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Economic Growth, Energy Consumption and Human Capital Formation: Implication for Knowledge-based Economy

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ABSTRACT

This study examines the relationship between technology, human capital and economic growth and also attempts to establish their implications on knowledge based economy in Nigeria. The data used for the study are from secondary sources while the new growth model was also adopted. The dependent variable in the model is the level of real output while the explanatory variables are gross capital formation and government expenditure on education. The result of the causality test shows that is a uni-directional relationship running from gross capital formation and real output, human capital formation and real output growths do not Granger cause each other while causality runs from human capital to capital formation and vice versa. The implication of the result; the increase in economic growth has not improve the rate of capital formation in Nigeria. The study concluded that Nigeria has been slow to identify the strands of global knowledge due to the following: Weak institutions; limited awareness and disincentives preventing them from taking the root to the knowledge and information based- economy. Based on the findings the study recommended; strategies in which education can be incorporated into the growth system. Research and development should be encouraged as well and polices that promote output through savings.

Keywords: Economic Growth, Human Capital Formation, Knowledge and Information Based Economy, Technology
JEL Classifications: O47, O15, G14

1. INTRODUCTION

The development of human capital involves increasing skills, knowledge, specialization productivity and creativity of people through process of human capital formation. Technology also on the other hand promotes growth and development. OECD (1996) stressed that science, technology and industry policies should be formulated to maximize performance and well-being in "knowledge-based economies"[1]. To promote growth and development in a country, knowledge is inevitable. Knowledge

involves the role of information; training and learning process towards achieve growth and development. To some scholars, investment in such areas are noted as most important for long run growth and development (Razim, 2012 Annabi and Lan, 2007; Matthew et al., 2019; Matthew et al., in press). According to Kefela (2010), knowledge based economy is a situation where the citizens of a country accumulate, disseminate, and use knowledge for growth and development of their nation. It is worth to mention that creation of wealth through knowledge based economy is more efficient that create of wealth through natural resources. The neo-classical production function shows the relationship between growth and technology. In this function, human capital is included which capture the effect of knowledge and information based

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1   A knowledge based economy is an economy which is directly based on the production, distribution and use of knowledge and information.

weconomy. Given the neoclassical production, there is allowance for diminishing returns when additional input of capital is used. The improvement in technology may not be captured in this model, despite the fact that technology is a function of growth.

Knowledge is important in the growth model. Knowledge is capable to increase the rate of returns on investment. Knowledge on the other hand, can also spill over from one production sector to another sector, while the cost of new idea is little. The spillovers can remove or lower constraints that may result from used of capital. According to some scholars, incorporating knowledge into standard production functions is a difficult issue, since knowledge as a factor of production in the model disregards some fundamental economic principles such as scarcity. Knowledge and information are given in surplus, so there is no scarcity in their uses. To promote output through knowledge and information is embodied in investment in both human capital formation and technology. Though knowledge about technologies may varies or the same across countries but are necessary when a country needs to acquire skills. Awang (2004) and Zainol (1999) emphasized that that well equipped productive agents will promote economic performance and competitiveness that may be necessary to move the economy to the path of knowledge based. That is, to achieve promoting knowledge based economy development of human capital, research and development (R&D) and other knowledge oriented programmes are crucial (Ismail and Jajri, (1998); Lichtenberg (1992); Barro and Sala-i-Martin, (1995) and Artelaris et al. (2007), Matthew et al. (2018)).

Despite the importance of human capital and technology to promote growth by the Nigerian government, the income per capita is still low and its transmission to knowledge based and information economy still remain empirical findings. So the question is what is the direction of human capital formation, technology and economic growth in Nigeria and what implication(s) does it have in transforming the country to information and knowledge based economy? In attempting to answer these questions, scholars in Nigeria had focused more on the relationship between education and health, education and economic growth and so on For example, Adelowokan (2012) examines growth effect on education and health expenditure using a static regression model; the author's finding shows that there is a long-relationship between human capital spending and economic growth using Engle-Granger two-step co-integration procedure.

Odior (2011) analyses the dynamic (direct and indirect) effect of government policy on education and its relation to cyclical economic growth. Odior looks at the effect on the long run using integrated sequential dynamic computable general equilibrium (CGE) model Owen (1995). It was shown by the author that the reallocation of government expenditure to education sector is significant in explaining economic growth in Nigeria. Chude and Chude (2013) examine the impact of government expenditure on economic growth in Nigeria from 1977 to 2012 using an Error Correction Model (ECM). The authors show that the total expenditure on education is highly and statistically significant and have positive relationship on economic growth. Oluwatobi and Ogunrinola (2011) also examine government expenditure

on human capital development and its implication for economic growth in Nigeria using co-integration technique and a Vector Error Correction (VEC) model. The authors show that there exist a positive relationship between government recurrent expenditure on human capital development and the level of real output, while capital expenditure is negatively related to the level of real output. So this work is distinguished from others by examining the relationship between technology, human capital and economic growth and also attempts to establish their implications on knowledge and information based economy in Nigeria. UNESCO (2005) describe a knowledge society as one which is nurtured by its diversity and its capacities[2].

In order to address the above objectives, the paper has been structured into five sections. Starting with the introduction section, Section two presents the literature review and theoretical framework. Section three is the methodology. Section four presents the analysis of data and discussion of result. Section five presents the conclusion and recommendations of the paper.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This section presents a brief literature review. Alias et al. (2000), Othman (1999) and Samsudin (1999) show that economic growth cannot be separated from technological changes, and that the latter in turn depends on human capital involved in research. Technology development can be measured in terms of the personnel involvement in R&D or the development allocation and expenditure for R&D. Acemoglu and Pischke (1999) observed that although formal educational attainment is the most common indicator of human capital, on-the-job training (or training at the workplace by firms) may be at least as important in determining productivity. For firms investing in the human capital of their workers this is often seen to be a mechanism for increasing the employability of poorly educated prospective employees, improving the productivity of existing employees, and enhancing the flexibility and adaptability of all workers (Jacobs et al., 1996). An important distinction that is made in the literature with regard to training is the difference between general and specific training. Though both types of training increase the marginal productivity of the worker, general training tends to be portable to other employers, while specific training, to a large extent, could be regarded as non-portable to other employers. General training impacts the worker's production capability in all jobs by an equal amount, irrespective of the firm under consideration, while specific training impacts the worker's productivity only in the current job (Lynch and Black, 1998; Borjas, 1984; Afolayan et al., 2019; Osabohien et al., 2019).

Romer (1986), Lucas (1988) and Mankiw et al. (1992), Romer (1990) examine the relationship between education and knowledge. Lucas's (1988) stressed that human capital is similar to what is called population wide education. This shows the

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2   By this definition, it means an economy that utilizes all resources and information to achieve optimal output. Not necessarily focused on physical inputs but as well as non-physical inputs.

important of education in promoting knowledge based economy. Romer (1986) as well emphasized that education relates if not direct but indirect to the frontier of science and technology. Though empirical findings had shown weak correlation between education and economic growth in some countries (Benhabib and Spiegel (1994) and Pritchett (1997); Caselli et al. (1996); Knowles and Owen (1995)) while In contrast, works by some scholars had shown positive correlation (Barro and Sala-i-Martin (1995), Sala-i-Martin (1997), McMahon (1998), Temple (1999), Bils and Klenow (2000), Self and Grabowski, (2004), Matthew et al. (2019)).

There is no consensus in literature, but most the empirical research used the traditional models of growth and development. These models did not account for some important aspect the new growth models[3]. In the new growth model, there are dynamic linkages or feedback to growth. As such there is both direct and indirect effect as stressed by Romer (1986). The indirect impact could be measured by productivity improvement which is embodied in the investment of human capital (McMahon, 1998; Brempong et al., 2004) Hojo (2003). Haldar (2009) examined the relationship between growth and education using time series data. The scholar show that among the three growth models (physical capital, human capital and export led growth), the human capital accumulation led growth model is more relevant to Indian economy. For a country to promote growth and development via knowledge based economy there is need for concurrently in education base, innovation systems, and information. During this process, improved institutional system cannot be neglected. Knowledge and innovation have always played a crucial role in economic and social development (Matthew et al., 2018; Matthew et al., 2019: Udah, 2011).

Traditional growth model have been strengthened by new growth theorists. In the new growth model, education plays a vital role to promote growth and development. According to Romer (1996), Arrow (1962); Romer and Romer (2007), education and innovative aptitudes has the foundation to create competitive economies[4]. The new growth theory stressed two important points.
1. The perspective of technological progress as a product of economic activity is different from the traditional theories that take technology as a given, or a product of non-market forces. New growth theory is often called "endogenous" growth theory, because it internalizes technology into a model of how markets function.
2. Also, in the new growth theory, knowledge and technology are characterized by increasing returns, and these increasing returns drive the process of growth[5].

The important factor of new growth theory is that knowledge and information is the engine of growth. Knowledge can be

extremely shared and reprocess for use again, and are not limited in accumulation. So principle "diminishing returns" cannot take place in this process. In the new growth model, increasing returns to knowledge is recognized as the main factor for economic growth.

Romer (1986) the output of the firm is the function of its physical capital and the labour stock. The labour is connected by the state of knowledge at time t and A_t is given as;

$$Y_{ti} = f(K_{ti}, A_t L_{ti}) \qquad (1)$$

In this model variable G_t is assumed, that is the stock of experience and information at time t. the stock of experience is a function of past investments of all firms in the economy.

$$G_t = \int_{-\infty}^{t} I_s d_s = K_t \qquad (2)$$

Technology is assumed to be endogenously given by A[6]

$$A_t = G_t^n \quad (0 < n < 1)$$

State of knowledge in the model is a positive but has a decreasing function in respect ot state of experience and information. Rewritten equation (1) using what is referred to as learning – by- investing hypothesis[7].

$$Y_{ti} = f(K_{ti}, L_{ti}, k_t) \qquad (3)$$

The model afore-specified is for an individual, on aggregate it will be:

$$Y_t = f(K_t, L_t, k_t)$$

$$Y_t = K_t^\alpha . L_t^\beta . k_t^n \qquad (4)$$

Where $Y_t = \sum_{i}^{N} Y_{ti}$, $K_t = \sum_{i}^{N} K_{ti}$ and $L_t = \sum_{i}^{N} L_{ti}$

N is the number of firms in the economy. To intensive representation, we divide equation (4) by L_t to get the intensive representation,

$$y_t = K_t^\alpha . k_t^n \qquad (5)$$

From equation 5, two things can be deduced:
1. Models featuring technological advances that endogenously generate externality effects - the production function in equation (5) exhibits increasing returns to scale due to the presence of spillover effects coming from knowledge, information and or education.
2. In the model, the technology used exhibits constant returns, due to the accumulation of all types of capital - human and knowledge are present.

The accumulation of knowledge capital will promote the development of the knowledge-based economy. The extraordinary progress in information and communications technology, together

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3   With the new growth model, knowledge and information are incorporated into the model. This is used as the theoretical framework of this study.
4   From this, education must incorporate and integrate with the structure of the economy to promote growth and development, which most developing countries need to focus more on.
5   Romer is credited with stimulating New Growth Theory, but as Romer himself notes, (Romer 1994b) there is really nothing new about the theory itself. The central notion behind New Growth Theory is increasing returns associated with new knowledge/information or technology.

6   In the endogenous growth model it is assumed to be exogenously determined while it is endogenously determined in the new endogenous growth model.
7   Used in the growth model.

with technological advance and world competition along with changing demand is the reason why knowledge is becoming more important[8].

3. METHODOLOGY

3.1. Model Specification
Following the new neoclassical growth model by Romer (1986), equation 5 above can be rewrite as:

$$Y_t = f(CF_t, HCF_t) \tag{6}$$

In equation (6) Y_t is the output, CF is the capital through capital formations and HCF_t is the experience and information (which explained in the theoretical framework as the function of the investment in education or training).

To determine the direction of relationship, the study adopted Granger causality test and the equations are stated below (pair wise):

For variables Y_t and CF_t,

$$Y_t = \alpha_1 + \sum_{t=1}^{n} \alpha_{11}^{i} Y_{t-1} + \sum_{j=1}^{n} \alpha_{12}^{j} CF_{t-1} + e_{1t} \tag{7}$$

$$CF = \alpha_2 + \sum_{t=1}^{n} \alpha_{21}^{i} Y_{t-1} + \sum_{j=1}^{n} \alpha_{22}^{j} CF_{t-1} + e_{2t} \tag{8}$$

For variables Y_t and HCF_t,

$$Y_t = \beta_1 + \sum_{t=1}^{n} \beta_{11}^{i} Y_{t-1} + \sum_{j=1}^{n} \beta_{12}^{j} HCF_{t-1} + e_{3t} \tag{9}$$

$$HCF = \beta_2 + \sum_{t=1}^{n} \beta_{21}^{i} Y_{t-1} + \sum_{j=1}^{n} \beta_{22}^{j} HCF_{t-1} + e_{4t} \tag{10}$$

For variables CF_t and HCF_t,

$$CF_t = \partial_1 + \sum_{t=1}^{n} \partial_{11}^{i} CF_{t-1} + \sum_{j=1}^{n} \delta_{12}^{j} HCF_{t-1} + e_{5t} \tag{11}$$

$$HCF_t = \partial_2 + \sum_{t=1}^{n} \partial_{21}^{i} CF_{t-1} + \sum_{j=1}^{n} \delta_{22}^{j} HCF_{t-1} + e_{6t} \tag{12}$$

In equations 7 to 12, it is assumed that the error terms are not correlated and each variable is treated as both dependent and independent variables (lag of the variable). That is each equation contains the lag of its own variable and the other independent variable. Majority of studies (Barro and Sala-i-Martin, 1995; Brunetti et al., 1998, Hanushek and Kimko, 2000) have measured the quality of human capital using proxies related to education like school-enrolment rates, tests of mathematics and scientific skills among others.

3.1.1. Decision rules
In the equations above (7 to 12); if $\alpha_{12} \neq 0; \alpha_{21} = 0$- Unidirectional relationship (from gross capital formation to output); $\alpha_{12} = 0; \alpha_{21} \neq 0$

- Unidirectional relationship (from output to gross capital formation); $\alpha_{12} \neq 0; \alpha_{21} \neq 0$- Bi-directional relationship (between the output and gross capital formation); $\alpha_{12} = 0; \alpha_{21} = 0$- Independence is suggested (None). Also; $\beta_{12} \neq 0; \beta_{21} = 0$- Unidirectional relationship (Human capital formation to output); $\beta_{12} = 0; \beta_{21} \neq 0$ Unidirectional relationship (from output to Human capital formation); $\beta_{12} \neq 0; \beta_{21} \neq 0$- Bi-directional relationship (between output and human capital formation; $\beta_{12} = 0; \beta_{21} = 0$ - Independence is suggested (None). $\partial_{12} \neq 0; \partial_{21} = 0$- Unidirectional relationship (Human capital to Gross capital formation); $\partial_{12} = 0; \partial_{21} \neq 0$- Unidirectional relationship (Gross capital formation to human capital); $\partial_{12} \neq 0; \partial_{21} \neq 0$- Bi-directional relationship (between human capital and gross fixed capital formation); $\partial_{12} = 0; \partial_{21} = 0$- Independence is suggested (None).

3.2. Data Source and Estimation Technique
The sources of data are derived from the Federal Office of Statistics (FOS) (now National Bureau of Statistics [NBS]) Economics and Statistics Review, various issues of the Central Bank of Nigeria (CBN) Statistical Bulletin and Annual Reports. The study focused on the period between 1981 and 2017. The Model examined the nexus of economic growth, technology and human capital formation in Nigeria. Human capital, technology and economic growth are proxied by government expenditure on education, gross capital formation and real GDP growth.

4. DATA ANALYSIS AND DISCUSSION OF RESULT

4.1. Stationarity Test
The summary result is presented in the appendix (Appendix 1). Using the Augmented Dickey Fuller test of stationarity, all the variables are non-stationary at their level forms but are all integrated of order one I(1), that is, they attain stationarity after first differencing. Hence, the fear of spuriousity of regression is allayed.

4.2. Granger Causality Test
The full result of the Granger causality test is presented in the appendix (Appendix 2). All variables are presented in their logarithmic growth forms, where LRGDPg = Growth in the log of real output used to measure economic growth; LGFCFg = Growth in the log of gross fixed capital formation which is used as a proxy for growth in capital formation (CF); LGEEg = Growth in the log of government expenditure on education and is used as a proxy for growth in human capital (HCF). The results showed that $\alpha_{12} \neq 0$ but $\alpha_{21} = 0$, that is there is a uni-directional relationship running from LGFCFg to LRGDPg; this implies that gross capital formation Granger causes real output and the reverse does not ensue. In other words, capital formation helps in predicting the behaviour of real output in Nigeria. With respect to LGEEg and LRGDPg, the coefficients β_{12} and β_{21} are both equal to zero. Thus independence is suggested. This implies that human capital formation and real output growths do not Granger cause each other. Hence no one helps in predicting the behaviour or performance of the other in Nigeria. As for LGEEg and LGCFg, the coefficients ∂_{12} and ∂_{21} are both not equal to zero. This means that Granger causality runs from human capital to capital formation and vice versa (i.e., a

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8   It is important to be a part of the knowledge based economy because information and knowledge are replacing capital and energy as primary wealth-creating assets.

bi-directional relationship between them). Therefore, in Nigeria, human capital can be used to predict the behaviour of capital formation and vice versa.

5. CONCLUSION AND RECOMMENDATIONS

This paper had examined the implications of economic growth, energy consumption and human capital formation on knowledge-based economy. The findings of the Granger causality test show that $\alpha_{12} \neq 0$ but $\alpha_{21} = 0$, which means that is a uni-directional relationship running from LGFCFg to LRGDPg (that is gross capital formation Granger causes real output). But on the other way round, the real output does not granger cause gross capital formation. The implication of this is that, the increase in economic growth that the country witness as not improve the rate of capital formation in Nigeria. The transmission mechanism of GDP to capital formation mostly should be through savings. The accumulation of capital will facilitate the evolution of the knowledge and information based economy. Knowledge and information based economy according to the new neoclassical economy is the most powerful engine of production. So Nigeria's government needs to ensure that polices that promote output through savings are to be encouraged.

Also for the analysis, given that LGEEg and LRGDPg, the coefficients β_{12} and β_{21} are both equal to zero. Thus independence is suggested. That is human capital formation and real output growths do not Granger cause each other. Investment in human capital encourages division of labour, which on the other hand promote specialization and hence increase in output per head and also at the aggregate level. Also in new neoclassical model of output, knowledge and information based economy is embodied in investment in human capital. What matters here is not the quantity of the education but the quality of education. So Nigerian's government needs to develop strategies in which education can be incorporated into the growth system. R&D should be encouraged as well. One special aspect of knowledge makes it critical to growth. Knowledge is subject to increasing returns because it is a non-rival good, an economy that is knowledge and information based has the opportunities for growth which may be regarded as almost limitless, price is not the function of output – because in the case of knowledge, markets may not send the right price signals. The social benefits and the private costs of new knowledge creation diverge. As a result of additional use of knowledge has zero marginal cost, once the knowledge is created, any positive price for knowledge is too high." And finally, Knowledge and information based economies tend toward monopolistic competition[9].

The result for LGEEg and LGCFg, the coefficients ∂_{12} and ∂_{21} are both not equal to zero. This means that Granger causality runs from human capital to capital formation and vice versa (i.e. a bi-directional relationship between them). Therefore, in Nigeria,

human capital can be used to predict the behaviour of capital formation and vice versa. So the study concluded that many developing countries (including Nigeria) have been slow to identify the strands of global knowledge, if the basic components of the knowledge economy are readily available, why not appropriate for developing countries for growth and innovation? The challenges are due to the following: weak institutions; limited awareness and disincentives preventing them from taking the root to the knowledge economy. All this needs to be appropriately addressed to create and economy that is knowledge and information- based.

6. ACKNOWLEDGMENTS

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9   Econometric studies have repeatedly shown that the social rate of return to research (the value of all of the economic benefits received by society) is typically two to five times higher than that private rate of return (the profits accruing to the individual or the company that pioneered the innovation) (Jarboe and Atkinson 1998).

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APPENDIX

Appendix 1: Stationarity test (Augmented Dickey Fuller – ADF test)

Variable	Critical values			T-statistic	Order of integration
	1%	**5%**	**10%**		
LGEEg					
Level	−3.6891	−2.9719	−2.6251	−1.2309	
1st difference	−3.6891	−2.9719	−2.6251	−5.1985	I(1)
LGFCFg					
Level	−3.6537	−2.9571	−2.6174	−0.7613	
1st difference	−3.6617	−2.9604	−2.6192	−9.8633	I(1)
LRGDP					
Level	−3.6617	−2.9604	−2.6192	0.8192	
1st difference	−3.6617	−2.9604	−2.6192	−3.4270	I(1)

Appendix 2: Granger causality test

Pairwise granger causality tests			
Date: 01/25/15 Time: 20:04			
Sample: 1981 2013			
Lags: 2			
Null Hypothesis:	**Obs**	**F-statistic**	**Prob.**
LGFCFg does not Granger cause LRGDPg	31	5.47506	0.0104
LRGDPg does not Granger cause LGFCFg		0.10943	0.8968
LGEEg does not Granger cause LRGDPg	31	1.56002	0.2292
LRGDPg does not Granger cause LGEEg		0.46301	0.6345
LGEEg does not Granger cause LGFCFg	31	4.78920	0.0170
LGFCFg does not Granger cause LGEEg		3.43013	0.0476