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DIGITALIZATION AND INNOVATION IN NIGERIAN FIRMS

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ABSTRACT

This study examined the determinants of digitalization and its impact on innovation in Nigeria. The study applied the logit regression and propensity score matching (PSM) on data sourced from the World Bank 2014/2015 enterprise survey. The result from the logit regression shows that size of the firm, educational qualification of the top manager of the firm, business age, employment growth and sector of operation are the major significant determinants of the extent to which firms digitalized in Nigeria. On the other hand, the result from the propensity score matching shows that digitization is positive and significant in explaining the level of firms' innovation in Nigeria. This means that an increased level of ICT will synonymously increase the level of firms' ability to innovate. Based on the results, the study concludes by recommending that managers of various firms should employ a tactical approach to improve on the rate of digitization and innovation to achieve the desired level of productivity.

Contribution/Originality: This study is one of very few that have investigated the determinants of digitalization and its impact on innovation using the logit regression and propensity score matching (PSM) methods.

1. INTRODUCTION

Technological progress has been recognized as being one of the significant drivers of innovation. Growing evidence shows that innovation is essential for the competitiveness and development of firms (Arvanitis, Loukis, & Diamantopoulou, 2011; Karakara & Osabuohien, 2020), not only for developed countries, but it is also required for developing countries, including Nigeria (OECD, 2010). This is necessary because innovation is an important avenue to improve effectiveness, expand activities and move to higher value-added accomplishments (Buesa, Heijs, & Baumert, 2010; Karakara & Osabuohien, 2020; OECD, 2010).

The new technological trends, such mobile services, social media, cloud computing, big data and robotics, have supported new ways of collaborating, organizing resources, designing products, matching complex demands and offers, developing new standards and enhancement of firms' productivity (Markus & Loebbecke, 2013). This

development has enormously changed the competitive environment and reshaped traditional business approaches, models and processes (Bharadwaj & Noble, 2015). Digitization and innovation are the most extended and significant technological developments in all sectors of the economy. This forms the motivation for this study because information and communication technology (ICT) helps to drive radical and disruptive innovations, which can impact firms' production processes and their entire scope of products and services.

The study by Abramova and Grishchenko. (2020) posits that ICT is one of the significant factors which could make drastic changes in industries. Although the study found a positive effect of ICT on labor productivity, the possible negative impact on unemployment is yet to be confirmed by research. An intersectoral comparison study in Russia indicated heterogeneous effects. Though ICT has become widespread in recent times, its impact on labor productivity and unemployment have been gradual. Studies which focused on the technological aspect of unemployment due to ICT confirmed that automation and computerization are the main reasons for potential unemployment (jobless growth). The study by Biagi and Falk (2017) posited that ICT has a less direct or negative association with innovation. The study is structured into five sections. Following this introduction is the review of the literature and theoretical perspectives. Section three explains the method, the results are presented and discussed in section four, and the study concludes with section five.

2. LITERATURE REVIEW

2.1. Digitalization, ICT and the Industrial Sector

It can be argued that the digital revolution holds undeniable opportunities that could transform economies and produce development outcomes across interacting sectors, but more so for firms or industries. The shift in how work should be done differently from what prevailed in the pre-fourth industrial revolution era has led to grey areas in the creation of newer chances to boost productivity and overshoot production and revenue targets for firms.

To optimize the benefits of the digital revolution vis-à-vis firms' activities, Bógdał-Brzezińska (2020) mentions that certain conditions must be met. The first step to achieving this is access to cheap or affordable infrastructure and connections without which an argument for digitalization could not be made in the first place (Beecroft, Osabuohien, Efobi, Olurinola, & Osabohien, 2019). A decent level of education and skill, which serves as a pointer to appreciable know-how in the operation and use of the available digital channel, is seen as the next important factor or condition. Last, the required condition is trust—the assurance that end-users of digital platforms have no need to worry about the safety and security of their electronic transactions as the global interchange of data and information via the internet increases. The adoption and use of information and communication technology (ICT) in a bid to enhance practices in the informal sector rides on the extent of digital inclusiveness of the players. New developments in ICT, as well as the continued adoption of the same at various levels, requires informal sector agents to embrace changing trends globally without falling into the disadvantage of digital schism or isolation (Srinuan & Bohlin, 2011). Indeed, there are arguments that uneven access and use of ICT, due to a skewed distribution, can lead to polarized growth trends with one side leaning more on the positive side and the other towards the negative (Norris, 2001; Organisation for Economic Co-operation and Development (OECD), 2001; van Dijk, 2006; van Dijk & K., 2003; van Dijk, 2002). In this sense, it becomes a matter of necessity that supportive policies that help reduce or ultimately close the digital divide are in place to enhance actors in the grey economy to obtain and share information effortlessly. With more fluid and balanced access to information, transaction costs and time are expected to reduce, ceteris paribus. In contrast, the surge in the volume of transactions is expected to increase sales and earnings, and consequently, growth (Adeleye & Eboagu, 2019).

2.2. Digitalization, ICT and Innovation Nexus: Theoretical Perspectives

The major advantage that the new way of work ushered by globalization, digitalization and ICT adoption confers on the world of business ensures that households, firms and economies share in the opportunity to escape

poverty. Thriving in a world that is now centered around technology and innovation requires business owners to be receptive to the new status quo promptly as they integrate into the new economy, while those unable to embrace this change will be left behind (Steinmueller, 2001). Digitization results in innovation – improvement in the process of service and product offering – as old methods and styles are replaced with newer ones aided by the use of ICT infrastructure (Beecroft et al., 2019). Several studies have delved into the core of this popular premise, and some theories have been instrumental in explaining the nexus between digitization, ICT and innovation.

Christensen (1997); Christensen (2006) put forward a theory of disruptive innovation that explains the leading role that digitalization and ICT adoption plays in business strategy. This theory describes how business models change within a market or group of markets as technologically driven ideas and processes tend to reshape incumbent practices, thus creating challenging situations for those either unwilling or too slow to innovate or catch up. Technology within existing structures of businesses open up new markets for the innovatively consistent ones. Relatively smaller firms with fewer resources and less market strength use the range of technological ideas and resources as well as other ICT related tools to take advantage of market segments that have been neglected by incumbent businesses who are more focused on high-end trade.

This market segment provides an opportunity for "disruptive" entrepreneurs and business owners to penetrate the market by providing more efficient services and better products at lower costs than the incumbents. Eventually, these innovatively driven businesses move upmarket as they are now capable of satisfying incumbents' mainstream utility preferences and they ultimately take over entire market shares over time (Christensen, Raynor, & McDonald, 2015). However, the wide misunderstanding of the theory's concept and the frequent misapplication of the same by many stands as a major critique of this theory's success in explaining the role of digitalization on firms' performance.

Based on the works of the famous Austrian economist, Joseph Schumpeter, in 1942, the creative destruction hypothesis emphasizes the importance of innovation to development at both the micro and macro levels. Creative destruction primarily involves the transformation from long-standing practices into more innovative and tech-driven processes and controls that eventually yield more significant levels of development via improved productivity while rendering erstwhile techniques redundant. Schumpeter (1942) imprinted this theoretical concept on the role of entrepreneurs as creative innovators, whose success is akin to economic growth. Accordingly, the process of innovation by entrepreneurs would involve appropriate investment in new products, new approaches and new technologies, while the old techniques become irrelevant and obsolete.

Schumpeter (1942) maintains in his description of what the creative destruction theory entails that entrepreneurs are frequently in search of what is known as "monopoly rents" so they can enforce the evolution of social and economic structures. Hence, economic development, according to Schumpeter, is described as a natural result of internal market forces, which is borne out of the need to seek profit. The theory further downplays the central position of market equilibria in the market process; rather, innovation by technology adoption and competition is preferred in place of the former. To Schumpeter, adoption of new technologies would cause a temporary disequilibrium but will open up new opportunities, while older technology enthusiasts will be left out. This, therefore, is the central ideology of innovation by creative destruction (Kopp, 2019).

Based on Joseph Schumpeter's view on the concept of creative destruction, the leapfrogging hypothesis applies to studies on economic growth and innovations within the industrial sphere. The theory explains the role of technological innovations in keeping firms and industries more competitive than their incumbents as the newer entrants rapidly adapt to higher levels of productivity and development (Miller, 2001). The main point of this hypothesis maintains that newly adopted technologies by risk-taking firms and organizations can force incumbent firms with old technologies, which are less motivated, into redundancy. With the adoption of these new technologies and systems, which mainly include the use of a broad range of ICT related tools as well as the adoption of digital technologies, firms, organizations and economies can move forward rapidly from an erstwhile position of

non-digitalization and crudeness. It is this form of rapid change in process and technology that leads to higher levels of development.

Sauter and Watson (2008) submit that specific policy by the government is necessary to ensure that industrial structural transformation beyond a country's factor endowment is made possible as the promotion of high-tech and high-domestic value-added firms and industries becomes pertinent. These policies must be implemented to help develop both absorptive capacities of the adopting firms and their technical capabilities in order to fully realize the benefits of leapfrogging. In this way, generic functional policies which improve the educational standard as well as more specific procedures that are capable of stimulating innovation in the interested sector(s), such as the informal sector, become of interest (Sauter & Watson, 2008). Therefore, an appropriate mix of economic, industrial and research and development (R&D) policies are viewed as essential to achieving digital transformation and, consequently, growth.

The argument that the introduction of technology in the quest to digitalize business processes and controls results in negative structural outcomes, popularly known as technological unemployment, is well-known in economic discourse and was popularized by British economist John Maynard Keynes in the 1930s. This theory of technological unemployment is centered on the ideology that technological change or innovation introduces labor-saving alternatives and other more efficient mechanical processes or automation thereby displacing physical labor. In this sense, automated processes minimize the need for social roles resulting in massive job losses as labor-intensive roles are replaced by machines (Graetz & Michaels, 2015). Accordingly, the technological change–unemployment debate has created a dichotomy in perspective; there are now those regarded as optimists on the far left and pessimists on the far right.

The far-left optimists, according to Katz and Margo (2014), posit that only short-run displacements resulting from innovations are experienced and that long-term effects are cancelled due to compensation effects. This view corroborated Keynes (1930)'s position that the introduction of technological innovation in firms and industries would only cause a temporary malalignment in the labor market. To the far-rightists, on the other hand, technological change and automation assume a lasting effect on employment as new technologies are believed to cause a massive decline in the total number of workers employed over time. It is in this respect, according to Katz and Margo (2014), the term "Luddite fallacy" arises, which communicates the thinking premised on the belief that innovation would have a lasting harmful effect on employment. The position of the World Bank (2019) on the impact of digitalization, technological change and innovation on jobs and growth gives a somewhat balanced opinion, which offers a rare but fair submission.

According to the World Bank (2019) development report, although automation may destabilize labor in the short run, technological innovation and digital inclusion could help in the creation of new industries and the expansion of existing industries while opening up more unique channels for job creation at the same time. Skepticism about the future direction of works and labor market outcomes in the world as we know it now depends heavily on efforts pooled towards equipping people with the requisite knowledge, education, skills and experience necessary to promote economic development. Indeed, conscious and continuous efforts to make people more productive is a vital step towards promoting the improvement and sustenance of any economy. With technological change comes a new drive in demand for highly skilled labor and the consequent quest for a skills upgrade to match the available opportunities. It is in this way that the consideration for a knowledge-based economy becomes a critical case.

Kefela (2010) identified the importance of intellectual capital—the ability to conceive or generate new ideas—over savings and investment in the makeup of a truly knowledge-based economy. With the ability to acquire, create, disseminate and use knowledge in more efficient ways, greater levels of economic and social progress will be experienced rather than placing sheer importance on savings and investments. With more knowledge-based efficiency, Kefala argues, there is bound to be improved cost efficiency in production. Houghton and Sheehan (2000)

and Kefela (2010) argued that knowledge-based creativity is fast outpacing the place of the natural endowment as a faster wealth creator. Accordingly, they argued that investment in human capital, institutions, technology, and innovative and competitive enterprises all contribute to the growth and development of nations, as the global front now suggests a more knowledge and technology-based revolution era against the industrial revolution age.

Sharma, Kwame, and Bekoe (2008) itemized what are identified as the four pillars of a knowledge society. According to the authors, appropriate focus on quality public spending on infrastructure, the will to ensure good governance, deliberate efforts to promote high levels of human capital, and the resolve to preserve and promote indigenous culture are the backbone of any society that wishes to operate as a knowledge-based society. Furthermore, Sharma et al. (2008) maintained that an economy that wishes to enjoy buoyancy and sustained prosperity must be knowledge-based with a geographical position that allows for free and easy access to a ready market, enjoys a sound political, technological and legal structure, and a respectable flow of knowledge both within and into the economy. In this regard, careful investment in education, health, institutional quality and relevant technology is non-negotiable. Opportunities must be created for all to access and equitable distribution of the wealth generated must be spread evenly. With these in place, the possibility of a viable future that is premised upon a well-established set of rules that birth innovation through knowledge, capacity enhancement and utilization, promote the use and deployment of the right tools and strategies can be realised (Inayatullah, 2008). With these, a created condition for a paradigm shift in the way work is done and doing business generally is established and the overall economy is expected to graduate towards higher echelons of development over time.

2.3. Empirical Review

Development benefits that accrue due to the use of technology are enormous. Greater levels of inclusion, innovation and efficiency can be achieved through transformational effects of digital technology. According to the World Development Report [WDR] (2016), digital technology has the potential to reduce information costs across adopting businesses and economies since business activities become cheaper as transaction costs are lower. This makes doing business easier, thus promoting growth and development. Greater inclusion is also assured given a broad range of digital expansion as the information base grows. In this way, people can access information more freely and quickly, thus improving the timeliness of transactions.

Another benefit drawn out from the World Development Report is the fact that digital technology helps create information goods. E-goods, such as online music, news, digital currencies, e-commerce services, e-gaming and e-learning platforms, are products provided via digital means which make life easier. The world has transformed from a broad range of physical products to a much more comprehensive range of e-products. By this, it is undeniable that the demand for labor production and output given this evolution will not be as it was some decades ago. The new way of working in this digital age is one which is pro-inclusive, requires improved efficiency (i.e., highly automated) and is innovation-driven. Individuals whose current skills are unable to match the current demand for technology-based production will have to invest in re-skilling or settle for much less, or worse still, remain irrelevant in the labor market.

In addition to the World Development Report [WDR] (2016) report on the digital economy and its place in the future of work, both globally and in Nigeria, a host of other studies have been dedicated to addressing the implications of digitalization and innovation on the informal economy. For instance, Hansen (2019) explored digital entrepreneurship and the impact of digitalization on Beijing's entrepreneurial environment. Using 20 semi-structured interviews among core entrepreneurs in China's capital, the study found that local business owners experienced a higher level of trust in society but not in institutions. In the study, Hansen (2019) uncovered the critical role played by the country's government, as well as digitalization, in ensuring an improved business environment and increased opportunities for all. Rindfleisch, O'Hern, and Sachdev (2017) agree that the digital revolution helps create a data-rich environment.

In their study, they observed that, with an increase in the introduction and adoption of technology in business and government concerns, firms and governmental agencies are increasingly amassing and analyzing consumer data. Information that includes bank account details, web browsing behavior, online shopping data, social media information and activities, etc. are frequently collected, stored, analyzed, interpreted and presented to make firm-level or government-related decisions that otherwise shape the economy towards pro-developmental causes. Some of this information is transformed into what is called innovative physical products in an approach termed "innovation from data".

Using panel data on 54 African countries from 2005 to 2015, Adeleye and Eboagu (2019) showed that ICT adoption tends to enable Africa to skip traditional developmental stages. The study further revealed that mobile telephone subscriptions in particular exhibit the most considerable output elasticity and have the most significant leapfrogging potential. However, to harness these inherent benefits of ICT innovation, it is expedient to make access to the use of ICT facilities easy, cheap and affordable. In other words, the cost of buying a mobile phone must be reduced with regard to internet, subscription, and connectivity rates. Hewett, Rand, Rust, and Van Heerde (2016), Lamberton and Stephen (2016) and Yadav and Pavlou (2014) in their research highlighted the increasing importance and interest in data and innovation. According to them, the connection between data and innovation exerts a substantial impact on business owners' abilities to obtain a rich and diverse reserve of information that enables them to better understand client behavior and preferences with a view to developing innovative new products. With a heavily information-driven production pattern, producers can supply custom-tailored products and services to their respective consumers.

To Bharadwaj and Noble (2015) and McAfee, Brynjolfsson, Davenport, Patil, and Barton (2012), data services serve as a crucial input to a firm's innovation activities. Bharadwaj and Noble (2015) emphasized the need for firms to consciously transform raw data into useful information and develop insights from the information derived from the raw data. Then, insights developed can be transformed into custom-tailored solutions. This transformative progression in production pattern is what Lamberton and Stephen (2016) and McAfee et al. (2012) noted as being the main driver for the development of an enhanced new product offering. With digital transformation and revolution, some authors believe, comes an increase in production levels and, consequently, growth.

This is premised on the transformative role that innovation plays in ensuring an increase in production and sales, value creation, customer satisfaction and an easing of the overall business environment (Downes & Nunes, 2013; Matt, Hess, & Benlian, 2015; Parviainen, Tihinen, Kääriäinen, & Teppola, 2017). For instance, Parviainen et al. (2017) pointed out that using digital communication and virtual networks in business changes the overall game and improves the ease of doing business, thus leading to competitive advantage. Digital adoption and innovation, it is argued in this regard, create more jobs, expand opportunities and propel overall economy-wide growth (McAfee et al., 2012). Further, Fitzgerald, Kruschwitz, Bonnet, and Welch (2014) and Liere-Netheler, Packmohr, and Vogelsang (2018) noted that digitization of business processes globally has been useful in areas such as e-government, e-banking, e-marketing, e-tourism and e-health.

Some scholars, despite the numerous advantages that accrue due to digital revolution and innovation, believe that an increase in technological advancement and adoption may be consequential to growth. Frey and Osborne (2017), for instance, warned of an impending massive job loss given the introduction of technology in business. They believe that digital processes and automation of labor-driven processes will lead to employee reduction in primarily low ordered jobs. To Greengard (2016) and Allcott and Gentzkow (207), cybersecurity risks, as well as uncontrolled or errant data, may put businesses and individuals at risk. The World Development Report [WDR] (2016) also adds that despite the positive spillovers of digitalization and innovation in companies and entire economies, the development impact of technology and ICT adoption is falling and disproportionate. In the report published by the World Bank, digital technology is believed to change the world of work but has left the labor market more polarized while increasing inequality within countries. There now appears to be a broadening of

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internet facilities and access, but weak governance and institutional indicators still persist. Hence, despite increases in the level of digitalization and innovation as time passes, the challenges mentioned above have hitherto continued (World Development Report [WDR], 2016).

While the decision regarding the overall effect of digitalization and innovation still pivots around both sides of the debate, expectations are still very high regarding the positive results and other advantages that accrue due to innovation and ICT adoption in businesses. Scholarly efforts from various disciplines have continued their efforts to discover and highlight the importance of increased digitalization and how the adoption of the same may change the form and structure of businesses in the pursuit of an improved economy.

3. METHODOLOGY

3.1. Model Specification

Growing evidence shows that innovation is essential for the competitiveness and development of firms (Arvanitis et al., 2011; Karakara & Osabuohien, 2020), not only for developed countries, but it also required for developing countries (OECD, 2010). This is major because, innovation is an important avenue to improve effectiveness, expand activities and move to higher value-added accomplishments (Buesa et al., 2010; Karakara & Osabuohien, 2020; OECD, 2010).

Given these reasons, recognizing the significant factors influencing the innovation functioning of businesses, in most cases, are called the 'determinants of innovation', is a significant question in research. Extant literature has shown various innovation determinants, and outside the conventional innovation factors there has been widespread theoretical literature on the impact of digitization to drive innovation. However, limited empirical examination of this impact has been conducted by studies, such as those by Karakara and Osabuohien (2020); Arvanitis et al. (2011) among others, but limited studies have examined the potential of digitization to drive innovation in the Nigerian context.

This study applied the logit regression and propensity score matching (PSM) to achieve its objectives. Innovation (the outcome variable) is proxied by research and development (R&D) as seen in Karakara and Osabuohien (2020), Ziyae, Jusoh, and Madadian (2020) and Gërguri-Rashiti, Ramadani, Abazi-Alili, Dana, and Ratten (2017). The estimated model is specified in Equation 1.

$$Innov_i = \varphi D_i + \psi X_i' + e_i \qquad\qquad (1)$$

Where, Innov means innovation of find i, φ is the constant term and D_i is a dummy variable representing youth digitization of firm i. The dummy variable takes the value of 1 if firm i innovates, and 0 if otherwise. X_i is the vector of the firm's characteristics. Similarly, ψ captures the coefficient of the firm's characteristics, where $\psi = 1, 2, \ldots N$ and e are the stochastic terms which capture other variables not included in the model.

3.2. Data and Variables

Data for the study was obtained from the World Bank 2014/2015 enterprise survey for Nigeria as used by Karakara and Osabuohien (2020) and Gërguri-Rashiti et al. (2017). The survey sampled approximately 2,676 enterprises across sectors (manufacturing and services).

Innov presents innovation (the outcome variable) measured by "*during the last three years, did establishment spend on formal R & D activities?* This is categorical in nature and is 0 if the firm did not spend on R & D in the last three years and 1 if the firm did. Digitization is measured by the extent of ICT usage—firms that communicate with clients and suppliers via email. X is a covariate, such as the size of the firm, year of firm registration or start of operation), industry or sector in which the firm operates (service or manufacturing), employment growth, business age, number of times the firm has experienced a power outage, the gender and educational qualifications of the top

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manager of the firm and employment growth, and i is the cross-sectional dimension of the data. Employment growth was calculated by the formula: $EGR = \left(\frac{EEM}{BEM}\right)^{\frac{1}{busage}}$, where EGR is employment growth and EEN is the number of permanent, full-time employees at the end of the last fiscal year. BEM is the number of full-time employees of the establishment when it started operations and *busage* is the age of the firm in years. Firm size was grouped into four: micro or inform (< 5), small (> 5 and < 19), medium (> 20 and < 99) and large (> 100).

4. RESULTS AND DISCUSSION

4.1. Socioeconomic Characteristics of Firms

The socioeconomic characteristics of the firms presented in Table 1 show that only 19.12% of the firms innovate, while 80.88% of the firms do not. In addition, Table 1 shows that the enterprises are predominantly small, representing about 52% of the firms, about 12% and 28% percent are micro and medium firms, respectively, and 8% are large firms, and a high percentage (about 73%) of firms did digitalize. This finding poses a worrisome situation because for both service and manufacturing firms to experience exponential growth, ICT must be embraced (Mwantimwa, 2019; Sapprasert, 2010). The presence of ICT or digitalization gives rise to a higher increase in profitability and productivity of firms. About 56% of the firms are service-oriented, while the remaining are manufacturing firms.

Employment growth of these firms has been slow, as Table 1 shows that most of them recorded growth of 50% and below. This slow growth is perhaps due to the fact that most of the firms are non-adopters of ICT. The presence of ICT enhances firms' productivity and output, and enhancing these variables will create employment opportunities for the firm (Karakara & Osabuohien, 2020; Mwantimwa, 2019; Sapprasert, 2010). Most of the firms (about 52%) were established in the 2000s; very few (1%) were established before 1960. In the same vein, 6% of the firms have been in existence for over 50 years, about 17% have been in existence for 40 to 49 years, 696 firms (representing about 26%) have been in existence for between 30 to 39 years. However, most of the firms (about 34%) were aged between zero and nine years.

Most (about 87%) of the top managers of the firms are male while the smaller proportion (13%) are female, which shows the existence of gender inequality in most firms today. Studies have shown the financial performance of firms increase when more women occupy managerial positions (Salloum, Azzi, Mercier-Suissa, & Khalil, 2016; Wu & Cheng, 2016). Regarding educational qualifications of the top managers of the firms, about 27% and 7% have tertiary and post-tertiary education, respectively. While about 2% have no education, about 5% and 32% of the respondents' have primary and secondary education, respectively. About 24% of the respondents acquired vocational training.

4.2. Test of Mean Difference

The test of the mean difference of variables between firms that digitalized (ICT adopters) and firms that did not digitalize (non-adopters) is presented in Table 2. The results show that ICT adopters and non-adopters significantly differ in firm size, year of establishment, industry, employment growth, business age, gender and educational qualification. However, there is no significant difference for power outage, which could be due to both adopters and non-adopters having access to alternative means of power generation when there is a power outage. It is expected that the output of firms who adopt ICT should differ from those who do not (Mwantimwa, 2019). ICT usage enhances firms' processes, and by extension, adopters have a higher output; the results clearly support this assertion. Almost all the variables statistically differ between adopters and non-adopters because access to ICT (use of email, cellphones and websites) has a positive impact on productivity (Karakara & Osabuohien, 2020).

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Table 1. Socioeconomic characteristics of firms.

Variable	Frequency N = 2,676	Percentage	Mean
Innovation			
Yes	507	19.12	
No	2,145	80.88	
ICT Adoption			
Yes	718	73.17	
No	1,958	26.83	
Firm Size			
Micro	316	11.81	
Small	1,395	52.13	
Medium	740	27.65	
Large	225	8.41	
Year of Firm's Establishment			
Before 1960	26	0.98	
1960 to 1969	32	1.21	
1970 to 1979	80	3.02	
1980 to 1989	220	8.3	
1990 to 1999	574	21.64	
2000 to 2014	1403	52.9	
Industry			
Manufacturing	1180	44.1	
Services	1496	55.9	
Employment Growth			
l50 and below	1483	55.42	
$51-100$	480	17.94	535
$101-150$	253	9.45	
$151-200$	234	8.74	
$200+$	226	8.45	
Business Age			
$50+$	160	6.03	
$40-49$	445	16.78	443.67
$30-39$	697	26.28	
$20-29$	137	5.17	
$10-19$	303	11.43	
$0-9$	910	34.31	
Power Outage (number)			
$0-500$	465	22.94	
$501-1000$	1538	75.88	507
$1001-1500$	15	0.74	
$1501-2000$	9	0.44	
Gender of the Manager			
Female	332	12.52	
Male	2320	87.48	
Educational Qualification			
No education	46	1.73	
Primary education	121	4.56	
Secondary education	851	32.09	
Vocational training	648	24.43	
Tertiary education	724	27.3	
Post-tertiary education	180	6.79	

4.3. Determinants of Digitization (ICT Usage)

Results of the determinants of digitization on innovation is shown in Table 3. For each estimated regression, the study stated the estimates for the parameters and marginal effects; additional information is provided using the marginal effects after the logit regression. Table 3 shows that firm size has a statistically significant relationship with ICT adoption. It shows an increased possibility of firm size will have about a 16.16% positive marginal effect on ICT. This implies that, as a firm increases in size, there is a higher probability of digitalization. From the result,

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micro and small firms have a significant and negative effect on digitalization, while medium and large ones have a positive impact. By implication, medium and large firms have about 11.09% and 40.7% possibility, respectively, of digitalizing compared to micro and small firms. Firm size plays a vital role in the decision to adopt information and communications technologies (ICTs); as the size of a business increases, firms begin to search for more efficient ways to enhance their operations (Taylor, 2019).

Table 2. Test of mean difference between variables.

Variables	Adopters (N = 362)	Non-Adopters (N = 567)	Mean Difference	t-Test
	Mean Values			
Firm size	718	1,958	–0.5891208	18.1000*
Year of establishment	718	1,934	–0.4537913	-2.3625*
Industry	718	1,958	–0.0830049	-3.8410*
Employment growth	718	1,958	–0.3227129	-5.6100*
Business age	718	1,934	–0.3988443	-5.3280*
Power outage	577	1,450	0.1663599	0.8888
Gender	718	1,934	–0.0303382	-2.0987*
Educational qualification	718	1,934	–0.865542	-8.5783*

Also, the result shows that the year of a firm's establishment does not have a statistically significant impact on digitalization. Increase in business size is determined predominantly by innovation and age of business and not the year of establishment. Regarding business age, an increase in age calls for more ICT expansion to drive innovation (Gupta, Guha, & Krishnaswami, 2013; Taylor, 2019). There are two main types of sectors considered in this study—manufacturing and service. Table 3 also shows that the sector of operations has a positive influence on ICT adoption; a unit increase in operations increases the demand for ICT.

The operations of both the service and manufacturing sectors demand ICT adoption (Mwantimwa, 2019; Sapprasert, 2010). In similitude, employment growth has a statistically significant relationship with ICT adoption. Table 3 shows the marginal effects of employment growth; a unit increase in employment growth increases the demand for ICT (Aminu & Raifu, 2019).

The gender of the manager and educational qualification both have a statistically significant influence on ICT adoption in firms; a unit increase in either or both variables will lead to more demand for ICT, and the financial performance of firms increases when more women occupy managerial positions (Salloum et al., 2016; Wu & Cheng, 2016).

4.4. Impact of Digitization on Firms' Innovation

The nearest neighbor matching (NNM) and the Kernel-based matching (KBM), which are the most widely used and recognized matching algorithms, were employed for the sensitivity check. From the outcome of the propensity score matching, shown in Table 4, using the average treatment effects on the treated (ATT) for both matching algorithms (NNM and KBM), it can be concluded that ICT or digitization is statistically significant and positive in explaining the level of firms' innovation.

Table 3. Determinants of ICT Adoption by Firm Using the Logit Regression

Variable	Coef.	ME	Coef.	ME	Coef.	ME	Coef.	ME	Coef.	ME
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Year of establishment	0.0157	0.0030	0.0172	0.0033	0.0219	0.0042	0.0191	0.0037	0.0219	0.0043
	(0.289)	(0.289)	(0.232)	0.232	(0.124)	(0.124)	(0.178)	(0.178)	(0.131)	(0.131)
Sector/operation	0.3849*	0.0723*	0.4010*	0.0760*	0.2954*	0.0566*	0.3262*	0.0626*	0.3868*	0.0745*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.005)	(0.002)	(0.002)	(0.000)	(0.000)
Employment growth	0.0798*	0.0152*	0.1398*	0.0269*	0.1168*	0.0226*	0.1278*	0.0248*	0.1166*	0.0228*
	(0.049)	(0.049)	(0.000)	(0.000)	(0.003)	(0.003)	(0.001)	(0.001)	(0.003)	(0.003)
Business age	0.1024*	0.0195*	0.1658*	0.0319*	0.1590*	0.0308*	0.1651*	0.0320*	0.1406*	0.0275*
	(0.003)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Power outage	–0.0173	0.0033	–0.0222	–0.0043	–0.0095	–0.0018	–0.0145	–0.0028	–0.0160	–0.0031
	(0.221)	(0.221)	(0.104)	0.103	(0.488)	(0.488)	(0.284)	(0.283)	(0.249)	(0.249)
Gender of the manager	0.1987	0.0365	0.3270*	0.0592*	0.3218*	0.0587*	0.3169*	0.0580*	0.3177	0.0585*
	(0.232)	(0.214)	0.042	0.030	(0.045)	(0.033)	(0.048)	(0.035)	(0.051)	(0.038)
Educational qualification	0.1805*	0.0344*	0.2354*	0.0453*	0.2235*	0.0432*	0.2336*	0.0453*	0.2172*	0.0424*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Total firm size	0.8720*	0.1661*								
	(0.000)	(0.000)								
Micro firms			–1.1685*	–0.1754*						
			(0.000)	(0.000)						
Small firms					–0.6503*	–0.1267*				
					(0.000)	(0.000)				
Medium firms							0.5430*	0.1109*		
							(0.000)	(0.000)		
Large firms									1.7578*	0.4070*
									(0.000)	(0.000)
Constant	–3.5530*		–2.7808*		–2.4047*		–2.9667*		–2.8533*	
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
Observation	2,027		2,027		2,027		2,027		2,027	
Log likelihood	–1069.1327		–1126.3339		171.00		–1132.436		–1101.47	
Prob > chi2	0.0000		0.0000		0.0000		0.0000		0.0000	
LR chi2(8)	283.18		168.78		171.00		156.57		218.51	
Pseudo R2	0.1169		0.0697		0.0706		0.0647		0.0902	

Note: The p-value is in parenthesis ( ). *, **, and *** represent statistical significance at the 1%, 5%, and 10% levels, respectively. ME = marginal effect. Coef. = coefficient.

Table 4. Impact of digitalization on innovation.

Sample	Adopter	Non-Adopter	Difference	S.E.	T-Stat
Nearest Neighbor Matching (NNM)					
Unmatched	0.2669	0.1345	0.1324	0.0184	7.21*
ATT	0.2666	0.1376	0.1289	0.0312	4.14*
ATU	0.1336	0.19486	0.0612		
ATE		0.0806			
Kernel-based Matching (KBM)					
Unmatched	0.2669	0.1345	0.1324	0.0184	7.21*
ATT	0.2666	0.14101	0.1255	0.0229	5.46*
ATU	0.13361	0.2344	0.1009		
ATE		0.1079			

Note: * means significant.

The region of common support is presented in Figure 1. Here, a graphic representation of the distribution of the estimated propensity score indicates that the condition of common support is met. This is owing to the fact that there is a considerable overlap in the dissemination of the propensity score of both groups.
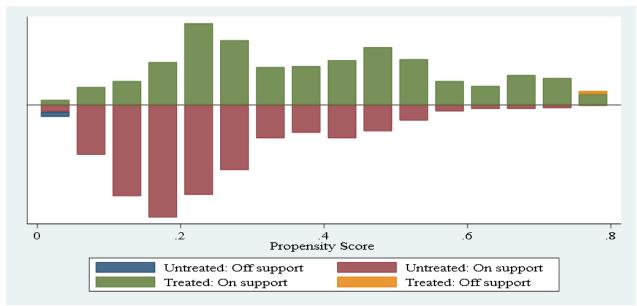

Figure 1. Region of common support.

5. SUMMARY, CONCLUSION AND DIRECTION FOR FURTHER STUDIES

There has been empirical literature on the innovation potential of ICT, which concludes that ICT are strong drivers of radical and disruptive innovations in firms' processes, products and services. However, only limited empirical studies have been conducted concerning the impact of ICT digitalization on innovation in order to examine to what extent the high and enthusiastic expectations of this literature are realised for filling this gap left by previous studies. This study examined the determinants of digitalization and their impacts on innovation using the logit regression and propensity score matching. The results from the logit regression show that size of the firm, educational qualification of the top manager of the firm, business age, employment growth and sector of operation are the major determinants of the extent to which a firm will digitalize. The result from the PSM shows that digitalization is positive and significant in explaining the level of firms' innovation. This means that an increased level of ICT will synonymously increase the level of firms' innovation. Therefore, based on the results, the study concludes that digitalization is a positive and significant driver of innovation. This implies that, to enhance efficiency, there is a need for firms to adopt digital technologies. Therefore, further studies should focus examining the impact of digitalization on innovation using different approaches.

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