** (**2020**), who found that innovation activities undertaken within the Rwandan manufacturing industries stimulated product innovations. It is worth mentioning that undertaken these activities do not guarantee innovations, but they are catalyst for successful innovations in the long run.

Our results have shown the important contributions new employees can offer in terms on technological innovations. Across all the model specifications, it is evidenced that stimulate product and process innovation by approximately 8%. The greatest impact is seen in the service sector where they are probable to increase process innovations by 20%. These new employees can be new sources of new knowledge and ideas that can complement the existing knowledge stock. However, our results must be interpreted with caution, it is not the new employees per say that matters, but their skills, knowledge, and experience. If the new employees are well-educated with university degrees, they have increased absorptive capacities, which can affect the likelihood of introducing new products or processes (**Martínez-Sánchez**, **Vicente-Oliva**, **& Pérez-Pérez**, **2020**). Our results are not different from the conclusions reached by **Medase** and **Abdul-Basit** (**2020**) and **Karakara** and **Osabuohien** (**2020**), who all find that new employees have an inherent baggage of new knowledge that is essential to stimulate the innovative potentials of firms.

Furthermore, our findings have attested to the significance of digitalization and how information and communication technology (ICT) infrastructure can accelerate organizational practices and innovation. Across all sectors, firms with internet connections are on average 20 percentage points more likely to improve their organizational practices while those that use e-mail to communicate with their suppliers or clients are 3 percentage points more likely to introduce organizational innovations. The impact of digitalization was also evidenced in the manufacturing sector, but not the service sector. The adoption of digitalization helps firms to embark on research using the Internet, solicit new ideas and feedback from customers and clients. These feedbacks and interaction produce new knowledge that firms can use to implement organizational innovations. A study by **Karakara** and **Osabuohien** (**2020**) confirm our findings that Ghanaian firms that adopt digitalization improve their organizational innovations.

The literature on innovation have stressed the importance of engaging in R&D and its positive impact on new product and process development. Our results have also confirmed that across all sectors and the manufacturing sector R&D increase the probabilities of technological innovations. It increased the likelihood of introducing new products and processes across all sectors by 17 and 10%. And for the manufacturing sector by 13 and 8%. The results show that engaging in external R&D had no positive impact on both technological and non-technological innovations. This result confirms our results on collaboration especially with Ghana' knowledge institutions, which showed no impact of both technological and non-technological innovations. Without engaging in R&D, firms will lack the ability to gain new knowledge and absorb new technologies. Our results contradict the finding of **Afful** and **Owusu** (**2017**), who concluded that R&D drives nontechnological innovations in Ghana's manufacturing sector. However, our results support the findings of a related study in Nigeria by **Adeyeye et. al**. (**2013**), who concluded that in-house R&D positively influence technological innovation but in the service sector.

Investment in machinery acquisition has also been demonstrated to stimulate technological innovations in across all sectors combined and in the manufacturing sector. However, the strongest impact of investment in machinery acquisition was on marketing innovation in the manufacturing sector, where it increases the probability of increasing marketing innovations by 48%. This is not surprising because when firms procure new machinery, it can help to improve previous processes and product development. The impact can be significant when it replaces the manual way of doing things previously. It is not surprising machinery acquisition was not a significant factor driving innovations in the services sector as this sector does not require sophisticated machinery to thrive. Our results authenticate the findings of **Akinwale**, **Akinbami**, and **Akarakiri** (**2018**), who also concluded that the acquisition of advanced machinery significantly influences technology capabilities of indigenous Nigerian oil firms.

Lastly, our results have affirmed the important statistically significant role played by the availability of internal funding on both technological and non-technological innovations. The results show that sources of funding for firms' innovations are bracketed with some significant heterogeneities. To our surprise, only firms own funding was statistically significant in these regards. Public funding and funding from private sources negatively impacted on all measures of innovation across all sectors. Our results validate the claim that Ghana has truncated levels of financial inclusion and firms access to finance remains a foremost challenge. With the limited access to external finance from the public and private sources, large majority of firms must rely on internal finance for investments in innovations and its related activities (**Appiah et al.**, **2019**). Finally, one of the major constraints to accessing finance from external sources is the high collateral demands, most of the financial institutions demand real property as the most common type of collateral. Firms without these collaterals are limited and prohibited to accessing formal finance (**Boateng & Poku**, **2019**). Our results partially confirm the findings of a similar study in Nigeria by **Adegboye** and **Iweriebor** (**2018**), who find that both internal and external funding sources improve investment in technological and non-technological innovation. However, our results contradict the findings of similar research in Ghana by **Udimal**, **Jincai**, **Musah**, and **Hua** (**2019**), who concluded that public funding promoted technological innovations.

Conclusion

Studies on innovations have been widely carried out in the developed countries of Europe and North America. However, in the context of developing countries research on firm-level innovation is gradually gaining momentum. This paper aimed at analyzing the potential factors driving innovations. In agreement with the literature, we assessed the impacts of firms' collaborations, innovation funding, digitalization, internal and external R&D and human capital (new employees) role in stimulating innovations. The results corroborate the view that internal R&D and innovation support activities increase the likelihood of successful technological innovations. These activities should be understood as they are preconditions for innovation and do not automatically lead to innovations. The impact that internal R&D have on the likelihood of introducing new products and services in Ghana is particularly large in the manufacturing sector but not in the service sector.

Our results point to the importance of digitalization in enhancing non-technological (organizational) innovations. Firms that have internet connections and those that use e-mails to support their clients were probable to improve their organizational innovations. The greatest impact of digitalization was witnessed in the manufacturing sector than within the service sector. The policy implication of these results is that, improving accessibility and affordability of internet connection is very vital for successful innovation. Government and the telecom companies need to work toward subsidizing internet prices

to make it cheaper to encourage all firms to connect and use the internet for their business needs (**Jibril**, **Kwarteng**, **Pilik**, **Botha**, **& Osakwe**, **2020**). Supporting information and communication technology (ICT) infrastructure needs to be upgraded to ensure improved and uninterrupted connectivity.

Our results have shown that firms collaborations in Ghana is underestimated with firms and knowledge institutions work independently rather than collaboratively. Previous studies in emerging countries (see **Storz et al.**, 2021) have proven that university-industry linkages result in the creation of innovations. However, our results proved otherwise that this collaboration is almost non-existent in the case of Ghana. This is a worrying development as this leads to continuous stagnation in innovation because firms benefit from the knowledge from universities when they collaboration and this fuels sustainable innovation. Policy makers need to encourage universities and other public research organizations to be more entrepreneurial. Needed financial support and incentive structures for research and development needs to be increased to promote quality research from these academic institutions. Furthermore, these academic institutions need to reform their curriculum and modus operandi to reflect current market demands, carrying out economically viable research that can be appropriated and commercialized by firms to aide their innovation potentials.

Finally, our analysis shows the impact new employees can have on technological innovations in both the manufacturing and service sectors. New employees can infuse new knowledge into their new companies and help spur innovations. This said does not mean that all new employees can enhance innovations. Firm managers and human resource managers need to pay key attention to the personnel they employ to join their teams. Emphasis on recruitment must be on bringing in skilled and experienced personnel, its these skilled and educated workforce that are endowed with higher absorptive capacities to absorb new knowledge and technologies and apply it to further innovation (**Li**, **2011**).

Our findings have implications for the literatures on open and close innovation, and public support for innovation in developing economies. We contribute to the literature in three ways. First our results contribute to the growing open innovation literature as we have shown that vertical and horizontal innovation collaborations with other firms, clients and suppliers and universities positively impact technological and nontechnological innovations in Ghana. These various innovation partnerships result in new knowledge and expertise that are catalysts for firm-level innovations which is in line with the open innovation theory. Second, our results contribute to the resource-based view theory as we have shown that human capital (new employees) and access to funds (internal funding) are positively related to technological and non-technological innovations. New employees are vital sources of new knowledge and ideas that positively impact on technological innovations. Highly skilled new employees and access to funds from internal source become vital strategic resources that can spur firm-level innovations. Though our results have shown that new employees matter for firms' innovation process, this is yet to receive scholarly attention. Third, our work makes a novel contribution to the literature on innovation and how digital technologies can be harnessed to drive firm-level innovations in developing economies like Ghana (**Kagermann, 2015**). This relationship is yet to be explored, so our findings set the pace for research to establish this vital relationship. Our findings show that the adoption of digitalization and ICT within firms increase the likelihood of contributing to organizational innovations especially in the manufacturing sector.

There are several limitations encountered in this study that should be tackled by future research. First, the findings of our research are limited to just Ghana with heterogeneous sector composition. Though we used a panel data spanning 11 years with the last year of 2013, the data is not current and might not be a true reflection of the status quo of innovations in Ghana. Future research could use current

panel data if they become available, to make the results more robust and allow us to see the recent trend of innovation development. Second, future work may explore the regional dynamics of innovations to identify how regions differ in terms of innovations and whether regional endowments and institutions influence regional innovations and entrepreneurial activity. Another limitation of our research stems from the measurement of technological and non-technological innovations adopted. Though these measures have been widely used as proxies for innovation, they are subjective as they ignore the extend of novelty of these innovations that are new to the market. For a better understanding of innovations, we recommend future research to consider other objective and insightful measures for innovation, such as new product for product innovation or patents for process innovation. These insightful measures provide useful understandings about the origin and originators of technology R&D (**Buerger**, **Broekel**, **& Coad**, **2012**). Thus, patenting process and information can be useful in determining where new ideas come from and how they contribute and indorse new inventions.

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