The Importance of Human Capital Resources for Sustainable Economic Growth in East African

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Abstract

This study examines the important contributions of human capital resources for sustainable economic growth in East African over the period 1980–2018. Even if there is a rapid growth in the number of schools and students' enrolment in the education system in East Africa, the reality on the ground shows that the lowest level of human capital development raises the issues of employment challenges. In this regard, the estimation results reveal that the growth rates of human capital resources (HCR) and the physical capital stock (PCS) have long-run effects on the growth rate of gross national income (GNI). In addition, the short–term transmission mechanism of the vector autoregressive (VAR) system also indicates that HCR growth hugely contributes to the development of PCS through GNI.

Keywords: Economic Growth, Dynamic Panel, Human Capital Resource, and Wavelet Analyses
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1. Introduction

The underlying concept of human capital is traced back to Adam Smith, though the term was first used as applications by Pigou (1928), and followed by Becker (1964) and Mincer (1974). According to Becker, investment in human capital could be analogous to investment in physical capital. By investing in education, a potential employee is able to achieve a higher level of productivity that can be reflected in a higher wage or salary pay. However, early criticisms of human capital theory pointed out that the probability of earning differentials would result in various factors such as innate ability, motivation, social class and gender (Merrett, 1966). The crucial underlying assumption of labour market works in such a way that higher productivity reflects higher wage and that the effect of education on human productivity can be separated from other factors.

Human capital endowment, skills and capacities of the people in the productive sectors can be important determinants of long-term economic development. For an individual, or a community, investing in human capital is more crucial than any economic resources (World Economic Forum, 2013). Human capital is an essential element to the economic growth since better educated people are more likely to innovate, adopt new technology and enhance productivity (Lucas, 1993; Romer, 1993 and Fishlow, 1966). Moreover, advancement in technology and more income generation and accumulation of wealth can be created in countries where high levels of human capital resources are available than those that do not have (UNHD, 2014). In addition, good governance, institutional reform and improvement in the educational system can play a more important role in raising economic output and efficiency of a country (Gylfason and Hochreiter, 2008).

According to the studies by UNDP (1997, 2013) and World Economic Forum (2013), a sustained improvement in Sub–Saharan Africa human development is found to be very low. This problem is common to East African countries as they are part of the Sub-Saharan Africa, facing similar economic, social and environmental challenges in the development process. The potential challenges include inequality and equity concerns, high rates of poverty, unemployment and inflation rates (United Nations, 2013). Even though the low level of human development in East Africa, there has been a rapid growth of some aspects of human capital, particularly the expansion of education in terms of the number of schools and students' enrollments. However, the growth of the human capital stock itself has not been matched with a commensurate rise in physical capital due to the low level of income growth and the low returns to the education investment as the study shown by Simon and Francis (1998).

Most scholars argue that considering only the physical capital is impossible for the poor countries to sustainable growth. Poor countries must concentrate first on technological progress generated and easily adopted by human capital. Second, they gradually need to accumulate physical capital as the economy depends more on technological progress than the physical capital. In this sense, this study seeks to examine the importance of human capital resources for sustainable economic growth in East Africa.

Thoroughly studying several related empirical literature, an attempt has been made to develop a unique approach to the economic analysis. This study begins with a transformed original data into demeaned dataset (the difference between the individual and the common average in the series of date), to make sure the non–violating classical econometric assumptions of no autocorrelation and cross–sectional independence among panel countries. In fact, it has been checked by these and others issues with the help of their respective standard methods of tests. Calculating some indices is used as explanatory variables along with human capital resources (HCR), taking GDP growth rate as a dependent variable over–time. The human capital resources are sought by applying geometric mean associated with index composite of life expectancy, education, income and school enrolment mean indices. The physical capital stock is calculated using an inventory method.

It is also intended to make a methodological contribution to the economic analysis by designing a new approach called *panel time scaling wavelet*. The panel time scaling wavelet analysis enables us to separate a long timeseries into different layers. It is applicable to make the bivariate analyses by extending the traditional standard methods of the panel multivariate VAR transmission channel method to ensure the dynamic intertemporal causal effects and estimation coefficients of the main determinants and the real GDP growth rate in the short, medium and long term. These kinds of methodological analyses are new in the academic arena as they have never been used in macroeconomic panel data. Thus, it is possible to say that a new insight has been added as a significant contribution to the development of existing knowledge on the economic analysis, by identifying a gap in the statement of the problem that ultimately makes this study a different one.

Understanding and addressing the challenges related to human capital is thus a fundamental to overcome the problems of short-term stability and the long-term growth, providing prosperity and competitiveness of the nations in the region. In this regard, the purpose of this study is to analyze empirically the main determinants of economic growth while the general objective is to examine the importance of HCR to the economic growth in the short, medium and long run. Thus, this kind of study conducted in this area is of the most significant one in order to provide tangible information for the policymakers to take some actions and to serve as a foundation for motivating other researchers to conduct further studies on related areas.

Following is section two that describes the reviewed related literature. The subsequent sections are intended to deal with the methodological issues and empirical findings and discussions. Finally, the main findings of the study are presented with a conclusion Provided.

2. Review of the Related Literature

In this section, an attempt has been made to carefully review the related empirical literature to human capital resources and physical capital stocks development and their relationship with economic growth from different studies. Among others, the studies by Kanu and Ozurumba (2014), Rakotoarisoa, Shapouri and Trueblood (2014), Orla et al., (2013), and Ndambiri et al., (2012) are examined. Furthermore, empirical studies of Richard and Blessing (2010), Daniel and Marc (2004), Paula, John and Goddard (2001), Freddy et al., (2003), Jess and Mark (1994), Jorgenson and Fraumeni, (1989, 1992), and Wei (2004) have been explored. Out of these empirical studies, the most comprehensive are Jorgenson and Fraumeni, (1989, 1992) as they have used income-based approach on the US economy and Wei (2004) based on a lifetime labor income and gross human capital formation on Australian economy since both of them reveal that investment in education and training are used to measuring human capital.

Despite the fact that various kinds of human capital stocks measurement are developed, estimating the relationship between educational attainment and enrolment in primary, secondary and tertiary education in terms of human capital investment are the most important variables to be considered (see Kyriacou, 1991). Mankiw, Romer and Weil (1992) also added to the views of estimating the coefficients of production function using flows of investment as a proxy for capital stocks. Barro and Lee (1993) and Wossmann (2003) also showed the positive effect of human capital on macroeconomic performance using indicators such as number of educational facilities, ratio of government expenditure on training to GDP and per capita expenditure on education. Some other studies like Barro (1991) and Mankiw, Romer and Weil (1992) took school enrolment as a proxy for human capital and Benhabib and Spiegel (1994) and Krueger and Lindahl, (2001) used the average years of schooling of workers for human capital. The per capita wealth is used as a proxy for human capital in various regions of the world by disaggregating several factors into human capital, physical capital and natural resources (for detailed see Barro, 1998).

The contribution of human capital formation to economic growth has been described in many studies by Urélien and Yannick (2015), Sahbi and Jaleleddine (2015), Wendy and Umar (2013), Catia (2013), and Edgar, Alexander and Axel (2012). Similarliy, studies by Alexandra and Jacob (2011), Andrew, Robert and Fabio (2007), Verma, Wilson and Pahlavani (2007), Wang and Yao (2002), and Schultz (1998) are also included in the study because of their studies on the contribution of human capital to the economic growth.

It is observed that the empirical study of Yasmina and Stephen (2004) that emphasized the cross-country patterns of economic growth in estimating stochastic frontier production function for the eighty developed and developing countries have been assessed. Omolola (2013) also shows the benefits from migration aspects. There is also one important work by Mohsen and Maysam (2013) that investigates the causal relationship between gross domestic investment and GDP for the Middle East and North African countries using panel cointegration analysis over the period of 1970–2010. The studies result show that there is a strong causality from economic growth to investment. Furthermore, Kanayo, (2013) has empirically shown the evidence from the developing countries perspective and his study suggests that the importance of human capital formation to economic growth has been the major drive of the nation’s development process.

The panel data econometrics has been used for estimating and forecasting purposes as cited by (Baltagi, 2005). Dynamic panel estimators have increasingly been used in growth theory (Baltagi, 2005, Easterly, 1997 Islam, 1995 and Arellano and Bond, 1991). The dynamic relationships are characterized by the presence of lagged dependent variable that appears as independent variable with other regressors. The long-run estimation under dynamic panel econometric models explains macroeconomic events by specifying preferences, technology and institutions and predicts as well as what is actually produced, traded and consumed and how these variables respond to various shocks (William, 2010).

Bichaka and Christian (2008) use unbalanced panel data from1980 to 2004 for thirty-seven African countries. They also tried to show that the aggregate impact of remittances that are related to human capital resources of a given country have impacts on economic growth. In this regard, the study reveals that remittances are boosting growth in countries where financial systems are less developed as they send money to their home country. However, Valeriia (2009) investigated the impact of capital flight on economic growth from one hundred thirty-nine countries in the year interval of 2002 to 2006 that displayed a negative impact on GDP growth. This presentation is because of the fact that even if in a country where high level of human capital resources is secured, the growth rate of GDP can be influenced by other factors such as capital withdrawal. Bangake and Eggoh (2010) studied the international capital mobility of thirty-seven African countries with panel cointegration methods over the period of 1979–2006. The findings indicated that the lowest are non-oil producing countries as opposed to that of oil producing ones.

Khaled and Willi (2006) studied the role of education and human capital in Egyptian economic growth from the year 1959 to 2002 using the Solow residual. They came to conclude that education and human have not been able to form a consensus of the causality between human capital and growth. Similarly, Mohamed and Nassima (2003) have made an assessment on the labor outcomes in Algeria and they came up with the conclusion that the main problems behind the low contribution of labor market lie on inefficient labor market institutions, absence of economic diversification and low participation of the private sector in the economy.

Comparing the Sub–Saharan Africa countries with the South East Asian countries on the economic growth potential, Michael (2011) pointed out that in the 1950s and1960s most Asian countries economy were destined for prolonged poverty, while Africa was totally engaged in independence victory that ultimately encouraged great optimism. However, the East Asian economic performance has given rise to a large literature in studying the so-called growth 'miracle', while the Sub–Saharan Africa has attracted attention for exactly the opposite reason. The failure of many countries in the region led to the failure in maintaining sustainable per-capita income growth after the 1970s (Robin, 2011). This is due to the fact that sustainable per-capita income growth causes high growth rate of GDP.

According to the study by Oleg, Daniel and Romain (2012), in the decomposition of labor productivity growth, physical capital accumulation is the largest share in economic growth. On the other hand, Jeffrey and Andrew (1997) suggested that the slow growth in Africa is the result of poor economic policies due to lack of openness to international markets and geographical factors such as lack of access to the sea and the tropical climate. Arthur and Maxime (2014) empirically tried to show the influence of macroeconomic volatile on physical capital accumulation in the Sub-Saharan economies. This study indicated that a one-unit increase in the conditional standard deviation of the real effective exchange rate led to a 0.011 percentage decrease in the stock of physical capital.

Coming to East Africa, regardless of the economic theory that postulates that an increase in investment in human capital and physical capital leads to an increase in economic growth. However, the specifically the Kenyan case doesn't show the stated fact (see Nelson and Fredrick, 2006). Moreover, a significant decline in domestic savings over the years, there is an increase in the growth of fixed capital formation in Ethiopia. This is due to the low level of per capita income, potentially one major factor of the low level in savings (EEA, 20003/04). This is true because saving rate, income and economic growth have positively related. It is also observed that the empirical work of Khadharoo and Seetanah (2006) on the relationship between public capital and economic growth of the Mauritius economy over the period 1950–2000, using the vector error correction model which to indicate that public capital had significantly contributed to the economic performance.

In summary, the reviewed empirical studies show the importance of human capital resources for sustainable economic growth. The study looks into the analysis in depth for the important contributions of human capital resources to economic growth with certain combined methods. The methods are dynamic panel transmission channels of the VAR system, and they have been further extended to the bivariate panel wavelet time scale analysis.

3. Methodology of the Study

3.1 Data Sources and Variables descriptions

Panel datasets of nine selected East African countries including Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Rwanda, Tanzania and Uganda are used to undertake the panel analyses over the period of 1980–2018. The sources of data for this study are from the World Bank development indicators, the United Nations aggregate databases and International Monetary Fund Economic outlook. It is considered that data on gross national income (GNI) at constant 2005 USD price, (which has been recently available on the series of dataset) is the dependent variable while other are explanatory variables. The explanatory variables comprise of a total factor productivity (TFP), human capital resources (HCR) that uses a proxy for human development and physical capital stock (PCS) are the author's calculated indices. The indexed variables are calculated by the author based on the economic theory as it can be seen under specification of dynamic panel econometric model.

3.2 Measuring Physical Capital Stock and Human Capital Resources

In economics, physical capital is a factor of production consisting of machinery, buildings, computers among others. Marshall and Mariam (2005) have estimated a fixed capital consumption as a part of measurements for the net national income and multi-factor productivity changes. Physical capital is the difference between gross investment and fixed capital consumption as it is pointed out by (Berlemann and Wesselhoft, 2014) in their study.

Human capital measures are sensitive to alternative assumptions about income growth and discount rates, smoothing and imputation of labor force and school enrolment data (Michael, 2011). In addition, conventional measurement of human capital focuses neglecting the importance of its non-monetary aspects such as creating added-values and social networks. Therefore, a direct measurement of human capital resources is a difficult task (Kwon, 2009). However, the United Nations (2008) study emphasises that an accurate measure of labor and capital inputs is based on the breakdown of aggregate hours worked and aggregate capital stocks into various components are essential. The hours worked are cross–classified by educational attainment gender and age with the aim to proxy for differences in work experience. Thus, human capital is increasingly believed to play an important role in the growth process, even if adequate measuring of its stock remains controversial as the evidence is supported by the economic theory cited in (Trinh et. al., 2002).

Human capital resource may be measured either by human capital index or human development index. Human capital index is a new measure for capturing and tracking the state of human capital development around the world while human development index is a summary measure for assessing long-term progress in three basic dimensions of human development such as long and healthy life, access to knowledge and decent standard of living (UNDP, 2013).

3.3 Specification of Dynamic Panel Econometric Model

Countries endowed with large stock of human capital eventually emerge as technological leader in a specific time and maintain the leadership as long as human capital advantage is sustained (Jess and Mark, 1994). Fairly strong positive association exists between the gross income and the life expectancy across developing countries, even though the associations do not reveal causality (Oded, 1993).

In order to calculate human development index used as a proxy for human capital stock, it is considered that the (UNDP, 2013) minimum and maximum values of the goalposts of the observed values in the time series interval 1980–2012. The justification for choosing these values as a reference time period is that there is no any other dataset which refers about human development index set by UNDP. The values are set in order to transform indicators into indices between 0 and 1. The maximum value is set at 83.6 years for life expectancy of Japan in 2012 (since this value has not been determined on the yearly basis) the expected years of schooling at 18 years. The combined education index of 0.971 from New Zealand in 2010 and the gross national income GNI of 87,478 USD in purchasing power parity of Qatar in 2012 are also considered. While the minimum values are set at 20 years for life expectancy, at 0 years for education variables and at $100 for the national income per capita NIPC (UNDP, 2013 and CIA, 2006, 2015).

Therefore, by defining human capital accumulation (HCR) as human development index, the geometric mean of normalized indices of life expectancy index (LEI), school mean enrolment Index (SMEI), education index (EI) and income index (II) are calculated in the following way:

$$\mathrm{HCR} \equiv \mathrm{HDI} = (\mathrm{LEI} \times \mathrm{EI} \times \mathrm{II})^{\frac{2}{3}} \quad \textbf{(1)}$$

where LEI is the ratio of the difference between life expectancy at birth in years and minimum value to the difference between maximum and minimum values, SMEI denotes the ratio of the difference between mean of school enrolment and minimum value, EI represents the ratio of the difference between the square root of the LEI and SMEI product and observed minimum value to the difference between maximum and minimum values and II is the ratio of the difference between GNI and minimum value in logarithmic term to the difference between the maximum and minimum values in logarithmic term.

The school life expectancy is the total number of years of schooling from primary to tertiary level that a child can expect to receive, assuming that the probability of his or her being enrolled in school at any particular future age is equal to the current enrolment ratio at that age (CIA, 2006, 2015).

Under perpetual inventory method as Berlemann and Wesselhoft (2014) have mentioned the net physical capital stock at the beginning of the current period (PCS_t) can be expressed as the sum of one period lag in physical capital stock (PCS_{t-1}) and total investment (TI_{t-1}) minus fixed capital consumption (FCC_{t-1}) which causes depreciation. Thus, it can be calculated that the current physical capital stock based on this perpetual inventory theory as:

$$PCS_t = PCS_{t-1} + \mathrm{TI}_{t-1} - \mathrm{FCC}_{t-1} \qquad \textbf{(2)}$$

This implies that the change in physical capital stock (ΔPCS_t) is given by

$$\Delta PCS_t = PCS_t - PCS_{t-1} = \mathrm{TI}_{t-1} - \mathrm{FCC}_{t-1} \qquad \textbf{(3)}$$

The initial capital stock based on Harberger (1978) approach of the neoclassical growth theory can be employed which relies on the assumption that the economy is in its steady state. As a consequence of output grows at the same rate as capital stock would be given as:

$$g_{GDP} = g_{PCS} = \frac{\mathrm{TI}_{t-1}}{PCS_{t-1}} - \delta = \frac{PCS_t - PCS_{t-1}}{PCS_{t-1}} \Rightarrow PCS_{t-1} = \frac{PCS_t - PCS_{t-1}}{g_{GDP}} \qquad \textbf{(4)}$$

Plug Equations (4) and (3) into Equation (2), then the result looks (**5**)

$$PCS_t = \frac{\mathrm{TI}_{t-1} - \mathrm{FCC}_{t-1}}{gGDP_t} + \mathrm{TI}_{t-1} - \mathrm{FCC}_{t-1} \qquad \textbf{(5)}$$

In the actual context, the production function tends to be increasing returns to scale according to neoclassical model (Schmidt-Hebbel.1994 and Easterly and Levine, 1994). Adding to this, in the model specification of the classical theory, there exist technological spillovers and increasing returns to scale (Barro and Sala-i-Martin, 2003). Accordingly, it can be expressed as a gross national income (GNI) as dependent variable whereas technological level of total factor productivity (TFP), human capital resources (HCR), and physical capital stock (PCS) and total labor forces (TLF) as explanatory factors; following the endogenous model specification in the Cobb-Douglas production function as

$$\mathrm{GNI}_t = \mathrm{A_t}(\mathrm{HCR_t})^{\alpha_t}(\mathrm{PCS})_t^{\beta_t}(\mathrm{TLF})_t^{\gamma_t}\mathrm{e}^{\varepsilon_t} \quad ,\alpha+\beta+\gamma>1 \qquad \textbf{(6)}$$

It is possible to0 take log differences of Equation (6) to set up the relationship for long-term growth from time t-1 to time t can be specified as

$$(\mathrm{lnGNI_t} - \mathrm{lnGNI_{t-1}}) = \alpha_t \mathrm{lnA_t}(\mathrm{HCR_t}) - \mathrm{lnA_{t-1}}(\mathrm{HCR_{t-1}}) + \beta_t(\mathrm{lnPCS_t} - \mathrm{lnPCS_{t-1}}) + \gamma_t(\mathrm{lnTLF_t} - \mathrm{lnTLF_{t-1}}) + (\mathrm{ln}\varepsilon_t - \mathrm{ln}\varepsilon_{t-1}) \qquad \textbf{(7)}$$

Specifying the first term in Equation (7), $\mathrm{TFP_t}$ depends on the level of human capital, reflecting the effect of domestic endogenous innovation. Take the expected value in both sides of Equation (7) and divide by $\frac{1}{\alpha_t}$ then it can be done as the expected total factor productivity $\mathrm{TFP_t}$ depending on the level of human capital resources given by

$$\mathrm{E}[\mathrm{lnA_t}(\mathrm{HCR_t}) - \mathrm{lnA_{t-1}}(\mathrm{HCR_{t-1}})] = \mathrm{E}\left(\frac{\mathrm{lnGNI_t} - \mathrm{lnGNI_{t-1}}}{\alpha_t}\right) - \mathrm{E}\left(\frac{\beta_t}{\alpha_t}(\mathrm{lnPCS_t} - \mathrm{lnPCS_{t-1}})\right) - \mathrm{E}\left(\frac{\gamma_t}{\alpha_t}(\mathrm{nTLF_t} - \mathrm{lnTLF_{t-1}})\right) - \mathrm{E}\left(\frac{(\mathrm{ln}\varepsilon_t - \mathrm{ln}\varepsilon_{t-1})}{\alpha_t}\right)$$

Since the expected value of error term $E(ln\varepsilon_t - ln\varepsilon_{t-1})$ is zero, TFP_t augmented with human capital can be, thus

$$\mathrm{TFP_t} = \left(\frac{\mathrm{lnGNI_t} - \mathrm{lnGNI_{t-1}}}{\alpha_t}\right) - \left(\frac{\beta_t}{\alpha_t}\right)(\mathrm{lnPCS_t} - \mathrm{lnPCS_{t-1}}) - \left(\frac{\gamma_t}{\alpha_t}\right)(\mathrm{lnTLF_t} - \mathrm{lnTLF_{t-1}})$$

$$\mathrm{TFP_t} = \left(\frac{\Delta\mathrm{lnGNI_t}}{\alpha_t}\right) - \left(\frac{\beta_t}{\alpha_t}\right)\Delta\mathrm{lnPCS_t} - \left(\frac{\gamma_t}{\alpha_t}\right)\Delta\mathrm{lnTLF_t} \qquad \textbf{(8)}$$

where $\frac{\alpha_t}{\alpha_t+\beta_t+\gamma_t}$, $\frac{\beta_t}{\alpha_t+\beta_t+\gamma_t}$ and $\frac{\gamma_t}{\alpha_t+\beta_t+\gamma_t}$ are the share of human capital resources, physical capital stock and total labour force in total costs derived from (6). Their respective elasticity in continuous and discrete form in each are given as

$$\alpha_t = \left(\frac{\partial lnGNI_t}{\partial lnHCR_t}\right)\left(\frac{lnHCR_t}{lnGNI_t}\right),\ \beta_t = \left(\frac{\partial lnGNI_t}{\partial lnPCS_t}\right)\left(\frac{lnPCS_t}{lnGNI_t}\right) \text{ and } \gamma_t = \left(\frac{\partial lnGNI_t}{\partial lnTLF_t}\right)\left(\frac{lnTLF_t}{lnGNI_t}\right) \ \&\ \alpha_t = \left(\frac{\Delta lnGNI_t}{\Delta lnHCR_t}\right)\left(\frac{lnHCR_t}{lnGDP_t}\right),$$

$$\beta_t = \left(\frac{\Delta lnGNI_t}{\Delta lnPCS_t}\right)\left(\frac{lnPCS_t}{lnGNI_t}\right) \text{and } \gamma_t = \left(\frac{\Delta lnGNI_t}{\Delta lnTLF_t}\right)\left(\frac{lnTLF_t}{lnGNI_t}\right).$$

Therefore, based on the idea of Baltagi (2005), it can be expressed as $\mathrm{lnGNI_{it}}$ as a function of total factor productivity ($\mathrm{TFP_{it}}$), human capital resources ($\mathrm{HCR_{it}}$) and physical capital stock ($\mathrm{PCS_{it}}$). These explanatory variables are the most influential determinants, which potentially affect the economic or GDP growth rate of a country. The dynamic panel form including lagged dependent variable can be expressed in terms of panel vector autoregressive VAR system contains a set of n variables plus error term is given by

$$\mathrm{lnGNI_{it}} = \pi_0 + \pi_{1p}\sum_{l=1}^{P} \mathrm{lnGNI_{i,t-l}} + \pi_{2q}\sum_{l=0}^{q} \mathrm{TFP_{i,t-l}} + \pi_{3m}\sum_{m=0}^{r} \mathrm{HCR_{i,t-m}} + \pi_{4n}\sum_{n=0}^{s} \mathrm{PCS_{i,t-n}} + \varepsilon_{it} \qquad (\mathbf{9})$$

Where π are parameters to be estimated and p, q, r and s denote optimal lag length. $\boldsymbol{\varepsilon_{it}}$ are white noise random disturbances. In dynamic panel data regression described in Equation (9), it is not possible to apply the OLS, GLS, Fixed and Random effects methods because $\mathrm{lnGNI_{i,t-1}}$ is correlated with $\boldsymbol{\varepsilon_{it}}$ so that the results will be inconsistent. If $\boldsymbol{\varepsilon_{it}}$ is independently identical distribution iid, it will be correlated with $\mathrm{lnNIPC_{i,t-1}}$. It is supposed that GNI_{it} be a p ×1 vector of cross-section i in period t, follows a non-stationary VAR (p) process.π_0 is a k ×1 vector with the j-th element representing the deterministic component of the model ϑ_{it} are a k ×1 vector of disturbances and are independent N (0, $\Omega_{i,t}$) for t=1, T (see Anderson et al. ,2006).

Based on lagged observations used as the explanatory variables, dynamic estimators are designed to address the problems of the unobserved specific effects and the joint endogeneity of explanatory variables (Alonso-Borrego and Arellano, 1996). In dynamic panel estimators, it is possible to apply the differenced equation to remove any bias and potential parameter inconsistency arising from simultaneity bias created by the unobserved country-specific effects and use lagged values of the original regressors. In cases where the cross-sectional dimension is small- and the-time dimension is relatively large, the standard time series techniques are applied to the systems of equations and the panel aspect of the data should not pose new technical difficulties (Breitung and Pesaram ,2005).

The importance of time scale wavelet analysis is desirable one to find the local orthonormal bases consisting of small waves that dissect a function into layers of different scale. The segmentation of time series into different layers makes a very powerful wavelet analysis in the short, medium and long run and now it has been become popular and increasingly used in economic literature (see Ramsey and Lampart, 1998; Almasri and Shukur, 2003 Hacker, Karlsson, and Månsson, 2012 and Reboredo and Rivera–Castro, 2014). The maximal overlap discrete wavelet decomposition in the methodology that it is used to allow for moving averages at every scale level and avoids the problems of calculating the moving averages consistently throughout the series by reusing observations in a circular loop. The last value of the original series is simply the first value of that series (Hacker, Karlsson and Månsson, 2012). Since wavelets are local orthonormal bases consisting of small waves that dissect a function into layers of different scale. Given the Haar function with the domain [0,1], the wavelet transformation is

$$f(x) = C_0 + \sum_{\lambda=1}^{n} \sum_{k=0}^{n\, 2^{\lambda-1}} C_{\lambda k \psi}\,(\lambda, k, \psi) \qquad \mathbf{(10)}$$

where C_0 is the overall mean of the data and it along with the $C_{\lambda k\psi}$values are the wavelet coefficients?

Suppose there is a vector of actual time series observations y, with its elements ordered according to uniform units of time, as are the vectors with the level–λ smooth and detail series,S_λ and D_λ. Let the level-zero smooth series $s_0$is defined to be the same as the vector of actual observations y. The following two formulae describe how the smooth and detail series are calculated at scale levels of 1 and higher,

$$S_{\lambda,t} = \frac{S_{\lambda-1,t-2^{\lambda-1}} + 2S_{\lambda-1,t} + S_{\lambda-1,t+2^{\lambda-1}}}{4} \text{ and } D_{\lambda,t} = \frac{-S_{\lambda-1,t-2^{\lambda-1}} + 2S_{\lambda-1,t} - S_{\lambda-1,t+2^{\lambda-1}}}{4}$$

It is always the case that the original series may be reconstructed by adding to the smooth series of the largest scale level consider dΛ, the sum of the detail series from level 1 to level Λ is given by

$$y = S_{\Lambda} + \sum_{\lambda=1}^{\Lambda} D_{\lambda} \qquad \textbf{(11)}$$

Where below are demonstrated the patterns on how these equations work for three scale levels, keeping in mind that $S_{0,t} = y_t$ at scale level, 1 it is calculated as:

$S_{1,t} = \frac{y_{t-1}+2y_t+y_{t+1}}{4}$, $D_{1,t} = \frac{-y_{t-1}+2y_t-y_{t+1}}{4}$, $S_{2,t} = \frac{S_{1,t-2}+2S_{1,t}+S_{1,t+2}}{4}$, $D_{2,t} = \frac{-S_{1,t-2}+2S_{1,t}-S_{1,t+2}}{4}$,$S_{3,t} = \frac{S_{2,t-4}+2S_{2,t}+S_{2,t+4}}{4}$, $D_{3,t} = \frac{-S_{2,t-4}+2S_{2,t}-S_{1,t+4}}{4}$ & $S_{4,t} = \frac{S_{3,t-8}+2S_{3,t}+S_{3,t+8}}{4}$, $D_{4,t} = \frac{-S_{3,t-8}+2S_{3,t}-S_{3,t+8}}{4}$.

The associated wavelet details, D_1 to D_{Λ} are the decompositions of the two data at different timescales and S_{Λ} represents the long-term trend at scale level Λ, which corresponds to zooming out the camera lens and looking at the broad land scape (Hacker, Karlsson, and Månsson, 2012).

In this kind of method, the estimation is clearly made not at a time, but one after another by taking others explanatory variables remain constant. This means when the estimation of the inter–temporal causal relationship of the growth rate of real GNI–HCR is made, while others are assumed to be unchanged and panel wavelet time scaling of the bivariate analysis which are jointly determined by the panel VAR method, it is possible to use Equation (9) as:

$$lnGNI_{it}^{D_{j,t}} = \Gamma_0 + \sum_{k=1,D_{j=1}}^{K,j=h} \Gamma_1^{(k)} lnGNI_{i,t-k}^{D_{j,t}} + \sum_{k=1,D_{j=1}}^{K,j=h} \Gamma_2^{(k)} HCR_{i,t-k}^{D_{j,t}} + \sum_{k=1,D_{j=1}}^{K,j=h} \Gamma_4^{(k)} PCS_{i,t-k}^{D_{j,t}} + \varepsilon_{it}$$

where D stands for the differences, K for the number of lag length, i for the cross-sectional dimension, and t for time dimension, are respectively. j=1, …, h, denotes time scale decomposition into different layers of the entire panel datasets.

4. Discussions and Empirical Findings

4.1 Optimum Lag-length Determination

Lag-length determination is the key point in the process of testing and estimation. The Akakie information and other criteria are often used to choose the optimal lag length distributed-lag models. In the estimation of optimum lag-length, it is possible to compute log-likelihood function and various types of information criteria for each choice used in accordance with the analyses made in the studies by (Johansen,1988,1991,1995). Thus, for pre-estimation of an VAR model selection to be used, together with the final prediction error (FPE), Akaike information criteria (AIC), Schwarz information criteria (SiC) and Hannan-Quinn information criteria (HQic) with the least values indicating (see Akakie, 1974) as shown below (in Table 4.1). Therefore, the optimum lag length of three that is going to be used for the entire analysis is chosen.

Table 4.1 Choosing of Optimum Lag Length

VAR Lag Order Selection Criteria
Endogenous variables: $lnGNI_{it}, HCR_{it}, TFP_{it}, PCS_{it}$

Lag	LogL	FPE	AIC	SIC	HQIC
0	-16117.31	3.46e+13	48.2012	48.2416	48.2169
1	-10617.12	2781676	31.8658	32.1487	31.9754
2	-10489.88	2117686	31.6931	32.1184	31.7966
3	-10470.57	2026137*	31.6429*	32.0907*	31.6404*
4	-10442.37	2278941	31.6663	32.6765	32.0576

* indicates lag order selected by the criterion with the least values

4.2 Panel and Individual Cointegration T-tests

It is necessary to take into account the panel cointegration methodology developed by Johansen (1988,1991,1995) which highlights that one can be confident when eigenvalues problem is solved and inferences of the test hypothesis about cointegrating relationship among the variables are confirmed. Like panel unit root tests, panel cointegration tests can be interested as it is more powerful than the individual time series cointegration tests. The interactions of short-run dynamics between the cross-sections influence of other members in a panel of the cross-section brings a long-run equilibrium. These differences can make ranks in the cross-sectional cointegration (Anderson, Qian and Rasch, 2006).

Accordingly, conducting the Johansen cointegration tests for a panel of ten countries a priority and following that it is possible to obtain the number of cointegration equation which is found to be four. The test for individual separately at the 5% level of significance is calculated using the trace and the maximum eigenvalue tests. Thus, Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Rwanda, Tanzania, Uganda and Zambia have shown number of equations as (3,1) ;(4,1) ;(1,0) ;(1,1) ;(1,1) ;(2,1) ;(2,0) ;(1,0) ;(1,1) and (0,0), respectively. The numbers in the brackets are the trace and the maximum eigenvalues in their order of respect. Out of ten countries, Zambia is rejected since there is no cointegrating equation in both cases of tests. When the trace and the maximum eigenvalue is statistically different, it is necessary to take trace test (Alexander, 2001). that is the reason why nine countries have passed with cointegrations. Finally, a test is conducted for a panel of nine countries, excluding Zambia. The test results are shown in (Table 4.2).

Table 4.2: Johansen test of Panel Cointegration for HCR- Economic Growth

Dependent Variable: ln (GNI)

Hypothesized No of CE(s)	Trace Test				Maximum Eigenvalue Tests		
	Eigenvalue	Statistic	5% C. Value	P. Value	Eigenvalue	5% C.V.	P. Value
None	0.2187	119.75	47.856	0.0000*	64.413	27.584	0.0000*
At most 1	0.1043	55.339	29.797	0.0000*	28.758	21.132	0.0035*
At most 2	0.0752	26.581	15.495	0.0007*	20.417	14.265	0.0047*
At most 3	0.0233	6.1638	3.8415	0.0130*	6.1638	3.8415	0.0130*

The Johansen test of Panel Cointegration performed for unrestricted Rank(r). * denotes rejection of the null hypothesis at the 5% level of significance. The trend assumption is linear deterministic with optimum lag-length of 3.

The results in (Table 4.2) show that the Johansen test for cointegration for a panel of nine countries in the unrestricted rank multivariate analyses do exist. The null hypothesis of no cointegration is rejected, at most one, two and three cointegrations. Since the trace and maximum eigenvalue statistics exceed their respective critical values conventionally at the 5% level of significance. Both tests indicate there are four cointegrating equations.

Both the trace and the maximum eigenvalue tests in the first column of (Table 4.2) indicate that the number of cointegrating vectors, in which the hypotheses of the variables are non-cointegrated ($r = 0$) against the alternative of one or more cointegrating vectors ($r > 0$). Since the values of trace statistic (0) and maximum eigenvalue statistic (0) exceed their respective critical values at the 5 % significance level. the null hypothesis is rejected at zero cointegrating vectors (r=0) and accept the alternative hypothesis of more than zero cointegrating vectors (r>0). Likewise, the values of trace statistic (1) and maximum eigenvalue statistic (1) are also greater than their respective critical values at the 5 % significance level. the null hypotheses rejected at $r \leq 1,\ r \leq 2\ and\ r\ \leq 3,$ cointegrating vectors (r=1, r=2 and r=3), however, it is impossible to reject the alternative hypotheses of more than one, two and three cointegrating vectors (r>1, r>2 and r>3). From these tests it is suggested that the Johansen test of trace and maximum eigenvalue reveal number of cointegration vectors is four within the series of lnNIPC, TFP, HCR and PCR. Hence, the undertaken variables are integrated of the same order in the variable in each four series data and they move together towards the long run equilibrium or they have long run relationship.

4.3. Cross-sectional Dependence and Endogeneity Tests

Before estimating parameters, data must be cross-sectionally independent by applying the demeaned method (i.e., the difference between actual observation and common mean) of the panel. Since estimation in the presences of cross–sectional dependence causes bias and inconsistency as Andrew (2005) pointed out. It is considered that the standard augmented Dickey–Fuller ADF regression with the cross–section averages of lagged levels and first-differences of the individual series for cross–sectional dependence test (Pesaran, 2007). The limiting distribution of this test is different from the Dickey–Fuller distribution due to the presence of cross–sectional lagged level in which (Pesaran, 2003) uses a truncated version of (Im-Pesaran and Shin,1997) test to avoid the problem of moment calculation (Baltagi,2005). Based on an AR (ρ) error specification, the relevant individual cross sectional augmented Dickey–Fuller (CADF) statistics are computed from the ρ^{th} order cross- section.

With the transformed data by the demeaned method in (Walter, 2003), regression is made to consider the differenced variable as dependent and its one period lagged as independent variables. Eventually after transformation of the original data, a test is carried out for the cross-sectional dependence of the individual explanatory variables (for detailed information, see Pesaran, 2007). Consequently, it is confirmed that there is no cross-section dependence among four explanatory variables. The output generated for the test will be accessed from the author based on the request. Finally, before arriving at the process of estimation of the parameters, it is necessary to check endogeneity problem that arises from simultaneous equations model with the help of two stages least squares 2SLS, (see, Wooldridge, 2002, 1997a for detailed). In the presence of endogeneity problem, estimation becomes bias and inconsistent. Consider the following simultaneous equations of $\text{lnGNI} - \text{HCR}$ model where lnGNI and HCR are endogenous variables whereas others are predetermined.

$$\text{lnGNI} = \beta_0 + \beta_1\text{HCR} + \beta_2\text{PC}S + \mathbf{u} \qquad (\mathbf{9}\boldsymbol{a})$$

$$\text{HCR} = \beta_{10} + \beta_{11}\text{lnGNI} + \beta_{12}\text{TFP} + \text{v} \qquad (\mathbf{9}\boldsymbol{b})$$

Equation $(9a)$ and $(9b)$ is exact–identified. Here, the two stages least squares 2SLS is applied for solving the problem of endogeneity as a result of simultaneous equations model. The reduced form equations estimated by OLS. That is, a regression of HCR on PCS and TFP is made by OLS method. The estimated human capital resource HCR–OLS is obtained. Then it is estimated that lnGNI as a function of HCR–OLS and PCS using (9). A regression of lnGNI on PCS and TFP is made by OLS method and the estimated lnGNI is obtain. Finally, HCR is estimated as a function of the estimated lnGNI and TFP by the OLS. These procedures are known as the two stages least square method 2SLS.

4.4 Dynamic Panel VAR Estimation of Long-run Coefficients

Based on the three-optimum lag–lengths (found in section 3.4.1), now it is possible to estimate the long–run parameters using panel VAR model and make use of other analyses. Unlike the analyses of long–run estimation parameters in various forms such as the Hayakawa and Kurozumi (2008) dynamic OLS, Phillips and Moon (1999, 2000) panel fully modified OLS estimators, Kao and Chiang (2000) panel fully modified OLS estimators and Anderson, Qian and Rasch (2006), the estimated coefficients result of panel vector autoregressive (VAR) model are asymptotically unbiased and normally distributed. Thus, the obtained results are revealed as follows.

Table 4.4.1: Dynamic panel VAR estimation of long-run Coefficients for HCR model

Variable	Coefficient	t-Statistic	P. Value
$\mathbf{lnGNI2SSLS_{it-1}}$	1.1082	12.900	0.0000**
$\mathbf{lnGNI2SLS_{it-2}}$	-0.0769	-0.6141	0.5397
$\mathbf{lnGNI2SLS_{it-3}}$	-0.0668	-0.7934	0.4283
$\mathbf{HCR2SLS_{it-1}}$	-0.3518	-1.4555	0.1468
$\mathbf{HCR2SLS_{it-2}}$	0.8384	2.7136	0.0071**
$\mathbf{HCR2SLS_{it-3}}$	-0.5019	-2.1969	0.0289*
$\mathbf{TFP_{it-1}}$	-0.0003	-0.1512	0.8799
$\mathbf{TFP_{it-2}}$	0.0021	1.4118	0.1592
$\mathbf{TFP_{it-3}}$	-0.0029	-2.0019	0.0463*
$\mathbf{PCS_{it-1}}$	0.0575	6.1274	0.0000**
$\mathbf{PCS_{it-2}}$	-0.0011	-0.0926	0.9263
$\mathbf{PCS_{it-3}}$	-0.0183	-1.9972	0.0469*
Constant	-0.0028	-0.2865	0.7747
R-squared	0.9653		
F-statistic	596.56		
Prob F-statistic)	0.0000		

** and * denote the level of significance at 1% and 5% with the optimal lag length of three. In order to make free from endogeneity problem, it is estimated that data on GNI and HCR by 2SLS and denoted as GNI2SLS and HCR2SLS. Model Diagnostics: The residual error terms are normally distributed, free from the problem of Autocorrelation and heteroskedasticity. The test results have been accessed from the author.

The results in (Table 4.4.2) can be interpreted as follows. One year lagged in the gross national income; two years lagged in human capital resources and one year lagged in physical capital stock have positively significant impact on the current gross national income (lnGNI) in the short run for a panel of nine East African countries over the period 1980–2018. Again, by looking at the coefficient of determination, R–squared value in (Table 4.4.1), the regression results show that about 96.5 percent variation in ln (GNI) is due to the joint effect of TFP, HCR and PCS. The F-statistic value is statistically significant which indicates our model specification is adequate and fit to the data.

Table 4.4.2 Short–run cumulative causal effects in the panel VAR transmission by Wald test

Hypothesized causal effect of the first variable on third variable through the second variable	χ^2	P. Value
1. H_0: HCR causes lnGNI and lnGNI causes PCS		
$lnGNI = F(HCR)$ and $PCS = F(lnGNI)$		
$HCR2SLS_{it-1} = HCR2SLS_{it-2} = HCR2SLS_{it-3} = 0$	8.1177	0.0333*
&		
$lnGNI2SLS_{it-1} = lnGNI2SLS_{it-2} = lnNGNI2SLS_{it-3} = 0$	7.9466	0.0471*
2. H_0: lnGNI causes HCR and HCR causes PCS		
HCR= F(lnGNI) and PCS= F(HCR)		
$lnGNI2SLLS_{it-1} = lnGNI2SLLS_{it-2} = lnGNI2SLLS_{it-3} = 0$,	20.695	0.0001**
&		
$HCR2SLS_{it-1} = HCR2SLS_{it-2} = HCR2SLS_{it-3} = 0$	7.1959	0.0659
3: PCS causes lnGNI and lnGNI causes HCR		
$lnGNI = F(PCS)$ and HCR= F(lnGNI)		
$PCS_{it-1} = PCS_{it-2} = PCS_{it-3} = 0,$	51.971	0.0000**
&		
$lnGNI2SLS_{it-1} = lnGNI2SLS_{it-2} = lnGNI2SLS_{it-3} = 0$	20.695	0.0000**

** and * denotes rejection of the hypothesis at the 1%, and 5% level of significance using the optimal lag-length of three.

After excluding the insignificant TFP from the panel VAR system in (Table 4.4.1), it can be conducted that the short-term VAR transmission mechanism channels using the Wald test and all the results are significant, except

HCR as you can see in (Table 4.4.2). This implies that there is a significantly important contribution of human capital resource (HCR) to the development of physical capital stock (PCS) through gross national income in log form (lnGNI). The growth of lnGNI has also a positive implication towards the accumulation of PCS via HCR. Explicitly it can be demonstrated that the inter-temporal relationship between the estimated lnGNI and HCR using the wavelet time scale analyses.

Table 4.4.3: Impulse–response Granger causality test of wavelet time scales for HCR model

Accumulated Responses from	Short-term	Medium-term	Long-term
lnGNI to HCR	0.0044	0.0099	0.0697
Calculated χ^2–value	(12.10)	(20.27*)	(57.85*)
HCR to lnGNI	-0.0007	-0.0001	0.0117
Calculated χ^2–value	(28.06*)	(35.16*)	(52.66*)

* Denote rejection of the null hypothesis of the explanatory doesn't Granger cause of the dependent variable. The lnGDP–2SLS and the FSD–2SLS denote the estimation of GDP in log form and FSD by 2SLS method to overcome the problem of endogeneity. It is calculated that the combined probability in the short, medium and long–run values in the time scale horizons using the formula, $\chi^2 = -2\sum_{i=1}^{L} \ln(P_i^2)$ where $-2\ln P_i$ which has a chi-square χ^2distribution and i stands for country 1, 2, 3..., L (see detailed information in Dmitri et.al., 2002 and Fisher, 1932).

The combined calculated χ^2 in the parentheses were compared with the conventional χ^2 which have been available in (Brooks, 2008). These conventional χ^2 of 15.98 at the 5% level of significance for 9 degrees of freedom which represents number of countries for HCR. Using the optimal lag–length of three in a VAR system, it is calculated that the chi-square and probability values for each country. a simple mean calculation is used for the combined mean coefficient of the time scale, denoted by time scale of β_1, β_2 and β_3 which represent the short, medium and long-term effects of HCR on GNL and vice versa. Finally, it is conducted that the Granger causality tests and estimation coefficients of a panel wavelet analysis in the time scale horizon decompositions with the help of VAR methods.

As it can be seen from (Table 4.4.3) unlike the usual causal effects, the wavelet analysis breaks down the entire series of data from the 1980 to 2018 one layer after another into the immediate Short, Medium and Long term. The results in (Table 4.4.3) show that the accumulated responses of GNI to HCR are positive significant in the medium and long terms while that of HCR to GNI are significantly negative in the short and medium terms and significantly positive in the long run for a panel of nine East African countries. These effects slightly increase over time which indicates that there are bi-directional inter-temporal causal relationships between HCR and GNI in the long-run. These mean, more educated and skilled human capital can produce sufficient amount of real gross national income for the countries and the reverse also holds true. thus, calculations are based on the Chlesky variance-response function with the help of the standard error of the Monte Carlo simulation.

The possible explanation for the unexpected negative accumulated response from HCR to GNI in the short and medium term may be the low-level capacities of the economy that are unable to accommodate more educated and skilled people. The empirical results of this study somehow are related to some previous studies such as the link between human capital and labor market of the Pakistan economy study by (Qadri and Waheed ,2014) and the critical unemployment high level in economic growth of the Spain and the Cyprus though the level of human capital. It is expressed as a percentage of tertiary educated in the study of (Cadil, Petkovováa and Blatnáb,2014). This idea may be also related to the studies by (Sahbi and Jaleleddine,2015, Mohsen and Maysam,2013, Ndambiri et al., ,2012, Anderson, Qian and Rasch,2006 and Freddy et al.,2003).

5. Conclusion

Human capital resource is the basic foundation for economic growth. Human capital endowments allocated to the productive sectors can be an important determinant of economic growth. The skills, knowledge, and innovation that people accumulate in due course are the greatest assets in such countries. Thus, it is possible to say that human capital brings sustainable economic growth.

Moreover, the East Africa region has the lowest level of human capital development, nevertheless, it displays a rapid growth in the expansion of education. The expansion of education system for the development of human capital stock itself has not been matched with a proportionate rise in physical capital due to the low level of income growth and the low returns to educational investments (Simon and Francis, 1998) that caused by the low levels of accommodation of the economy. This highlights the issue of employment challenges that women are going through more than men are. Instead of attending schools, they are being forced to marry at an early age. Due to financial constraints and traditional cultures their education opportunities are denied. In fact, labor theories and policies do not usually include a gender approach to labor challenges in modern economic theory.

Thus, physical policy is an important element in addressing the development of human capital issue in East Africa. This physical policy is all about the effective system of taxation on revenue generation for the governments and mobilizing other resources for inequality and equity concerns. However, in East Africa, this policy would be ineffective when it comes to narrowing the gap in societies in terms of income and wealth inequalities in addition to the lack of inclusiveness of economic growth for all beneficiaries.

In this study, the tests for non-stationery and others, before ultimately estimate the coefficients are conducted. The observed estimation indicates that the growth rates of human capital resources (HCR) and the physical capital stock (PCS) have long-run effects on the growth rate of gross national income (GNI) in a panel of nine East African countries over the period of 1980 to 2018. The short–term transmission mechanism of the VAR system applied in accordance with the Wald test which indicates that HCR growth contributes hugely to the development of PCS through GNI. The GNI growth has also a positive role in accumulating PCS via HCR.

It is explicitly demonstrated that the dynamic inter–temporal relationship between gross national income and human capital growth using a panel wavelet analysis in time scaling decomposition. Thus, the accumulated responses of GNI to HCR are positively significant in the medium–and long–term, while that of HCR to GNI are significantly negative in the short- and medium–run but positive in the long-run. These effects are slightly increased over time which indicates, there are bi–directional inter–temporal causal relationships between HCR and GNI and their robust estimation parameters are made. This leads to say that more educated and skilled human capital can produce sufficient amount of real gross national income for the countries and the vice versa. The possible explanation for the unexpected negative accumulated response from HCR to GNI in the short– and medium–terms may be the low-level capacity of the panel economy in East African countries to accommodate more educated and skilled people. It is also possible to argue that more due attention should be given to HCR than any other in attempt to achieve sustainable development in the process of successful economic progress.

The main policy recommendation of the study is that East Africa countries' governments should give more attention to human capital resources than any other. This is true because in order to achieve sustainable development in the process of successful economic progress, well-developed human capital plays a central role in the performance of the economy.

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