National Innovation System and Economic Development in Nigeria

Mr. Jonathan Gimmy Leo

Innovation and Technology Policy Department, Nigerian Institute of Social and Economic Research (NISER), Ibadan, Oyo State. Nigeria

***Abstract*: The paper analyzed the National Innovation System (NIS) and economic development in developing countries like Nigeria. The objectives of the paper were to examine the nature of innovation systems in Nigeria. It also investigates the effects of NIS on economic growth and development in Nigeria. The review of literature suggests that NIS is more than just technological innovations, it includes the interrelationships between firms, governmental institutions, NGOs, and international institutions who engage in one form of R&D activity or the other in a country. The paper employed both descriptive statistics and generalized linear models (GLM) to explain the NIS and economic development in Nigeria. The results from the descriptive analysis revealed that the nature of the Nigerian innovation system is weak and still evolving. It reveals that low performance and high variations in NIS indicators such as industrial design applications, patent right applications, trademark applications, methodology assessment of statistical capacity, high technology exports, ICT goods exports, ICT goods imports and ICT services exports, and agricultural raw materials exports and imports in Nigeria. The regression results also revealed that NIS (R&D expenditures) is a significant positive determinant of economic growth and development in Nigeria. The paper also showed that human capital, industrial production, stock market capitalization, trade openness, foreign direct investment, and exchange rate regimes are significant determinants of economic growth and development in the NIS in Nigeria. Projecting economic growth and development to higher levels and achieving the projections remains the main objective of government policies in Nigeria.**

***Key Words*: Innovation System, Institutions, Firm Performance, Growth & Development, Nigeria**

JEL Classification: O10, O30, O33, Q01, Q55

I. INTRODUCTION

Economists in the past had explained the process of achieving economic growth from the perspective of the National Innovation System (NIS). Lundvall, et al., (2002) traced the origin of innovation systems to Adam Smith's work on Wealth of Nations. Joseph Schumpeter's principle of creative destruction envisaged an innovation system in which new production units or products replaces the old ones in the economy.[1] Growth was viewed in this perspective until 1956 when Robert Solow posited that economic growth can be achieved through technological innovation. The new growth theory by Paul Romer in 1990 further advanced the explanations of the process of achieving economic growth.[2] But the NIS was central to every perspective on economic growth. According to Fagerberg and Srholec (2008) economists who emphasized the crucial role of technology in development tend to argue that catching up in technology is by no means a free ride because countries who failed to develop appropriate technological capabilities should expect to lag in the growth process. Building technological capabilities require that firms collaborate with other organizations or firms within the framework of institutional rules. The institutions or actors involved in the innovation system are key to the technological performance of the country in question. According to OECD (1997), innovation and technical progress are a result of a complex set of relationships among actors or institutions producing, distributing and applying various kinds of knowledge.[3]

The Nigerian innovation system is evolving and is still at its early stage of development. In the 2020 National Business Innovation Survey, The National Centre for Technology Management (NACETEM) reported that Nigeria has a weak innovation system and needs to invest in Science, Technology and Innovation (STI) to support sustainable economic growth.[4] Uchechukwu et al., (2016) argued that the weak NIS is a result of challenges facing technological diffusion in Nigeria. He maintained that the legal system does not encourage technological innovation coupled with the lack of adequate research facilities, insufficient human capital and poor government policies in the country. Adeoti et al., (2010) and Adeoti (2020) review of economic and STI policies in Nigeria revealed that government intervention to promote the innovation system has so far been weak and ineffective. Since Nigeria's independence, the NIS has been weak, unstructured and underdeveloped with little or no investments. The innovation system could not sufficiently encourage technological innovations given the prevailing lack of adequate research facilities, insufficient human capital and poor government policies in the country (Uchechukwu et al., 2016).

[1] Schumpeter, J., (1942), Capitalism, Socialism and Democracy. Harper and Brothers Publishers, New York and London

[2] Romer (1990) posited that economic growth is not exogenously determined as proposed by Solow, but that it is endogenously determined by factors such as results from R$D, knowledge and human capital investment.

[3] The actors or institutions involved in the NIS are firms, public research institutes, universities, and the people within the institutions. Their interaction is largely on joint research, personnel exchanges, cross-patenting, purchase of equipment etc. (OECD, 1997).

[4] https://www.bing.com/newtabredir?url=https%3A%2F%2Fthenationonlineng.net%2Fnigeria-weak-on-innovation-infrastructure%2F

R&D activities were underfunded and neglected by the institutions and past governments. Infrastructural and innovation deficits and a lack of effective patent rights remain in the NIS in Nigeria. Weak patent rights and inadequate infrastructures have constrained the ability of economic agents to identify and harness technological innovations in many sectors of the economy. The weak NIS were largely due to weak institutional arrangements, poor STI policies, and inadequate funding of sectors in the NIS. This frustrated innovation culture and the diffusion of innovation became daunting as a result of weak institutional support for innovation in the country.

However, recent developments in the Nigerian innovation system have witnessed increased budgetary allocations for critical infrastructures in the NIS such as the setting up of institutional and legal frameworks (e.g., National Research and Innovation Council (NRIC), National Council on Science, Technology and Innovation (NCSTI)) and establishment of the National Research and Innovation Fund (NRIF), the Automotive Development Fund (ADF), the National Communication Development Fund (NCDF), etc. (Ibidapo-Obe, 2012). The Developments in the innovation system policies are expected to improve the NIS and generate the desired growth in the economy. Experience from other countries like China revealed that the Chinese government focused its NIS policy on social entrepreneurship in the rural sector and achieved sustained economic growth for over two decades (Wu, et al., 2016). The main aim of this paper is to examine the nature of innovation systems in Nigeria and also analyze the effect of NIS on economic growth and development in Nigeria.

II. LITERATURE REVIEW

II.I. Conceptual Review

The National System of Innovation has been defined in several ways by different researchers in different countries. The definitions have always portrayed a system of interaction between stakeholders or actors in generating knowledge, competencies and learning in the NIS. According to Lundvall (2004), NIS may be defined in evolutionary terms regarding how different national systems create diversity, reproduce routines and select firms, products and routines. He argued that the most important reason for seeing NIS as an evolutionary concept is the strategic role it gives to Knowledge and learning. It was on this basis that he redefined NIS as the elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge and are either located within or rooted inside the borders of a Nation State (OECD, 1997). Metcalfe (1995) as in OECD (1997) defined NIS as that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which defined new technologies. Nelson and Rosenberg (1993) defined NIS as the set of institutions whose interactions determine the innovative performance of national firms (Feinson, 2010). According to Freeman (1987) as in Feinson (2010), NIS is the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.

Therefore, there is no single accepted definition of NIS anywhere in the world. The definitions may vary with country and economic systems. But the acceptable definition may include the following ingredients; institutions or organizations, technological innovations, interactions or relationships, knowledge and Nation-State or country. We define NIS as the interconnected systems of institutions (both public and private) that innovates and interact in the production, diffusion and use of new knowledge or technological invention in a country. However, Economic Growth is defined as the sustained increase in the gross domestic product (GDP) of a country over a period usually one year. The GDP of a country is the total market value of all goods and services produced in a year. Economic growth in Nigeria has recently slowed down due to economic recessions and weak NIS. Economic development encompasses economic growth and structural transformation of the economy and welfare of the citizen of a country over a period. The innovation system has not been properly linked or connected to facilitate the easy flow of knowledge between institutions and firms. Firms operate largely in isolation from the institutions and the people. The interdependence of institutions and private firms has been low until recently when the NIS was improved upon with the new STI policy of 2012 and some institutional backups (Ibidapo-Obe, 2012).

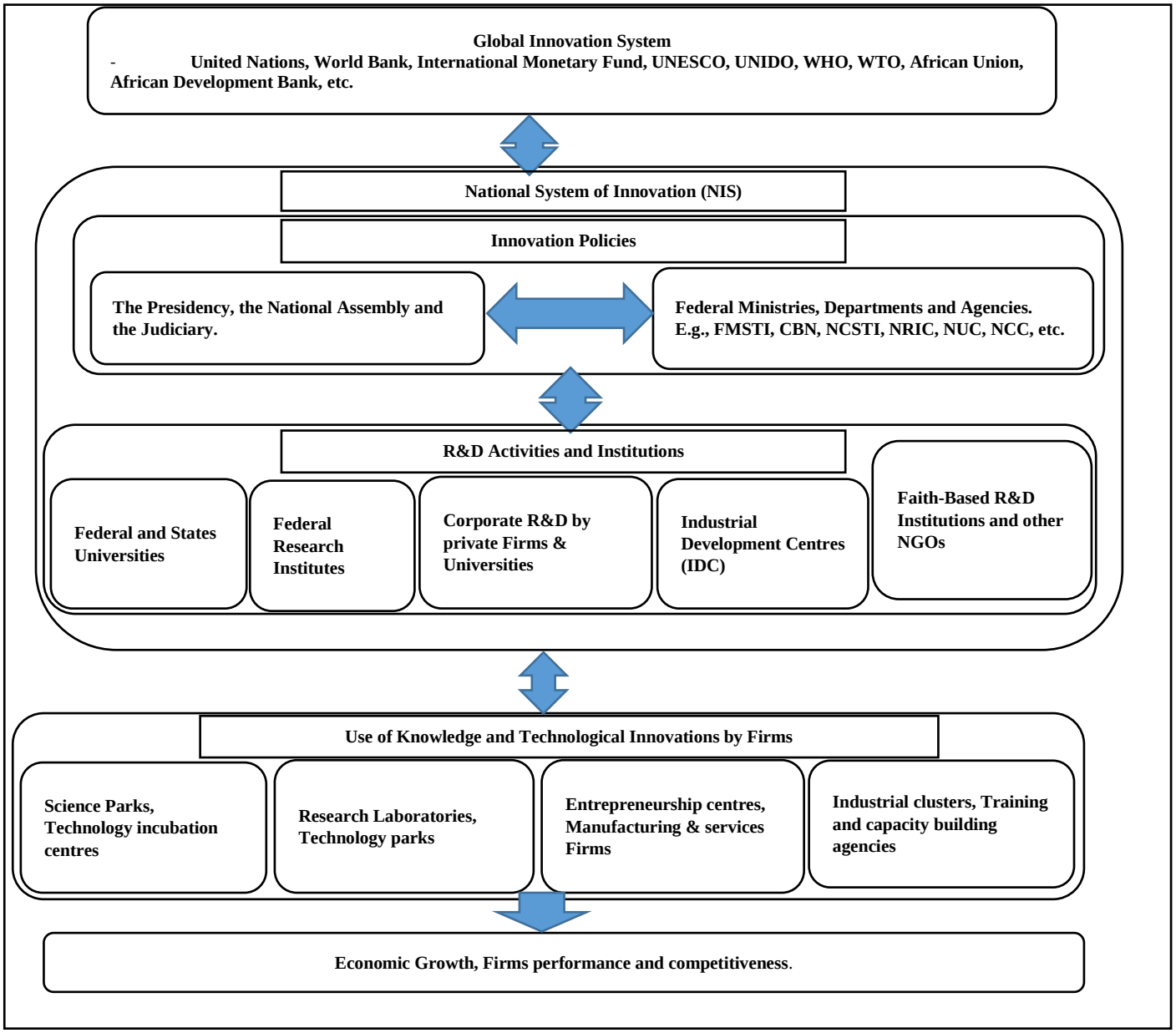
II.II. National Innovation System Institutional Mechanism in Nigeria.

Several attempts have been made to explain how institutions and stakeholders or actors in the NIS interact with each other in terms of the flow of knowledge, information and innovation functions in the country. Adeoti et al., (2010) viewed the NIS as an integrated system of economic and institutional agents directly promoting the generation and use of innovation in a national economy. The interrelationships between institutions are aimed at generating new knowledge or innovations through R&D that promote economic growth and improves firm performance and the welfare of the citizens.[5] In Figure I, the paper presented the framework for NIS in Nigeria. The global innovation system (GIS) is made up of international institutions (such as World Bank, United Nations, UNESCO, UNIDO etc.) and multinational firms that generate knowledge

[5] Klime and Rosenberg, (1986) defined knowledge as the stock part of science while research is seen as the flow part of creating new knowledge or knowledge that adds to the accumulated knowledge of the NIS (Adeoti 2010).

and new technological innovations. This knowledge and innovations are exchanged between countries for global development and peace. The NIS is made up of national institutions that make the innovation policies for the country. The national institutions in the NIS also interact with the GIS institutions in areas of R&D, knowledge flows and innovation policies.

Figure I: Framework for National Innovation Systems in Nigeria.



Source: Author's Conceptualization from Garifullin and Ableav (2015).

The national institutions interact with each other concerning innovation policies through R&D activities with corporate firms and public enterprises. The legal backing and institutional framework rest with the Presidency, National Assembly and the Judiciary. The Federal Ministries, Departments and Agencies (MDAs) and funding institutions and programmes (such as CBN, BoI, NACB, NRIF, ADF, etc.) regulate and execute the innovation policies in the NIS.[6] In the execution of the innovation policies, knowledge-generating institutions (Federal and State Universities) and R&D

[6] Similar institutional arrangements exist at state and local government's levels in Nigeria.

institutions (Federal research institutes) and firm R&D activities, private universities, industrial development Centres (IDC) and faith-based R&D institutions and non-governmental organizations (NGOs) play a crucial role in the production, diffusion and creation of new knowledge and technological innovations. The institutions also interact with the regulators to ensure that the objectives of NIS are achieved through R&D activities in the country. The interactions between universities, research institutes and firms have been deeply investigated within and outside the framework of NIS (Kruss, et al., (2015). The knowledge generated is also applied and tested in science parks, incubation centres, research laboratories, entrepreneurship centres, manufacturing and services firms, industrial clusters and training and capacity-building agencies for onward use by firms in the country. Therefore, building technological innovation capability requires investment in R&D and interrelationships between firms and institutions. Fan, et al., (2009) argued that the role of government in the NIS is to create the enabling infrastructures for innovation by improving the business environment, establishing a well-balanced intellectual property rights protection system, investing in human resources, enhancing the R&D infrastructure to attract private investment, encouraging the establishment of industrial clusters and increasing financial resources available for innovation by providing direct funding for basic research and developing competitive financial markets.

As shown in Figure I, the endpoint of the interrelationships between a firm's innovative activities and institutional innovations in the NIS is economic growth, firm's performance and competitiveness. The interrelationships in the NIS are a complex process in Nigeria because of the current state of technological advancement and the business environment. The innovation system is constrained by so many factors such as capital constraints, infrastructural constraints, lack of adequate skills, international competition from high technological firms, and innovation confronts from the GIS. However, Nigeria's potential in the business environment remains untapped by firms operating in the country. As efforts are being made to improve the business environment, firms must strategically cooperate and innovate their path to greater performance in the country and abroad.

II.III. Theoretical Review

Apart from the explanations of the neoclassical theoretical developments in achieving economic growth, the technology acceptance model (TAM) tried to explain how economic agents come to accept and use innovation or knowledge in the NIS. The TAM model was first introduced by Fred Davis in 1985. He argued that system use is a response that can be explained or predicted by user motivation which in turn is directly influenced by an external stimulus consisting of the actual system's features and capabilities (Chuttur, 2009). According to this theory, firms and individuals are influenced by three main factors namely the attitude of the user of the technology, the perceived usefulness of technological innovation and the perceived ease of use of the new knowledge or technology.[7] NIS approach focused on the increasing attention given to the economic benefits of knowledge and technological innovations in the country. Proponents of NIS would suggest investment in knowledge such as R&D, education and training and innovative workplace approaches as key ingredients in achieving economic growth and firm performance (OECD, 1997). It is the perceived usefulness of knowledge and other technological innovations that derive firms into investment in R&D and technology acquisitions. Theoretical and empirical studies have demonstrated that technological progress is the cause of economic growth and development in most developed countries (Fan, et al., (2009).[8]

The role of collaborative activities by firms in the NIS is crucial for a firm's innovative performance. NIS studies in Norway and Finland have indicated that the share of new products in overall sales is higher among firms involved in cooperative ventures. In the European Union, cooperative research programmes revealed an increase in a firm's competencies and skills that positively influence a firm's innovative capacity (such as networking capabilities, and the ability to identify and adapt useful technologies (OECD, 1997). Therefore, the NIS can help government promote innovation-led growth based on the fact that competitive market situations are necessary, but may not be a sufficient condition for stimulating innovation and driving the benefits from knowledge accumulation for firms and individuals (OECD 1999). In developing countries, understanding the interactions among institutions is key to enhancing private firm's innovative performance by the government of the country.[9]

II.IV. Empirical Review

Fagerberg and Srholec (2008) studied the NIS, capabilities and economic development using factor analysis on 25 indicators and 115 countries between 1992 and 2004. The study identifies the type of capabilities which are critical for technological catching up including the development of an innovation system, the quality of governance, the character of the political system and the degree of openness of the economy to trade and foreign direct investments. The results showed that innovation systems and governance were crucial and significant for economic development and technological catching up. There was evidence that the degree of openness to trade and foreign direct investments matter in economic growth. The political system was a significant determinant for economic development in developed countries while it was insignificant in developing countries due to unconducive environments. Wu, et al., (2016) examined the NIS, social

[7] https://en.wikipedia.org/wiki/technology_acceptance_model

[8] Factors such as the effectiveness of physical capital, labour, productivity of human capital and investment in R&D, intellectual, physical and human capital contribute to economic development (Fan, et al., 2009).

[9] Innovative performance encompasses not only technological innovations (i.e., diffusion of new products and services of a technological nature into the economy) but also include non-technological forms of innovations (such as organizational or institutional innovations)

entrepreneurship, and rural economic growth in China using panel data regression analysis. The results revealed that the NIS had a significantly positive effect on rural economic growth and this impact varies between the coastal and interior areas depending on government-led R&D expenses and labour mobility in China. They also revealed that government-led technology policy within the NIS framework promote economic growth. Still, they showed that government-led R&D expenditures (social entrepreneurship), education at the tertiary and secondary levels and labour mobility positively impact rural economic growth in rural China.

Empirical studies have also examined the effects of innovation on economic growth. In Nigeria, Iyoboyi and Na-Allah, (2014) used a dynamic ordinary least square method to report that innovation which was proxied by technology-embodied capital imports had a significant positive impact on economic growth. Also, Uchechukwu et al., (2016) analyzed the role of innovation in the Economic Development of Nigeria. They reported that the level of innovation and technology in Nigeria is low and the Nigerian patent law is weak. They identify the challenges to innovation to include institutional framework, inadequate human capital, lack of research or innovation infrastructures, and poor networks of business community. Adeoti and Olabamiwa, (2009) examined the cocoa innovation system in the NIS and its interrelationships with government policies on cocoa rebirth in Nigeria. The findings of the study showed that the cocoa innovation system is still relatively weak and measures to strengthen it appear unarticulated. The Findings also suggested that government policy should aim at organizing Cocoa rebirth initiatives as an innovation-focused programmes that enables interactive learning among actors in cocoa research, production and industrial processing.

In a similar study, Siyanbola et al., (2016) reviewed the process of STI policy in Nigeria using scientific indicators in a system analysis framework. The review showed that Nigeria has not given enough support for STI policies in terms of funding R&D activities and science-related activities. Other science-related sectors (like agriculture, energy, ICT, health etc.) are facing a similar situation from the government. The STI policies that was design in 2011 focused on innovation and commercialization of knowledge in Nigeria. Institutional support was provided for the new STI Policy to flourish in Nigeria. However, the development and integration of the STI indicators in the national innovation system can serve as a framework for utilizing scientific evidence in policymaking and generate greater economic growth in Nigeria. Ukpabio, et al., (2017) examined the impact of technological innovations on the performance of manufacturing firms in Nigeria from a sample of 305 firms using correlation and hierarchical regression analysis. The results showed that product and process innovation are positively correlated with a firm's performance. They further revealed that product and process innovation had a significant positive relationship with firm performance in Nigeria. Olughor, (2015) used regression analysis to also revealed that innovation influences the business performance of SMEs in Nigeria. Pece et al., (2015) similarly used the OLS technique to show evidence of a significant positive relationship between innovation and economic growth in the Central East European (CEE) Countries.

Using panel regression analysis, Liao (2019) demonstrated a significant negative spillover effect from innovation leaders on economic growth and a significant positive spillover effect from innovation peers on economic growth. The influence of government intervention on innovation performance has also been done by Wang (2018) in Hong Kong and Singapore. Using a difference-in-difference analysis of innovation patents in the two countries, Wang (2018) found significant evidence for the effectiveness of government intervention in influencing the scope of innovation activities and technological development. The study revealed that innovation activities in Singapore are largely policy-driven and dominated by big firms and players while in Hong Kong industry innovation activities is less active but the local industry has a dynamic innovation base contributed by small firms. Singapore was known for strong government intervention while Hong Kong was famous for its positive non-intervention policy that minimizes the power of the government in influencing the market. Chen and Yuan (2007) analyzed the innovation strategies of firm in Chinese high-tech industries using multiple regression analysis. The study found that outsourcing is the major innovation strategy adopted by most high-tech firms in China. They further revealed that Chinese firms have insufficient internal R&D expenditures, weak absorptive capacity and high technological import feature in their innovative activities. They further revealed that although Chinese firms prefer outsourcing strategy in their innovation activities, the contribution of outsourcing is much smaller than that of internal R&D (i.e., when expenditures increased by the same rate, the innovation output from internal R&D is twice the output of outsourcing).

III. METHODOLOGY

This study examines the nature of innovation systems in Nigeria. It also investigates the effects of NIS on economic development in Nigeria from 2000 to 2019. Data were obtained from four main sources namely; World Bank's World Development Indicators, United Nations Development Programme (UNDP), Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS). The data from the World Bank were mostly unavailable for the time frame however, the author still made the best use of the available data. Data were collected on patent applications by residents and nonresidents, industrial design applications, residents and nonresidents by count, trademarks applications, residents and nonresident by count, high technology exports, ICT goods export and imports in total goods exported and imported, ICT service exports and agricultural raw materials exports and imports. These

indicators portray Nigeria's innovation capability (Fagerberg and Srholec 2008).[10]

Patent application by residents and nonresidents are indicators of innovation in Nigeria because a patent protects an invention (a product or process that provide a new way of doing something or offers a new technical solution to a problem) to the owner of the patent for a limited period usually 20 years.[11] Another indicator of innovation in Nigeria is industrial design applications by residents and nonresidents because it confers exclusive rights against unauthorized copying or imitation of the design (such as industrial products and handicrafts) by third parties for a limited period of 15 years. Trademarks application by residents and nonresidents also indicate innovation activities because it protects the owner of the mark by ensuring the exclusive right to use it to identify goods or services or to authorized another to use it in return for payments.[12] Innovation is also indicated by high technology exports which are exported products with high R&D intensity such as aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery (World Bank 2021). ICT goods exports or imports include computers, peripheral equipment, communication equipment, consumer electronic equipment, electronic components and other information and technology goods exported or imported. ICT service exports include computers and communications services (telecommunications and postal and courier services) and information services (computer data and news-related service transactions).

Table I: Data Sources and Description

Indicator	Description	Source
Industrial design	Industrial design applications, nonresidents and residents by count	World Bank
Patent rights	Patent applications, nonresident and resident	World Bank
Methodology Assessment of statistical capacity	Methodology Assessment of statistical capacity (scale 1-10)	World Bank
Trademarks	Trademark applications nonresidents and residents by count	World Bank
High technology exports	High technology exports	World Bank
ICT goods	ICT goods exported or imported	World Bank
ICT service	ICT service exports	World Bank
Agricultural raw materials	Agricultural raw material exports and imports	World Bank
Economic development (Y)	GDP per capita i.e., ratio of real GDP to total population (in ₦ thousands)	CBN
Economic growth (GDP)	Real GDP (in ₦ billion)	CBN
National Innovation System (RD)	R&D expenditures (in ₦ billion)	NBS
Industrial Production (IP)	Industrial production in GDP (in ₦ billion)	CBN
Trade openness (TO)	Ratio of total trade volumes to GDP (in ₦ billion)	CBN
Human capital (HC)	Human development index (HDI)	UNDP
Direct investments (FDI)	Inflow of Foreign direct investment (FDI) (in US$ million)	CBN
Exchange rate (EXR)	Official exchange rate (₦/$)	CBN
Funding system (SMC)	Stock market capitalization (in ₦ billion)	CBN

The methodology indicator measures a country's ability to adhere to internationally recommended standards and methods (World Bank 2021).[13] The data from the World Bank were examined descriptively in the study. For the Nigerian innovation system, data were also collected from the UNDP, CBN and NBS for the regression analysis. Economic development is measured by gross domestic product per capita which is the ratio of real GDP to the total population of Nigeria (Fagerberg and Srholec 2008).[14] The objective of the NIS is to enhance the achievement of sustainable development goals and welfare of the citizen and this is reflected in the distribution of income in the country.[15] Economic growth is proxied by real GDP values in Nigeria. Research and development expenditures (R&D) is a component of the gross fixed capital formation in Nigeria. R&D expenditures is used as the proxy for the NIS because it measures some resources used for developing new products or processes (Fagerberg and Srholec 2008) and also captures government innovation policies (Wu et al., 2016). Empirical studies have demonstrated government involvement in promoting R&D in Singapore and China (Wang 2018) and the Nigerian Government is behaving similarly. The R&D expenditure according to Ibidapo-Obe, (2012) is one Percent of the GDP in Nigeria. The value of industrial production is another innovation indicator in the NIS. Industrial production is made up of mining, manufacturing, electricity, gas, steam and air conditioner, water supply, sewage waste management and construction. Data were collected on industry output in GDP from the CBN. Trade openness and the inflow of foreign direct investment (FDI) are another innovation indicator in the NIS. Trade openness was measured as the ratio

10 Technological capability is the ability to develop and exploit knowledge commercially while Innovation capability is the ability to innovate products or services (Fagerberg and Srholec 2008).

[11] Patent right applications are registered through the patent cooperation Treaty procedures or with a national patent office (World Bank 2021). Patent application was used as proxy fo9r knowledge stock by WU et al., (2016).

[12] Industrial design and trademark applications are registered with national or regional intellectual property (IP) offices and designation received by relevant offices through the Hague system and the Madrid system respectively (World Bank 2021).

[13] The methodology score calculated as the weighted average of 10 underlying indicator scores. The final methodology score contributes 1/3 of the overall statistical capacity indicator score (World Bank 2021).

[14] Pece et al., (2015) used the value of real GDP for economic growth while Iyoboyi and Na-Allah (2014) have used GDP per capita as a proxy for economic development in Nigeria.

[15] GDP per capita revealed the level of income distribution per head in Nigeria and it indicates the living standard of the population.

of total trade (i.e., exports plus imports) to GDP. Trade openness and inflow of FDI facilitates technology transfers (spillovers) and stimulate innovation (Fagerberg and Srholec 2008). This is particularly true if the foreign exchange rates are at par with the currency of other technologically advanced countries. The official exchange rate of the Naira to the United State Dollar was used in this study.

The quality of human capital proxied by the human development index (HDI) is a composite index that measures the average achievement in three basic dimensions of human development (i.e., a long and healthy life, knowledge and a decent standard of living).[16] Human capital provide the knowledge, managerial skills and competencies needed to innovate in the NIS (Fagerberg and Srholec 2008). The quality of human capital depends on the level of education, health and skills possessed by the citizens of the country. The Nigerian financial system plays an important role in mobilizing resources for innovation purposes and technological development in the NIS. The stock market capitalization of listed companies in the domestic capital market (Fagerberg and Srholec 2008) was used as a proxy for funding R&D activities and the NIS. The list of indicators and their description are shown in Table I.

The Model

The model of this paper is an aggregate production function that captures the NIS and other exogenous variables in the economy. This paper's model adopts Fagerberg and Srholec (2008), Pece et al., (2015) and Iyoboyi and Na-Allah (2014). The model differs from Fagerberg and Srholec (2008) in that it is centred around Nigeria and the non-availability of data on geography, nature and history, governance and political systems. Another point of difference is the inclusion of industrial production in GDP and exchange rates. The paper contributes to knowledge by investigating the framework and links between NIS and economic development in Nigeria. Therefore, economic growth (real GDP) is expressed as a function of NIS proxied by R$D expenditures, human capital, industrial production, stock market capitalization, trade openness, foreign direct investments and exchange rate regimes. The economic development model is also expressed to depend on the same exogenous variables. The model is presented in equation 1&2 as follows;

$$GDP_t = \mathcal{F}(RD_t, HC_t, IP_t, SMC_t, TO_t, FDI_t, EXR_t) \dots (1)$$

$$Y_t = \mathcal{F}(RD_t, HC_t, IP_t, SMC_t, TO_t, FDI_t, EXR_t) \dots \dots \dots \dots (2)$$

The economic growth model (equation 1) and development model (equation 2) are expressed in first difference and stochastic form as in equation 3&4 as follows;

$$\Delta GDP_t = \theta_0 + \theta_1 \Delta RD_t + \theta_2 \Delta HC_t + \theta_3 \Delta IP_t + \theta_4 \Delta SMC_t + \theta_5 \Delta TO_t + \theta_6 \Delta FDI_t + \theta_7 \Delta EXR_t + \mathcal{E}_t \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (3)$$

$$\Delta Y_t = \beta_0 + \beta_1 \Delta RD_t + \beta_2 \Delta HC_t + \beta_3 \Delta IP_t + \beta_4 \Delta SMC_t + \beta_5 \Delta TO_t + \beta_6 \Delta FDI_t + \beta_7 \Delta EXR_t + \mu_t \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (4)$$

A-priori expectation of the models are that $\theta_1 and\ \beta_1 > 0, \theta_2 and\ \beta_2 > 0, \theta_3 and\ \beta_3 > 0, \theta_4 and\ \beta_4 > 0, \theta_5 and\ \beta_5 > 0, \theta_6 and\ \beta_6 > 0, and\ \theta_7 and\ \beta_7 > 0$

Where;

Δ = Change

GDP_t = Economic growth proxied by real GDP at time t

$Y_t =$ Economic development proxied by GDP per capita at time t,

$RD_t =$ the NIS proxied by research and development expenditures at time t,

$HC_t =$ Human capital at time t,

$IP_t =$ Industrial production in GDP at time t,

$SMC_t =$ Stock market capitalization as a proxy for funding the NIS at time t,

$TO_t =$ Trade openness at time t,

$FDI_t =$ inflow of foreign direct investment at time t,

$EXR_t =$ Exchange rate regimes at time t,

$\mathcal{E}_t =$ the stochastic error or random term at time t,

μ_t = white error term

$\theta_0 and\ \beta_0 =$ The intercept or constant terms of the economic growth and development models respectively.

$\theta_i and\ \beta_i =$ The slopes or the coefficients of the respective explanatory variables of the economic growth and development models respectively with i= 1, 2, …., 7

$\mathcal{F} =$ Functional notation.

Estimation Techniques and Analysis

The study begins with the descriptive analysis of the World Bank's data on few variables that characterized the nature of innovation systems in Nigeria. The author analyzed the innovation system using descriptive statistical tools such as mean, standard deviation, etc. Apart from the descriptive analysis, the author estimates the first difference equations using the Generalized Linear Models (GLM) technique (Newton-Raphson/Marquardt steps). The GLM is a technique that extends ordinary least square (OLS) to permit for non-normal stochastic and non-linear systematic components. The GLM framework of Nelder and Wedderburn (1972) generalizes linear regression by allowing the mean component to depend on a linear predictor through a non-linear function and the

[16] *The HDI was collected from the UNDP website on human development indicators.*

distribution of the stochastic component be any member of the linear exponential family.[17] GLM encourages the relaxation of distributional assumptions associated with a model, motivating the development of robust quasi-maximum likelihood (QML) estimators and robust covariance estimators for use in these setting. The coefficient covariance method is the heteroscedasticity and autocorrelation consistent (HAC) (Newey-West) approach with observed Hessian information matrix, Bartlett Kernel option and Newey-West automatic bandwidth method. The EViews output produces statistics (such as standard errors, z-statistics, probability values, restricted quasi-likelihood (LR) statistics and its probability value, restricted deviance, dispersion, Pearson statistics, etc.) that will be used to validate the efficient estimates of the models. The author used Wald's test to test for the joint significance of the regression estimates. The restrictions on the models are linear in coefficients. The expected dependent variables (economic growth and development) were forecasted in a graph.

IV. EMPIRICAL RESULTS AND DISCUSSION

The results in Table II showed the descriptive statistics of the variables that characterized the nature of NIS in Nigeria. The average nonresident industrial design applications were 84 between 2000 and 2019 in Nigeria. The average resident industrial design application by count was 827 during the same period in Nigeria. The standard deviation or the variability of the industrial design applications of nonresident and residents were 44.72 and 189.77 respectively. High standard deviation values indicated high variability in industrial design application from their averages in Nigeria. Thus, the results suggest a weak innovation system arising from low industrial design applications in Nigeria. Similarly, the average nonresident and resident patent right applications were 473 and 76.8 respectively. The standard deviations for patent applications by non-residents and residents were 325 and 30 respectively. This also suggests a weak innovation system given the low number of patent applications in Nigeria between 2000 and 2019. However, Pece et al., (2015) and Wu et al., (2016) used patent applications as a proxy for knowledge stock to report that there is a significant positive relationship between patent counts and economic growth and development. Average nonresidents and residents Trademark applications were 8,381 and 15,865.5 respectively in Nigeria. The deviations in trademark applications of non-residents and residents were 1,094.7 and 3,947.8 respectively. This high variability in trademark applications from the mean again suggest a weak innovation system in Nigeria given the low number of trademarks applications. Pece et al., (2015) reported a significant positive impact of the number of trademarks applications on economic growth.

The average methodological assessment of statistical capacity was 39.4 while the standard deviation was 8.99 between 2000 and 2020. This suggest that Nigeria's ability to adhere to internationally recommended standards and methods is low. The variability of Nigeria's methodology assessment of statistical capacity from the average was high meaning that there is a weak innovation capacity since internationally recognized standards are largely not adhered to. In Nigeria, high technology exports accounted for only 3% (US$104.2 million) on average of total manufactured exports between 2000 and 2019. However, the country still lacks adequate capacity to produce and export products with high R&D intensity. This is supported by the high variability (3.13% (US$140.2 million)) of high technology exports from the mean in Nigeria. To further support this fact, the ICT goods and ICT services export for Nigeria during the period were only 0.004% and 2.18% (US$67.3 million) on average of total goods and total services exported respectively. However, ICT goods imports accounted for about 4.61% on average of total goods imported into Nigeria during the same period. This suggested that the most advance technological products and services are imported into Nigeria. The high standard deviations of ICT goods export (0.005%), ICT service exports (1.24% (US$71.6)) and ICT goods imports (1.73) showed that there is high variability or deviations in Nigerian innovation systems. These results revealed a weak innovation system in Nigeria.

Table II: Descriptive Statistics of Nigerian Innovation System Indicators from 2000-2019

Innovation System Indicators	Obs.	Minimum	Maximum	Mean (average)	Std. Deviation
Industrial design applications, nonresident, by count	6	26.00	147.00	84.00	44.72
Industrial design applications, resident, by count	6	638.00	1146.00	827.167	189.77
Patent applications, nonresidents	6	150.00	869.00	473.33	325.06
Patent applications, residents	6	42.00	120.00	76.83	30.22

[17] GLM technique encompasses a broad and empirically useful range of specification that includes linear regression (OLS), Logistics and Probit analysis and Poisson models (EViews 10 User's Guide)

Methodology Assessment of statistical capacity (scale 0 - 100) *	17	20.00	50.00	39.41	8.99
Trademark applications, nonresident, by count	3	7,317.00	9,504.00	8,381.00	1,094.69
Trademark applications, resident, by count	6	11,221.00	20,560.00	15,865.50	3,947.80
High-technology exports (% of manufactured exports)	11	1.10	12.26	3.00	3.13
High-technology exports (current US$)	11	7,388,348.00	509,929,276.00	104,233,651.73	140,235,616.49
ICT goods exports (% of total goods exports)	17	0.00	0.02	0.004	0.005
ICT goods imports (% total goods imports)	18	2.46	9.49	4.61	1.73
Agricultural raw materials exports (% of merchandise exports)	18	0.01	7.27	1.28	2.13
Agricultural raw materials imports (% of merchandise imports)	18	0.60	4.21	1.23	0.97
ICT service exports (% of service exports, BoP)	13	1.02	5.76	2.18	1.24
ICT service exports (BoP, current US$)	13	20,216,899.47	289,566,781.60	67,345,850.54	71,644,293.31

Source: Author's computation from World Bank's World Development Indicators (2021) Note: * means that the 2020 values were included in the computation.

Agricultural raw material exports and imports as a percentage of merchandised exports and imports accounted for 1.28% and 1.23% on average of merchandised exports and import between 2000 and 2019 in Nigeria respectively. Most of the agricultural raw materials exported are primary products with little or no value addition in Nigeria. The agricultural exports have a high deviation from the mean suggesting that they are volatile in the global market. Also, agricultural raw materials (such as farm inputs and implements, tractors, machinery, etc.) are imported for tertiary production in Nigeria. The low agricultural raw materials exports and imports suggests that the Nigerian innovation system is still weak in the agricultural sector. Generally, the descriptive analysis suggests that the nature of innovation systems in Nigeria is weak due to low statistical performance and high variations in some key innovation indicators (such as industrial design applications, patent rights applications, trademarks applications, methodology assessment of statistical capacity, high technology exports, ICT goods exports, ICT goods imports and ICT services exports, and agricultural raw materials exports and imports) in the NIS in Nigeria.

Impact of National Innovation System (NIS) on Economic Growth and Development

Given the results of the descriptive analysis, the author estimated the first difference equations specified in equations 3 and 4 to examine the effect of NIS on economic growth and development in Nigeria. The reason is to determine the extent of impact on the economy given the recent innovations being introduced in the economy. The GLM technique was used to estimate the models and the results are presented in Table III. The intercept terms in both growth and development models are significant at 5% and 1% level respectively. A glance at the results in Table III revealed that all the coefficients of the explanatory variables in both equations are significant and met the a-priori expectations of the models except the stock market capitalization (SMC_t) that is having a negative sign. The coefficient of the NIS (R&D expenditures) had a significant positive impact on economic growth and development at a 1% level of significance. If R&D expenditures changes or rises by ₦1 billion, economic growth will increase by 85.48 units while economic development increases by 0.559 units in Nigeria. This finding is consistent with past studies such as Fagerberg and Srholec (2008) that found a significant positive relationship between the innovation system and economic development and Pece et al., (2015) who also found that R&D expenditures significantly and positively influence economic growth. Therefore, changes in the NIS through investment in R&D will change the level of economic growth and development in Nigeria. Investment in R&D and R&D expenditures stimulate the NIS by facilitating the production of products and processes that have high R&D intensity in the country and thereby promoting R&D activities, firm performance and competitiveness, economic growth and development. Although the expenditures on R&D was shown to be significant in influencing economic growth and development, Nigeria still lacks the technological capability to produce mass products or processes with high R&D intensity because the NIS is still weak (Kruss et al., 2015) and is at the early stage of development. Another reason for the lack of technological capability is that funding R&D activities in Nigeria is very poor. The capital market is underdeveloped and accessing the market by firms has been low due to risks associated with R&D in Nigeria. The government recently initiated funding programmes such as NRIF which is yet to be fully assessed by firms and R&D institutions. Human capital had a significant positive relationship with economic growth and development in Nigeria. A change in human capital development by 1%, will change the level of economic growth by 118,668.5 units while economic development changes by 948.79 units in Nigeria. This finding is consistent with Iyoboyi and Na-Allah, (2014) who found that human capital is positively related to economic development. Human capital provides the quality, skills, competencies, capacity and capabilities to innovate in the NIS. Low levels of human capital development will mean low innovation systems in Nigeria. Therefore, investment in human capital as propounded by the new growth theory is key to technological innovations and economic growth in the country.

The UNDP Human Development Report (2020) puts it this way, ‘‘to steer actions towards transformational change, it is important to empower people by enhancing equity, pursuing innovation and instilling the sense of stewardship of nature. Human capital can make this possible and the realization of the sustainable development goals in Nigeria.

The coefficients of industrial production in the two models were significant at 10% and 5% level of significance respectively. If the value of industrial production changes by ₦1 billion, economic growth will change by 0.047 units while economic development changes by 0.00042 units in Nigeria. This means that industrial production had a significant positive impact on economic growth and development in Nigeria. An increase in industrial output will influence the NIS by increasing the growth of SMEs and services firms in similar line of production. This may lead to the growth of industrial clusters and collaborative corporate R&D activities in the country. Firms can perform and compete better in an environment where they can innovate and introduces new products or processes in the market at a low cost. However, low industrial output entails low innovation activities by firms and enterprises in the country. The coefficients of stock market capitalization were significant but had the wrong sign in the two models. It means that stock market capitalization had a significant negative impact on economic growth and development in Nigeria. Wu et al., (2016) found the financial markets to be insignificant determinants of economic growth and development in China. A plausible explanation for the wrong sign of stock market capitalization is that funding R&D in the Nigerian capital market require high risks. Most SMEs are subject to insolvency risks and obtaining loans for R&D activities add to their cost of operations and tends to erode their profit margins. Funding the NIS is a high risks adventure that requires government interventions. Government interventions could be in the form of collaborative R&D and funding support for SMEs to engage in collaborative R&D with research institutes and universities to innovate and enhance their performance and competitiveness globally. Understanding the risks involved in the NIS and the interrelationships between research institutions will pave way for greater innovation and economic growth in Nigeria.

Table III: Regression Results of the effects of NIS on Economic Growth and Development

Variables	Equation 3 Economic growth (D(GDP))	Equation 4 Economic development (D(Y))
Constant (C)	-189.78** (0.035)	-2.968*** (0.000)
$D(RD_t)$	85.48*** (0.000)	0.559*** (0.000)
$D(HC_t)$	118668.5* (0.065)	948.79* (0.056)
$D(IP_t)$	0.047* (0.091)	0.00042** (0.042)
$D(SMC_t)$	-0.124** (0.026)	-0.0009* (0.078)
$D(TO_t)$	1191.80** (0.021)	17.546*** (0.000)
$D(FDI_t)$	0.696*** (0.007)	0.0059*** (0.000)
$D(EXR_t)$	23.968** (0.033)	0.218** (0.018)
Deviance	10599405	532.38
Restricted deviance	1.47E+09	60260.29
Deviance statistic	189275.1	9.5068
LR Statistic	7693.67*** (0.000)	6282.63*** (0.000)
Dispersion	189275.1	9.5068
Pearson statistics	189275.1	9.5068

Source: Author’s. Note: 1) the values in parenthesis are the probability values (p-values) of the estimates, 2) *, ** and *** denotes significant at 10%, 5% and 1% levels of significance respectively.

The coefficient of trade openness was significant in both equations. If the degree of trade openness increased by 1%, economic growth will increase by 1,191.8 units while economic development increases by 17.55 units in Nigeria. This means that trade openness had a significant positive relationship with economic growth and development in Nigeria. The finding is consistent with Fagerberg and Srholec (2008) that showed trade openness to be significant and positively related to economic development. However, the result is contrary to Iyoboyi and Na-Allah, (2014) who reported a significant negative relationship between trade openness and economic development in Nigeria. In practice and Economic theories, the link between trade openness and economic growth are positive because it facilitates technological diffusion and transfer of knowledge or technology from technologically advanced countries to less developed economies. Therefore, changes in the degree of trade openness influence the NIS through the inflow of foreign technologies, investment capital and services that make the innovation system more complex and effective in stimulating economic growth in Nigeria. Experience in Nigeria has shown that a high degree of trade openness discourages the growth of domestic industries and SMEs because of foreign competition. Even at that, domestic firms can improve their competitive capabilities with the right investments in R&D in Nigeria.

Similarly, the coefficient of FDI was significant at a 1% level indicating that foreign direct investment had a significant positive relationship with economic growth and development in Nigeria. With a change in FDI by US$1 million, economic growth will increase by 0.696 units while economic development increases by 0.0059 units in Nigeria. Foreign Direct Investment makes the importation of foreign technology possible and influences the NIS by promoting technology transfers and growth of SMEs in Nigeria. This improves the innovation system and economic growth in Nigeria. The inflow of FDI into Nigeria is easier when the exchange rates are favourable relative to the United States Dollar. If the exchange rate depreciates by ₦1, economic growth increases by 23.97 units while economic development increases by 0.218 units in Nigeria. In other words, official

exchange rate regimes had a significant positive relationship with economic growth and development in Nigeria. Currency depreciation encourages domestic production and exports in Nigeria. It also discourages the importation of goods and services that can be produced domestically. The NIS is influenced by increased domestic productivity that led to economic growth and development in the economy.

Table IV: Wald Test Results

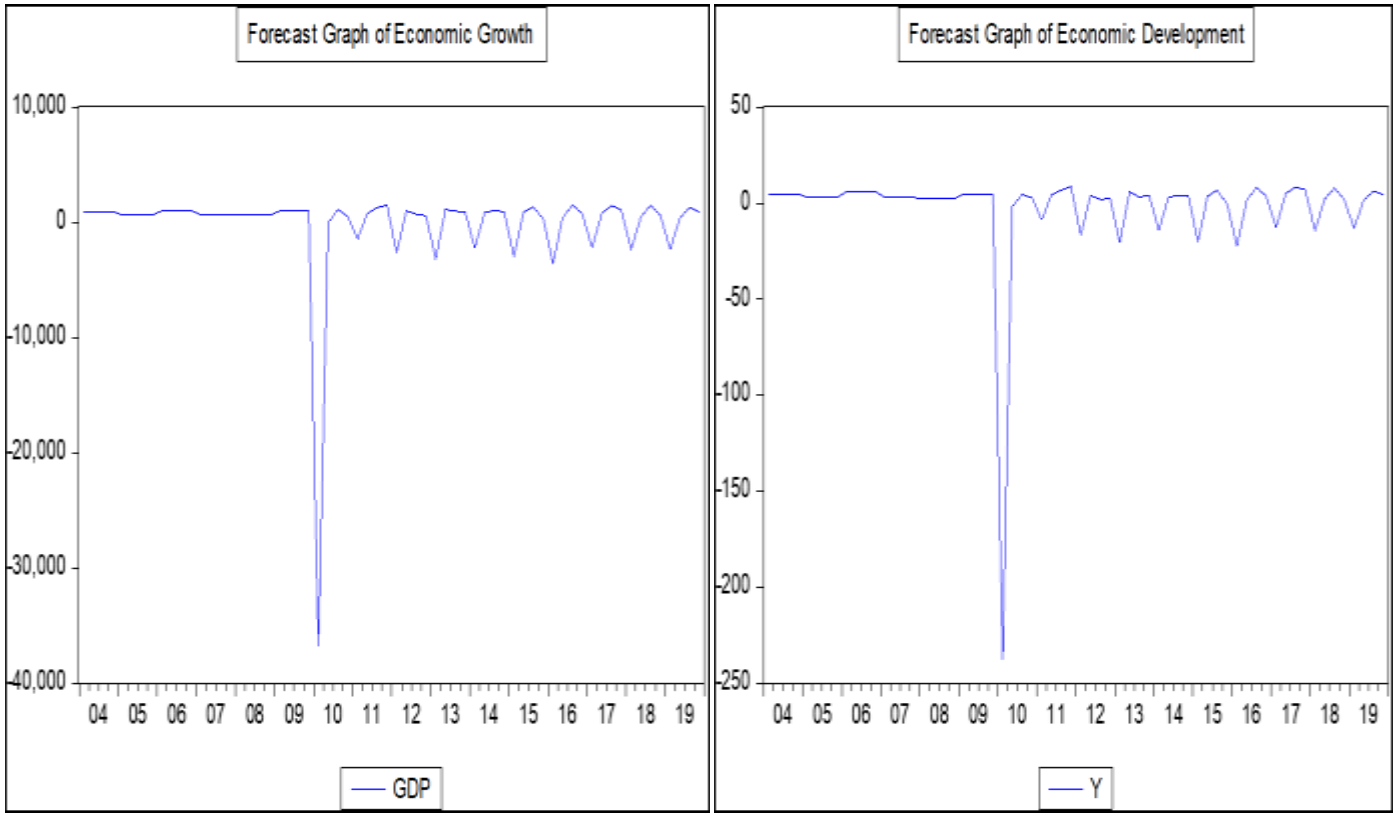
Model	Test Statistic	Value
Economic Growth (equation 2)	F-statistic	1369.36*** (0.000)
	Chi-square	9585.52*** (0.000)
Economic development (equation 3)	F-statistic	1546.18*** (0.000)
	Chi-square	10823.26*** (0.000)

Source: Author's. Note: 1. Values in parenthesis denote p-values, 2. *** denotes significant at 1% level of significance

The value of the deviance in the growth model is higher than the development models.[18] The scale deviance is the same for both models (i.e., 55.99). This suggests that both economic growth and development models have goodness of fit as 55.99% of the deviance are explained by both models in the regression line. This is supported by the LR-statistic of 7,693.67 and 6,282.63 for the growth and development models respectively. The restricted quasi-likelihood statistic (LR-statistic) were significant at a 1% level of significance implying that both the growth and development models are significant and have goodness of fit. Furthermore, the author tested for the joint significance of the regression estimates in both models using Wald's test and the result is presented in Table IV. The results revealed that the regression estimates are jointly significant at a 1% level in both the economic growth model and economic development model.

The forecast graph of the dependent variables (economic growth and development) is presented in Figure II. The graphs indicate that both changes in real GDP and GDP per capita are having outliers and moving in the same direction. Projecting economic growth to higher levels and achieving the projections will remain the main objective of government policies in Nigeria.

Figure II: Forecast graph of Economic Growth and Development in Nigeria.



Source: Author's

[18] *If the deviance is divided by the dispersion, we obtained the scale deviance which is sometimes used as a measure of goodness of fit.*

V. CONCLUSION AND POLICY RECOMMENDATIONS

The paper explained the NIS and economic development in Nigeria. The objectives of the paper were to examine the nature of innovation systems in Nigeria. It also investigates the effects of NIS on economic growth and development in Nigeria. The review of literatures suggest that NIS is more than just technological innovations, it includes the interrelationships between firms, governmental institutions, NGOs, and international institutions who engage in one form of R&D activity or the other in a country. The paper employed both descriptive statistics and generalized linear models (GLM) to explain the NIS and economic development in Nigeria. The results from descriptive analysis revealed that the nature of the Nigerian innovation system is weak and still evolving. The descriptive statistical analysis revealed low performance and high variations in NIS indicators such as industrial design applications, patent right applications, trademark applications, methodology assessment of statistical capacity, high technology exports, ICT goods exports, ICT goods imports and ICT services exports, and agricultural raw materials exports and imports in Nigeria. The regression results also revealed that NIS (R&D expenditures) is a significant positive determinant of economic growth and development in Nigeria. The author also showed that human capital, industrial production, stock market capitalization, trade openness, foreign direct investment, and exchange rate regimes are significant determinants of economic growth and development in the NIS in Nigeria. Wald's test revealed that the regression estimates are jointly significant in Nigeria. Projecting economic growth and development to higher levels and achieving the projections remains the main objective of government policies in Nigeria.

Although the NIS (expenditures on R&D) was shown to be significant in influencing economic growth and development, Nigeria still lacks the technological capability to produce mass products or processes with high R&D intensity because the NIS is still weak and is at the early stage of development. Another reason for the lack of technological capability is that funding R&D activities in Nigeria is very poor. The capital market is underdeveloped and accessing the market by firms has been low due to risks associated with R&D in Nigeria. The government recently initiated funding programmes such as NRIF which is yet to be fully assessed by firms and R&D institutions. Therefore, Government innovation policies influence the NIS and the performance of firms in the economy. The following recommendations are preferred to the Government;

1. The Government policies should prioritize R&D activities as a way of developing the NIS and improving the firm's performance in Nigeria.
2. The Government policies should also improve the funding system for R&D activities in the NIS to give room for collaborative R&D by firms. This will reduce the cost on firms and thereby promote the firm's competitiveness globally.
3. The Government policies should improve human capital development indicators such as education, health and living standard of the citizens in Nigeria. The quality of education and health go a long way in improving the income levels of citizens and hence their standard of living.
4. Government policies should stimulate industrial production through the growth of SMEs and industries that add value to agricultural raw materials and solid minerals in the country.
5. The exchange rate policies should be stable to avoid fluctuations in the NIS. Exchange rate stability attracts foreign direct investment and promote a healthy macroeconomic environment in Nigeria.
6. Government policies should also attract foreign direct investments in the NIS. This is to make technological diffusion faster and quicker in the country.

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