IOSR Journal of Economics and Finance (IOSR-JEF)
e- ISSN: 2321-5933, p-ISSN: 2321-5925. Volume 9, Issue 3 Ver. III (May - June 2018), PP 53-63
www.iosrjournals.org

Knowledge Capital, Human Capital Stocks and the Growth of Africa Economies: A Panel Data Analysis

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Abstract: *This paper seeks to answer the question of how Africa economies can sustain growth. The endogenous growth model developed by Romer (1986) and Lucas (1988) has focused on the role of human capital and by modification, knowledge capital as a main source of increasing returns and divergence in growth rates between developed and underdeveloped countries. Can African countries sustain their economic growth through intensifying human and knowledge capital as productive inputs? The paper provides an empirical test of the endogenous growth model in particular, the "Rival" human capital models of Romer (1990) and non-rival 'idea' models of Lucas (1988), for Africa economies using a panel of Africa data on human and knowledge capital stocks. The study employed two different Panel Cointegration techniques, the Panel ARDL (PMG) and the Fully Modified OLS on two aggregate production functions (knowledge capital based and human capital based models) The study was able to establish that the poor growth of Africa economies is not a woe but the result of poor and not sustained accumulation and use of human and knowledge capital. Convergence will be observed for African economies if they intensify on subsidies for education, research and development.*
Key Words: *Human capital, Knowledge capital, Endogenous growth, Effective labor, Pool Mean Group*

Date of Submission: 18-06-2018 Date of acceptance: 03-07-2018

I. Introduction

Since the 1950s, economic growth has been one of the main topics of economic discipline. In this context, the sources of economic growth have been analyzed by different economic theories. These theories can be decomposed into two groups, namely modern neoclassical theory and evolutionary economic theory. In the modern neoclassical economic theory, the technological progress is considered as the main determinant of the long-run economic growth. In this regard, the sources of economic growth differences among countries are analyzed by using various types of models. In the earliest studies, it is assumed that technological progress is exogenous (Solow-Swan model). Constant returns to scale and perfectly competitive market structure assumptions are the main characteristics of these studies.

After the developments in the economic theory, technological progress has been taken into account in a different way by a new line of models, namely endogenous growth models. More specifically, technological progress is endogenously determined process in these models. Contrary to the previous models, increasing returns to scale, which stem from externality and the monopolistic market structure, play a significant role in endogenous growth models. We have come to the conclusion that, although it suffers from some weaknesses, endogenous growth model proposes a more realistic explanation for the economic growth process.

As regard economic growth in Africa, Africa economies have always witnessed low growth rate when compared with developed economies. The growth rate recorded in 2016 especially across Africa was very poor. The fall in commodity prices, which persisted until early 2016, has tested the validity of the "Africa Rising" narrative. Table 1.0 is a list of estimates of the real gross domestic product growth rate (not rebased GDP) in African states for the latest years recorded in the CIA World Fact book. Only fully recognized sovereign states with United Nations membership are included on this list.

Table 1.0: REAL GDP OF RECOGNISED AFRICAN STATES

Rank	Country	GDP growth rate (%)	Year
1	Ivory Coast	8	2016 est.
2	Tanzania	7.2	2016 est.
3	Zenegal	6.6	2016 est.
4	Djibouti	6.5	2016 est.
5	Ethiopia	6.5	2016 est.
6	Kenya	6	2016 est.
7	Rwanda	6	2016 est.
8	Mali	5.3	2016 est.
9	Togo	5.3	2016 est.
10	Burkina Faso	5.2	2016 est.

11	Central Africa Republic	5.2	2016 est.
12	Seychelles	4.9	2016 est.
13	Uganda	4.9	2016 est.
14	Cameroon	4.8	2016 est.
15	Guinea-Bissau	4.8	2016 est.
16	Benin	4.6	2016 est.
17	Niger	4.6	2016 est.
18	Sierra Leone	4.3	2016 est.
19	Sao Tome and Principe	4	2016 est.
20	Democratic Republic of Congo	3.9	2016 est.
21	Egypt	3.8	2016 est.
22	Guinea-Bissau	3.8	2016 est.
23	Eritrea	3.7	2016 est.
24	Somalia	3.7	2016 est.
25	Algeria	3.6	2016 est.
26	Cape Verde	3.6	2016 est.
27	Mozambique	3.6	2016 est.
28	Mauritius	3.5	2016 est.
29	Ghana	3.3	2016 est.
30	Mauritania	3.2	2016 est.
31	Sudan	3.1	2016 est.
32	Zambia	3	2016 est.
33	Botswana	2.9	2016 est.
34	Malawi	2.7	2016 est.
35	Gabon	2.5	2016 est.
36	Lesotho	2.4	2016 est.
37	Madagascar	2.4	2016 est.
38	The Gambia	2.3	2016 est.
39	Comoros	2.2	2016 est.
40	Liberia	2	2016 est.
41	Morocco	1.8	2016 est.
42	Republic of the Congo	1.7	2016 est.
43	Tunisia	1.5	2016 est.
44	Angola	0.9	2016 est.
45	South Africa	0.5	2016 est.
46	Swaziland	0.5	2016 est.
47	Namibia	0.2	2016 est.
48	Zimbabwe	-0.3	2016 est.
49	Burundi	-0.5	2016 est.
50	Chad	-1.1	2016 est.
51	Nigeria	-1.7	2016 est.
52	Libya	-3.3	2016 est.
53	Equitorial Guinea	-9.9	2016 est.
54	South Sudan	-13.1	2016 est.

On the average, Africa's growth slowed to 2.2% in 2016, down from 3.4% in 2015. This fall in gross domestic product (GDP) growth underscores the importance of a few big economies on Africa's overall growth performance in 2016. Eight countries, namely Liberia, Morocco, Republic of Congo, Tunisia, Angola, South Africa, Swaziland and Namibia all had growth rates lower than this average. Countries like Zimbabwe, Burundi, Chad, Nigeria, Libya, and Equatorial Guinea recorded negative growth rate as shown in Table 1.0. That is their economies entered recession. Nigeria carries the largest weight accounting for 29.3% of Africa's GDP. The recession experienced in Nigeria therefore had a more adverse impact on Africa's GDP growth than the recessions in Chad, Libya, Burundi, Zimbabwe, and the likes (Table 1.0).

The purpose of this paper is to provide an empirical test of the endogenous growth model for Africa economies using a panel of Africa data on human and knowledge capital stocks. In particular, the paper explicitly tests the "Rival" human capital models of Romer (1990) and non-rival 'idea' models and Lucas (1988), which behaves just like the neoclassical model with labor and human capital augmenting technological change and which exhibits the usual constant or diminishing returns to capital accumulation, warranting a steady state growth path. The basic idea of the Romer model for example is that, the raw materials that we use have not changed much throughout time, but as a result of technical progress the instructions that we follow to combine them have become vastly more sophisticated. Thus, technical progress is the driving force behind economic growth and so should be modeled endogenously.

Endogenous growth theory holds that investment in human capital; innovation and knowledge are significant contributors to economic growth. In effect the theory primarily holds that the long run growth of an economy depends on policy measures. For example subsidies for research and development or education increase the growth in some endogenous growth models by increasing incentives for innovation. The question this paper seeks to answer is whether the endogenous growth model could be the theoretical foundation of Africa's economic transformation. Can African countries sustain their economic growth through subsidies for education, research and development?

II. Brief Review Of Literature

Endogenous growth model has been subject to empirical testing by different authors using different economies. Barro (1991) initiated it by regressing cross-country per capita income growth on a set of ancillary variables including the primary school enrollment ratio as a proxy variable for human capital. He found the initial level of human capital to be a significant determinant for economic growth.

Kyriacou (1991) constructed a cross-country human capital index from data on average school years in the labor force and school enrollment ratios. From the cross-country regression of per capita income growth, he finds the coefficient of initial human capital stock to be positive and significant but that of human capital growth to be negative and insignificant. However, Kyriacou's index is still another proxy variable limiting the validity of his empirical findings.

Huh and Kim (2003) identified one of the key differences between exogenous and endogenous growth models as that a transitory shock to investment share exhibits different long-run effects on per-capita output. Exploring this difference, they evaluated the empirical relevance of the two growth models for the G-7 countries. The underlying shocks were identified by an application of a dynamic factor model. Results show that a transitory shock to investment share permanently increases per-capita output in four countries, offering support to the endogenous growth model. This shock also contributes considerably to accounting for the long-run variability of per-capita output. Overall, the endogenous model is found to be empirically more plausible than previous time series studies suggest.

Klenow (1998) indirectly tested a series of growth models using data for 449 United States (US) manufacturing industries. He ran a series of ordinary least squares (OLS) regressions using time-averaged cross-section data, in order to investigate total factor productivity (TFP) growth relationships, and then used these regression results to evaluate the predictions derived from five growth models. Each of the models can be assigned to one of three different classes: Exogenous growth models, rival human capital accumulation models, and non-rival idea accumulation ('idea') models. The latter two belong to the broader class of endogenous growth models.

Hans-Jürgen E. and N. McLellan (2001) separated the endogenous growth literature into two classes of growth models: Rival human capital models and non-rival 'idea' models. Both classes differ in their positive and normative implications for growth. Following Klenow's (1998) approach, they used industry panel data to investigate which class of growth models might be the most appropriate for the New Zealand economy: Exogenous growth, or one of the two classes of endogenous growth models. In contrast to Klenow's findings for the United States, in the New Zealand case rival human capital models seem more applicable, though none of the models correctly predicts all of the empirical relationships.

III. Theoretical Framework And Model Specification.

In Neoclassical Exogenous Growth Models technological progress is the engine of growth. According to the models technological improvements are automatic and determined outside the model (exogenous). On the contrary, Endogenous Growth Models try to explain this engine of growth so as to understand the economic forces underlying technological progress.

The endogenous growth model developed by Romer (1986) and Lucas (1988) has focused on the role of human capital from the outset as a main source of increasing returns and divergence in growth rates between developed and underdeveloped countries. The model has been refined and extended further by Romer (1990) himself, Rebelo (1991), and Stokey (1991).

Endogenous growth theory holds that economic growth is primarily the result of endogenous and not external forces. Endogenous growth theory holds that investment in human capital, innovation, and knowledge are significant contributors to economic growth. The theory also focuses on positive externalities and spillover effects of a knowledge-based economy which will lead to economic development. The endogenous growth theory primarily holds that the long run growth rate of an economy depends on policy measures. For example, subsidies for research and development or education increase the growth rate in some endogenous growth models by increasing the incentive for innovation.

A hallmark of the endogenous growth literature is that permanent changes in variables that are potentially affected by government policy lead to permanent changes in growth rates. This is the result in both the early "AK" growth models of Romer [1986, 1987], Lucas [1988], and Rebelo [1991], as well as in subsequent models focusing more explicitly on endogenous technological change by Romer [1990], Grossman and Helpman [199la, 1991b] and Aghion and Howitt [1992]. This "growth effects" result stands in marked contrast to the neoclassical growth model proposed by Solow [1956], in which the presence of long-run growth depends crucially on exogenous technological progress.

Two versions of endogenous growth theory, the knowledge capital-based and the human capital based growths are summarized as follows

A. Knowledge Capital and Endogenous Growth. (A focus on Research and Development)

Arrow (1962) focused on the "idea" model that Capital accumulation embeds technological improvements. This was buttressed by Romer 1982. This approach models the production of improvements in technology by including "knowledge capital" along with physical capital. A two-sector model is used because we assume that knowledge production does not follow the same production function as goods production; there is Research and Development R&D (or knowledge-production) sector alongside the usual sector producing physical goods. The introduction of a second sector requires the use of some new modeling techniques. For example, aggregate resources must now be divided between the production of "goods"—either physical capital or consumption goods—in one sector or the production of knowledge in the other.
The model is as follows. Firms' production function is given as

$$Y_i = AK_i^{\alpha} L_i^{1-\alpha}$$

Where A is the Total Factor Productivity (TFP). Technology A depends on Capital Stock. The higher the capital stock the more the economy is able to use new technologies

$$A = BK^{1-\alpha}$$

Where K is the aggregate level of capital stock and B is the learning factor (positive externality). If we Impose symmetry across firms and substituting in the production function, we get the aggregate production function

$$Y = BKL^{1-\alpha}$$

Assuming that population L is constant and equal to 1. Then, the aggregate production function becomes,

$$Y = BK$$

This production function is characterized by constant return to scale. The marginal productivity of capital is constant and equal to the average productivity of capital and is B. The law of motion of capital is

$$\dot{K} = sY - dK$$

Hence the growth rate of capital is

$$\frac{\dot{K}}{K} = s\frac{Y}{K} - d = sB - d$$

Given that $\frac{Y}{K} = B = constant$, $\frac{\dot{K}}{K} = \frac{\dot{Y}}{Y}$. If $sB > d \Rightarrow$ the growth rate is positive. The rate of growth of A is $\frac{\dot{A}}{A} = (1-\alpha)\frac{\dot{K}}{K} = (1-\alpha)(sB-d)$

Contrary to the Solow model, the rate of growth of technology depends on the rate of growth of capital. At the same time technology affects capital. Growth is an endogenous process. No transitional dynamics. An increase in savings means that the growth rate increases permanently

Following from the Arrow and Romer model we specify our endogenous growth and learning model for this study, with the assumption that population growth rate in African economy is not equal to 1, as

$$Y = BK^{\alpha}L^{1-\alpha}$$
$$\ell nY = \ell nB + \alpha\ell nK + (1-\alpha)\ell nL + e$$
$$\ell ncgdpo = \ell nB + \alpha\ell nck + (1-\alpha)\ell nL + e \quad \text{....1}$$

This is the aggregate production function with knowledge capital.
Y = cgdpo = Output-side current real GDP at current PPPs (in mil. 2011US$)

$$B = \frac{A}{K} = \frac{TFP}{K} = knowledge \quad capital \quad proxy$$

TFP = ctfp = TFP level at current PPPs (USA=1)
L = emp. = Number of persons engaged (in millions)

B. Human capital and Endogenous Growth. (A focus on education and training)

By human capital we mean acquired characteristics that make workers more productive. Although it encompasses such characteristics as health, strength, and stamina, the most commonly analyzed sources of human capital are the education, training, and experience that a worker embodies. Since education and training involve the transmission of knowledge, it might seem like human capital is the same as the knowledge capital we study in the R&D model. However, there is a crucial difference. Knowledge capital is potentially a public good whereas human capital is not. An easy way of distinguishing between them is to think about the two major roles that most professors play. Professors most often go to the classroom, where they are imparting existing knowledge to students. This increases the students' human capital, but does not create new knowledge for society. When they are not in the classroom, professors are likely to be engaged in research. If successful, this research leads to new knowledge capital that everyone can potentially share on a non-rival basis. Thus, simply put, society's knowledge capital is everything that is known by someone in the society; your human capital includes your personal familiarity with and ability to use part of that knowledge. Your human capital is personal to you—the fact that you have obtained knowledge may make you more productive but it does not usually raise anyone else's productivity. Thus human capital does not have the public-good characteristics of knowledge capital.

This "rival" production function according to **Lucas (1988)** model is given as

$$Y = K^{\alpha}(AL)^{1-\alpha}$$

Where A = H, that is Human Capital. Human capital increases labor productivity, with L = 1

$$Y = K^{\alpha}H^{1-\alpha}$$

If we define s_K as the amount of GDP spent for capital accumulation. For simplicity and without loss of generality, we now assume that the capital depreciation rate is d = 0. Hence,

$$\dot{K} = s_K Y = s_K K^{\alpha} H^{1-\alpha}$$

If we define s_H as the amount of GDP spent for human capital accumulation.

$$\dot{H} = s_H Y = s_H K^{\alpha} H^{1-\alpha}$$

If we define $\gamma = \frac{H}{K}$, substituting in the law of motion of capital and dividing by K

$\frac{\dot{K}}{K} = s_K \gamma^{1-\alpha}$ Similarly $\frac{\dot{H}}{H} = s_H \gamma^{-\alpha}$ Consider that $\frac{\dot{\gamma}}{\gamma} = \frac{\dot{H}}{H} - \frac{\dot{K}}{K}$

If $\frac{\dot{H}}{H} > \frac{\dot{K}}{K} \Rightarrow \frac{\dot{\gamma}}{\gamma} > 0$ and increases. If γ increases $\frac{K}{K}$ increases, while $\frac{H}{K}$ reduces, so that $\frac{\dot{\gamma}}{\gamma}$ decreases.

On the contrary if $\frac{\dot{H}}{H} < \frac{\dot{K}}{K} \Rightarrow \frac{\dot{\gamma}}{\gamma} < 0$ and γ decreases. If γ decreases, $\frac{\dot{K}}{K}$ decreases, while $\frac{\dot{H}}{H}$ increases, so that $\frac{\dot{\gamma}}{\gamma}$ increases. The process stops only when $\frac{\dot{H}}{H} = \frac{\dot{K}}{K}$ and $\frac{\dot{\gamma}}{\gamma} = 0$

Following from Lucas (1988), the second model to be tested by this study is the aggregate production function with human capital specified as follows.

$$\ell nY = \alpha \ell nK + (1-\alpha)\ell nAL + e$$

$$\ell ncgdpo = \alpha \ell nck + (1-\alpha)\ell nAL + e \quad \text{....2}$$

AL = effective labor. = Human capital multiplied by labor.

IV. Data And Description Of Variables

With the growing use of cross-country data over time to study purchasing power parity, growth convergence and international R&D spillovers, the focus of panel data econometrics has shifted towards studying the asymptotic of macro panels with large N(number of countries) and large T (length of the time series) rather than the usual asymptotic of micro panels with large N and small T. A strand of literature applied time series procedures to panels, worrying about nonstationarity, spurious regression and cointegration. In this study 46 African countries were studied for 34 years based on data availability. The descriptive statistics of the variables are presented in Table 2.0.

Following the endogenous models for this study, the following variables were modeled. Output-side real GDP at current PPPs (in mil. 2011US$) (CGDPO), Capital stock at current PPPs (in mil. 2011US$)(CK), total factor productivity level at current PPPs (USA=1) (CTFP), Human capital index, based on years of schooling and returns to education (HC), Number of persons engaged (in millions (EMP). All data were sourced from the Penn World Table, version 9.0. (Feenstra, Robert and Marcel 2015). Other variables generated from the data following the requirements of endogenous model are Effective labor (AL) which is knowledge (human capital index multiplied by labor) and Learning Factor (B) a positive externality synonymous with the ratio of technology to capital stock. It is generated by dividing total factor productivity with capital stock.

V. Panel Unit Root Test

The cointegration properties of the variables involved determine the appropriate specification of the production function. If the series cointegrate, the relationship between economic growth, capital and labor should be interpreted as a long-run equilibrium, as deviations are mean reverting. However, it has been widely acknowledged that standard unit root and cointegration tests can have low power against stationary alternatives, see for example Campbell and Perron (1991). Panel tests make progress in this respect. Since the time series dimension is extended by the cross section, inference relies on a broader information set. Therefore, gains in power are expected, and more reliable evidence can be obtained. However, first generation panel unit root and cointegration tests are often based on the assumption of independent panel members. Because of common shocks, this condition is hardly fulfilled in applied work. In the presence of cross section dependencies, the tests are subject to large size distortions, see Banerjee, Marcellino and Osbat (2004,2005). The situation gets worse if the number of cross sections is increased. To overcome these deficits, panel unit root tests have been developed that control for the dependencies via a common factor structure. A similar approach is also relevant for cointegration.

The study employed two different Panel Unit root tests to test the non-stationarity of the variables in the models so as to know the appropriate estimation method for our models. The Fisher-ADF Unit root test w has a heterogeneous hypothesis and the Im, Peseran and Shin (IPS) is also based on heterogeneous hypothesis.

Im, Pesaran and Shin (1997, 2003) IPS propose a test based on the average of the ADF statistics computed for each individual in the panel. The IPS and Fisher tests relax the restrictive hypothesis

assumption of the Levin, Lin and Chu LLC test that the autoregressive parameter of yit¡1 is the same under the alternative hypothesis; The Fisher test has the advantage over the IPS test in that it does not require a balanced panel; The Fisher test can use different lag lengths in the individual ADF regressions and can be applied to any other unit root test. However, the Fisher test has disadvantage that the p-values have to be derived by Monte Carlo simulations.

Table 2: Augmented Dickey Fuller Unit Root Test

	AT LEVEL		**DIFFERENCED**		
Variable	**ADF Fisher Chi-square**	**Prob**	**ADF Fisher Chi-square**	**Prob**	**I(d)**
Cgdpo	47.9323	1.0000	763.892	0.0000	I(1)
Ck	7.88935	1.0000	192.474	0.0000	I(1)
Ctfp	61.1277	0.2353	585.952	0.0000	I(1)
Emp	8.84513	1.0000	513.483	0.0000	I(1)
Hc	29.8305	1.0000	922.408	0.0000	I(1)
AL	59.0662	0.2957	622.722	0.0000	I(1)
B	180.65	0.0000			I(0)

Table 3: Im, Peseran and Shin Unit Root Test

	AT LEVEL		**DIFFERENCED**		
Variable	**IPS Statisitics**	**Prob**	**IPS Statisitics**	**Prob**	**I(d)**
Cgdpo	22.3577	1	-24.1377	0	I(1)
Ck	51.3837	1	-4.31019	0	I(1)
Ctfp	-0.16184	0.4357	-24.9552	0	I(1)
Emp	33.7032	1	-13.26	0	I(1)
Hc	10.7318	1	2.16806	1	I(2)
AL	0.48053	0.6846	-24.2268	0	I(1)
B	-9.17801	0			I(0)

The results in the two unit root tests in Tables 2 and 3 show that all the variables are integrated of different order. For the Knowledge Capital model (equation 1), the variables are cgdpo, B, ck, and emp. All the variables are integrated of order one I(1), except B, the learning factor that is stationary at its own level. The implication of this is that the Fully Modified OLS (FMOLS) or the Dynamic OLS (DOLS) are not applicable to test for cointegration in the model, hence we result to the Panel ARDL(Pool Mean Group). For the Human Capital model (equation 2), the variables are cgdpo, ck and AL. It is to be noted that all these variables are integrated of order one, I(1). This implies that the Fully Modified OLS (FMOLS) or the Dynamic OLS (DOLS) are applicable to test for cointegration in the model if the variables cointegrate.

VI. Panel Cointegration Analysis

This section discusses the results of cointegration regression of the knowledge capital based endogenous model and the human capital based model respectively. For the knowledge capital nbased model, variables are integrated of different order, hence the use of Panel ARDL Cointegration technique. The result is presented in Table 6. For the human capital based model, the variables are integrated of oder one, I(1), hence the use of the Dynamic Panel and Panel Fully Modified OLS techniques.

Table 6: Panel ARDL for Endogenous Growth and Knowledge Capital based Model

Dependent Variable: D(CGDPO)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
B	0.0174996	0.00108952	16.06071	0.0000
CK	0.252889	0.011587	21.82447	0.0000
EMP	0.277885	0.017654	15.74042	0.0000
Short Run Equation				
COINTEQ01	-0.08091	0.028822	-2.80705	0.0051
D(B)	0.4105121	0.123107	3.33458	0.0009
D(CK)	0.150438	0.039475	3.810912	0.0001
D(EMP)	0.542608	0.117890	4.60263	0.0000
C	-808.385	306.4205	-2.63816	0.0085
Mean dependent var	2934.206	S.D. dependent var		15261.75
S.E. of regression	5974.986	Akaike info criterion		16.00955
Sum squared resid	3.36E+10	Schwarz criterion		16.64743
Log likelihood	-8491.15	Hannan-Quinn criter.		16.2511

The result in Table 6 presents both the long-run and short-run respectively. In the long-run model all coefficients affect economic growth positively and are statistically significant at 5% level. A unit increase in knowledge capital leads to less than proportionate increase in output (0.0174). A unit increase in physical capital and labor also lead to less than proportionate increase in output respectively in the long –run. These coefficients are also elasticity coefficients since the model is Cobb-Douglas model. The implication is that addition of the coefficients determines the rate of returns. The addition of the elasticity coefficients is 0.546, suggestion a diminishing returns. This confirms the proposition that when knowledge capital is low in economy, physical capital and labor becomes less effective. Knowledge capital plays a significant role in the long run economic growth; if knowledge enters through labor it is labor augmenting (Harrod neutral). If it enters through capital it is capital augmenting. The short-run coefficients also conform to a priori expectation as they are all positive and highly significant. The short-run results also confirm that there is disequilibrium in output growth in the short run as shown by the negative value of the ECM (-0.08091) which the variable are trying to correct. The ECM is well signed showing that growth is in disequilibrium in the short run across African economies; a combination of knowledge capital, labor and physical capital investment are trying to adjust growth to equilibrium. The speed of the adjustment as measured by the magnitude of the ECM is 0.0809. The speed is about 8% per period. This is a very slow speed. Knowledge capital is a major engine of short-run and long-run growth as proposed by the endogenous growth theory. But the rate at which growth is achieved endogenously is slow in African economies is very slow. The rate of return in the short run is greater than 1, implying increasing returns. Unfortunately it cannot be sustained in the long run due to the low coefficients of knowledge capital across the economies.

Table 7 : Johansen Fisher Panel Cointegration Test for Lucas Model

Series: CGDPO CK AL				
Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)				
Hypothesized	Fisher Stat.*		Fisher Stat.*	
No. of CE(s)	(from trace test)	Prob.	(from max-eigen test)	Prob.
None	247.5	0	217	0.0000
At most 1	87.75	0.0025	75.94	0.0261
At most 2	80.9	0.0103	80.9	0.0103

The second model is the Human Capital based aggregate production function. Since the presence of a unit root is detected in the variables of the second model then it is necessary to check for the presence of a cointegrating relationship among the variables. There are two types of panel cointegration tests in the literature.

The first is similar to the Engle and Granger (1987) framework which includes testing the stationarity of the residuals from a levels regression. The second panel cointegration test is based on multivariate cointegration technique proposed by Johansen (1988). However, panel techniques may be better in detecting cointegration relationships since a pooled levels regression combines cross-sectional and time series information in data when estimating cointegrating coefficients.

We describe human capital, according to Lucas as making labor more effective. Since all the three variables in this model are I(1), a condition for Johansen Panel cointegration is met. The result of the cointegration test is shown in Table 7. The results show that both the Trace and Maximum Eigenvalue test reject the hypothesis of no cointegration up to 2, showing that there are at most two cointegrating panels in the model.
In the cointegrated panels, using ordinary least square (OLS) method to estimate the long-run equation leads to biased and inconsistent estimator of the parameters. OLS estimates suffer from asymptotic bias unless the regressors are strictly exogenous, so that the OLS standard errors cannot generally be used for valid inference. Pedroni (2000) proposes fully modified ordinary least square (FMOLS) estimation while Kao and Chiang (2000) and Mark and Sul (2001) recommend the dynamic ordinary least squares (DOLS) as the alternative methods of panel cointegration estimation. FMOLS estimation corrects for endogeneity and serial correlation to the ordinary least square (OLS) estimator. To correct for endogeneity bias and to obtain an unbiased estimator of the long-run parameters, DOLS uses a parametric adjustment to the errors by augmenting the static regression with the leads, lags, and contemporaneous values of the regressors in first differences. Both FMOLS and DOLS provide consistent estimates of standard errors that can be used for inference.
According to Kao and Chiang (2000) FMOLS and DOLS estimators have normal limiting properties, even though DOLS estimator outperforms FMOLS estimator in empirical analysis.
Both the FMOLS and DOLS were used in this study and they produce similar results. The results are reported in Tables 8 and 9 respectively.

Table 8: Panel Fully Modified OLS Estimates for Human Capital Model

Dependent Variable: CGDPO				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CK	0.222463	0.008777	25.3453	0.0000
AL	0.015938	0.0004248	37.5201	0,0000
R-squared	0.985918	Mean dependent var		63400.09
Adjusted R-squared	0.98514	S.D. dependent var		136029
S.E. of regression	16582.2	Sum squared resid		2.74E+11
Long-run variance	5.57E+08			

Table 9: Panel Dynamic OLS Estimates for Human Capital Model

Dependent Variable: CGDPO				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CK	0.253456	0.009309	27.22662	0,0000
AL	0.014964	0.0004216	35.4866	0.0000
R-squared	0.992857	Mean dependent var		61943.09
Adjusted R-squared	0.991608	S.D. dependent var		132779.2
S.E. of regression	12163.77	Sum squared resid		1.29E+11
Long-run variance	2.43E+08			

The results in Tables 8 and 9 show that coefficients of physical capital and human capital (effective labor) are both positive and significant at 1% level. The R^2 of bothe the FMOLS and the DOLS are very high (98% and 99% respectively) implying that the model perform well. The coefficient of physical capital is higher compared to that of human capital as observed in the first model where Knowledge capital is used. If physical capital increases by a unit (say 100%) output increases by 0.25 units (25%), which is less than a unit in the long run. Likewise an increase in labour effectiveness through human capital development by a unit (100%), result to output increases of 0.014 units (about 1.4%) in the long run. Human capital is a significant factor in aggregate production but has been less effective in African economies. It complements both physical capital and labor, and therefore, income growth cannot be explained by physical capital and labor only.

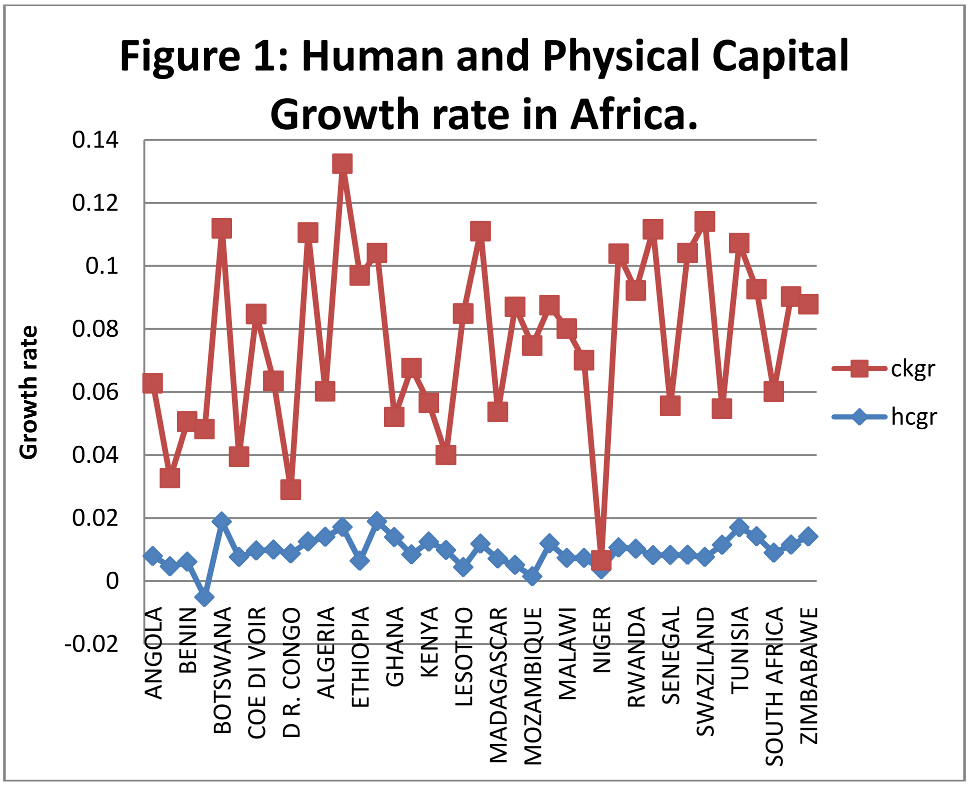
VII. Human Capital In Africa And The Convergence Hypothesis

If there is increasing returns to total capital (a + **c** > l), the rate of return will increase as the capital stocks (both human and non-human) grow, as discussed in Romer (1986). This provides an explanation of why the convergence of growth rates among different economies is not universally observed, but it rules out the possibility of steady state equilibrium. Therefore, the later model of Romer (1990) and Rebelo (1991) assumes constant returns to total capital (a + c = 1). Under the assumption of constant returns to capital, the rate of return will be given as constant regardless of the level of total capital stocks. In this case, the growth rate of total capital will also be constant and equal to the growth rate of per capita income. The economy is always at the steady state by assumption.

The dynamics of the Lucas endogenous model postulates that for a steady state growth, the growth rate of human capital in the economy must be greater than the growth rate of capital stock accumulation. Simply put the marginal rate of substituting acquisition of knowledge for physical capital must be increasing in the economy. That is If $\frac{\dot{H}}{H} > \frac{\dot{K}}{K} \Rightarrow \frac{\dot{\gamma}}{\gamma} > 0$ and increases. The dynamics of growth through growth of human capital is thus $\frac{\dot{\gamma}}{\gamma} = \frac{\dot{H}}{H} - \frac{\dot{K}}{K}$ this explains the process and rate of growth resulting from invention and consequent technical progress. According to Endogenous growth theory, for a growing economy which has not yet arrived at a long-run steady state and has not completed its productivity convergence to the industrial nation level, human capital plays the role of accumulating capital, complementing physical capital and labor rather than providing economy-wide externality as hypothesized by the endogenous growth models.

Table 10: Human Capital and Physical Capital Growth rate for Africa Economy

Country	$\frac{\dot{H}}{H}$	$\frac{\dot{K}}{K}$	$\frac{\dot{\gamma}}{\gamma}$	**Country**	$\frac{\dot{H}}{H}$	$\frac{\dot{K}}{K}$	$\frac{\dot{\gamma}}{\gamma}$
ANGOLA	0.0079	0.0549	-0.047	**MADAGASCAR**	0.0071	0.0466	-0.0395
BURUNDI	0.004647	0.02803	-0.02338	**MALI**	0.0051	0.0819	-0.0768
BENIN	0.0061	0.0445	-0.0384	**MOZAMBIQUE**	0.00147	0.07326	-0.07179
BURKINA FASO	-0.0051	0.0533	-0.0584	**MURITUS**	0.0119	0.0756	-0.0637
BOTSWANA	0.0188	0.0931	-0.0743	**MALAWI**	0.0073	0.0728	-0.0655
CENTRAL AFR.	0.0076	0.0319	-0.0243	**NAMIBIA**	0.0073	0.0628	-0.0555
COE DI VOIR	0.00964	0.0751	-0.06546	**NIGER**	0.0037	0.0029	0.0008
CAMEROON	0.00992	0.0536	-0.04368	**NIGERIA**	0.0106	0.0933	-0.0827
D R. CONGO	0.0087	0.0203	-0.0116	**RWANDA**	0.0102	0.082	-0.0718
CONGO	0.01248	0.09805	-0.08557	**SUDAN**	0.00817	0.1034	-0.09523
ALGERIA	0.01398	0.0462	-0.03222	**SENEGAL**	0.00824	0.0474	-0.03916
EGYPT	0.0171	0.1153	-0.0982	**SEIRALEONE**	0.00828	0.0958	-0.08752
ETHIOPIA	0.0064	0.0906	-0.0842	**SWAZILAND**	0.0076	0.1065	-0.0989
GABON	0.01888	0.0852	-0.06632	**TOGO**	0.01145	0.0433	-0.03185
GHANA	0.0139	0.03818	-0.02428	**TUNISIA**	0.017	0.09023	-0.07323
GAMBIA	0.0084	0.05923	-0.05083	**UGANDA**	0.01416	0.07843	-0.06427
KENYA	0.01244	0.04413	-0.03169	**SOUTH AFRICA**	0.00894	0.05123	-0.04229
LIBERIA	0.0098	0.0302	-0.0204	**ZAMBIA**	0.0115	0.07877	-0.06727
LESOTHO	0.00439	0.0805	-0.07611	**ZIMBABAWE**	0.01408	0.07374	-0.05966
MOROCCO	0.0118	0.0992	-0.0874				



It can be seen from Figure 1 and Table 10 that on the average, within the period covered by this study (1970 to 2016), the growth rate of physical capital accumulation (ckgr) across African economies are greater than the growth rate of human capital (hcgr) leading to a decreasing growth rate. Growth of human capital across African economies was below 0.002 (2%), while physical capital grows up to about 14% in some African country. The argument of endogenous growth theory can be summarized as follows. Inventors discover new 'designs' (through Research and Human capital development) or blueprints while enjoying free access to 'knowledge' on all existing 'designs'. Exclusive rights to produce a unique type of machine using a new 'design' are bought by machine producers. New machines are rented by final-product firms. Growth in the final-product sector occurs as a result of increasing the range of the machinery in use. This phenomenon of economic growth through knowledge and human capital development and the convergence theory is still very backward across African economies as revealed in Figure 1.

Human capital is a distinctive measure of cumulative effect of activities such as formal education and on-the-job training that generates innovations.

VIII. Conclusion

In this study, we are able to establish that the poor growth of Africa economies is not a woe but the result of poor and not sustained accumulation and use of human capital. In summary, convergence will be observed for developing economies which make use of human and knowledge capital as productive inputs. On the other hand, divergence will be observed between developing economies which could not make use of human capital as a productive input and developed economies which enjoy an economy-wide externality from accumulated human capital stocks. This explains the wide gap in between developed economies of the world and Africa economies. It also implies that until a converging economy's human capital reaches a certain threshold point, the externality implied by endogenous growth models cannot be expected. Until that stage, human capital will serve as a productive input rather than as a source of sustained growth. From the viewpoint of endogenous growth theory, these findings provides us with an explanation for observed divergence between rich countries and poor countries. The explanation is a conjecture that developing economies which make use of human capital as a productive input and continue to accumulate knowledge in through innovative research and development can converge, while those which cannot may diverge. Only after the accumulation of human capital reaches a certain threshold can physical capital provide the economy with externality.

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Ayeni, R. K "Knowledge Capital, Human Capital Stocks and the Growth of Africa Economies: A Panel Data Analysis "IOSR Journal of Economics and Finance (IOSR-JEF) , vol. 9, no.3, 2018, pp. 53-63