

Urgaia, Worku R.

Working Paper

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GLO Discussion Paper, No. 218

Provided in Cooperation with:

Global Labor Organization (GLO)

Suggested Citation: Urgaia, Worku R. (2018) : The Role of Human Capital Resources in East African Economies, GLO Discussion Paper, No. 218, Global Labor Organization (GLO), Maastricht

This Version is available at:

<https://hdl.handle.net/10419/179538>

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The Role of Human Capital Resources in East African Economies

Worku R. Urgaia

Addis Ababa University, Ethiopia and JIBS, Jonkoping University, Sweden

Abstract

This study deals with the role of human capital resources in economic growth. In economic growth, human capital is an important stock component that can affect the gross national income GNI more than gross domestic product GDP since GNI comprises the GDP itself and other income resources obtained from abroad. The empirical results of transmission mechanism channels in vector autoregressive model indicate that the observed human capital has long-run effects on the national income in a panel of nine East African countries from the year 1980 to 2015. The short-term transmission mechanism channels show that there is an important contribution of human capital resources HCR to the development of physical capital stock through GNI. The GNI has also a positive impact on the accumulation of physical capital stock via HCR. In addition, we also apply the time scaling decomposition of a panel wavelet analysis in Granger causality tests. The tests show that HCR and the GNI have a bi-directional causal relationship in the short-run, medium-and long-run. The recent trend shows that East Africa has the lowest level of human capital development which raises the issues of employment challenges faced by women more than men although it has achieved a rapid growth in expanding education. We, therefore, suggest that more due attention should be given to human capital resources than any other in attempt to achieve sustainable development in the process of successful economic progress.

JEL Classification: J00, J24

Keywords: *Dynamic Panel VAR, Transmission Channel, HCR, GNI and Granger Wavelet Analyses*

1. Introduction to Human Capital Resources

Human capital endowment, skills and capacities of the people in the productive sectors can be an important determinant of long term economic development. For the individual, societies and economies as a whole, investing in human capital is crucial; even more in the context of shifting population dynamics employing World Economic Forum (2013). Human capital is essential to economic growth since better educated people are more likely to innovate, adopt new technology and enhance productivity (see Lucas, 1993; Romer, 1993 and Fishlow, 1966)).

Advance in technology, education and income hold ever-greater promises longer, healthier and more secure lives are generated by human capital resources according to the study by UNHD (2014). The gross domestic product GDP is said to be the measure of a country's overall economic output based on location while the gross national income GNI is the total value that is produced within a country, which comprises of the GDP along with the income obtained from other countries such dividends and interests.

The sources and patterns of economic growth, the factor flows and impact of national policies on economic growth are based on total factor productivity TFP other than capital accumulation. TFP is crucial for understanding the differences in economic growth and income across countries as suggested by Easterly and Levine (2002).

Capital stock in the process of adding to the stock of real productive resources, which refers to net additions of capital stock such as buildings and other intermediate goods John (1997), is another important consideration. Increasing an economy's capital stock magnifies its capacity to producing more goods and services that can lead to an increase in sustainable economic growth. The replacement of physical capital by human capital accumulation as the prime engine of economic growth has changed the qualitative impact of inequality on the process of development.

In early stages of industrialization, physical capital accumulation is the principal source of economic growth, inequality enhances in the process of development by channelling resources towards individuals whose marginal propensity to save is higher. In later stages of development, however, human capital has become the main engine of economic growth; a more equal distribution of income, even in the presence of credit constraints can affect capital and economic growth in a positive way (Oded, 2011).

In recent time, however, there has been the lowest level of human development in Africa, despite the fact that a rapid growth of some aspects of human capital, particularly; the expansion of education, notwithstanding starting from low level of income. The expansion of the human capital stock itself has not been matched by a commensurate rise in physical capital due to low level of income growth and low returns to the education investment according to the study by Simon and Francis (1998). Michael (2011) argues that in the 1950s and 1960s, most Asia's economies were destined for prolonged poverty, while Africa's independence encouraged great optimism. While the East Asian economic performance has given rise to a large literature in studying the so-called growth 'miracle', the Sub-Saharan Africa has attracted attention for exactly the opposite reason. The failure of many countries in the region have failed to sustain per-capita income growth after the 1970s Robin (2011).

Sustained improvement in the Sub-Saharan Africa human development is found to be the lowest level in the world as the assessment made by UNDP (1997, 2013) and World Economic Forum (2013). Easter African countries have shared equality predicament with the Sub-Saharan African, facing similar economic, social and environmental challenges in the development process such as inequality, high poverty rates, unemployment and many others UNEC (2013). Therefore, understanding and addressing the challenges related to human capital is thus fundamental to the short term stability and the long term growth, providing prosperity and competitiveness of nations. Thus, countries included in the sample study, such as Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Rwanda, Tanzania and Uganda will be undertaken in panel analyses.

The motivation of this study is to investigate the role of human capital resources in economic growth using dynamic panel transmission channels in vector autoregressive VAR model and wavelet time scale analysis. In this study we look into the short-run, medium-and long-run empirical analyses genuinely generated for the application of growth rate. Thus this study adds unique key important contribution to the existing knowledge in growth accounting analyses. In this study, we examine the importance, the empirical evidence and the descriptive statistics of HCR. In the meantime, we explore whether both human and physical capital accumulations are equally important or whether one of them is more significant to economic growth. Most scholars argue that only considering physical capital is impossible for the poor countries to make sustained growth. Poor countries must concentrate first on technological

progress generated and easily adopted by human capital and then gradually accumulate physical capital as the economies depend more on technological progress than physical capital.

The paper is structured as follows: it provides an introduction, a highlight about physical and human capital resources and their importance to economic growth. Section two describes the existing literature. The subsequent sections are intended to deal with methodological issues; empirical findings and discussions. Finally, the main findings of the study are summarized in a concluding section.

2. Review of the Related Literature of Human Capital Resources

There are a number of related studies on economic growth, human resources and capital stock. Carefully surveyed literature of human capital resources, physical capital stocks development and their relationship with economic growth have been observed by Kanu and Ozurumba (2014), Rakotoarisoa, Shapouri and Trueblood (2014), Orla et al. (2013), Ndambiri et al. (2012), Richard and Blessing (2010), Daniel and Marc (2004), Paula, John and Goddard (2001), Freddy et al. (2003) and Jess and Mark (1994).

Empirical studies of Arthur and Maxime (2014) tries to show the influence of macroeconomic volatile on physical capital accumulation in the Sub-Saharan economies. It indicates that a one-unit increase in the conditional standard deviation of the real effective exchange rate leads to a 0.011 percentage decrease in the stock of physical capital. In the decomposition of labor productivity growth, Oleg, Daniel and Romain (2012) argue that physical capital accumulation is the largest share in economic growth whereas the evidence suggested by Jeffrey and Andrew (1997) indicates that the slow growth in Africa as a 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.

Despite economic theory postulates, increases investment in human capital and physical capital that leads to increase in economic growth. However, in East African economy, specifically, the Kenyan case, this has not been true according to Nelson and Fredrick (2006). Large decline in domestic savings over the years, while increasing the growth of fixed capital formation in Ethiopia, due to that fact that the low level of per capita income, potentially one major factor of the low level in savings EEA (20003/04).

We also describe the empirical work of Khadharoo and Seetanah (2006) on the linkage between public capital and economic growth of Mauritius economy over the period 1950–2000.

They use vector error correction model, which indicates that public capital has significantly contributed to the economic performance.

Furthermore, the empirical evidence from the developed countries suggests the importance of human capital formation to economic growth has been the major driver of the development process; this notwithstanding, Nigeria has been a subject of debate Kanayo (2013). In addition, Bichaka and Christian (2008) also try to show aggregate impact of the remittances on economic growth using unbalanced panel data from 1980 to 2004 for 37 African countries. It is found to be that remittances boosting growth in countries where financial systems are less developed. However, Valeriia (2009) investigates the impact of capital flight on economic growth of 139 countries in the year interval of 2002 to 2006 that displays a negative impact on GDP growth. Bangake and Eggoh (2010) study the international capital mobility of 37 African countries with panel cointegration methods over the period of 1979-2006. The findings indicate that the lowest being for non-oil producing compared to that of oil producing countries.

The role of education and human capital for the Egyptian economic growth in Khaled and Willi (2006) study from the year 1959 to 2002 using the Solow residual, has not been able to form a consensus of the causality between human capital and growth. While from the same region, the assessment on the labor outcomes in Algeria the study by Mohamed and Nassima (2003) has come up with the conclusion that the main problems behind the low contribution of labor market lies with inefficient labor market institutions, absence of economic diversification and the low participation of private sector in the economy.

Empirically, the contribution of capital formation to economic growth has been described in many studies such as Urélien and Yannick (2015), Sahbi and Jaleleddine (2015), Wendy and Umar (2013), Catia (2013), Edgar, Alexander and Axel (2012), Alexandra and Jacob (2011), Andrew, Robert and Fabio (2007), Verma, Wilson and Pahlavani (2007), Wang and Yao (2002) and Schultz (1998). The study by Yasmina and Stephen (2004) emphasis the cross-country patterns of economic growth by estimating stochastic frontier production function for 80 the developed and the developing countries. Omolola(2013) sees the benefits from migration; Mohsen and Maysam (2013) investigate 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 results show that there is strong causality from economic growth to investment.

In summary, the related empirical studies help us to identify the importance of human capital for the economic growth. Despite the fact that some of them describe negative relation, they provide key concepts to economic analyses. Hence, fundamentally based on these empirical literatures, this study, however, looks into the analysis in depth for the role of human capital resources in economic growth with certain combined methods. The methods are dynamic panel transmission channels of the VAR system, the wavelet time scale decomposition and the impulse response models.

3. Data Sources and Methodology of the Study for Human Capital

3.1. Data Sources and Variables for Economic Growth, HCR and Others

A panel data set of nine selected East African countries over the period of 1980-2015 are obtained from the World Bank development indicators, the United Nations aggregate databases and International Monetary Fund Economic outlook. Data on gross national income per-capita at constant 2005 USD price is the dependent variable while other explanatory variables comprise total factor productivity TFP, human development index as a proxy for human capital resources HCR and physical capital stock PCS index. The indexed variables are based on own calculations.

3.2. Measuring Physical Capital Stock and Human Capital Resources

In economics, physical capital is factor of production consisting of machinery, buildings, computers and the like. Marshall and Mariam (2005) estimate fixed capital consumption as part of measurements for the net national income and multi-factor productivity changes. It is the difference between gross investment and fixed capital consumption (Berlemann and Wesselhoft, 2014).

Regarding human capital resources, Kwon (2009) argues that direct measurement is a difficult task. He observes that the conventional measurement of human capital focuses on the monetary perspective, neglecting the importance of its non-monetary aspects such as creating added-values, social networks etc. Michael (2011) also claims that human capital measures are sensitive to alternative assumptions about income growth and discount rates, smoothing and imputation of labor force and school enrolment data. The UN (2008) emphasis an accurate measure of labor and capital inputs based on the breakdown of aggregate hours worked and aggregate capital stock into various components. The hours worked are cross-classified by educational attainment gender and age with the aim to proxy for differences in work experience.

Trinh et al (2002) explains that human capital is increasingly believed to play an important role in the growth process, even if adequate measuring its stock remains controversial.

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). The stock of human capital measurement has been developed to serve different analytic purposes. Notwithstanding these differences, many professionals have expressed common interest in developing monetary measures for human capital as useful complement of physical capital. For instance, Jorgenson and Fraumeni (1989, 1992) present the most comprehensive study using income-based approach to measuring human capital for the US economy and Wei (2004) presents experimental measures of human capital formation for Australian economy, measured as lifetime labor income; gross human capital formation is measured as the sum of investment in education and training.

Despite the fact that, various kinds of measures for human capital stocks have developed, Kyriacou (1991) estimates the relationship between educational attainment and the enrolment in primary, secondary and tertiary education of human capital investment past values. Mankiw, Romer and Weil (1992) also estimate the coefficients of production function using flows of investment as a proxy for capital stocks. The performance of human capital is measured with the help of macroeconomic indicators such as total number of years of schooling in the labor force, number of educational facilities, ratio of government expenditure on training to GDP and per capita expenditure on education in accordance with empirical studies by (Barro and Lee, 1993 and Wossmann 2003). Some of studies take proxies for human capital, which include school enrolment (Barro, 1991; Mankiw, Romer and Weil, 1992); average years of schooling of workers in Benhabib and Spiegel (1994); Krueger and Lindahl (2001) among others. Studies carried out by Barro(1998) have analyzed per capita wealth in various regions of the world by disaggregating several factors into human capital, physical capital and natural resources.

Human capital is more important and valuable than physical capital. As we cannot put the price on human life, the skills, the knowledge and the experiences of human being are more valuable than machines, production, computers etc. People can provide talent and services for a

lifetime while most physical capital depreciates over time. Human capital accumulation is commonly cited as a precondition for development. It has long been considered as an important factor for economic development. We employ human development index, which is a composite statistic index of life expectancy, education and income per capita as a proxy for human capital stocks in this study.

3.3. Specification of Dynamic Panel Econometric Model for HCR

Countries endowed with large stock of human capital eventually emerge as a technological leader in finite time and maintain its leadership as long as its 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 associations do not reveal causality Oded (1993). Hence, human capital accumulation has been estimated using human development index in this study.

To calculate human development index used as a proxy for human capital stock, we consider the UNDP (2013) minimum and maximum values of the goalposts of the observed values in the time series interval 1980–2012. 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, the world level for school life expectancy at 12 years, 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 NIPC (see UNDP, 2013 and CIA, 2006, 2015).

Therefore, by defining human capital resource (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

$$HCR \equiv HDI = (LEI \times EL \times II)^{\frac{2}{3}} \quad (3.3.1)$$

Where,

$$LEI = \frac{\text{Life expectancy at birth(year)} - \text{Minimum value}}{\text{Maximum Value} - \text{Minimum value}},$$

$$SMEI = \frac{\text{Mean of school enrolment} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}},$$

$$EI = \frac{\sqrt{(LEI)(MSEI)} - \text{Observed Minimum value}}{\text{Maximum value} - \text{Minimum value}} \quad \&$$

$$II = \frac{\ln(\text{GNI}) - \ln \text{Minimum value}}{\ln(\text{MaxximumValue}) - \ln(\text{Minimum value})}$$

The school life expectancy is the total number of years of schooling from primary to tertiary 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 the perpetual inventory method, 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 the physical capital stock (PCS_{t-1}) and in the investment gross (IG_{t-1}) minus fixed capital consumption (FCC_{t-1}) causes a depreciation Berlemann and Wesselhoft (2014). Thus we calculate the current physical capital stock as

$$PCS_t = PCS_{t-1} + IG_{t-1} - FCC_{t-1} \quad (3.3.2)$$

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

$$\Delta PCS_t = PCS_t - PCS_{t-1} = IG_{t-1} - FCC_{t-1} \quad (3.3.3)$$

The initial capital stock based on Harberger(1978) approach employs the neoclassical growth theory, 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

$$g_{GDP} = g_{PCS} = \frac{IG_{t-1}}{PCS_{t-1}} - \delta = \frac{PCS_t - PCS_{t-1}}{PCS_{t-1}} \quad (3.3.4)$$

Solving for PCS_{t-1} from (3.3.4) and plugging into (3.3.3.3) and (3.3.3.2), then we will have

$$PCS_t = \frac{IG_{t-1} - FCC_{t-1}}{g_{GDP}} + IG_{t-1} - FCC_{t-1} \quad (3.3.5)$$

In the real environment, the production function tends to be increasing returns to scale with augmented the neoclassical model Schmidt-Hebbel (1994) and Easterly and Levine (1994). In this model, there exist technological spillovers and increasing returns to scale (see Barro and Sala-i-Martin, 2003). Accordingly, we can express gross national income GNI as the combined contributions of technological level TFP, human capital resources, physical capital stock and total labor forces; following the Solow model specification in the Cobb-Douglas production function as

$$\text{GNI}_t = A_t(\text{HCR}_t)^{\alpha_t}(\text{PCS})_t^{\beta_t}(\text{LF})_t^{\gamma_t}e^{\varepsilon_t}, \alpha + \beta + \gamma > 1 \quad (3.3.6)$$

We take log differences of eq.(3.3.6) to set up the relationship for long-term growth from time t-1 to time t can be specified as

$$\begin{aligned} (\ln \text{GNI}_t - \ln \text{GNI}_{t-1}) &= \alpha_t \ln A_t(\text{HCR}_t) - \ln A_{t-1}(\text{HCR}_{t-1}) + \beta_t (\ln \text{PCS}_t - \ln \text{PCS}_{t-1}) \\ &\quad + \gamma_t (\ln \text{LF}_t - \ln \text{LF}_{t-1}) + (\ln \varepsilon_t - \ln \varepsilon_{t-1}) \end{aligned} \quad (3.3.7)$$

Specifying the first term in eq. (3.3.7), total factor productivity TFP_t depends on the level of human capital, reflecting the effect of domestic endogenous innovation. Take the expected value in both sides of eq. (3.3.7) and divide by $\frac{1}{\alpha_t}$ then we get the expected total factor productivity TFP_t depending on the level of human capital resources given by

$$\begin{aligned} E[\ln A_t(\text{HCR}_t) - \ln A_{t-1}(\text{HCR}_{t-1})] \\ &= E\left(\frac{\ln \text{GDP}_t - \ln \text{GDP}_{t-1}}{\alpha_t}\right) - E\left(\frac{\beta_t}{\alpha_t} (\ln \text{PCS}_t - \ln \text{PCS}_{t-1})\right) \\ &\quad - E\left(\frac{\gamma_t}{\alpha_t} (\ln \text{LF}_t - \ln \text{LF}_{t-1})\right) - E\left(\frac{(\ln \varepsilon_t - \ln \varepsilon_{t-1})}{\alpha_t}\right) \end{aligned}$$

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

$$\begin{aligned} \text{TFP}_t &= \left(\frac{\ln \text{GNI}_t - \ln \text{GNI}_{t-1}}{\alpha_t}\right) - \left(\frac{\beta_t}{\alpha_t}\right) (\ln \text{PCS}_t - \ln \text{PCS}_{t-1}) - \left(\frac{\gamma_t}{\alpha_t}\right) (\ln \text{LF}_t - \ln \text{LF}_{t-1}) \\ \text{TFP}_t &= \left(\frac{\Delta \ln \text{GNI}_t}{\alpha_t}\right) - \left(\frac{\beta_t}{\alpha_t}\right) \Delta \ln \text{PCS}_t - \left(\frac{\gamma_t}{\alpha_t}\right) \Delta \ln \text{LF}_t \end{aligned} \quad (3.3.8)$$

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. Their respective elasticity in continuous and discrete form in each are given as

$$\begin{aligned} \alpha_t &= \left(\frac{\partial \ln \text{GNI}_t}{\partial \ln \text{HCR}_t}\right) \left(\frac{\ln \text{HCR}_t}{\ln \text{GNI}_t}\right), \beta_t = \left(\frac{\partial \ln \text{GNI}_t}{\partial \ln \text{PCS}_t}\right) \left(\frac{\ln \text{PCS}_t}{\ln \text{GNI}_t}\right) \text{ and } \gamma_t = \left(\frac{\partial \ln \text{GNI}_t}{\partial \ln \text{LF}_t}\right) \left(\frac{\ln \text{LF}_t}{\ln \text{GNI}_t}\right) \& \\ \alpha_t &= \left(\frac{\Delta \ln \text{GNI}_t}{\Delta \ln \text{HCR}_t}\right) \left(\frac{\ln \text{HCR}_t}{\ln \text{GNI}_t}\right), \beta_t = \left(\frac{\Delta \ln \text{GNI}_t}{\Delta \ln \text{PCS}_t}\right) \left(\frac{\ln \text{PCS}_t}{\ln \text{GNI}_t}\right) \text{ and } \gamma_t = \left(\frac{\Delta \ln \text{GNI}_t}{\Delta \ln \text{LF}_t}\right) \left(\frac{\ln \text{LF}_t}{\ln \text{GNI}_t}\right). \end{aligned}$$

Therefore, based on Baltagi (2005), we can express $\ln \text{GNI}_{it}$ as a function of total factor productivity TFP_{it} , human capital resources HCR_{it} and physical capital stock PCS_{it} . 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

$$\begin{aligned} \ln GNI_{it} = & \pi_0 + \pi_{1p} \sum_{l=1}^p \ln GNI_{i,t-l} + \pi_{2q} \sum_{l=0}^q TFP_{i,t-l} \\ & + \pi_{3m} \sum_{m=0}^r HCR_{i,t-m} + \pi_{4n} \sum_{n=0}^s PCS_{i,t-n} + \varepsilon_{it} \end{aligned} \quad (3.3.9)$$

Where π are parameters to be estimated and p, q, r and s denote optimal lag length. ε_{it} are white noise random disturbances. In dynamic panel data regression described in eq. (3.3.3.9), we cannot apply the OLS, GLS, Fixed and Random effects methods because $\ln GNI_{i,t-1}$ is correlated with ε_{it} so that the results will be inconsistent. If ε_{it} is independently identical distribution *iid*, it will be correlated with $\ln NIPC_{i,t-1}$. We suppose GNI_{it} be a $p \times 1$ vector of cross-section i in period t , follows a non-stationary VAR (p) process. π_0 is a $k \times 1$ vector with the j -th element representing the deterministic component of the model ϑ_{it} are a $k \times 1$ vector of disturbances and are independent $N(0, \Omega_{it})$ for $t=1, \dots, T$ (see Anderson et al. ,2006).

In recent time, panel data econometrics has been used for estimating and forecasting purposes cited by Baltagi (2005). Dynamic panel estimators have increasingly been used in studies of growth (See Baltagi, 2005; Easterly, 1997; Islam, 1995 and Arellano and Bond, 1991). These dynamic relationships are characterized by the presence of lagged dependent variable 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 what is actually produced, traded and consumed and how these variables respond to various shocks William (2010).

Based on lagged observations use of 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 the dynamic panel estimators, we 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).

In order to investigate the casual relationship between annual real gross national income per-capita and human capital resources in East Africa from the year 1980 to 2015, this study uses a panel wavelet analysis for Granger causality test. Multi-resolutionary wavelet decomposition analysis for a maximal overlap discrete wavelet transform (MODWT) which utilizes moving averages of the original data and moving averages of moving averages used for filtering the data. However, using moving averages, the MODWT loses orthogonality which is the characteristic of basic discrete wavelet transformation (DWT). To maintain consistency in the transformation of the data series, the data is considered as a circular loop, with the observation following the last one simply being the first observation (see Hacker, Karlsson and Mansson, 2012).

The segmentation of time series into different layers makes use of wavelet analysis become popular in economic analysis in the short-run, medium-and long-run horizons according to studies by Ramsey and Lampart(1998), Almasri and Shukur (2003), Hacker, Karlsson and Mansson (2012) and Reboredo and Rivera-Castro (2014). The supreme important of the time scale in a panel cointegrated methodology where variables move together is desirable. Since wavelets are local orthonormal bases consisting of small waves that dissect a function into layers of different scale (see some important notes and formula in Common Appendix).

4. Discussions and Empirical Findings for HCR- Economic Growth

4.1. Optimum Lag-length Determination for HCR model

Lag-length determination is the key point in the process of testing and estimation. Akaike Information and other criteria are often used to choose the optimal lag length distributed-lag models. In the estimation of optimum lag-length, we 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, and 1995). The optimal lag length determination using order selection criteria is found to be three, since the lowest value of each criterion assumes the most appropriate model. Thus, this three optimal lag length will be used for the analysis throughout the paper. The test results have been accessed from the author.

4.2. Panel and Individual Cointegration tests for HCR-Economic Growth

We also take into account about panel cointegration methodology developed by Johansen (1988), (1991) and (1995). Johansen highlights that one can confident when eigenvalues problem is solved and inferences of the test hypothesis about cointegrating relationship. Like panel unit root tests, panel cointegration tests can be motivated for its more powerful than individual time series

cointegration tests. The interactions of short-run dynamics between the cross-sections influence other members in a panel of the cross-section's temporary long-run equilibrium error. These differences make ranks in the cross-sectional cointegration Anderson, Qian and Rasch (2006).

Accordingly, first, we conduct the Johansen cointegration tests for a panel of ten countries and we obtain that number of cointegration equation is found to be one. Then we also test for individual separately at the 5% level of significance 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. Numbers in the brackets are trace and maximum eigenvalues. Out of ten countries, Zambia has been rejected since there is no cointegrating equation in both cases of tests. When the trace and the maximum eigenvalue statistically different, we should prefer to take trace test Alexander (2001) that is why nine countries have passed with cointegrations. Finally, we conduct test for a panel of nine countries, excluding Zambia, in which the test results are shown in Table 4.2.

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

Dependent Variable: lnGNI-OLS followed by estimated HCR-OLS and PCS							
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*

We perform the Johansen test of Panel Cointegration 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.

Table 4.2 shows the Johansen test for cointegration for a panel of nine countries in the unrestricted rank multivariate analyses. We reject the null hypothesis of no cointegration, at most one, two and three cointegrations since the trace and the 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 number of cointegrating vectors, which are the hypotheses of the variables not 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, we reject the null hypothesis of 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, we would reject the null hypotheses of $r \leq 1$, $r \leq 2$ and $r \leq 3$, cointegrating vectors ($r=1$, $r=2$ and $r=3$), however, we would fail to reject the alternative hypotheses of more than one, two and three cointegrating vectors ($r>1$, $r>2$ and $r>3$). From these tests we suggest 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; they move together towards the long run equilibrium or they have long run relationship.

4.3. Cross-sectional dependence and Endogeneity tests for HCR-Economic Growth model

Before estimating parameters, data must be cross-sectional 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) points out. We consider the standard augmented Dickey–Fuller ADF regression with the cross-section averages of lagged levels and first-differences of the individual series Pesaran(2007) for cross–sectional dependence test. 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 the Im- Pesaran and Shin (1997) test to avoid the problem of moment calculation Baltagi(2005). Based on an $AR(\rho)$ 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 Walter (2003), we make regression considering the differenced variable as dependent and its one period lagged as independent variables. Eventually after transformation of the original data, we test for cross-sectional dependence of the individual explanatory variables Pesaran(2007). Consequently we confirm that there is no cross-section dependence among four explanatory variables. The output for the test has been accessed from the author. Finally before arriving at the process of estimation of the

parameters, we have to check endogeneity problem that arises from the simultaneous equations model with the help of two stages least squares 2SLS, (see Wooldridge, 2002, 1997a for detailed). In the presence of endogeneity, estimation becomes bias and inconsistent. Consider the following simultaneous equations of lnGNI – HCR model where lnGNI and *HCR* are endogenous variables whereas others are predetermined.

$$\ln\text{GNI} = \beta_0 + \beta_1\text{HCR} + \beta_2\text{PCS} + u \quad (3.10 \text{ a})$$

$$\text{HCR} = \beta_{10} + \beta_{11}\ln\text{GNI} + \beta_{12}\text{TFP} + v \quad (3.10 \text{ b})$$

Equation (3.10 a) and (3.10 b) 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. We first estimate the reduced form equations by OLS; that is, we make a regression of HCR on PCS and TFP by OLS method and obtain the estimated human capital resource HCR-OLS. Then we estimate lnGNI as a function of HCR- OLS and PCS using (3.3.9). We also make a regression of lnGNI on PCS and TFP by OLS method and obtain the estimated lnGNI. Finally we estimate HCR as a function of the estimated lnGNI and TFP by the OLS. These procedures are known as the 2SLS method.

4.4 Dynamic panel VAR estimation of long-run coefficients in HCR model

Based on the three optimum lag-lengths found in section 3.4.1, now we can estimate the long-run parameters using panel VAR model and make use of other analyses. The analyses of long-run estimation parameters have received a remarkable attention in various forms. Such as dynamic OLS of Hayakawa and Kurozumi(2008); panel fully modified OLS estimators of Phillips and Moon(1999, 2000); panel fully modified OLS estimators of Kao and Chiang(2000) and panel vector error correction models of Anderson, Qian and Rasch (2006) in which the results are asymptotically unbiased and normally distributed estimated coefficients.

Table 4.4 Dynamic panel VAR estimation of Long-run Coefficients for HCR model

Variable	Coefficient	t-Statistic	P. Value
$\ln\text{GNI}2\text{SLS}_{it-1}$	1.1082	12.900	0.0000**
$\ln\text{GNI}2\text{SLS}_{it-2}$	-0.0769	-0.6141	0.5397
$\ln\text{GNI}2\text{SLS}_{it-3}$	-0.0668	-0.7934	0.4283
$\text{HCR}2\text{SLS}_{it-1}$	-0.3518	-1.4555	0.1468
$\text{HCR}2\text{SLS}_{it-2}$	0.8384	2.7136	0.0071**
$\text{HCR}2\text{SLS}_{it-3}$	-0.5019	-2.1969	0.0289*

TFP _{it-1}	-0.0003	-0.1512	0.8799
TFP _{it-2}	0.0021	1.4118	0.1592
TFP _{it-3}	-0.0029	-2.0019	0.0463*
PCS _{it-1}	0.0575	6.1274	0.0000**
PCS _{it-2}	-0.0011	-0.0926	0.9263
PCS _{it-3}	-0.0183	-1.9972	0.0469*
Constant	-0.0028	-0.2865	0.7747

The Joint Wald Test

Joint Null Hypothesis	χ^2	P. Value
$\ln\text{GNI2SLS}_{it-1} = \ln\text{GNI2SLS}_{it-2} = \ln\text{GNI2SLS}_{it-3} = 0$	3080.7	0.0000**
$\text{HCR2SLS}_{it-1} = \text{HCR2SLS}_{it-2} = \text{HCR2SLS}_{it-3} = 0$	7.6863	0.0430*
$\text{PCS}_{it-1} = \text{PCS}_{it-2} = \text{PCS}_{it-3} = 0$	50.588	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, we estimated 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.

R-squared	0.9653
F-statistic	596.56
Prob(F-statistic)	0.0000

By looking at the coefficient of determination (R-squared value), we claim that about 96.5 percent variation in lnGNI is due to the facts that change in TFP, HCR and PCS. The F-statistic value is statistically significant which indicates our model specification is adequate and fit to the data. One year lagged in the estimated gross national income, two years lagged estimated in human capital resources and one year lagged in physical capital stock have positively significant impact on the estimated GNI for a panel of nine East African countries over the period 1980-2015. The bottom portion of Table 4.3 also indicates that the joint cumulative the Wald test up to three periods lagged of the estimated GNI, HCR and PCS have significantly impact on the current estimated GNI.

Table 4.4 Long-term panel VAR transmission mechanism channels by Wald test for HCR model

Hypothesized	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 & lnGNI2SLS _{it-1} = lnGNI2SLS _{it-2} = lnGNI2SLS _{it-3} = 0	8.1177 7.9466	0.0333* 0.0471*
2. H_0 : lnGNI causes HCR and HCR causes PCS HCR = F(lnGNI) and PCS = F(HCR)		
lnGNI2SLS _{it-1} = lnGNI2SLS _{it-2} = lnGNI2SLS _{it-3} = 0, & HCR2SLS _{it-1} = HCR2SLS _{it-2} = HCR2SLS _{it-3} = 0	20.695 7.1959	0.0001** 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, & lnGNI2SLS _{it-1} = lnGNI2SLS _{it-2} = lnGNI2SLS _{it-3} = 0	51.971 20.695	0.0000** 0.0001**

** 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, we conduct the long-term transmission mechanism channels using the Wald test. As we can see the results from Table 4.4, all hypotheses are significant, except HCR causes PCS. These imply that there is a significantly important contribution of human capital resource HCR to the development of physical capital stock PCS through gross national income per capita lnGNI. The growth of lnGNI has also a positive role towards the accumulation of PCS via HCR. Explicitly we can demonstrate the inter-temporal relationship between the estimated lnGNI and HCR using the wavelet time scale analyses.

Table 4.5 Impulse-response Granger causality test for 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. We consider the optimal lag length found to be three in a VAR system in calculating the chi-square value for each country. Then we calculate the combined chi-square for the time scale horizons using the formula, $\chi^2 = -2 \sum_{i=1}^L \ln(\chi_i^2)$ where $-2 \ln p_i$ which has shown a chi-square distribution and i stands for country 1, 2, 3,..., L (see detailed in Dmitri et.al. ,2002 and Fisher ,1932). We compare these combined χ^2 (which is available is available in Brooks, 2008) with the conventional χ^2 of 16.92 at the 5% level of significance for 9 degrees of freedom which represents number of countries.

We extend the VAR analysis with the determined three optimum lag-lengths to the impulse-response functions. It is because impulse- response is more appropriate method for more than two optimal lag-lengths. We obtain mean coefficients for the time scale decomposition of a panel wavelet analysis in the Granger causality test. Thus, Table 4.5 shows 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 that more educated and skilled human capital can produce sufficient amount of real gross national income for the countries and the reverse also holds true. Calculations are based on the Chlesky variance-response function with the help of the standard error of Monte Carlo simulation.

For the economy in a panel, 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 that unable to accommodate more educated and skilled people. The empirical results of this study somehow related to some previous studies such as the link between human capital and labor market of the Pakistan economy in 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, expressed as a percentage of tertiary educated in Čadil, Petkovová and Blatnáb

(2014). Moreover, they 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).

The benefit we provide from this study is the combined analyses of different methods. The methods are dynamic panel transmission mechanism channels in VAR model of the multivariate panel and wavelet time scaling of the bivariate impulse-response bi-directional dynamic causal relationship. This is the new approach for the economic analysis which adds to the existing knowledge. We also argue that due attention should be given to the human capital resources more than any other for the economy to progress successful.

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. However, East Africa has the lowest level of human capital development nevertheless; it displays a rapid growth in the expansion of education. This highlights the issue of employment challenges that women are going through more than men. Instead of attending school, they are being forced to marry at an early age, due to financial constraints and traditional cultures that curb their education opportunities.

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 in East African region. This physical policy is all about the effective system of taxation on revenue generation for the governments and other resources of mobilization as well as inequality and equity concerns. However, in East Africa, this policy would be in effective when it comes narrowing the gap in societies in terms of income and wealth inequalities in addition to the lack of inclusiveness in economic growth for all beneficiaries. The expansion of human capital stock itself has not been matched by 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) caused by the low levels of accommodation in the economy.

In this study, we conduct the tests for non-stationary behavior of panel unit roots, individual

and panel cointegrations, cross-section dependence, endogeneity and other phenomena such as wavelet analysis in Granger causality and panel autocorrelation and ultimately we estimate the coefficients. Our estimation indicates that the growth rates of human capital resources and the physical capital stock have long-run effects on the growth rate of gross national income per-capita in a panel of nine East African countries over the period of 1980 to 2015. The long-term transmission mechanism of the VAR system applied in accordance with the Wald test indicates that human capital growth contributes hugely to the development of physical capital stock through gross national income. The GNI growth has also a positive role in accumulating PCS via HCR.

We explicitly demonstrate the dynamic inter-temporal relationship between gross national income and human capital growth using panel wavelet analysis in time scaling decomposition. The test shows that 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 slightly increase over time which indicates that there are bi-directional inter-temporal causal relationships between HCR and GNI in the long-run. Which leads us to say that more educated and skilled human capital can produce sufficient amount of real gross national income for the countries and vice versa. Possible explanation for the unexpected negative accumulated response from HCR to GNI in the short- and medium- term may be the low level capacity to accommodate more educated and skilled people by the panel countries.

This study, therefore, suggests that the analyses of dynamic panel transmission channels in both VAR model and Granger causality test of wavelet analyses in panel data set. They add new ideas to the existing knowledge. It also argues that due attention should be given to human capital resources in attempt to achieve sustainable economic development.

In this study we use the combined analyses of different methods such as dynamic panel transmission mechanism channels in VAR model of the multivariate panel and wavelet time scaling of the bivariate impulse-response bi-directional dynamic causal relationship. We, therefore, suggest that the analyses of dynamic panel transmission channels in the VAR model for the long-run effect and the wavelet time scaling in Granger causality tests for the short-medium-and long-run effects in a panel dataset are essential. This is the new approach for the economic analysis which adds to the existing knowledge. We also argue that more due attention

should be given to human capital resources than any other in attempt to achieve sustainable development in the process of successful economic progress.

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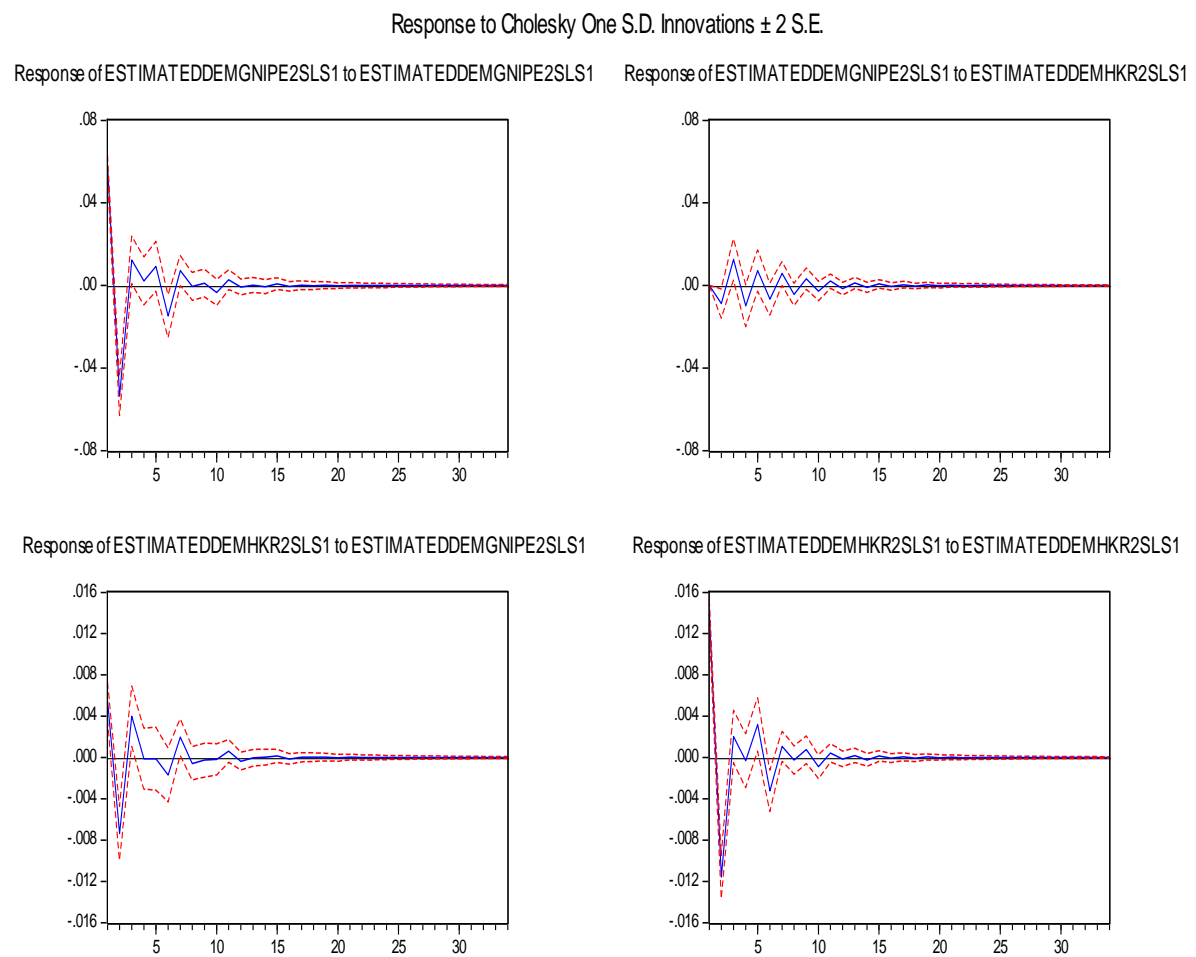
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Appendix

1. Short- term Time Scaling Horizon

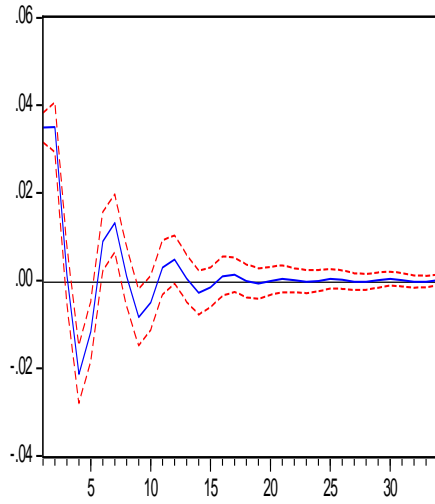


1000,000 times simulations using Monte Carols

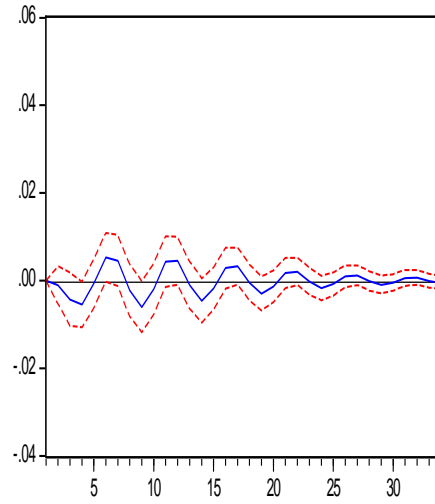
2. Medium-- term Time Scale Horizon

Response to Cholesky One S.D. Innovations ± 2 S.E.

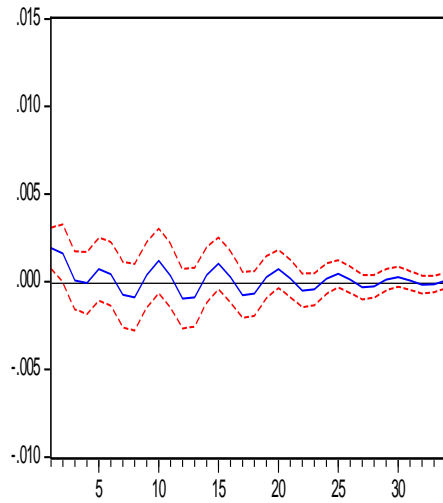
Response of ESTIMATEDDEMGNIP2SLS2 to ESTIMATEDDEMGNIP2SLS2



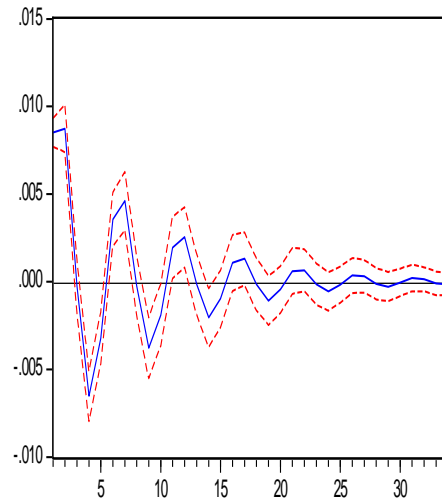
Response of ESTIMATEDDEMGNIP2SLS2 to ESTIMATEDDEMHKR2SLS2



Response of ESTIMATEDDEMHKR2SLS2 to ESTIMATEDDEMGNIP2SLS2



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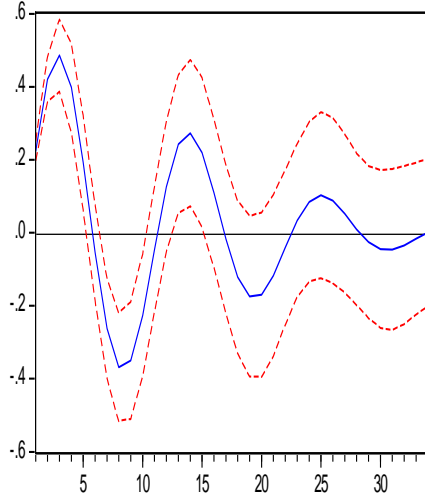


1000,000 times simulations using Monte Carols

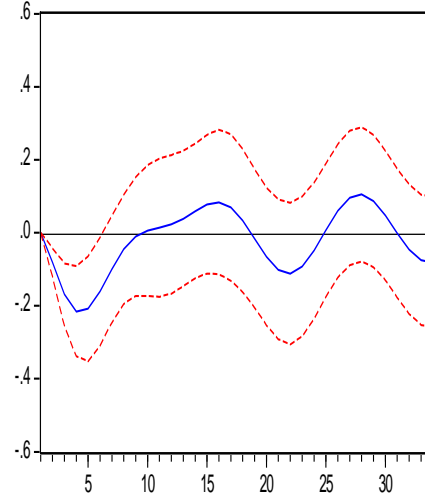
3. Long-term Time Scale Horizon

Response to Cholesky One S.D. Innovations ± 2 S.E.

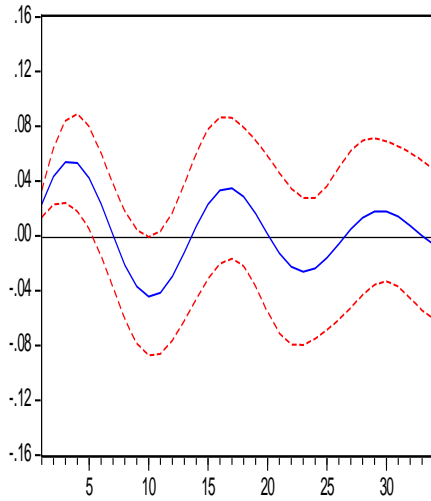
Response of ESTIMATEDDEMGNIPE2SLS3 to ESTIMATEDDEMGNIPE2SLS3



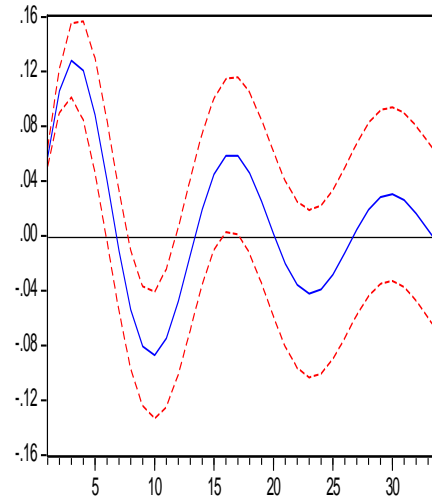
Response of ESTIMATEDDEMGNIPE2SLS3 to ESTIMATEDDEMHKR2SLS3



Response of ESTIMATEDDEMHKR2SLS3 to ESTIMATEDDEMGNIPE2SLS3



Response of ESTIMATEDDEMHKR2SLS3 to ESTIMATEDDEMHKR2SLS3



1000,000 times simulations using Monte Carols

Fig. C Time Scales Decomposition of the Wavelet Analyses for Economic Growth and HCR