HUMAN CAPITAL-ECONOMIC GROWTH NEXUS IN AFRICA: HETEROGENEOUS PANEL CAUSALITY APPROACH

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Abstract

This paper examines the causal relationship between human capital and economic growth for a panel 29 African countries. In particular, the study applied theoretically consistent panel unit root procedures and panel cointegration tests that account for the presence of cross-sectional dependency among the members of a panel. To ascertain the direction of causality between human capital and economic growth, the study applies the heterogeneous panel causality test proposed by Dumitrescu and Hurlin. This test has the ability to control for the presence of both heterogeneity and cross-sectional dependence that might be present in the panel. To determine the signs of the relationship between the two variables, the study applied the dynamic OLS. The results from the heterogeneous panel causality test provide evidence in support of bidirectional causality between human capital and economic growth for the sample countries. The results from the dynamic OLS indicate that human capital and economic growth have significantly positive effect on each other. This finding reinforces the need for the sample countries to work in tandem in promoting education as an engine of economic growth.

INTRODUCTION

Economic growth as measured by growth in the GDP or growth in the per capita GDP varies from country to country. These variations explain why some countries are characterized as rich, thus ensuring high standards of living than poor countries. The implication therefore is that while the level of real GDP is a good measure of economic prosperity, the growth of real GDP (economic growth) is a good gauge of economic progress (Mankiw, 2008).Understanding what accounts for the differences in economic growth and standard of living as a consequence among the countries has become very crucial as countries construct their sustainable economic development strategies and policies. Over the years, developing/poor countries have attempted to increase their capital base as part of their development efforts. Many a time, this is achieved through international trade liberalization through which multinational corporations act as the conduit for technological and capital transfers to the countries. This posits an argument that may infer that economic growth can mostly be achieved through capital accumulation.

There has been the need to decompose capital between physical capital and human capital. Traditionally, research has concentrated on the role of physical capital accumulation via improvements in productivity. However, the issue of labor-augmenting characteristics of human capital has ushered in new debates on human capital as a supply factor (Awel, 2013; Adekola, 2014; Abbas, 2000).There is a tremendous body of knowledge that tends to provide evidence for the nexus between human capital and economic growth given that human capital, in economics, is defined as "the knowledge and skills that workers acquire through education, training, and experience (Mankiw, 2008). As such, effective investment in human capital becomes an increasingly important element in long-term economic growth and development strategies. This notion is supported by the World Bank study reported by Awe and Ajayi (2010). The study reported that human capital on the average, accounts for 64 percent of total wealth vs 16 percent and 29 percent for physical and natural capital respectively of the 192 countries sampled. Moreover,not only does an increase in human capital improve worker productivity, it is also necessary for optimum utilization of physical capital (Qadri and Waheed, 2011). As a result, countries position their stock of human capital a one area that they may possess some comparative advantage in vying for foreign investments.

The relationship between economic growth and human capital has been extensively explored by researchers. However, most of the earlier studies on this issue have produced mixed results in the literature. For instance, Adekola (2014) explores the relationship between public expenditure on human capital and economic growth for Nigeria using data from 1961 through 2012. Applying the cointegration procedures proposed by Johansen (1988) and the vector error correction model of Engle and Granger (1987) he finds that public expenditures of federal and states governments have significantly positive impact on human capital in Nigeria. Krueger and Lindahl (2001) argue that education has positive effect on economic growth for mainly countries with low education levels. Engelbrecht (2003) investigates the impact of human capital on economic growth for OECD countries. He finds that human capital has a positive effect on economic growth for the sample of OECD countries under study. Jorgenson and Fraumeni (1992) examined the relation of human capital to economic growth for the United States for the time period from 1948 through 1986. They find that human capital has positively significant effect on economic growth for the United States.

De la Fuente and Domenéch (2000) using their own compiled data, find that changes in educational attainment have significantly positive effect on economic growth for OECD countries. Benhabib and Spiegel (1994) using the Cobb-Douglas aggregate production function examined the relationship between human capital and economic growth. They find that human capital is not a determinant of economic growth, as the regression coefficient on human capital is negative and statistically insignificant. They attribute the negative regression coefficient on human capital to the fact that most of the countries in their sample, especially those from the continent of Africa, started the period with unusually low stocks of human capital.

Pritchett (2001) examined the relationship between economic growth and human capital. He finds that increases in human capital do not promote economic growth for the sample of developing countries under study. Pritchett attributes his finding to the fact that the political and institutional environment could be bad enough that the accumulation of human capital weakens economic growth. He further suggests that the quality of education could be so low that years of schooling fail to create any level of human capital. Finally, he maintains that returns on education may have rapidly declineddue to an increase in the supply of - and stagnant demand for - educated labor.Mankiw *et. al.* (1992) explore the relationship between economic growth and human capital for a group of 98 countries. They find that human capital accounts for approximately 49 percent of the variations in economic growth for the countries under study.

Reza1 and Valeecha (2012) examined the relationship between education and economic growth for Pakistan using regression analysis. They failed to find supportive evidence that education promotes economic growth in Pakistan. They attribute their finding on the inability of the Pakistan government to provide employment opportunities for its students. Most students who complete their education fail to secure jobs that would enable them to meaningfully contribute to the national economy. Lack of jobs in Pakistan forces some of its graduates to go abroad in search of employment opportunities which leads to brain drain inthe country. Barro (2001) examined the relationship between education and economic growth for a group of 100 countries using data running from 1965 through 1995. He finds that economic growth is positively related to starting level of average years of school attainment of adult males at the secondary and higher levels. He attributes this finding to the fact that educated employees tend to complement new technologies. He however did not find similar results between school attainment and economic growth for females at the secondary and higher levels.

From the preceding brief literature review, it is apparent that African countries have not received adequate attention with regard to the relationship between economic growth and human capital. Most of the studies in the literature focused attention on the relation of human capital to economic growth in the context of the OECD countries. To this effect, the present study extends the debate on the relationship between human capital and economic growth for a panel of 29 African countries using more recent econometric techniques in panel data approach. Specifically, the study applies the heterogeneous panel causality test proposed by

Dumitrescu and Hurlin (2012). This testing procedures adopted by the study because it has the ability to control for the presence of both heterogeneity and cross-sectional dependence that might be present in the panel.

The remainder of the paper is organized as follows. Following the present introduction, Section 2 discusses the methodology. Section 3 presents the data and empirical results. Section 4 furnishes the conclusions and policy implications of the study.

METHODOLOGY

The empirical analysis of the study begins with the application of a battery of cross-sectional dependency tests such as those proposed by Breusch and Pagan (1980), Pesaran (2004) and Hashem M. Pesaran, Aman Ullah, and Takashi Yamagata (2008). It is important to account for the presence of cross sectional dependency in the data generating process, as this has implications for the validity of panel unit root and heterogeneous Granger causality test results. For instance, O'Connell (1998) argues that failure to control for contemporaneous correlations between series in a panel could lead to the rejection of the joint unit root hypothesis. The implantation of the Breusch and Pagan (1980) Lagrange Multiplier (LM) procedure requires the estimation the following panel data model:

$$y_{it} = \alpha_i + \beta' x_{it} + + \mu_{it} \quad (1)$$

In equation (1), y is the depend variable (in our case human capital or economic growth), i represents the cross-sectional dimension, tis the time index, x_{it} represents kx1 vector of independent variables. α_i and β_i respectively, stand for individual intercepts and the slope coefficients that are permitted to vary across panel members. Under the LM CD test, the null hypothesis of no cross-sectional dependence [i.e. H_o: $Cov(u_{it}, u_{ij}) = 0$, for all t and $i \neq j$] is tested against the alternative, H_1: $Cov(u_{it}, u_{jt}) \neq 0$, for at least one pair of $i \neq j$. The LM test statistic for cross sectional dependency is calculated as follows:

$$LM = T \sum_{t=1}^{N-1} \sum_{j=i+1}^{N} (\hat{\rho}_{ij}^2) \quad (2)$$

In equation (2), N is the number of cross sections, T is the sample size and $\hat{\rho}_{ij}$ stands for the correlation coefficient between the residuals obtained from individual OLS estimations. The test statistic is distributed as $\chi n(n-1)/2$. The LM test statistic is valid in the cases where N is small and T is sufficiently large. To mitigate this shortcoming, Pesaran (2004) proposed a scaled version of the Breusch and Pagan (1980) LMtest statistics which is applicable if $T \rightarrow \infty$ and $N \rightarrow \infty$. The scaled version of the LM procedure is as follows:

$$CD_{lm} = \sqrt{\frac{T}{N(N-1)}} \sum_{t=1}^{N-1} \sum_{j=i+1}^{N} (\hat{\rho}_{ij}^2) \quad (3)$$

The CD_{lm} statistic is assumed to be asymptotically normally distributed. However, CD_{lm} can be applied when either T>N or N>T. Although the CD_{lm} test can be applied even when N and T are large, it however exhibits size distortions in the cases where N is large and T is small. To overcome this weakness, Pesaran (2004) advanced the following test:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{t=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 - 1) \quad (4)$$

Pesaran (2004) shows that the CD test has exactly mean zero for fixed T and N and that the procedure is robust to heterogeneous dynamic models including multiple breaks in slope coefficients and/or error variances, provided the unconditional means of y_{it} and x_{it} are time-invariant and their innovations have symmetric distribution. The null hypothesis under each of the procedures is that there is no cross-sectional dependence among the members of the panel. The null hypothesis is rejected if the calculated test statistic is greater than the critical value at the conventional levels.

However, Pesaran, et al. (2008) have shown that the conventional CD tests tend to lack power, especially when the population average pair-wise correlations are zero while the underlying individual population pair-wise correlations are non-zero. To overcome this drawback, Pesaran, et al. (2008) proposed the bias-adjusted LM test which is given by:

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{t=1}^{N-1} \sum_{j=i+1}^{N} (\hat{\rho}_{ij}) \frac{(T-k-1)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\nu_{Tij}} \quad (5)$$

In equation (6), μ_{Tij} and ν_{Tij} represent the exact mean and variance of $(T-k-1)\hat{\rho}_{ij}^2$. The LM_{adj} test follows asymptotically standard normal distribution. The null hypothesis under the LM_{adj} is that there is no cross-sectional dependence among the members of the panel

This paper next applies the panel unit root test proposed by Hadri-Kurozumi (2012). The Hadri-Kurozumi panel test can be implemented in situations where both T>N and T<N. The test accounts for cross-sectional dependency that might be present in the panel. It also allows for serial correlation. The null hypothesis under the Hadri-Kurozumi panel test is that the series do not contain unit root. The alternative hypothesis that the series in the panel are unit root processes. Under the Hadri-Kurozumi panel unit root test, the long-term variance is estimated in two ways namely — Z_A^{SPC} and Z_A^{LA}. The seemingly unrelated regression technique is used for the Z_A^{SPC} test and as such the bootstrap techniques is used to obtain the test statistic and the associated p-value. In the Z_A^{LA} method, t-stat and p-value

aretaken into account. The Z_A^{SPC} method is preferred over the Z_A^{LA} if there is evidence of cross-sectional dependence in the panel. On the other hand, Z_A^{LA} is preferred over the Z_A^{SPC} technique if there is evidence against cross-sectional dependence in the panel. In the interest of brevity, details pertaining to Hadri-Kurozumi panel unit root test will not be discussed here. However, the interested reader is referred to Hadri-Kurozumi (2012) for detailed description of the procedure.

PANEL GRANGER NON-CAUSALITY TESTS

The study applies the panel Granger non-causality test (HNC) proposed by Hurlin (2004, 2005) and Dumitrescu and Hurlin (2012). The test is implemented under the assumption of no cross-sectional dependency. Nevertheless, the procedure has been shown through Monte Carlo simulations to produce unbiased results even in the presence of cross sectional dependency. The test consists of two distributions namely asymptotic and semi-asymptotic. The asymptotic distribution is valid when T>N. On the other hand, the semi-asymptotic distribution is appropriate when N>T. The bootstrap critical values, obtained through simulations are used when there is evidence of cross-sectional dependency among the series in the panel.

The Dumitrescu and Hurlin (2012) panel Granger non-causality test is given by:

$$y_{1,t} = \alpha_{1,1} + \sum_{k=1}^{k} \gamma_i^k y_{1,t-k} + \sum_{k=1}^{k} \beta_i^k, x_{1,t-k} + \mu_{i,t} \quad (6)$$

Where y and x are two stationary series (in our case, economic growth and human capital).

$$H_0: \beta_i = 0 \qquad \forall i = 1, 2, \ldots\ldots\ldots\ldots\ldots N$$

$$\text{with } \beta_i = (\beta_i^{(1)} \ldots\ldots \beta_i^{(k)}) \quad (7)$$

$$H_1: \beta_i \neq 0 \qquad \forall i = 1, 2, \ldots\ldots\ldots\ldots\ldots N \quad (8)$$

$$\beta_i \neq 0 \qquad \forall i = N,+1, N_1+2, \ldots\ldots, N \quad (9)$$

Under the HNC, the alternative hypothesis permits some of the individual vectors (β_i) to be equal to zero. The Dumitrescu-Hurlin test involves three average statistics including $W_{N,T}^{HNC}$, $Z_{N,T}^{HNC}$ and Z_N^{HNC}. The average statistic given by $W_{N,T}^{HNC}$ is expressed as follows:

$$W_{N,T}^{HNC} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \quad (10)$$

In equation (10), $W_{i,T}$ represents the individual Wald statistical values for the cross-sections. The average statistic given by $Z_{N,T}^{HNC}$ has asymptotic distribution which is expressed as follows:

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2K}} (W_{N,T}^{HNC} - K) \;\; T, N \rightarrow \infty \quad N(0,1) \quad (11)$$

$$W_{i,T} = (T - 2K - 1)\left(\tilde{\varepsilon}_i \phi_i \tilde{\varepsilon}_i \middle/ \tilde{\varepsilon}_i M_i \tilde{\varepsilon}_i \right), \text{ i=1,……,N} \qquad (12)$$

The average statistic Z_N^{HNC} has semi-asymptotic distribution associated with the null HNC hypothesis is given by the following expression:

$$Z_N^{HNC} = \frac{\sqrt{N}[W_{N,T}^{HNC} - N^{-1}\sum_{i=1}^{N} E(W_{i,T})}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(w_{i,T})}} \qquad N \to \infty, N(0,1) \quad (13)$$

The existence of cross-sectional dependence among the panel member requires that the 5 percent critical values simulated from 50,000 replications of the benchmark model and the 5 percent of the approximated values be utilized.

DATA

The data set consists of annual observations on GDP per capita and human capital (proxied by index of human capital per person, based on years of schooling and returns to education as suggested by Barro and Lee (2012) and Psacharopoulos (1994), respectively).The data were obtained from the Penn World Tables (PWT) version 8 provided by Feenstra *et al.* (2013). This study adopts the PWT data set because the GDP per capita of the sample countries are expressed in a common currency. Simply put, the PWT estimates of GDP per capita are based on purchasing power parity. The period under consideration runs from1963 through 2010. The sample countries are Benin, Botswana, Cameron, Central African Republic, Cote d'Ivoire, Democratic Republic of Congo, Republic of Congo, Gabon, Gambia, Ghana, Kenya, Lesotho, Mali, Mauritania, Morocco, Mozambique, Mauritius, Malawi, Namibia, Niger, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia and Zimbabwe. The economic growth variable is calculated as the first differences of the GDP per capita for the various sample countries. To ensure data consistency, the human capital variable is expressed as changes in index of human capital per person.

EMPIRICAL RESULTS

This section discusses the empirical results of the study. Table 1 presents the results from the various cross-sectional dependence tests. The results indicate that the null hypothesis of no cross-sectional dependency across the countries in the panel should be rejected at the conventional levels of significance. For instance, the test statistics for economic growth are 472.158, -6.196, -4.236, 8.398, respectively for the LM, CD_{lM}, CD, and the bias adjusted CD procedures. These test statistics are statistically significant at the 1 percent level of significance. Similarly, for human capital variable, the CD test statistics 449.911, -5.789, -4.044, and 8.376, respectively for the LM, CD_{lM}, CD, and the bias adjusted CD procedures reject the null hypothesis of no cross sectional dependence at least at the 10 percent level of significance. Taken together, these results suggest that the null hypothesis of no cross-sectional dependence should be rejected. These results imply that shocks to either economic growth or human capital in one of the sample countries can be easily transmitted to the other countries in the panel.

TABLE 1
Cross-Sectional Dependence Test Results

	Test Stat	Probability
Panel A: Economic Growth (EG)		
LM (Breusch and Pagan 1980)	472.158^{***}	0.013
CDlm (Pesaran 2004)	-6.196^{***}	0.000
CD (Pesaran 2004)	-4.236^{***}	0.000
Bias Adjusted CD Test	8.398^{***}	0.000
Panel B: Human Capital (HC)		
LM (Breusch and Pagan 1980)	449.911^{*}	0.065
CDlm (Pesaran 2004)	-5.789^{***}	0.000
CD (Pesaran 2004)	-4.044^{***}	0.000
Bias Adjusted CD Test	8.376^{***}	0.000

*** and * indicate the rejection of the null hypothesis of no cross-sectional dependence at the 1% and 10% levels, respectively.

To account for the presence of cross-sectional dependencies in the panel, the study implements the Hadri and Kurozumi (2008) panel unit root tests. The results from the Hadri and Kurozumi (2008) procedures are displayed in Table 2. The results suggest that the null hypothesis of stationarity should not be rejected, with the exception of the results from the Z_A^{SPC} test; for human capital. The test statistics 0.062 (p-value =0.475) and 0.865 (p-value =0.194) respectively, for Z_A^{SPC} and Z_A^{LA} are statistically insignificant in the case of economic growth variable, indicating the acceptance of the null hypothesis of stationarity. For human capital variable, the result from the Z_A^{SPC} procedure rejects the null hypothesis while that from the Z_A^{LA} test accepts the stationarity hypothesis. The presence of cross-sectional dependence in the panel implies that the test statistics from the Z_A^{SPC} procedure are the most appropriate for the study.

Having established the order of integration for economic growth and human capital variables, the study explores the existence of long run relationship between them by applying the Durbin-Hausman panel cointegration test. The Durbin-Hausman panel cointegration test is adopted because it has the ability to control for cross-sectional dependencies that might exist among panel members. Furthermore, the test can be applied when $y \rightarrow I(1)$ and $x \rightarrow I(1)$ or $I(0)$. Table

3 displays the results from the Durbin-Hausman cointegration test. The first model, economic growth is the dependent

TABLE 2
Hadri-Kurozumi Panel Unit Root Test Results

Variable	Test	Statistic	P-Value
Economic Growth (EG)	Z_A^{SPC}	0.062	0.475
	Z_A^{LA}	0.865	0.194
Human Capital (HC)	Z_A^{SPC}	5.981***	0.000
	Z_A^{LA}	0.096	0.462

*** Indicates the rejection of the null hypothesis of stationarity

variable while human capital is the dependent variable in the second model. The results from both the group (DH_g) and panel (DH_p) tests reject the null hypothesis of no cointegration between economic growth and human capita. The test statistics obtained from the equation with economic growth as the dependent variable are DH_g = 187.725 (p-value=0.000) and DH_p = 3.603 (p-value=0.000). Thesetest statistics are statistically significant at the 1 percent level of significance. Similar results are indicated for the model where human capital is the dependent variable. These results imply that there is long run relationship between economic growth and human capital.

TABLE 3
Durbin-Hausman Panel Cointegration Test Results

Dependent Variable	Test	Statistic	P-Value
Economic Growth (EG)	DH_g	187.725***	0.000
	DH_p	3.603***	0.000
Human Capital (HC)	DH_g	91151.265***	0.000
	DH_p	927.490***	0.000

*** indicates rejection of the null hypothesis of no cointegration at the 1% level of significance

To test for causality between economic growth and human capital, this study applies the heterogeneous panel causality test proposed by Dumitrescu and Hurlin (2012). The appropriate lags were determined to be 5 in all of the cases by the Bayesian Information Criteria. For robustness, the study calculates and reports the results for 5, 6 and 7 lags. Using 5, 6, and 7 lags, the results overwhelmingly reject the null hypothesis of non-causality from economic growth to human capital. For lag 5, the test statistics are 6.508, 12.837 and 1.787, respectively for W^{HNC}, Z_{NT}^{HNC} and Z_{N}^{HNC}. These test statistics are significant at least at the 10 percent level. Similarly, the test statistics 7.410, 20.522 and 3.105, respectively for W^{HNC}, Z_{NT}^{HNC} and Z_{N}^{HNC} suggest that causality runs from human capital to economic growth. The results for 6 and 7 lags corroborate those obtained from the use of 5 lags. Taken together, the results provide supportive evidence of feedback relationship between economic growth and human capital for sample countries. The finding of bidirectional causality between economic growth and human capital is consistent with Awel (2013).

TABLE 4
Dumitrescu-Hurlin Panel Granger Causality Test Results

	EG $\nrightarrow$ HC	HC $\nrightarrow$ EG
Panel A: Lags(k)=5		
W^{HNC}	6.508***	7.410***
Z_{NT}^{HNC}	12.837***	20.522***
Z_{N}^{HNC}	1.7878*	3.108***
Panel A: Lags(k)=6		
W^{HNC}	8.464***	10.159***
Z_{NT}^{HNC}	22.979***	38.789***
Z_{N}^{HNC}	2.744***	4.959***
Panel A: Lags(k)=7		
W^{HNC}	10.181***	12.602***
Z_{NT}^{HNC}	32.048***	56.438***
Z_{N}^{HNC}	3.224***	6.083***

***, **, and * indicate significance at the 1%, 5%, and 10% level respectively.

TABLE 5
Panel Dynamic OLS Long Run Estimates

	Effect of HC on EG		Effect of EG on	
Member	Coef.	Std. Error	Coef.	Std.
Panel A: Results for Individual Panel Members				
Benin	1.013***	0.004	0.993***	0.003
Botswana	0.999***	0.003	1.003***	0.002
Central African Republic	0.997***	0.004	1.003***	0.003
Cote d'Ivoire	1.005***	0.003	0.995***	0.002
Cameron	1.005***	0.003	0.997***	0.002
Democratic Republic of Congo	0.999***	0.003	1.001***	0.002
Republic of Congo	0.997***	0.003	1.005***	0.002
Gabon	1.012***	0.003	0.987***	0.003
Ghana	1.004***	0.003	0.992***	0.002
Gambia	1.006***	0.003	0.996***	0.002
Kenya	1.002***	0.003	0.999***	0.002
Lesotho	1.006***	0.002	0.997***	0.002
Morocco	1.000***	0.003	0.996***	0.002
Mali	0.997***	0.003	0.996***	0.002
Mozambique	0.988***	0.003	1.000***	0.002
Mauritania	0.987***	0.003	1.002***	0.002
Mauritius	0.996***	0.003	1.002***	0.002
Malawi	1.001***	0.002	0.999***	0.002
Namibia	0.999***	0.004	1.002***	0.003
Niger	1.012***	0.003	0.987***	0.003
Rwanda	0.990***	0.004	0.999***	0.004
Senegal	0.991***	0.004	1.004***	0.003
Sierra Leone	0.979***	0.004	1.018***	0.003
Togo	1.010***	0.004	0.993***	0.003
Tanzania	1.007***	0.005	0.990***	0.004
Uganda	0.995***	0.004	1.007***	0.003
South Africa	0.989***	0.004	1.010***	0.003
Zambia	0.987***	0.004	1.012***	0.003
Zimbabwe	0.990***	0.004	1.007***	0.004
Panel B: Pooled OLS				
	0.999***	0.001	0.999***	0.001

*** indicates significance at the 1% level.

The Granger causality tests are designed to determine which variable causes the other. These tests are not however designed to determine the sign (positive or negative) of the relationship between the variables in the model. To this effect, this study uses the panel-dynamic ordinary least square (PDOLS) method proposed by Mark and Sul (2003) to ascertain the sign of the long run relationship between economic and human capital.The PDOLS framework allows for individual heterogeneity through disparate short-run dynamics, individual-specific fixed effects and individual-specific time trends. The framework also allows a limited degree of cross-sectional dependence through the presence of time-specific effects (Mark and Sul, 2003, p. 656).

The values in parentheses show t-stat values. The approximated critical values for the average statistic are computed from Equation (30) of Dumitrescu and Hurlin (2012) for the case K=1. The simulated critical values are computed via stochastic simulations with 50,000 replications.

Table 5 displays the estimates from the PDOLS framework. Panel A of Table 5 displays the estimates for individual panel members. The results show that the impact of human capital on economic growth and vice versa varied from country to country. The results show that in all of the cases economic growth and human capital have significantly positive effect on each other. However, these results should be taken with caution as there are obtained from the single-equation DOLS with limited number of observations. In addition, Mark and Sul (2003) point out that the cross-sectional variation in the estimates obtained from single-equation DOLS framework is an indicative of the inherent difficulty in obtaining good estimates rather the evidence of disparate economic behavior. Panel B of Table 5 presents the estimates from the PDOLS. According to the results, economic growth and human capital have significantly positive influence on each other. For instance, in the equation for economic growth, the coefficient on human capital (0.999) is positive and statistically significant at the 1 percent level. This implies that a unit increase in human capital will increase economic growth by approximately 0.999. Similarly, a unit increase in economic growth promotes human capital by roughly 0.999. Taken together, the results from this study reinforce the importance of human capital investment in nascent economies, especially those in the African continent.

The PDOLS was estimated with 4 lead and lags. Common time effect was also controlled for.

SUMMARY AND IMPLICATIONS

This paper has used the heterogeneous panel causality approach to ascertain the relationship between economic growth and human for group of 29 African countries for the time period running from 1963 through 2010. Specifically, the study first tests for the presence of cross-sectional dependence in panel by applying a battery of procedures including Pesaran (2004) CD_{lm}, CD, and the bias adjusted CD test advanced by Hashem M. Pesaran, Aman Ullah, and Takashi Yamagata (2008). To determine the order of integration for the two variables, the study employed the Hadri-Kurozumi panel unit root which has the capacity to correct for the presence of cross-sectional dependence among panel members. To examine the long run relationship between economic growth and human capital, the study implemented the panel cointegration tests advanced by Durbin-Hausman. For Granger causality, the study utilized the heterogeneous panel causality test proposed by Dumitrescu and Hurlin (2012). Finally, to determine the sign of the relationship between economic growth and human capital, the panel dynamic OLS (PDOLS) technique proposed by Mark and Sul (2003) was applied.

The results from the various CD tests indicate that there is evidence of cross-sectional dependence in the panel. The results from the panel unit root tests indicate the economic growth variable is stationary process while the results for human capital was mixed. The results from both the group and panel cointegration tests suggest that the two variables share long run relationship. In other words, the two variables are found to be cointegrated. The results from the heterogeneous panel causality tests reveal that economic growth and human capital have bidirectional causality. Simply put, economic growth and human capital influence each other. The results from the PDOLS show that economic growth and human capital have significantly positive effect on each other. The results from this study support the notion that educated labor force is crucial in the creation, application, and adoption of new technologies, all of which engender economic growth. The findings of this study call for the authorities of the sample countries to increase their public expenditures on education.

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