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Nwaobi, Godwin

Quantitative Economic Research Bureau, Nigeria

14 October 2024

Online at <https://mpra.ub.uni-muenchen.de/122392/>  
MPRA Paper No. 122392, posted 17 Oct 2024 13:44 UTC

**PRODUCTIVE SECTORS AND DIGITAL  
DIFFUSION (ADOPTION) IN NIGERIA:  
EMPIRICAL EVIDENCE**

**GODWIN CHUKWUDUM NWAObI  
PROFESSOR OF ECONOMETRICS**

[gcnwaobi@gmail.com](mailto:gcnwaobi@gmail.com)

[gcnwaobi@quanterb.org](mailto:gcnwaobi@quanterb.org)

+2348035925021

**QUANTITATIVE ECONOMIC RESEARCH BUREAU  
ABIA STATE, NIGERIA, WEST AFRICA**

[www.quanterb.org](http://www.quanterb.org)

**AND**

**VISITING PROFESSOR OF ECONOMICS  
NIGERIA BRITISH UNIVERSITY**

**ABIA STATE, NIGERIA**

[www.nbu.edu.ng](http://www.nbu.edu.ng)

## **ABSTRACT**

As the most populous nation in Africa, Nigeria is uniquely positioned to reap the benefits of the emerging digital economy, and by accelerating access to digital technologies spurs innovation, efficiency and productivity which bring about choice and opportunities for greater growth and inclusion. Therefore, this research project shall provide evidence with respect to some aspects of inter-firm and intra-firm diffusion digital technologies in Nigeria. In other words, the proposed study intends to provide new empirical evidence with respect to the factors determining inter-firm and intra-firm diffusion of digital technologies by Nigeria productive enterprises. Furthermore, this research paper shall ascertain the extent to which patterns of digital adoption are different for domestic and foreign-owned firms. Econometrically, we propose to use a novel firm level (micro) panel data from the Nigerian manufacturing firms for the period between 2020 and 2025 as applicable.

**KEY WORDS:** Firms, diffusion, intrafirm, interfirm, Nigeria, panel data, **probit** model, digital technology, adoption, technology, enterprise, artificial intelligence, productivity, micro panel, innovations, digitalization

**JEL NO:** C55, C83, C80, D20, D22, L00, L10, L50, L60, L86, L96, M13, M15, O00, O14, O25, O30, O31, O32, O33, O38.

## 1.0. **BACK GROUND AND RESEARCH PROBLEM**

As a democratic secular (Multinational) state, Nigeria positioned itself to improve the lives of the people (after independence) as well as harnessing the resources that remain vital to the economy. Nationally, Nigeria is richly endowed with oil and gas as well as being blessed with large deposits of different minerals spread across the country. In fact, it is an established fact that Nigeria has the potential to become a major player in the global economy by virtue of its human and natural resource endowments. However, development of any phase is always linked with technology whereas technology happens with scientific advancement. In other words, developments in science and technology will fundamentally alter the way people live, connect, communicate and transact (with profound effects on economic development). Essentially, the technological revolutions of the 21<sup>st</sup> Century are emerging from new sectors based on micro-processors, telecommunications, biotechnology and nano-technology. Here, products are transforming business practices across the economy as well as the lives the people who have access to their effects.

Consequently, the Nigerian state must make science and technology a priority if the country hopes to expand its economic frontiers. While Nigeria, perhaps, has made some progress in socioeconomic terms in recent years, its human capital development remains weak due to underinvestment (World Bank, 2019). In fact, the country continues to face massive development challenges (Nwaobi, 2024A). These include the need to reduce dependency on oil and diversify the economy, addressing insufficient infrastructure, re-thinking weak and ineffective institutions as well as governance issues. Unfortunately, large pockets of Nigeria's population still live in poverty without adequate access to

basic services and thereby leading to the observed social and political unrest in the country.

However, rapid digital transformation is reshaping the global economy by permeating every sector and aspect of daily life as well as changing the way we learn, work, trade, socialize, and access information services. Yet, African countries such as Nigeria are currently capturing limited fraction of this growth.

Consequently, the African Union's Digital Transformation Initiative for Africa wants to see every African individual, business and governance by digitally enabled by 2030 (African Union, 2020).

In other words, the Digital Economy for Africa transformation initiative is underpinned by five principles: Comprehensive, transformation, inclusive, homegrown and collaborative. Therefore, for the sake of inclusive digital economy, African countries such as Nigeria would require building key foundational elements of a digital economy as follows: Digital infrastructure, digital platforms, digital financial services, digital entrepreneurship and digital skills. Specifically, digital entrepreneurship can be regarded as the creation of new ventures and the transformation of existing business through digital technologies. Broadly, these include the following segments:

- (A) New digital start-ups and mature digital scale-ups firms that have digital technologies at the core of their business model. In other words, they develop and transform the digital technology so as to deliver new improved products and services to their customers.
- (B) Digitally enabled businesses which utilize digital technologies such as social mobile, analytics and cloud solutions to improve

business operations, sharpen business intelligence as well as engaging with customers and stakeholders through new digital channels.

Consequently, given its large entrepreneurial population, digital enterprises (firms) has the potential to become in engine of economic transformation in Nigeria as well as setting the country on a new growth trajectory. But despite its entrepreneurial potential, Nigeria remains a minor player in the global digital economy in terms of exports of digital goods. And again, although urban enterprises are increasingly digital platforms for trading; Digitalization of firms in traditional industries and rural locations remain low (Anderson, et.al. 2017, World Bank, 2019, Nwaobi, 2024A). Notably, some of the reasons for low digital usage include low levels of digital literacy, limited internet access and high operational costs. However, larger firms are more actively using digital technology for basic business purposes (such as business communications) but more advanced uses of digital technology remain limited. Perhaps, the low penetration of digital technologies is symptomatic of the overall lack of innovation capacity among Nigerian firms. Therefore, despite the shortcomings, the dynamism of the Nigerian digital entrepreneurship ecosystem presents opportunities for development. Consequently, uncovering the factors driving digital technology adoption and diffusion in Nigeria is important and relevant for both research and policy. In other words, to the extent that a wide and fast diffusion of digital technologies is desirable; it is very important to understand those factors likely to increase the adoption and diffusion of these technologies in Nigeria. Therefore, using the entire Nigeria productive sectors, we intent to investigate the factors determining

inter-firm and intra-firm diffusion for a large number of digital technologies (inclusive of older ones and recently developed ones) using novel (firm-level) panel data models. The rest of this research proposal is structured as follows: Research objectives and working hypothesis are presented in section two. In section three, we discuss the digitalization process of Nigeria firms. Section four summarizes the theoretical and empirical literature while methodological framework is the subject of section five the data plan is presented in section six while the analytical structures and anticipated results are discussed in section seven.

## 2.0. RESEARCH OBJECTIVES AND HYPOTHESIS

In general, the overall objective of this research study is to investigate the factors driving inter-firm and intra-firm diffusion of the entire set of digital technologies in Nigeria. However, the specific objectives include the following:-

- (I) To identify the determinants of the adoption of digital technologies of firms (Inter-firm diffusion) and the extent of usage within firms (Intra-firm diffusion) in Nigeria economy.
- (II) To empirically analyze the extent of usage of digital technology within productive companies (enterprises) in Nigeria.
- (III) To examine the effect of in-house learning on the intra-firm diffusion of digital technology by the Nigeria firms.
- (IV) To analyze the determinants of a firms decision to digitalize particular combinations of functional fields of its activity within Nigerian productive ecosystem.

Basically, the research hypotheses are to be tested as follows:

- HO1.** That the presented theoretical framework is well suited to explain the inter-firm as well as intra-firm diffusion of digital technologies in Nigeria.
- HO2.** That the determinants of diffusion are not the same for all fields of digital technology.
- HO3.** That the extent of usage of digital technologies (Intra-firm diffusion) in a particular field is positively affected by the intensity of prior usage of such technologies in other fields of application (cross-learning).



**HO4.** That the extent of usage of advanced digital technologies in a particular field (intra-firm diffusion) is higher in firms that previously used older vintages of technologies in the same or a closely related field of technology (cumulative learning).

### 3.0. **NIGERIA ECONOMY AND DIGITAL DEVELOPMENT**

A multinational state, Nigeria is inhabited by numerous ethnic groups and has a massive land mass of fertility. The country is also blessed with a super abundance of both natural and human resources. Specifically, she is richly endowed with oil and perhaps has one of the largest oil reserves in the world. Furthermore, the country is also blessed with large deposits of several (different) minerals spread across geographical locations. Notably, as at the second half of the 19th century, the various nationalities (groups) that make up Nigeria were largely agricultural people. In fact, they were self-sufficient and produced variety of commodities that were exported overseas. Specifically, under the colonial rule, Nigeria remained an agricultural country that exported raw materials to Europe, as well as importing finished goods from it. However, economic re-engineering was set in when oil was found in 1950 and became exportable in 1958. Consequently, at the attainment of independence in 1960, Nigerians had every cause to celebrate and hoped for a better future. In fact, the nascent economy in this era was expected to blossom as it was dominated by manufacturing, agriculture and construction activities. Subsequently, the state took up the direction and planning of economic growth and development. And with the letter adoption of import substitution strategy, Nigerian government would be able to promote the emergence and expansion of domestic industries by replacing major importable. Unfortunately, the established government named industries and business were often inefficient and corrupt whereas productivity was low at its best.

Notably, the oil boom which Nigeria experienced in the 1970 helped the nation recover rapidly from its civil war (1966-1969) as well as

giving great impetus to the government's program of rapid industrialization. However, the unsteadiness surrounding the world oil prices between 1975 and 1978 as well as the burning desire of the Obasanjo administration to diversify the country's exports (to include non-oil export) gave rise to promulgation of export promotion Decree No 26 of 1976. Similarly, to ensure high quality production of non-oil goods as well as favorable comparison of these goods with foreign produced goods; the industrial promotion Decree No 40 of 1979 was promulgated operationally. Previous industrial policies which have direct or indirect effects on industrial development in Nigeria include the following (Emenike, 2010; NBS, 2017).

- (I) IMPORT DUTIES RELIEF ACT (1957).
- (II) INCOME TAX RELIEFB ACT (1958).
- (III) CUSTOM DUTIES (DUMPED AND SUBSIDISED GOODS) ACT (1958).
- (IV) CUSTOM (DRAW BACK) REGULATION (1959).
- (V) COMPANY INCOME TAX POLICY (1961).
- (VI) NIGERIAN ENTERPRISES PROMOTIONS DECREE (INDIGENIZATION DECREE) (1972 amended 1977).
- (VII) MANDATORY CREDIT GUIDELINES (1970).
- (VIII) SMALL SCALE INDUSTRIES CREDIT GUARANTEE SCHEME (1971).
- (IX) AGRICULTURE CREDIT GUARANTEE SCHEME (1973).
- (X) NIGERIA AGRICULTURE AND COOPERATIVE BANKING (1973).
- (XI) RURAL BANKING SCHEME (1977).

Unfortunately, early 1980s brought the most traumatizing period for Nigerians. In this era, the global economy witnessed a down turn with the crash of crude oil price, resulting in high inflation and reddish public finance. Again, when oil prices collapsed further in 1986,

Nigeria's economy was in a deep-seated crisis and the government was forced to adopt a comprehensive package of economic reforms. Basically, the promise of structural adjustment program (SAP) was a damaged control in the short run and necessary restructuring for sustainable growth in the medium to long run. In other words, the goal of the policy makers was a return to moderate rates of growth in production and of living standards. Here, although oil revenues remained low and government debt accumulated, agriculture and domestic manufacturing began to grow following improvements in the real exchange rate. Clearly, the economic recovery led to higher incomes, higher household expenditures and real gains for a large part of the population. Notably, some of the Nigeria's earlier anti-expert bias in manufacturing disappeared while producers switched from imported to local inputs. Statistically, the industrial sector (which had declined annually by 4.4% between 1981 and 1986) grew by 3.5% between 1986 and 1990 (World, Bank). However, the gradual loss of microeconomic control after 1990 eroded many of the positive changes that took place in the past years. In particular, the pressure on the external balance was exacerbated by the down turn in world oil prices between 1993 and 1994. Then, as a significant policy corrections to the rapidly worsening economic condition; the 1995 budget of guided deregulation was developed as well as policy confirmation by the 1996 budget. Structurally, in recognition of the critical rules played with respect to economic growth and development, successive governments availed various initiatives aimed at promoting productive enterprises in Nigeria. These measures include the following.

- (A) WORLD BANK ASSISTED SME1 (1985)
- (B) WORLD BANK ASSISTED SME2 (1990)
- (C) SECOND TIER SECURITY MARKET/SEC (1985)

- (D) PEOPLES BANK OF NIGERIA (1989)
- (E) NATIONAL ECONOMIC RECONSTRUCTION FUND (1992)
- (F) SMALL AND MEDIUM SCALE ENTERPRISES (SME) LOAN SCHEME (1997)
- (G) AFRICAN DEVELOPMENT BANK-EXPORT SIMULATION LOAN SCHEME (ADB-ESL) (1988)
- (H) NATIONAL DIRECTORATE OF EMPLOYMENT (1989).

Indeed, with the return to democracy in 1999, hopes were rekindled about the prospects of jump starting the economy. However, everyone underestimated the magnitude of the decay as well as challenges for a new beginning. Yet, it was on record that while some sectors recorded very high growth rates; others were decelerating. In fact, the observed instability in the pattern of growth has been a major characteristic of Nigerian sectoral growth performance and thus presents enormous challenge. Tactically, the average growth rate for the 1999-2003 period was about 3.6% with a per capital growth rate of 0-8 percent per annum which was far lower than the per capita growth rate needed to significantly reduce poverty. Therefore, NATIONAL Economic Empowerment and Development Strategy (NEEDS) was a bold step to plug sources of leakages and achieve macro stability as well as supporting more efficient use of resources to grow the economy. As Nigerians home grown poverty reduction strategy (PRSP), NEEDS was a medium term strategy (2003-2007) which derives from, the country's long-term goals of poverty reduction, wealth creation, employment generation and value re-orientation.

In fact, it was a nationally coordinated framework of action in close collaboration with state governments (via state economic Empowerment and development strategy known as SEEDS) as well as

local governments via local Economic Empowerment and Development Strategy known as LEEDS),. Structurally, the strategic intent of the government was to diversify the productive base of the economy away from oil and develop market-oriented private sector driven economic development with strong local participation. In fact, the main goal was to develop (in the process) an indigenous entrepreneurial class capable of competing in the global market (with dominant technology and skills). Unfortunately, the NEED document lacked articulation of sectorial linkages which should have guided the prioritization of attention to leading growth drivers within the economy. Again, the degree of consistency among intra and inter-sectorial targets could not be as certain or guaranteed. As a significant macroeconomic performance under needs, GDP recorded an average annual growth rate of 5.7% between 2000 and 2006.

Similarly, the non-oil sector recorded an average annual growth rate of 7.4% in 2004 to 8.2% in 2005 as well as inclusive growth rate of about 8.9% in 2006 (FGN, 2007). Unfortunately, there was no identifiable strategy for managing the distributional effects of growth under NEEDS (1).

After its expiration, NEEDS (2) was developed as a continuation of the vision, mission and strategies of NEEDS (1) with renewed set of targets to be achieved between 2008 and 2011. Basically, its main goal was poverty reduction, employment generation focus, wealth creation and value reorientation. Similarly, it focused at promoting inclusive growth by concentrating on the sectors where the poor and vulnerable groups are dominant. In other words, NEEDS (2) will focus on strategies that will assist in the creation of jobs and wealth as well as being a vehicle for the realization of United Nations, Millennium Development Goals (2000 – 2015).

As experienced in this strategic era, there was growth in the manufacturing sector without corresponding improvement in the level of capacity utilization. Notably, capacity utilization was constrained by weak physical infrastructure and lack of funds that made it difficult for firms to make investments in modern machines, information and communication technologies that are critical in reducing production costs, raising productivity and improving competitiveness. Furthermore, NEEDS document was perceived as a medium-term framework rather than long-term development initiative anchored on a medium-term implementation cycle. Therefore, there was danger of perceived incognizance of a medium-term framework seeking to address long term development problem.

Consequently, vision 20:2020 (Nigeria's long term economic transformation blueprint aimed at improving the welfare and living standards of the population as well as placing the country among top twenty economies of the world) was introduced in 2009 (FGN, 2009). Operationally, its implementation period was 2009-2013 as well as series of medium term plan (with first implementation plan of 2010-2013). Notably, in the last five year of the plan period, the economy experienced two recessions in 2016 and 2020 due to the remarkable decline in oil prices as well as the Covid-19 pandemic effects. Although the vision did well by identifying some fundamental constraints such as weak institutions and epileptic power supply; significant progress were not recorded in tracking these items.

Specifically, the sharp and continuous decline in crude oil prices (Since 2014) as well as failure to diversify the sources of revenue and foreign exchange in the economy, led to a recession in the second quarter of 2016 (FGN, 2017).

Regrettably, the challenges in the oil sector (Inclusive of the sabotage of oil export terminals in Nigeria Delta) negatively impacted government revenue and export earnings as well as the fiscal capacity to prevent the economy from contracting. Again, the government spending capacity was constrained by lack of fiscal buffers to absorb the shock as well as leakage of public resources due to corruption and inefficient spending.

Consequently, the strategic implementation Plan (SIP) for the 2016 budget of change was developed as a short-term intervention. Yet, in recognition of the need to do more, Economic Recovery and Growth Plan (ERGP) was also developed (FGN, 2017). As a medium term plan (2017-2020), ERGP builds on SIP and was basically developed for the purpose of restoring economic growth as well as leveraging the ingenuity and resilience of the Nigerian people. Again, the ERGP was also consistent with the aspirations of the United Nations Sustainable Development Goals (2016 – 2020) by way of addressing the critical dimensions of economic social and environmental sustainability.

Operationally, its main objectives were as follows:-

- (A) Restoring growth through macroeconomic stability and concentric economic diversification;
- (B) Investing in the Nigerian people through programs on social inclusion, job creation, youth empowerment and improved human capital; and
- (C) Building globally competitive economy through investment infrastructure, improved business environment and promotion of digital economy.

Although, ERGP was an emergence recovery plan primarily formulated to pull Nigeria out of recession; its overall performance was partially



commendable. Perhaps, the promptness and efficacy of government's fiscal and monetary policy responses to the pandemic led to the early exit from the recession. Similarly several enterprise development initiatives were very helpful. Some of the known initiatives include the following:-

- 1) BANK OF INDUSTRY (2001)
- 2) NIGERIAN AGRICULTURAL COOPERATIVE AND RURAL DEVELOPMENT BANK (2002)
- 3) SMALL AND MEDIUM ENTERPRISE DEVELOPMENT AGENCY OF NIGERIA (2003)
- 4) MICROFINANCE BANK ESTABLISHMENTS.
- 5) SMALL AND MEDIUM ENTERPRISE CREDIT GUARANTEE SCHEME (2010)
- 6) CENTRAL BANK OF NIGERIA NATIONAL COLLATERAL REGISTRY (2020)
- 7) DEVELOPMENT BANK OF NIGERIA (2017)
- 8) GOVERNMENT ENTERPRISE AND EMPOWERMENT PROGRAM (2018)
- 9) PRESIDENTIAL ENABUNG BUSINESS ENVIRONMENTAL (2016)
- 10) CENTRAL BANK OF NIGERIA ANCHOR BUSINESS PROGRAMME (2015)
- 11) CONDITIONAL GRANT SCHEME (2017)
- 12) SMEDAN ONE LOCAL GOVERNMENT ONE PRODUCT PROGRAMME (2016)
- 13) CAC INCENTIVISING BUSINESS REGISTRATION COMPLIANCE (2019)
- 14) GROWTH AND EMPLOYMENT MOBILITY INSTATES (GEMS)
- 15) CONVERSION OF INDUSTRIAL DEVELOPMENT CENTERS TO INDUSTRIAL PARKS AND CLUSTERS

- 16) CBN/MSME DEVELOPMENT FUND (2013)
- 17) ENHANCING FINANCIAL INNOVATION AND ACCESS (2007)
- 18) NUMEROUS TRAINING SCHEMES (2020)

Unfortunately, in this era, COVID-19 that started as health pandemic triggered an economic crisis. Therefore, given the prolonged nature of the crisis, the economic and human impact on Nigeria, were severe and was also exacerbated by volatile crude oil prices internationally. Consequently, the government developed a robust economic sustainability plan (ESP) containing policies, projects and measures aimed at stimulating (revitalizing) productive sectors of the Nigerian economy as well as other performing sectors (FGN, 2020). Basically, the main thrust of the plan was to respond to the challenges posed by COVID-19 pandemic as well as acting as a transition plan between plans.

Critically, the ESP was anchored on the following thrusts and principles:-

- (I) implementing fiscal and monetary measures aimed at stimulating the economy for the sake of quick recovery;
- (II) Preserving and creating jobs using locally sourced materials.
- (III) Protecting the poor and vulnerable groups as well as
- (IV) Cross-cutting imperatives such as nationwide broadband connectivity.

Strategically, the ESP stimulus package consists of a combination of fiscal and monetary policies, sectorial interventions and social programs. Operationally, the fiscal and monetary policies provided support to states, businesses, households and individuals through grants, tax relief, payroll support, tariff reductions as well as direct support to critical sectors. Notably, the ESP contributed significantly to

the Nigeria's early exit from the second recession within a short-time. Yet, some of the programs and measures had medium-term implications in terms of implementation.

Historically, the country has had four medium term development plans and one perspective plan as identified below:-

- (A) First National Development Plan (1967 – 1968)
- (B) Second National Development Plan (1970 – 1974)
- (C) Third National Development Plan (1975 – 1980)
- (D) Fourth national Development Plan (1981 – 1985)
- (E) First National Rolling Plan (1990 – 1992)

Subsequently, there was critical need to recognize the hierarchical relationship among a perspective plan, medium term plan and annual budget. Perhaps, this required ensuring a proper linkage of the annual budget to the plan (at the implementation stages). Again, there was need for continuity and commitment to agree policies programs and projects in order to enhance plan outcomes as well as the avoidance of multiple competing plans implementation. Consequently, the new National Development Plan (2021 – 2025) was designed to address the observed shortcoming identified in the design and implementation of ERGP and past development plans. Critically, five megatrends were taken into account during the design stage of the plan as follows: Fourth industrial revolution, regional trade, green economy, knowledge economy and demographic shifts (FGN, 2021). Operationally, to ensure that the new plan remains national, all the states of the federation, Federal capital territory administration, local government councils, organized private sectors, youths, labour unions as well as traditional and religious organizations were all involved in the preparation process. Essentially, the plan aims to lift millions of

Nigerian people out of poverty by 2025. In fact, it is being projected that Nigeria will make substantial progress towards achieving this goal through accelerated and sustainable economic growth. In other words, the plan envisions a country where the building blocks are put in place for everyone to attain their full potential. Therefore, it will focus on private sector-led growth to address the critical issues of job creation and poverty reduction.

Indeed, as recent macroeconomic and financial developments, economic growth in Nigeria slowed from 3.3% in 2022 to 2.9% in 2023 due to high inflation and sluggish growth in the global economy (which declined from 3.6% in 2022 to 3.2% in 2023). Notably, growth was driven by services and agriculture on the supply side as well as consumption and investment on the demand side (AFDB, 2024). Again, inflation rose from 18.8% in 2022 to 24.5% in 2023 because of the rising fuel costs and depreciating naira specifically, petrol prices increased by 167% (from N254 per liter in May 2023 to N671 in December 2023).

Similarly, the exchange rate depreciated by 95.6% in 2023 resulting from the fluctuating of the naira in June, 2023. However, monetary policy was tightened to control inflation with the policy rate increased from 17.5% (in January, 2023) to 18.75% (in December 2025). Unfortunately, the poverty level remains high with multidimensional poverty at 63% and income poverty at 40%. Yet, economic growth is projected to increase to 3.2% in 2024 and 3.4% in 2025; due to improved security, higher oil production and stronger consumer demand (AFDB, 2024).

Clearly, the headwinds include insecurity lower oil production, rising fuel and food prices as well as additional exchange rate depreciation.

On the other hand, the tailwinds include new oil production (to be driven by Denote oil finery) which is anticipated to lower energy prices as potential local market supplier.

**DIGITAL DEVELOPMENT:** Conceptually digital economy can be regarded as that part of economic output derived from digital technologies with a business model based on digital goods or services. In general, it is made up of various components such as platform economy, gig economy, industry 4.0, data analytics, robotics, artificial intelligence, machine learning, e-commerce, digital energy, smart energy, smart agriculture, digital finance, digital entrepreneur, digital infrastructures, digital skills, digital citizens, digital government, digital private sector, neural networks, etc (World Bank, 2019; Nwaobi, 2019).

Essentially, these can bring shared prosperity and reduced poverty. Thus, in the quest to reposition the Nigerian economy to take advantage of the many opportunities that digital technologies provide; the NATIONAL DIGITAL ECONOMY POLICY AND STRATEGY (NDEPS) was developed to be operational for a given period (2020 – 2023). Strategically, the NDEPS document is based on eight pillars for the acceleration of the National Digital Economy for a digital Nigeria (FGN, 2019). These pillars include development Regulations, Digital Literacy and skills, solid infrastructure, service infrastructure, digital services development and promotion, soft infrastructure, digital society and Emerging Technologies as well as indigenous content Development and Adoption.

Essentially, the document (NDEPS) aims to provide a plan for using digital technology as a platform for stimulating growth in all sectors of the economy through the development of digital economy for the

country. In fact, unlike information and communication technologies (ICT) which convey the concepts of the use of technology; digital technologies built upon and extend the concept of ICT to include creation focus rather than technology use. Clearly, these technologies encompass emerging technologies to develop for the innovative use of such technologies to develop the Nigerian economy. The fundamental objectives of the Digital economy Policy and strategy are as follows:-

- (A) Targeting significant broadband penetration in four years.
- (B) Accelerating digitalization of government processes and improving services delivery transparency and accountability.
- (C) Improving trust confidence and security around digital processes and activities.
- (D) Attracting and growing digital jobs across all sectors of the economy.
- (E) Developing the technology start up ecosystem by actively promoting innovation and entrepreneurship
- (F) Supporting the digital literacy of Nigerian citizens, business and government workers as well as enabling them to acquire cutting edge digital skills.
- (G) Achieving very high digital literacy level in Nigeria within the next decade.
- (H) Developing digital education curriculum so as to meet current and future needs of the digital economy.
- (I) Ensuring that indigenous technology companies are able to participate actively in the government funded technology programs as well as.
- (J) Ensuring that the policy and regulatory instruments are fit for purpose and actually supporting the digital business environment.

Operationally, the NDEPS shall be anchored on the pillars of DIGITAL NIGERIA roadmaps of the Federal Ministry of communications and Digital Economy under the direction of National Digital Economy Council, clearly, table 3.1 shows these pillars and associated responsibilities. Thus, Nigeria, through the National Information Technology Development Agency (NITDA) has realized that to ignite economic prosperity of her people (with the intention of helping the government in actualizing its plan) efforts must be directed at boosting the mandate to be alignment with National Digital Economy Policy and Strategy. Therefore, recognizing digital innovation and entrepreneurship as catalyst for the creation of values and prosperity in a digital economy has compelled NITDA to be investing in this digital industry. Specifically, the proposed National Digital Innovation and Entrepreneurship Centre (NDIEC) will house state of the art facilities designed to promote the concept of live, work and learn as appropriate. Essentially, the objectives of the centre are as follows:-

- A. To serve as a link to the existing and planned information technology hubs across the country in order to foster innovation and knowledge based ventures.
- B. To serve as a catalyst for creativity, innovation and entrepreneurship among the public and private sectors (and academia);
- C. To foster the development of emerging technologies such as Artificial Intelligence, Block chain, internet of things as well as other cutting edge technologies;
- D. To provide an enabling environment for technological start-ups to accelerate and experience innovation at scale; and
- E. To foster the development of indigenous businesses so as to become world class service providers.

**TABLE 3.1 NDEPS: PILLARS AND RESPONSIBILITIES**

<b>S/N</b>	<b>PILLARS</b>	<b>FOCUS</b>	<b>RESPONSIBILITIES</b>
(I)	DEVELOPMENTAL REGULATION	Effective Regulation the ICT and Digital sector in a way that enables development	(IA) Relevant laws (IB) Digital Economy Development Found (IC) Converged Regulation
(II)	DIGITAL LITERACY AND SKILLS	Providing Policy backing for massive training of Nigeria from all works of life in order to enable them obtain digital literacy as well as other digital skills.	IIA) Digital Nigeria Programme IIB) National Committee on Digital Skills, Innovation and Entrepreneurship IIC) Mentorship Programme
(III)	SOLID INFRASTRUCTURE	Deployment of fixed and mobile infrastructure to deepen the broadband penetration in the country	IIIA) Nigeria National Broadband IIIB) Data Centres IIIC) Satellite IIID) National Frequency Management



(IV)	SERVICE INFRASTRUCTURE	Support for Government Digital Services and provision of robust digital platforms to drive the digital economy.	IVB) E-Government Master plan IVB) Government Digital Services IVC) Nigerian E-Government Interoperability Framework Architecture IVE) E-Commerce Platforms
(V)	SOFT INFRASTRUCTURE	Strengthening Public Confidence in the use of Digital technologies and participation in the digital economy.	VA) Cyber security Awareness VB) CERRT (Computer Emergency Readiness and Response Centre) V) Emerging Technology Centres
VI	Digital Services Development And Promotion	Development of Vibrant Digital Ecosystem that support innovation Driven Enterprise (IDE) as well as MICRO SMALL AND MEDIUM ENTERPRISES (MSMEs) in a way that	VIA) Digital entrepreneurship VIB) Innovation Driven Enterprises VIC) Financial Technologies

		engenders innovation.	
VII		Focus on Tying the development of the Digital Economy to indices of wellbeing in the lives of the ordinary citizens; mentoring startups on Emerging Technologies and Deploying their solutions.	VIIA) Digital Inclusion VIIB) Financial Inclusion VIIC) Emerging Technology Centres
VIII	INDIGENOUS CONTENT DEVELOPMENT AND ADOPTION	Provision of a policy framework that gives preference to digitally skilled Nigerian for government funded projects in line with presidential executive orders.	VIIA) Promotion of Indigenous Content VIIIB) Support for Original Equipment Manufacturers VIIIC) Regulatory Guidelines For Nigerian Content Compliances.

Technically, while NDEPS appreciates the importance of identifying and supporting small and medium enterprises (SME); NDIEC would ensure that they will metamorphose into innovation Driven Enterprises (IDE). Comparatively, it is anticipated that IDE can have far more significant impact than SME on the economy.

Despite the above policy measures, the ability to effectively harness and fully exploit the benefits of the cyber domain was threatened by several inherent challenges. Nevertheless, these challenges were not insurmountable.

Consequently, the Nigerian approach to national cyber security was the development of a robust and adaptive digital ecosystem based on mutual collaboration and synergy of the triad of government, academia and industry as well as being reinforced by strong regional and international alliances (FGN, 2021 B). Notably, some of the policy responses include the following:-

- I. **National Cyber security policy and strategy (2014)**
- II. Cyber crimes (prohibition, Prevention, Etc) Act (2015)
- III. National Broadband Plan (2020)
- IV. National Cyber security policy and strategy (2021)
- V. Nigeria Data Protection Regulation (2019)
- VI. Nigeria Data Protection Regulation (2019)

Operationally, the main targets of cyber-attacks in the Nigeria cyberspace include cloud based systems, mobile devices, internet of things, data centres and networks of corporate establishments. Again, the expansion of cyber threats beyond computer systems and networks to cyber-physical systems (such as transportation technologies, air traffic control systems, smart devices and hydro power grids) is another unfortunate reality.

Specifically, these are seven major cyber threats of concern in Nigeria; cybercrime, cyber terrorism, child abuse and exploitation, elections interference, pandemic – induced cyber threats, as well as other related threats. However, in addition to government responses, Nigeria is blessed with a proactive and informed private sector playing critical roles in the regional and global cyber security solutions market. Similarly, country's multi-stakeholder National Cybercrime Advisory Council has spearheaded several efforts to provide strategic direction for cyber security in Nigeria.

However, the Federal Government have also initiated some far-reaching reforms to improve business climate in Nigeria so as to ease doing business and investments. Similarly, the NITDA, in furtherance of the executive public by working nationally to encourage speedy turn around for all its services as well as facilitating access to all governmental services related to its mandates. Basically, these measures were taken by implementing the following initiatives:

1. Automated Service for registration of information technology service providers and contractors so as to eliminate bureaucracy while ensuring that all documents and approvals be conducted digitally on the relevant platforms.
2. Registration and identification of talents, incubators and ecosystem development experts by granting easily recognizable badges and stickers to facilitate access during crisis periods such as COVID-19 pandemic.
3. Automated platforms for IT project clearance for Ministries, Departments and Agencies (MDA), such as Cloud-based system that enables all Federal Public Institutions to have their projects assessed and cleared in line with the Federal Government Directives

4. Innovation Portal designed to ensure adequate capture and support for innovators in Nigeria; such as one stop shop to register, identify and collaborative support for all the innovative ecosystems in Nigeria by providing priority program for start-ups and incubators in Nigeria. Yet, more recently, the FGN (2024A) has proposed a Bill for an Act to enable the growth of Digital Economy and Digital Governance in the country so as to improve the certainty of digital transactions, digital service delivery and related matters. Fundamentally, the objectives of the proposed bill are as follows:-
- (I) Enhancing the use of digital technology to grow Nigeria's economy;
  - (II) Creating an enabling environment for fair competition so as to promote innovation, growth and competitiveness for the Nigeria Digital Economy;
  - (III) Creating export-oriented capacities in Nigeria's digital economy so as to improve Nigeria's balance of trade and services,
  - (IV) Mandating, promoting and enabling the digital transformation of public institutions and government processes for efficient and effective service delivery;
  - (V) Encouraging and improving service delivery, openness and accountability for delivery of public or citizen digital services;
  - (VI) Providing legal framework to support international digital trade and investments using digital means; as well as
  - (VII) Creating a framework for the enhancement of digital economy governance among the MDA's.

Notably, the bill stipulates that notwithstanding the provisions of any other law but subject to the provisions of the constitution of the

Federal Republic of Nigeria (in all matters relating to digital economy and e-governance) the provisions of the Act shall override the provisions of any other law. Again, the regulatory agency in consultation with the relevant stakeholders shall determine, insert and publish digital literacy skills sets for Nigerians at various levels to be implemented through National Curriculum at all levels in both public and private sectors. As proposed, the regulatory agency shall also establish the regulations on the use and adoption of new and emerging technologies that relates to information technology (FGN, 2024A).

Similarly, the inaugural National Artificial Intelligence strategy (Landmark initiative aimed at harnessing the transformative potential of artificial intelligence to drive sustainable development innovation, national productivity and human well-being) will solidify Nigeria's position as African leader in Artificial Intelligence (AI) adoption (FGN, 2024B) operationally, the strategy will build on the already established National Centre for Artificial Intelligence and Robotics as well as various AI-specific government initiatives to enable knowledge-based economy furthermore, the FMICDE nationwide talent development (3MTT) aimed at training three million digital talents is positioning the country as a global hub for the application of artificial intelligence. Perhaps, the provision of research grants to AI startups through Nigeria Artificial Intelligence Research Scheme (NAIRS) in critical sectors of the economy; represents evidence of emerging entrepreneurial ecosystem clearly, the vision is to be a global leader in harnessing the transformative power of AI through responsible ethical and inclusive innovation, as well as fostering sustainable development through collaborative efforts. Therefore, considering Nigeria's strengths, weaknesses, opportunities and threats, the strategy has

three broad objectives for leveraging artificial intelligence (FGN, 2024B):

- (I) Using AI as a tool for economic growth and competitiveness.
- (II) Using AI as a tool for social development and inclusion, and
- (III) Using AI as a tool for technological advancement and leadership.

However, the sub-goals include the following:

- (1) Boosting economic productivity as well as enhancing efficiency and innovation across agriculture, manufacturing and service sectors.
- (2) Creating new industries and jobs as well as fostering the development of AI development while attracting investment and collaboration.
- (3) Attracting foreign investment as well as positioning Nigeria as a leader in responsible AI development while attracting investment and collaboration.
- (4) Improving access to essential services as well as utilizing AI to enhance healthcare delivery, education and financial for all Nigerians.
- (5) Addressing social challenges as well as leveraging AI to tackle such issues as poverty, inequality and climate change.
- (6) Empowering citizens as well as equipping individuals with skills and knowledge necessary to participate actively in the AI-driven future.
- (7) Developing indigenous AI expertise as well as building strong research and development ecosystem to foster innovation and local solutions.

- (8) Establishing ethical and regulatory frameworks as well as ensuring responsible and transparent development (Deployment) of AI.
- (9) Becoming a regional and global leader as well as positioning Nigeria as a key player in the global AI landscape.

Consequently, the comprehensive national AI strategy outlines the key pillars that will propel Nigeria towards achieving its vision. Operationally, each pillar will be supported by strategic objectives and actionable initiatives designed to drive progress across the AI development and adoption spectrum. Essentially, these pillars include Building foundational AI infrastructure; Building and sustaining world-class AI Ecosystem; Accelerating AI adoption and sector transformation. Ensuring responsible and ethical AI development; as well as developing a Robust AI Governance framework.



#### 4.0. Literature Review

Basically, enterprises firms can use digital technologies as an input in the production process as well as using it in the transaction process while selling their products or acquiring inputs. Again, digital technologies can enhance enterprise performance due to indirect cost saving such as labor costs and increased labour productivity; and direct cost reduction of firm's input such as information costs. Similarly, the use of digital technologies in the transaction process can foster input and output market expansion.

On the other hand, it might completely restructure the production process and transaction methods by way of increasing flexibility and output improvement. However, the early theoretical models of new technology diffusion (such as epidemic models) assumed that the adoption of new technology depends on the spread of information about its availability or other learning factors. Here, information spreading or epidemic learning help to reduce the uncertainty related to new technologies. Thus, the learning effects are assumed exogenous while the diffusion path is driven by the reduction in the cost or improvement in the quality of the new technology (Mansfield, 1963A; 1963B; 1968; stoneman, 2002).

In other words, at any point in time, only a number of potential adopters would wish to use the new technology. Therefore, the epidemic models predict that the adoption of new technology increases overtime as the risk to adoption decreases due to learning effects across and within firms (Battisti, et al 2007; Battisti and Stoneman, 2005). In contrast, another theoretical models link the variation in the preferred adoption sate to differentials in returns to potential adopters from adopting new technology.

Notably, rank models point to the firm heterogeneity as a driving factor behind differentials in gross returns from using new technology, and variation in the preferred adoption dates. In other words, firms with high returns from adoption of new technology will be early adopters while firms with low returns from adoption will be late adopters (Davies, 1979; Ireland and Stoneman, 1985; Geroski, 2000).

Similarly, the stock models assume that the benefit to marginal adopter from acquiring new technology with the increase in the number of previous adopters. In other words, for any cost of acquiring new technology; the adoption will not be profitable beyond certain number of adopters (Reinganwm, 1981; Karshenas and Stoneman, 1993). However, the order models assume that the return to a firm from adoption new technology depends upon its position in the order of adoption. Here, the anticipation is that high-order adopters achieve greater return than low-order adopters.

Therefore, the firm's decision to adopt new technology is influenced by waiting effects on profit (Ireland and Stoneman, 1985, Haller and Siedschlay, 2011).

Comparatively, interfirm diffusion (diffusion path of the number of firms using new technology) is quite distinct from intrafirm diffusion (intensity of using new technology by individual firms). Clearly, in the case of interfirm diffusion, the adoption decision may lead to revenue externality. But in the case of intra-firm diffusion, revenue externalities are internalized by way of marginal revenue appearance from the technological adoption.

However, using macroeconomic framework, technological-based productivity gains measured either as growth of average output per worker or a total factor productivity growth) can come from several

distinct channels (Acemoglu and Restrepo, 2013, 2019A, 2019B, 2022). Basically, these channels include automatic, task complementarily, automation deepening and new tasks. Automation or extensive-margin automation involves advanced technological models (Such as Artificial Intelligence) taking over and reducing costs in certain tasks.

Specifically, in using generative artificial intelligence, various mid-level clerical functions, text summary, data classification, advanced pattern recognition as well as computer vision tasks and be profitably automated.

Similarly, task complementarily can increase the productivity in tasks that are not fully automated and any likely raise the marginal product of labor. For instance, workers performing certain tasks may have better information or access to other complementary inputs. Notably, artificial intelligence technology may automate some subtask as well as enabling workers to specialize and raising their productivity in related job functions.

Again, automation Deepening can take place by way of increasing the productivity of capital in tasks that have already been automated. Here, an already-automated (IT) security task may be more successfully performed by generative (AI) tool. Furthermore, new tasks may be created by digital technologies (AI) which may impact the productivity of the whole production process (Acemoglu, 2024).

Empirical Literature: Unlike quantitative studies of intra-firm diffusion, most empirical studies on determinants of new technology diffusion have focused on inter-firm. In fact, most empirical studies suggest that inter-firm diffusion appears more critical in the earlier stages of adoption while intra-firm diffusion later becomes important in the

diffusion process (Battisti, and Stoneman, 2003, 2005). Numerically, a positive correlation between firm size and digital technology inclusive of information and communication technologies (ICT) adoption has been found in a number of empirical studies (Morgan, et al 2006; Fabiani, et al, 2005). However, other studies have found a weak and insignificant relationship between firm size and technological adoption. Specifically, Hollenstein (2004) showed that the observed relationship might be non-linear. Clearly, he showed that in the case of Swiss firm's sample; firm size was positively related to early and intensive use of digital technologies (but only in firm with about two hundred employees). Yet, in a related study, Crespi, et al (2016) examined the determinants of technological innovation and its impact on firm labour productivity. They found that the decision to invest in technologies innovation was strongly correlated with firm size and capabilities (using World Bank enterprise survey of seventeen Latin American Countries). Again, using data from a survey of Italian Manufacturing Firms, Caroli, et al (2019) found that digital transformation positively affected both financial and non-financial performance measures. In fact, they ascertained that the impact digital transformation is stronger for firms that engage in complementary organizational changes as well as firms that operate in more dynamic environments. For the case of Nigeria, Akaibi and Abdulraheem (2021) analyzed the effects of digital transformation on the organizational effectiveness of small and medium enterprises (SME). And by using a survey of sampled enterprises and structural equation modeling, they found positive correlation between digital transformation and business success.

IN other words, they found that small and medium-sized enterprises benefited greatly from embracing digital transformation in Nigeria. Similarly, Ihenyen, et al (2023) investigated the impact of digital

transformation on Nigeria business growth using descriptive research design and field survey's of sampled firms across various industries.

Notably, their studies revealed significant positive relationship between digital transformation adoption and financial performance of sampled enterprises. However, Olurinola, et al (2023) studies examined the determinants of digitalization and their impact on innovation in Nigeria.

Using logit regression model, propensity score, matching and World Bank Enterprise survey (2014/2025); they found that the size of the firm, educational qualifications, business age, employment growth and operational sector were the major determinants of firms digitalization in Nigeria. Similarly, the propensity score matching result showed that digitization was positive and significant in explaining the level of firm's innovation in Nigeria.

Indeed, as a concretion departure from the previous empirical studies, Hollenstein (2022) analyzed the determinants of the inter-firm and intra-firm diffusion of the entire set of digital technologies. Using unique firm-level dataset containing information from sampled companies of the entire Swiss business sector; they found that rank and epidemic effects are stronger in the case of intra-firm diffusion as compared to inter-firm diffusion (which might reflect the higher complexity of the first diffusion type).

However, the paper concluded that learning enhances the extent of the use of digital technologies through three main channels: Learning from outside sources, in-house cross-learning and in-house cumulative learning.

## 5.0. METHODOLOGICAL FRAMEWORK

Following Hollenstein (2022), Battisti, et.al (2009), Haller and Siedschlag (2011), Battisti, and Stoneman (2005), the theoretical framework model integrates the inter-firm and intra-firm diffusion into an encompassing framework that takes account of different theoretical approaches of demand side modeling of technology adoption. Basically, these include equilibrium models (rank, stock and order) as well as disequilibrium models (epidemic) that have dominated technological diffusion studies.

Essentially, the model states that a firm (I) in industry (j) will adopt a technology for the first time or increase its use within the firm when the marginal profit gain in time (t) is larger than the adoption costs ( $C_i$ ). Clearly, the model hypothesizes that the profits depend on those group of variables that reflect the different approaches of explaining technology diffusion. Notably, the adoption and the extent of intra-firm diffusion ( $X_i$ ) of firm (i) is determined by those categories of variable that capture rank effects, stock effects, order effects and epidemic effects. However, the above theoretical postulation can be expanded by taking account of several variable reflecting firm specific anticipated benefits from adoption.

Consequently, the theoretical model can be represented as follows:-

$$\mathbf{X}_i = \mathbf{F} (\mathbf{R}_i, \mathbf{R}_j, \mathbf{S}_{oj}, \mathbf{E}_i, \mathbf{E}_j, \mathbf{C}_i, \mathbf{B}_i) \quad (5.1)$$

**where  $X_i$**  = Adoption an extent of intra-firm diffusion of firm (i)

**$R_i$**  = Firm specific rank effects

**$R_j$**  = Industry specific rank effects

**$S_{oj}$**  = Firm stock and order effects

**$E_j$**  = Epidemic effects (reflecting the spread of information, learning and risk-reduction (non-market) intermediate externalities)

**E<sub>i</sub>** = In-house learning based on previous experience with digital technologies

**C<sub>i</sub>** = Costs of technology which consists of the price of the technology (which is largely the same for all firms) as well as firm and technology – specific installation, adjustment and switching cost.

**B<sub>i</sub>** = Firm-specific anticipated benefits from adoption.

Here, it may not be feasible to separate the stock and order effects from the epidemic type of learning. Therefore, the usage of digital technology at industry level can be included as a proxy variable reflecting the combined effect of **E<sub>j</sub>** and **S<sub>oj</sub>**. Consequently, a new theoretical equation can be specified as follows:

$$\mathbf{X}_i = \mathbf{F} (\mathbf{R}_i, \mathbf{R}_j, \mathbf{Interj}, \mathbf{Intra}_j, \mathbf{C}_i, \mathbf{B}_j) \quad (5.2)$$

**where X<sub>i</sub>, R<sub>i</sub>, R<sub>j</sub>, C<sub>i</sub>, B<sub>j</sub>** = defined as shown in equation. (5.1)

**Interj** = The proportion of firms in industry<sub>j</sub> having adopted at least one technology of the corresponding category of digital technologies.

**Intra<sub>j</sub>** = The mean number of digital technologies used by the firms of industry<sub>j</sub> in the corresponding field of technology and following, the above theoretical framework, our empirical model can be specified as follows:-

$$\mathbf{FDA}_{ijrt} = \mathbf{F} (\mathbf{MIF}, \mathbf{SMF}, \mathbf{MEF}, \mathbf{LAF}, \mathbf{OGT}, \mathbf{AGE}, (\mathbf{AGE})^2, \mathbf{MUP}, \mathbf{WAE}, \mathbf{MTS}, \mathbf{CLL}, \mathbf{EXP}, (\mathbf{EXP})^2, \mathbf{IND}, \mathbf{\Phi}_j, \mathbf{\Phi}_r, \mathbf{\Phi}_t, \mathbf{RDI}, \mathbf{INA}, \mathbf{FOF}, \mathbf{ADC}, \mathbf{AAB}) \quad (5.3)$$

**where FDA<sub>ijrt</sub>** = Adoption of digital technology in firm(i), industry<sub>j</sub>, region(r), at time (t)

**MIF** = Dummy variable for firm size - Micro Enterprises with less than 20 employees.

**SMF** = Dummy variable for firm size of small enterprises with 20-49 employees.

**MEF** = Dummy variable for firm size of medium enterprises with 50 – 249 employees

**LAF** = Dummy variable for firm size of large enterprises with 250 employees or more.

**OGT** = Output growth or turnover growth rate

**Age** = Firm Age

**(AGE)<sup>2</sup>** = Firm Age square term

**MUP** = Dummy variable indicating whether a firm is a multi-plant firm

**TAKES 1:** If enterprise has more than one plant

**TAKES 0:** Otherwise

**WAE** = Average wages per employee as proxy for human capital.

**MTS**=Share of managerial and technical employees or staff in all employees

**CLL** = Share of clerical staff in all employees.

**EXP and (EXP)<sup>2</sup>** = Export intensity capturing share of turnover exported which are measures of firm international competitiveness.

**IND** = Industry concentration generated with turnover data

**$\Phi_j$**  = Dummy variable to control for unobserved industry specific effects.

**$\Phi_r$**  = Dummy variable to control for unobserved region specific effects

**$\Phi_t$**  = Dummy variable to control for unobserved time specific effects

**RDI**=Dummy variable for research and Development activities that strengthen a firm's absorptive capacity for new technologies

**INA**= Innovation activity being captured by product innovation variable as well as process innovation dummy variable (cost reductions due to process innovations).

**FOF**= Dummy variable for foreign owned firms.



**ADC**=Adoption cost variables capturing barriers in the adoption of digital technologies and the factors include complexity, resources, uncertainty and security.

**AAB**=Adoption benefits anticipated variables capturing firm-level information on the relevance of those objectives that a firm may pursue by adopting digital technologies. Here, these variables are taken as measures of anticipated benefits of the inter-firm diffusion and intra-firm diffusion of digital technologies. These anticipation variables include efficiency, market and labour:

- I. **EFFICIENCY VARIABLES** indicates that a firm (by using digital technologies) expects to be able to increase internal flexibility and efficiency so as to improve the integration of firm-internal processes and reduce labour costs.
- II. **MARKET VARIABLE** captures several dimensions of expected improvements of a firm's market position such as enhanced knowledge of markets and clients; increased market flexibility; better integration into value chains as well as market oriented adaptation of the business model.
- III. **LABOUR** Captures firm's view that adopting digital technology is a useful instrument for attracting top quality employees as well as creating motivating jobs.

Econometrically, in order to estimate the inter-firm and intra-firm diffusion of digital technologies, we apply the following model specification.

$$\begin{aligned}
 \mathbf{FDA}_{ijrt} = & \alpha_0 + \alpha_1 \mathbf{MIF}_i + \alpha_2 \mathbf{SMF}_i + \alpha_3 \mathbf{MEF}_i + \alpha_4 \mathbf{LAF}_{ijrt} + \alpha_5 \mathbf{OGT}_{ijrt} \\
 & + \alpha_6 \mathbf{AGE}_{ijrt} + \alpha_7 (\mathbf{AGE})^2_{ijrt} + \alpha_8 \mathbf{MUP}_{ijrt} + \alpha_9 \mathbf{WAE}_{ijrt} + \alpha_{10} \mathbf{MTS}_{ijrt}
 \end{aligned}$$

$$\begin{aligned}
& + \alpha_{11ijrt} + \alpha_{12} \text{EXP}_{ijrt} + \alpha_{13} (\text{EXP})^2_{ijrt} + \alpha_{14} \text{IND}_{ijrt} + \alpha_{15} \Phi_j + \alpha_{16} \Phi_r \\
& + \alpha_{17} \Phi_t + \alpha_{18} \text{RDI}_{ijrt} + \alpha_{19} \text{INA}_{ijrt} + \alpha_{20} \text{FOF}_{ijrt} + \alpha_{21ijrt} \text{ADC}_{ijrt} + \\
& \alpha_{22} \text{AAB}_{ijrt} + \epsilon_{ijrt} \qquad \qquad \qquad (5.4)
\end{aligned}$$

As apriori, expectations and assuming that firms are early adopters of digital technologies (or using it more intensively) we shall then expect negative coefficients for  $\alpha_1$ ,  $\alpha_2$ ,  $\alpha_3$ , and  $\alpha_4$ . Yet, while we expect to find  $\alpha_5 > 0$ , the signs for  $\alpha_6$  and  $\alpha_7$  are ambiguous. Perhaps, the reason is that while older firms may show higher rates of digital technology adoption and use due to learning effects; younger firms may be better placed to adopt recent available technologies. Similarly, multiplant enterprises may be more likely to adopt digital technologies earlier so that they can spread the cost over several entities as well as benefiting from enhanced communication within group. However, as proxy for human capital (using wages per employee, managerial and technical staff share, and clerical staff share) we expect the parameters ( $\alpha_9$ ,  $\alpha_{10}$ ,  $\alpha_{11}$ ) to be positive and significantly different from zero. Yet, while we expect digital adoption and diffusion to be positively associated with export intensity ( $\alpha_{12} > 0$ ); its square term is included to capture possible non-linearity (where competitive pressure from exposure to foreign market is likely to increase less than proportionally beyond certain export intensity level). Thus, we expect  $\alpha_{13} \geq 0$  as the case may be. However, to proxy another effects of competition on the adoption and diffusion of digital technologies, we can use the measure industry concentration ( $\alpha_{14} > 0$ ).

Statistically, if the parameters  $\alpha_1$  to  $\alpha_{14}$  are significantly different from zero then the hypothesis of the presence of rank effects cannot be rejected. Notably, we can control from the unobserved industry effects, regional effects, regional effects, and time-specific effects (as

represented by  $\Phi_j$ ,  $\Phi_r$ ,  $\Phi_t$  dummy variables) for those industries, regions and years in our panel data set.

Operationally, foreign owned firms (captured as FOF dummy variable) are usually more innovative than domestic companies, since they have to compensate for the fact that they were less familiar with the local conditions of doing business. In other words, domestic affiliates may profit from the knowledge in flows from their foreign parent company. Therefore, we statistically expect a positive sign of the FOF variable ( $\alpha_{20} > 0$ ). And for the Research and Development dummy variable (**R.D1**) we expect a positive effect on diffusion ( $\alpha_{18} > 0$ ). Again we expect other innovation-related activities to favor diffusion. Thus, we anticipate positive effect of variable INA ( $\alpha_{19} > 0$ ). In contrast, for the variables capturing adoption costs, we expect negative effect on the inter-firm diffusion and intra-firm diffusion of digital technologies. However, as such barriers may be more binding at high than at low levels of diffusion; we may likely get a positive sign for some of the captured variables. Thus, the estimated parameters,  $\alpha_{21} \geq 0$ . Finally, for the adoption benefits anticipation variables, we expect a positive sign for the captured variables ( $\alpha_{22} > 0$ ).

Parametrically, in order to estimate equation **(5.4)** we shall use panel prohibit estimator since our dependent variables are the bivariate indicators of inter-firm digital technology adoption. Similarly, in the case of intra-firm digital adoption, the dependent variables are continuous and take values between 0 and 1.

Therefore, we shall also estimate a panel prohibit model (Papke and Woodridge, 1996; Haller and Siedschlag, 2011; Baltagi, 2005). Indeed, the panel prohibit model is appropriate for the proposed panel data set as it overcomes many of the econometric problems associated

with tobit or OLS models (when the dependent variables is continuous and taking values between 0 and 1).

Specifically, this research paper propose a non-linear function for estimating the expected values of dependent variables ( $Y_i$ ) conditional on a vector of covariates ( $X_i$ ) as shown below:

$$\mathbf{E}(y_i|X_i) = \mathbf{G}(x_i \beta) \quad (5.5)$$

**where  $\mathbf{G}$**  = any cumulative distribution function

$\beta$  = True population parameters by choosing the following logistic distribution.

$$\mathbf{E}(Y_i/X_i) = \frac{\exp(x\beta)}{1+\exp(x\beta)} \quad (5.6)$$

and suggestive the use of the following Bernoulli log-likelihood function; we obtain the quasi-maximum likelihood estimates ( $\beta$ ):

$$\mathbf{L}(\beta) = Y_i \log \{\mathbf{G}(X-\beta)\} + (1-y) \log \{1-\mathbf{G}(X,\beta)\} \quad (5.7)$$

Statistically, in all the regressions, the standard errors are likely adjusted for clustering at the firm level. However, it can be argued that foreign owned firms are more likely to be early adopters of digital technology as well as being important channels of new digital technology diffusion. Therefore, in order to capture the ownership effect on digital adoption and diffusion; we propose to estimate the models for all firms jointly as well as for domestic and foreign owned firms comparatively.

## 6.0. DATA PLAN

Operationally, the dataset to be used in this research study will come from a special survey to be conducted in the Nigerian productive sectors with the cooperation of National Bureau of statistics (NBS), Manufacturers Association of Nigeria (MAN) and World Bank (WB). Basically, the survey will deal with the use of digital technologies and its effect on the intended variables: Statistically, the survey will be based on the random sample of Nigerian firms drawn from the official enterprise census. We plan to use the survey result to provide descriptive statistical information about the use of digital technologies and obstacles for digitalization.

Indeed, as empirical justification and for the sake of controlling for individual heterogeneity panel data suggests that time series and cross-section studies not controlling the observed heterogeneity run the risk of obtaining biased result. Again, panel data gives more informative data, more variability, less **collinearity** among the variables, more degrees of freedom and more efficiency. In fact, unlike cross-sectional distributions that look relatively stable but hiding multitude of changes; Panel data are better able to study the dynamic of adjustment.

Furthermore, panel data are better able to identify and measure effects that are simply not detectable in pure cross-section data set (Baltagi, 2005; Nwaobi, 2018). Indeed, micro panel data gathered on individuals, firms and household may be more accurately measured than similar variables measured at the macro level. In other words, biased resulting from aggregation over firms may be reduced or eliminated. However, panel data is not a **paracea** and may not solve all the problems that cross-section study could not handle. Yet, the payoff for panel data is over long time periods. Consequently, we shall adopt a time period of five years (2020 – 2024) for the proposed research study.

## 7.0. **RESULTS ANTICIPATION AND DISSEMINATION**

Indeed, critical microeconomic and business indicators are increasing bleak in Nigeria. Thus, major efforts must be made to reverse the observed empirical trend. Therefore, this research project is found on the that, if the transformational power of digital technologies can be brought to bear, then Nigeria can participate in the emerging digital economy. Similarly, opportunities offered by digital induced changes are expected to open up new avenues for study and research. In other words, the research project will continue to stimulate learning for a broad spectrum of people, project, ideas, products and technologies in the various regions of the country.

However, results dissemination, loop closing and research result utilization can be seen as dynamically inter-linked processes that need to be integrated into all major stages of the research activities. Clearly, this perspective gives rise to an approach that ought to expand the number of boundary partners as well as shortening the time between traditionally conducted research and its utilization by critical stakeholder. Operationally, it is hoped that this research project will add value to the progress of change by linking what is learned from research to development outcomes in other words, the project will involve interaction and participation among stakeholders at all levels as well as ensuring that issues, problems and lessons are shared, adopted and fed back into the project implementation stages.

Essentially, the anticipated research outputs will include dissemination outputs such as publications, policy papers and conference proceedings. Finally, it is hoped, that this research output will add value to the process of change among Nigerian firms and enterprises

by linking what is learnt to the potential development and organizational outcomes.

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