Technological Innovation and Economic Performance in Developing Countries: Evidence from Nigeria

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Abstract: - **This study examines technological innovation and economic performance of developing countries with evidence from Nigeria. The study employed data from 1981 to 2016, and with variables such as gross domestic product, stock of physical capital, technology – proxy by total factor productivity, foreign direct investment, labour force and trade openness. The result yield support to the theoretical postulation of Solow and Swan (1986) that technological innovation is the driving force of growth; and for a state/country to move beyond the steady state, advancement in technology is equally the motivating factor. We conclude that for LDC's to achieve a meaningful economic growth, greater attention must be given to technological development, which could be through innovation or technological transfer.**

Key words: **Technology, Capital stock, Economic growth**

Jel classification: **O33, 040**

I. INTRODUCTION

The major growth in macroeconomic indicators is measured by the growth in national income, as this signifies the growth in production, investment, employment, export and consumption (Gurgula and Lach, 2013). Over time, economists have been on the quest to examine the sources as well as factors that propel the growth in economic output as well as economic development, and with recent works focusing on developing countries. From various conventional views emanated from different economists, economic growth has been viewed as a result of the transition of surplus labour from the capitalist sector and the subsistence sector (Lewis (1954)). To Harris and Todaro (1970), Gunnar (1968) and Fields (1980) economic growth and development involves the movement of people from rural to the urban area due to expected income differentials between rural and urban. To Solow and Swan (1956), growth in economic output is mainly a function of the stock of capital (capital formation/ accumulation), coupled with the growth rate in labour force and technological progress. Denison (1967) also buttresses the importance of capital accumulation in propelling economic growth. Romer (1986) considered the endogenous aspect of economic growth, and to him, economic growth hinged on investment in human capital, innovation and knowledge. Economic growth in the long-run to Romer (1986) was seen as being a function of investment in research and development which will increase the incentive for innovations. Other empirical work had also established economic growth to different factors such as foreign aids or foreign direct investment (Papanek 1973; Chinery and Strout, 1966) foreign aid and investment (de Mello, 1999), human capital investment (Lucas, 1988), and political, institutional and the degree of accountability (Owen, 1987) among others as a source of economic growth.

Virtually, all the growth theory placed greater emphasis on the impact of labour and capital in promoting economic growth and development, however, the recognitions of the role of technological change also has a prime effect of such issues (Mohammed, 2012). Technological change in the developing countries does not only means the innovations of new frontiers, but it also means the adaptations of these countries to existing processes and products aimed at achieving higher level of domestic production. In this regard, the ability to access technological know-how by firms and enterprises is crucial in shaping the extent to which product and services can be produced – both the basic necessity goods that will improve their standards of living, as well as those that could promote domestic output and international competitiveness (Mirani, 2013).

Innovation and technological change had been widely seen as major factors that propel economic growth of most developed countries in the post war era (Barrel and Pain, 1997). Ben-David (1996) also placed greater emphasis on the channels for the diffusion of knowledge (technological diffusion) in promoting economic growth. Innovation and technological change have greater impact in promoting labour productivity, which further brings about changes in the economic structure (Hulten, 2000). Audrey and Jaraji (2016) viewed that such structural change follows the pattern of "technological trend and the innovations of new technology which will support innovation, the introduction of new product and the availability of capital for such product development, displacement of existing products, management of entrepreneurial ventures, management of innovation in medium–sized and large organizations, organizational structures intended to facilitate innovation, investment strategies related to new science – or technology–based enterprises, the innovator as an individual and as a personality type, and technology transfer to developing nations."Economic growth might pinpoint the fact that employment has increased. The increase ineconomic output akin to the fact that there is an improvement in workers qualifications and skills. This way of improving the workers skills and existing stock of capital is known as technological

progress. Hence, technological progress restructured the economy by replacing the inefficient traditional sectors by the modern sectors (Stojkov, 2008).

Beyond theoretical postulations, the role of technological change output growth was prioritised in the European Union (EU) in their ten years developmental plans – 2000 to 2010 – of becoming the most competitive economy in the world by year 2010. The policy framework for achieving this objective in the EU was geared towards capital accumulation in all members countries, with the aim of establishing a knowledge-based economy. This was believed to take place as technological changes increases the productivity of factors of production and tends to enhances economic growth in the long-run. This was based on the theoretical postulations of Romer (1986) and Lucas (1988) as discussed above. Though the relative efficiency impact of technological change on economic growth in the EU during this period haveremain a subject of disputes among researchers' overtime.

Technological change has greater impact on the growth rate of the macroeconomic variables in an economy – at the macro level – and it determines the profitability as well as the market shares of firms at the micro level. The development of an economics only takes place when technology can be diffused to other social and cultural lives of the people (Çaliskan, 2015). He also argued that countries that can efficiently diffuse information and technology to all segment of the society can create more areas of employment in such countries.

Technology has now become a core factor in economic growth and development. The advent of technological progress has changed the focal point of industrial production through several revolutions (Nikoloski, 2016). The first industrial revolution is of paramount importance in history as it resulted to the substitutions of steam engine for industrial system design. This event started in the 18th century and caused a drastically change in the economic and the social life of the people through the replacement of physical man-power with engine. Stojkov (2008) argued that the advent of technology in this period led to the increase in child and female labour, unemployment and creates economic imbalance between different regions.

The second phase of technological progress was termed the automation or electromechanical revolution. This led to the growth in world economies. This is the era of the development of electricity, telephone, electric motors, automobile, telegraph, aircraft, etc. The third phase of technological progress is known as electronic revolution, which started before the World War II. During this period, a micro element known as transistor was developed which led to the development of computers and microprocessors. The current technological revolution is known as information revolution whose key element is the chip. This fosters the control of machine and engine with numerical control.

Verspagen (2000) in his conclusions assert that the major factor that propel economic growth as well as changes in growth rate is technology, i.e technology shapes economic growth. This further argued that the firm that develops an innovation cannot as well fully appropriate technology as technology has a spill over effects to other firms and nations. But innovation which leads to the development of new technology can leads to divergence in growth between firms and nations (Silverberg and Verspagen, 1995).In order to understand the real impact through which technological change influences economic performances and understanding the long-run determinants of technological change, there is need to examine it in less developed countries like Nigeria.

II. LITERATURE REVIEW

Theoretical Literature

Harrod – Domar Growth Model

The Harrod-Domar growth model shows through a mathematical equation, the existence of a direct relationship between savings and the rate of economic growth. The model, which attempts to integrate Keynesian analysis with the element of economic growth, assumes that economic growth is a direct result of capital accumulation in the form of savings. In addition, the Harrod-Domar growth model assumes a fixed coefficient production function and constant returns to scale.

Neo-Classical Growth Model

This model assumes that countries use their resources efficiently and that there are diminishing returns to capital and labor increases. From these two premises, the neoclassical model makes three important predictions. First, increasing capital relative to labor creates economic growth, since people can be more productive given more capital. Second, poor countries with less capital per person will grow faster because each investment in capital will produce a higher return than rich countries with ample capital. Third, because of diminishing returns to capital, economies will eventually reach a point at which any increase in capital will no longer create economic growth. This point is called a "state". The model also notes that countries can overcome this steady state and continue growing by inventing new technology.

The New Growth Model

This work will be an extension of the new growth model or endogenous growth model. The first ideas of new endogenous growth theory appeared in Paul M. Romer's work on the "Increasing Returns and Long-Run Growth" in 1986 and Robert E. Lucas‟ work on the "Mechanics of Economic Development" in 1988. Unsatisfied with Solow's explanation, economists worked to "endogenize" technology in the 1980s. They developed the endogenous growth theory that includes a mathematical explanation of technological advancement. This model also incorporated a new concept of human capital, the skills and knowledge that make workers productive. Unlike

physical capital, human capital has increasing rates of return. Therefore, overall there are constant returns to capital, and economies never reach a steady state. Growth does not slow as capital accumulates, but the rate of growth depends on the types of capital a country invests in. Research done in this area has focused on what increases human capital (e.g. education) or technological change (e.g. innovation).

A significant aspect of the new growth theory is the concept that knowledge is treated as an asset for growth that is not subject to the finite restrictions or diminishing returns like other assets such as capital or real estate. In particular, knowledge is an intangible quality, rather than physical, and can be a resource grown within an organization or industry. Under the new growth theory, nurturing innovation internally is one of the reasons for organizations to invest in human capital. By creating opportunities and making resources available within an organization, the expectation is that individuals will be encouraged to develop new concepts and technology for the consumer market.

Empirical Literature

The role of technology in economic growth was first initiated by the Austrian economist Joseph Schumpeter in the early 18th century and emphasis the role of new technology in promoting economic growth and development. Other attempt since then has been emerging on the measurement of the contribution of R&D in the development of various regions. According to Griliches (1996), the empirical findings of various researchers on the impact of technological change on economic growth can be summarised in three categories:

a) The Historical Case Study: This focus on the analysis of invention through R&D and its contributions to economic productivity and growth. The theoretical approach postulates the existence of positive relationship between technological progress (through learning) and economic growth. Starting with Schumpeter (1911) and the postulation of other economists, exert a positive relationship between expenditure on R&D and economic growth, and also conclude that the strength of the relationship varies with respect to each sector and the political institutions of a country (Mansfield (1991), Freeman and Soete (1997), Falk (2006))

b) The Early Contributions: This focused on the assessment of the impact of social and private rates of return on R&D (Lichtenberg and Siegel (1991), Griliches (1996), Terleckyj (1974 and 1980)). The impact of private and social rates on R&D was found to be different across different regions/countries and sectors. Griliches (1996) in his study found a contradictory result to the spill over effect of R&D. He found that the effect on R&D outlays at firms' level is not significantly lower than of the sector level. Though other studies negate the above findings of Griliches and stressed the importance of R&D and technical progress at firms' level in specific countries and region as posit by Zif and McCarthy (1997), Hall and Mairesse (1995), Bean (1995), Griliches and Regev (1995), Griliches (1990).

c) Recent Contributions: Lipsey and Carlaw (2001) in line with this examine the impact of private rate of investment on R&D in the US economy and found that the returns on R&D fall between 0.2 and 0.5. Gurgul and Lach (2012) conclude that the implications of government expenditure on R&D in not uniform, as they argued that the rational for government expenditure on R&D war born due to market failure characterized the R&D due to spill over effect (Helpman and Coe, 1995). Also, R&D is also fuelled with high risk which may not be profitable for private individual to embark on. This is the reason why Arrow (1962) argued that R&D could only be viewed from the social point of view. Goel et al (2008) in line with this posit that the expenditure of the government on R&D serves as incentives to the private sectors.Gurgula and Lach (2013) examine technological progress and economic growth with evidence from Poland using Granger-causality test approaches, with quarterly data from period Q1 2000 to Q4 2009 found that technological change Granger-causes GDP in Poland. More also, employment was also found to Granger-cause R&D expenditure. This hence shows a positive relationship between technological change and economic growth.

Beyond doubt, one can expect that R&D will not only foster high returns on investment, but also the improvement in the productive capacity of a firm, which enhances their market competitiveness and hence their profit (Cohen and Levinthal, 1989). Hence the positive impact of R&D expenditure contributes to economic growth and development of some countries. Tsipouri (2004) in his study in his study of the impact of R&D on the economic growth of the developed countries found that R&D has a positive correlation with the growth rate of GDP. The result found akin to the fact that such generalization is only applicable to countries with the similar economic structure.

The spill over effect of technological transfer through trade had also been examine by Raa and Wolff (2000); and Madden and Savage (2000). The researchers found that technological transfer to the modern sectors enhances the economic growth of the destination region.

The postulations of Solow (1957) of the significant role of technological progress in enhancing economic growth – support economic growth in the long run – had also been established by Fagerberg (1988), who in his study found a significant correlation between technological progress (proxied by R&D outlays) and the growth rate in per capita GDP. He found that countries that focused more on technological advanced – utilization – sectors tend to grow faster than their counterpart in other countries. Further research of Fagerberg (2000) established the fact that growth rate differs across countries than it was between industries within a country. Based on this assertion, Branstetter (2001) argued that spill over effect of technology is a national nature. Hence Krugman (1990) and Romer (1986 and 1990) follows the same observation and conclude that higher GDP rate should be expected from the large countries than the small

countries. Based on these conclusions motivate this work, in establishing the role of technological progress on the economic performance of LDC's with evidence from Nigeria.

III. METHODOLOGY

The empirical model of this work will adopt the neoclassical model of Solow (1956). The Neoclassical model is built on four variables which are output (Y), capital (K), labour (L), and knowledge (A). At every point in time it was assumed that capital, labour and knowledge are combined to produce the economic output. The production function can be given in Cobb-Douglas form as:

$$Y(t) = F\left[(K(t)^{\alpha}\{A(t)L(t)\}^{\beta}\right] - - - - - - - - (1)$$

$A(t)L(t)$ is the effective labour, α is capital productivity and$\beta$is labour productivity. Expressing this equation in terms of output per labour we have:

$$Y(t)/_{L(t)} = F\left[\left(K(t)/_{L(t)^{\frac{1}{\alpha}}}\right)^{\alpha} A(t)^{\beta}\right] - - - - - - - - (2)$$

To simplify the above equation, we obtain the natural log as:

$$ln\left(Y(t)/_{L(t)}\right) = \alpha lnK(t) - lnL(t) + \beta lnA(t)$$

$$ln\, y(t) = \alpha\, lnK(t) - lnL(t) + \beta lnA(t) - - - - (3)$$

Equation 3 expressed output per labour as a function of capital, labour and technology. Transforming this equation to an econometrics model and adding other control variables gives:

$$ln\, gdp(t) = \alpha_0 + \alpha_1 lnPC(t) + \alpha_2 lnLB(t) + \alpha_3 lnTEC(t) + \alpha_5 lnFDI(t) + \alpha_6 lnTO(t) + \mu_t - - - - - (4)$$

Where gdp is the output per labour, PC is the stock of physical capital, LB is the labour force, TEC is technology – proxied by total factor productivity (TFP), FDI is foreign direct investment, and TO is trade openness – which both will help in examining technological diffusion.These variables were also used by other researchers like Zif and McCarthy (1997), Hall and Mairesse (1995), Bean (1995), Griliches and Regev (1995), Griliches (1990) in theirempirical analysis. Therefore this model will be the bedrock for our analysis.

IV. RESULT DISCUSSIONS

Unit Root Test

The analysis started by observing the unit root and the order of integration of each variable are presented in table 1 below

Variables	ADF at Level	1% Critical Value	5% Critical Value	Prob. Value	ADF at first difference	1% Critical Value	5% Critical Value	Prob. Value
GDP	0.2057	-3.6329	-2.9484	0.9691	-3.8322	-3.6394	-2.9511	0.0061
TEC	-2.145	-3.6329	-2.9484	0.1045	-9.4383	-3.6394	-2.9511	0.0000
LF	-1.925	-3.6329	-2.9484	0.6275	-5.5637	-3.6394	-2.9511	0.0002
PC	-1.648	-3.6329	-2.9484	0.8643	-6.0222	-3.6394	-2.9511	0.0000
FDI	-1.351	-3.6329	-2.9484	0.5945	-7.0938	-3.6394	-2.9511	0.0000
TO	-1.638	-3.6329	-2.9484	0.4529	-6.1074	-3.6394	-2.9511	0.0000

The unit root result obtained shows that the variables were not stationary at the level form, but were stationary at first difference operation at 1% and 5% level of significance. Hence, we conclude that the variables are stationary at first difference.

Also in order to examine the long run relationship, we estimated the co-integration test using Engel-Granger co-integration test.

Variable	ADF at Level	1% Critical Value	5% Critical Value	Prob. Value
Residual	-4.540376	-3.632900	-2.948404	0.0006

The co-integration result shows that the variables are co-integrated. This is shown by ADF_{cal} (-4.45) >ADF_{tab}(-3.63 and -2.94).

Regression Result

The regression result is presented in table 3 below with log GDP as the dependent variable, and log (technology, foreign direct investment, labour force, physical capital and trade openness) being the explanatory variables.

VARIABLE	COEFFICIENT	t-value	Probabilty
C	102.8030	8.121283*	0.0000
LOG(TEC)	56.81615	5.718101*	0.0000
LOG(FDI)	0.070109	2.688479*	0.0116
LOG(LF)	-10.00673	-2.980945*	0.0057
LOG(PC)	2.439147	1.597953	0.1205
LOG(TO)	0.064619	2.257222*	0.0314

*indicates that the variables are significant at 5% level

Thus

$$LnRGDP = 102.8 + 56.81LnTEC + 0.07LnFDI - 10LnLF + 2.44LnPC + 0.06LnTO$$

The result obtained conformed to the a priori theoretical expectations as the technology was found to be highly elastic with respect to income. The elasticity of technology is 56.82 which,is above one, meaning that every investment made in technology has a greater effect on output growth in Nigeria. Foreign direct investment also shows a positive relationship with economic growth. The result shows that a unit increase in foreign direct investment will yield seven naira (the domestic currency) in the long run. The coefficient of labour force does not conform to its a priori theoretical expectation. This could be attributed to the fact that majority of the population of people in the labour force are unemployed. Hence, large portion of this population does not contribute to income.Stock of physical capital exerts a positive relationship with real GDP. This shows that real income is highly elastic with respect to capital. Trade openness also shows a positive relationship with real income.

V. CONCLUSION AND POLICY IMPLICATION

The result analysed so far shows that technology is a vital tool to promote economic growth. The result also yield support to theoretical postulations of Solow-Swan (1956). The policy implication of this model shows that technology has a greater role to play in their economic growth as shown by the positive significant of technology, foreign direct invest and trade openness. The negative and significant impact of labour force on economic growth shows that unemployment is a major threat to economic growth of this country. It therefore suggest that effort be put in place through the improvement in capital expenditure to generate higher productivity and employment.

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