Understanding the determinants of economic growth in East Africa is a crucial challenge since a significant share of the world’s poor lives in Africa, while sustained economic growth can move millions out of poverty, is a great important. In this sense, we study how the financial sector development (FSD), the involvement of human capital resources (HCR), and the inward flow of foreign direct investment (FDI) can affect economic growth. Using panel econometric methods, we investigate and obtain the results highlight the importance of the main determinants of the East Africa economic growth from the year 1975-2019. Thus the long-run estimation empirical results obtained by the multivariate autoregressive distributed lags, ARDL (2,1,1,1) method, reveal that both FSD and FDI have positively significant effects on economic growth in the panel countries. In addition, the bivariate wavelet analysis of panel ARDL (1,1) estimation, indicates both FDI and GDP growth rates have significantly positive contribution to each other and dynamic inter-temporal causal effects on one another in the short, medium, and long-terms.

**Keywords:** economic growth, panel data and time scaling wavelet analysis

**Introduction**

**Motivation of the Study**

This study focuses on how the financial sector development (FSD), the involvement of human capital resources (HCR), and the inward flow of foreign direct investment (FDI) have related to the economic growth. In this regard, we have motivated to analyze the economic growth using different methods, stating FSD, HCR, and FDI as the main determinants for economic growth in East Africa. Based on an extensive literature on the link between financial development, human capital resources, and foreign direct investment to the gross domestic product (GDP) growth rate, we try to attempt the paper has a clear goal, and the empirical analysis for nine countries in East Africa is carefully carried out in order to be able to provide new sharp insight into the existing literature. Wisely studying several related empirical literature, we try to make a unique approach to economic analysis.

First, with a transformed original data into a proper dataset, we make sure that we do not violate the classical econometric assumptions of no autocorrelation and cross-sectional independence among panel countries. In fact, we have checked these and others with the help of their respective traditional methods of test at the end before conducting the estimation parameters. We then continue in deriving various types of indices
formulas which we have used as explanatory variables. In the methodological section, the indices we have included comprise of the ratio of total domestic credit to real GDP as a proxy for FSD and we derive the index for human capital resources by applying geometric mean associated with the index composite of life expectancy, education, income, and school mean enrolment indices for which the demeaned datasets are to be fit.

We also intend to make a methodological contribution to the economic analysis by designing a new pane approach, wavelet time scaling, adding to the unique specified models with the derived indices. The panel wavelet time scaling analysis enables us to separate a long time-series into different layers. It is applicable to make the bivariate analyses by extending the traditional standard methods for cross checking of the estimated parameters by the standard methods. It is also to ensure the dynamic inter-temporal causal effects as well as to estimate the coefficients of the main determinants and the real GDP growth rate in the short, medium, and long-terms. The standard methods are panel of multivariate fully modified ordinary squares (FMOLS), vector error correction (VEC) model, variance decomposition and impulse response, and autoregressive distributed lags (ARDL) models. These kinds of methodological analyses are new, which have never been done by anyone prior to this study as far as we know.

Therefore, now we have contributed the new knowledge to the development of economic analysis both methodologically and theoretically, after identifying a gap in the statement of the problem which makes our study different. The purpose of this study is to analyze empirically the main determinants of economic growth. While the general objective is to examine the contribution of the FSD, the role of HCR, and the impact of FDI on economic growth in the short-, medium-, and long-run. The countries in East Africa have been recently trying to take steps to enhance dynamic macroeconomic stability by considering the intense situations and the importance of stability for poverty alleviation. Thus this kind of study conducted in this area is of the most important one in this regards, which helps to provide some tangible information for the policymakers to take some actions and serves as a foundation that can motivate other researchers to conduct further studies.

For the readers’ interest not to wait until the end to understand the main point presenting and the rest as robustness checks, we bring the state countries and the main findings at the beginning of introduction part of this study as follows. The state countries in a panel which included in this study are Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Rwanda, Uganda, and Zambia. Using panel econometric methods, we investigate and obtain the results highlight the importance of the main determinants for economic growth in East Africa from the year 1975-2019. Thus the long-run estimation empirical results obtained by the multivariate autoregressive distributed lags, ARDL (2,1,1,1) method, reveal that both FSD and FDI have positively significant effects on economic growth in the panel countries. The extended multivariate method—the estimation of panel ARDL (1,1) bivariate wavelet analysis, indicates both FDI and GDP growth rates have significantly positive contribution to each other and dynamic inter-temporal causal effects on one another in the short, medium, and long-terms.

Economic growth is an increase in the value added of the final goods and services produced over time at a fixed price adjusted to curb inflation (IMF, 2012). It is conventionally measured as a percentage rate of the real gross domestic product (GDP). The importance of long-run growth over time, even small rates of growth, has large effects. For example, the United Kingdom has an experienced of nearly a two percent average annual increased in GDP over 178 years very recent date. This resulted in a huge improved in better living condition (DFID, 2004). For a given GDP per capita and human capital, growth depends positively on the investment
ratio (Barro, 1996) and thus, a small difference in economic growth rates among countries can result in very different living standards for the people if this small difference continues for many years.

Economic growth can be determined by the level of financial sector development (FSD), the involvement of human capital resources (HCR), and the inward flow of foreign direct investment (FDI). Indeed, these determinants are also being influenced by their own factors. For instance, the power engines behind the economic growth of the functional financial intermediaries are determined by the growth rate of real GDP, gross capital formation, net official development assistance and aid received from abroad and the official exchange rates. In the meanwhile, gross national income (GNI), total factor productivity (TFP), and physical capital stock (PCS) in a given country have been the main contributors for the development of the HCR. Lastly, the FDI activities that take place in the economy are influenced by the amount of real GDP produced, official exchange rates, the level of index of openness and terms of trade.

The relationship between the financial sector development (FSD) and the economic growth has increasingly attracted researchers across the globe because of institutional differences and variation in capital allocation between and within economies. Financial sectors can be considered as financial services and institutions that lead to effective financial markets and access to capital and financial services (World Economic Forum, 2012). Capital markets in the financial systems can also contribute to growth by raising long-term finance for productive investment, diversifying investors’ risks, and improving the allocation of funds according to the study by Department for International Development (DFID, 2004).

However, the East Africa economies are characterized by underdeveloped capital markets, lack of capacity and regulatory framework, and poor supervision. There is also difficulty of accessing to the banking system, which constitutes the biggest component of the financial sector. Financial activities in the region are, by far infant and characterized by the monopolistic behavior of a few commercial banks, owned by governments. More importantly, the financial systems have remained highly exclusive. This exclusiveness is the result of market failures as proven by the empirical evidences in Beck and Maimbo (2013) and Abdi and Aragie (2012).

Human capital endowment, the skills and capacities that take place in the productive sectors are important determinant of long-term economic success. For the individual, societies, and economies, investing in human capital is critical, especially in the context of shifting population dynamics and utilizing limited resources (World Economic Forum, 2013). Because better educated people are expected more likely to innovate and adopt new technology and better productivity than less educated ones (Lucas, 1993; Romer, 1993), advances in technology, education, and incomes hold ever-greater promise of long, health and more secure lives as these advancements are generated by human capital resources (UNHD, 2014).

The level of human development in Africa is low, even though there has been a rapid growth of some aspects of human capital, particularly, the expansion of education in recent time. The expansion of human capital stock itself has not been matched by 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). A sustained improvement in Sub-Saharan Africa human development is found to be the lowest level (UNDP, 1997; 2013; World Economic Forum, 2013). The Eastern African countries have shared the low sustained income per capita with the Sub-Saharan African, facing similar economic, social, and environmental challenges in the development process such as inequality and equity concerns, high rates of poverty and unemployment, and many others (United Nations, 2013).

The impact of foreign direct investment (FDI) on economic growth is one of other various dynamic
resource inflows towards developing countries. It plays an important role in economic development by supplementing domestic savings, income growth, and employment generation. It is also used to bring integration into the global economy, transfer of modern technologies, enhancement of efficiency, and raising skills of domestic labor (see Dupasquier & Osakwe, 2006; Anyanwu, 2006; 2013 studies). Attracting FDI has been given a high priority in the strategies of economic renewal as advocated by policy makers at national, regional, and international levels. The experience of fast-growing East Asian countries and recently China has strengthened the belief of attracting FDI is the key to bridging the gap in the resources of low-income countries (United Nation, 2005). This is one of the factors that generate differences in economic growth across nations.

Therefore, to understand and address the challenges of the financial sector development contribution, the role of human capital resources and the impact of foreign direct investment on economic growth, we look into different debates on inter-temporal causal relationship. The justification we provide for this study would be as follows; the stronger financial sector governed by expansionary monetary and fiscal policies leads to the greater opportunity for the economy to be continuously growing up and in return, the dynamic economy accelerates the financial sector development. In this study, we also examine the importance, empirical evidence, and descriptive statistics of FSD, HCR, and FDI. In the meantime, we explore whether HCR are of greater importance than physical capital accumulation needed to speed up economic growth. Since poor economies must concentrate first on technological progress to generate and easily to adopt by HCR, then they gradually accumulate physical capital which relies on technological progress rather than physical capital.

**Review of the Related Literature**

Many theoretical and empirical analyses of economic growth have recognized the importance of human capital level defined as skills of the workforce (Mankiw, Romer, & Wei, 1992). The determinants influence economic growth at different levels, depending on the level of development achieved through various types of policies used. Michael (2011) argued that in the 1950s and 1960s, most of Asian economies were intended for prolonged poverty, while Africa’s independence encouraged great optimism. After the 1970s, however, the East Asian economic performance has made “miracle” in growth, while the Sub-Saharan Africa has attracted attention for the failure of many countries to sustain per-capita income growth (Robin, 2011).

Since the statement of works by Adam Smith and Malthus to the present day, many researchers have tried to find out the most important factors that influence growth by formulating new and improved theories and models. However, there has still no consensus on the key determinants of growth and an all-encompassing model (Boldeanu & Constantinescu, 2015). On top of these, Barro (2003) explained that growth rates vary enormously in different countries over long period due to economic policies, institutions, and national characteristics. Likewise, Paudel (2014) suggested that land-lockedness hampers economic growth but good governance, trade-openness, and coordinating infrastructure development with neighbors are significant aspects of the inter-country differences in growth rates among landlocked developing countries. In addition, Abdi and Aragie (2012) claimed that the Horn of African countries have poor economic growth as limited access to finance; low domestic savings, weak infrastructure, and inadequate human capital. However, these factors are the most significant constraints of economic growth.

Some empirical studies have shown that the determinants of economic growth are of great importance. For
instance, the study by Dewan and Hussein (2001) suggested that investment in both physical and human capital is necessary for economic growth in middle-income developing countries. While Gylfason and Hochreiter (2008) showed that good governance, institutional reforms and improvements in the educational system can play a more important role in raising economic output and efficiency.

There are several factors affecting economic growth in a given country according to various empirical studies. These include: The study by Petrakos and Arvanitidis (2008) suggested that political and institutional aspects in given economy play an important role in advancing growth. Upreti (2015) identified factors affecting economic growth in developing countries; Elkomy, Ingham, and Read (2015) investigated the role of income in determining FDI growth effects in emerging and developing countries as well as Ghazanchyan, Stotsky, and Zhang (2015) examined the growth drivers in Asian countries. Another study by Bassanini and Scarpetta (2001) argued that financial systems contribute to economic growth by providing funding for capital accumulation and helping inventing new technologies. Ghazanchyan, Stotsky, and Zhang (2015) also indicated that private and public investments are strong drivers of growth and the reduced financial risk and higher foreign direct investment have supported growth in Asian countries over the period 1980-2012.

In addition to the studies mentioned above, Rahman and Salahuddin (2010) provided the empirical analysis of Pakistan economic growth; Leon-Gonzalez and Vinayagathasan (2013) explored the determinants of growth in Asian developing economies; and Havi et al. (2013) explained the determinants of economic growth in Ghana. The study of Leon-Gonzalez and Vinayagathasan (2013) described that investment ratio and trade openness are positively correlated to growth, whereas government consumption expenditure is negatively correlated to growth in a panel of 27 Asian developing economies using Bayesian model averaging dynamic unbalanced panel data over the period 1980-2009.

Furthermore, Gylfason and Hochreiter (2008) studied and compared the economic growth performance of Estonia and Georgia; Paudel (2014) observed the determinants of economic growth in developing landlocked countries. Bassanini and Scarpetta (2001) said that financial systems contribute to economic growth by providing funding for capital accumulation and are among many studies that we consider. With regards to the Sub-Saharan Africa countries, Ndambiri et al. (2012) indicated that physical capital formation, a vibrant export sector, and human capital formation are substantial contributors to the economic growth using panel generalized method of momentum (GMM) in a panel of 19 countries from 1982-2000.

Growth differences across countries have been mentioned in various studies conducted by different researchers such as Leon-Gonzalez and Vinayagathasan (2013), Koop et al. (2012), Leon-Gonzalez and Montolio (2012), Moral-Benito (2010; 2012), Sala-i-Martin et al. (2004), and Fernandez et al. (2001), showing that some countries maintain more sustainable economic growth than others. The differences have come as the results of FSD, HCR, and FDI activities taking place in the economy.

In Sub-Saharan Africa, Michalowski (2012) indicated that the effects of FDI on economic growth have risen significantly over the last three decades, though the overall performance in attracting FDI seems to be disappointing. FDI inflows into Sub-Saharan Africa spread unevenly with a high degree of concentration in a few countries. In addition, Elkomy, Ingham, and Read (2015) elaborated that the effects of FDI are found to be stronger in low income countries and negatively weaker in upper-middle income countries in panel of 61 emerging and developing countries for the period of 1989-2013.

Despite the fact of the existence of mixed evidences regarding the impact of FDI on economic growth, the
states in Sub-Saharan Africa have urgently needed strong and more dynamic private sectors. Furthermore, more efficient and effective infrastructure provisions and increased investment from both domestic and foreign sources are required (Carkovic, & Levine, 2004).

In summary, we have investigated several studies in the above literature reviews, about the complementarities between financial sector development (FSD) and economic growth, human capital resources (HCR) and gross national income (GNI), and foreign direct investment (FDI) and economic growth even though the issues are quite known for many years. Regarding an important contribution of the FSD to economic growth, we have dealt with a number of controversial issues in the empirical studies. Some of them argue that financial development is unidirectional causality from economic growth to financial development while others show mixed results. Some others indicate that there has been a negative relationship between FSD and economic growth. However, some scholars suggest that there is no relationship between FSD and economic growth.

Therefore, this study comes up with the promise that the well-functioning financial sector development is the key and powerful engine to economic growth. The very strong financial sector generates enough local savings for making sustainable economic growth. This in turn leads to a greater productive investment in local business. In this regard, it enhances the effectiveness of the banking services as a channel for international streams such as private remittances. To this end, the financial sector provides the means for income-growth and job creation for the individual in addition to accelerates economic growth.

The related empirical studies of human capital resources in relation to economic growth help us to identify the importance, despite the fact that some of them describe negative relation, which provide key concepts to economic analyses. HCR may be measured either by human capital index or human development index. However, the former index is a new measure for capturing and tracking the state of human capital development around the world while the later one is a summary measure for assessing long-term progress in three basic dimensions of human development which involve 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.

FDI is one of the most dynamic resources flowing into developing countries that can be an important component for economic development, in terms of domestic savings in capital accumulation, employment generation and growth. It can also be used as a tool for integrating domestic economy into global one, transferring modern technologies, enhancing efficiency, and rising skills of manpower. An increase in FDI may be associated with improved economic growth due to the inflow of capital for the host country which makes a channel into new infrastructure and other projects to boost development endeavor.

After carefully examining the empirical studies related to FSD, HCR, and FDI, in relation to economic growth, this study looks for appropriate models. Thus we propose a new approach, a panel wavelet time scaling bivariate analysis (by extending the traditional multivariate analysis) such as autoregressive distributed lags (ARDL) and vector error correction (VEC). This new approach can reveal the inter-temporal causal effects with different information in different time horizon between the GDP growth rate and each of its main determinants. The determinants are the contribution of FSD, the role of HCR, and the impact of FDI. We also further examine whether the results of the classical estimation methods like ARDL and VEC models are harmonized with the new analysis, wavelet time scaling to some extent.
Methodology of the Study

The study uses the unbalanced macroeconomic annual data obtained from the UN aggregate databases, the World Bank development indicators, and the International Monetary Fund economic outlook, which cover from the year 1975-2019 for selected panel countries in East Africa.

Measuring Financial Sector Development and Human Capital Resources

A good measurement of financial development is crucial in evaluating the progress of financial sector development and understanding the corresponding impact on economic growth (DFID, 2004). However, in practice, it is difficult to measure the financial sector development given the complexity and dimensions it encompasses. Since financial sector in a country comprises varieties of financial institutions, markets, and products that can be measured as a rough estimate and does not fully capture all aspects of financial development, moreover, there has been very tough task for setting suitable indicators for measuring financial sector development.

However, many alternative indicators have been suggested in various studies which are related to financial development and economic growth. Four indicators are recommended as the indicators: The first one is the ratio of total money two \((M_2)\) in economy minus currency flow in economic circulation to nominal GDP used as an indicator of banking sector development (Levine, 1997; Anwar, Shabir, & Hussain, 2011). The second indicator is the ratio of domestic credit of private sector to nominal GDP. This indicator measures the quantity of investment financed by the banking sector. Many researchers use this indicator as a proxy for financial sector development (see King & Levine, 1993). The third indicator is the total amount of assets of the commercial banks with central bank to GDP ratio. The fourth indicator is average market capital to nominal GDP ratio which is used as an indicator for the development of stock exchange market that shows the financial and investment policy behavior depends on each other (Beck, Demirgüç-Kunt, & Levine, 1999).

Unlike all indicators mentioned above, we use the ratio of total domestic credit (that is the sum of public and private) to real gross domestic product (GDP) as a proxy for the FSD. This is that because nominal GDP is subject to inflation, the total money two \((M_2)\) minus currency in economic circulation results in extensive use of liquid currency outside the banking system. Further, this also subject to inflation as large amount of money is not controlled under monetary authority in developing countries. Furthermore, we do not also consider the ratio of domestic credit of private sector to nominal GDP because of its limitation in coverage. Credit provided to the government and other sectors would be incorporated. Finally, we also do not consider the ratio of total value of stock market over nominal GDP as an indicator, since there is almost no stock market in developing economies in general and in East Africa in particular.

In human capital resources, Kwon (2009) argues that a direct measurement is also a difficult task. So, conventional measurement of human capital focuses on the monetary perspective, neglecting the importance of its non-monetary aspects such as creating added-values and social networks. 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 study emphasizes (United Nations, 2008) that an accurate measure of labor and capital inputs based on the breakdown of aggregate hours worked and aggregate capital stock into various components are essential. The hours worked are cross-classified by the educational attainment in gender and age with the aim to proxy for differences in work experience. In all round, human capital is increasingly believed to play an important role in the growth process, even though adequate measuring of its stock remains controversial (Le, Gibson, & Oxley, 2002).
We have also measured human capital resource by human development index (Worku, 2017). It is a summary measure for assessing long-term progress in three basic dimensions of human development. These include long and healthy life, access to knowledge, and decent standard of living condition (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, the most comprehensive studies using income-based approach to measuring human capital for the US economy presented by Jorgenson and Fraumeni (1989; 1992) and an experimental measuring of human capital formation for the Australian economy by Wei (2004). According to these studies, human capital formation is measured as lifetime labor income and gross human capital formation as the sum of investment in education and training.

Despite the fact that various kinds of measures for human capital resource (HCR) have been developed, Kyriacou (1991) estimates the relationship between educational attainment and human capital investment seems to be the appropriate one. In addition, Mankiw, Romer, and Weil (1992) indicate the performance of human capital as macroeconomic indicators. In addition, 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 are important inputs for human capital measurement (Barro & Lee, 1993; Wossmann, 2003). So, we need all these to be into consideration. Hence, human capital accumulation has been estimated using human development index with the help of geometric method deriving the index (Worku, 2017).

**Model Specifications**

Now we want to make the model specifications by taking the main determinants as explanatory variables and the growth rate of real GDP as dependent one. The determinants are financial sector development (FSD), human capital resources (HCR), and foreign direct investment (FDI). This section tries to describe the methods that we make use of estimating the economic growth in East Africa. FSD, HCR, and FDI can contribute to economic growth only when sufficient absorptive capability of advanced technologies is available and an economic growth modeling with a continuum of agents indexed by their level of ability (Alfaro, 2000). In real environment, the production function tends to increase returns to scale with augmented neoclassical model (Schmidt-Hebbel, 1994; Easterly & Levine, 1994). In addition, there exist technological spillovers and increasing returns to scale (Barro & Sala-i-Martin, 2003) in the framework of the neoclassical model.

We consider the minimum and maximum values of the goalposts of the observed values in the time series interval 1980-2012 (UNDP, 2013). 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 the national income per capita (NIPC), according to the studies in UNDP (2013) and CIA (2006; 2015). 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).

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:

\[ HCR = HDI = (LEI \times EI \times II)^{\frac{2}{3}} \]

where,

\[ LEI = \frac{\text{Life expectancy at birth/year} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}} \]

\[ SMEI = \frac{\text{Mean of school enrolment} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}} \]

\[ EI = \sqrt{\frac{(LEI)(MSEI) - \text{Observed Minimum value}}{\text{Maximum value} - \text{Minimum value}}} \]

\[ II = \frac{\ln (\text{GNI}) - \ln \text{Minimum value}}{\ln (\text{Maximum Value}) - \ln \text{Minimum value}} \]

Having defined variables, now we can model a panel data for the total output in the economy which is mainly explained by gross domestic product (GDP) from the production function and we take the logarithm both sides of the function as follows.

\[ \ln GDP_{it} = \psi_0 + \psi_1 \ln FDI_{it} + \psi_2 FSD_{it} + \psi_3 HCR_{it} + \varepsilon_{it} \]  

(1)

Where \( \psi \) are estimable parameters, \( \ln GDP_{it} \) is real GDP in (log) form, \( \ln FDI_{it} \) is Foreign Direct Investment in (log) form, \( FSD_{it} \) is Financial Sector Development, \( HCR_{it} \) is Human Capital Resource, and \( \varepsilon_{it} \) denotes the error-terms, respectively. The error-term \( \varepsilon_{it} \) is independently and identical distribution, iid as well as \( i \) and \( t \) denotes individual country and time variant.

Most empirical growth models are estimated using panel data based on the hypothesis of conditional convergence, containing some dynamics lagged variables in the regressors (Islam, 1995). The long-run estimation of dynamic panel econometric model explains macroeconomic events by specifying preferences, technology, and institutions. It also predicts what is produced, traded, and consumed and how these variables respond to various shocks (William, 2010).

Consider a linear dynamic panel data involving lagged dependent variable by specifying as

\[ Y_{it} = \sum_{j=1}^{p} p_j Y_{it-j} + X_{it} \beta + \delta_{it} + \varepsilon_{it} \]  

(2)

The dynamic panel described in Equation (2) is characterized by two sources of persistence over time. These are autocorrelation due to the presence of lagged dependent variable among the regressors and individual effects characterizing the heterogeneity among individuals. Thus, we cannot apply the ordinary least squares (OLS), generalized least squares (GLS), fixed and random effects methods because \( Y_{it-j} \) is correlated with stochastic regressor innovations \( \delta_{it} \) and samples mean of \( Y_{it-j} \) is correlated with \( \varepsilon_{it} \) so that the results will be inconsistent (Baltagi, 2006).

The most widely used and efficient methods of estimation for the differenced equations are generalized method of moments (GMM) of Arellano and Bover (1995); fully modified ordinary least squares (FMOLS) of Pedroni (2000), and the dynamic panel least squares DOLS of Saikkonen (1992) and Stock-Watson (1993). The GMM system form developed and studied by Arellano and Bover (1995) and discussed in Ahn and Schmidt (1995) and Hahn (1999) are not only lagged levels used as instruments for first differences but lagged first differences used as instruments for levels which correspond to extra set of the moment conditions. There is an over-identified with GMM used with lags two and three in a dependent variable as instruments, but, this method we require a large number of time variable sets loses some observations in time series (Baltagi, 2006).
First differencing Equation (2) specification to eliminate an individual effects and produces an equation in the form of

\[ \Delta Y_t = \sum_{j=1}^{p} p_j \Delta Y_{t-j} + \Delta X'_{it} \beta + \Delta \epsilon_t \] (3)

Phillips and Hansen (1990) propose fully modified ordinary least squares (FMOLS) and Pedroni (2000) and Mark and Sul (2003) improve and apply it for estimators. In this regard, these scholars employ semi-parametric to eliminate the problem caused by the long-run correlation between cointegrating equation and stochastic regressor innovations. It is asymptotically unbiased which directly comes from the differenced regressions which can be formulated as

\[ \Delta X'_{it} = \gamma_{12} \Delta D_{1t} + \gamma_{22} \Delta D_{2t} + \Delta \hat{u}_{it} \] (4)

According to the study by Phillips and Hansen (1990), fully modified ordinary least squares (FMOLS) estimator is given by

\[ \hat{\beta}_{\text{FMOLS}} = \left( \sum_{t=1}^{T} Z_{it} Z'_{it} \right)^{-1} \left( \sum_{t=1}^{T} Z_{it} \epsilon'_t - T \left[ \hat{\lambda}_{12} \right] \right) \] (5)

\[ \Delta \ln Y_t = 100(\ln Y_t - \ln Y_{t-1}), \quad E(\Delta Y_{t-1} - \Delta \epsilon_t) = E((Y_{it-1} - Y_{it-2})(\epsilon_{it} - \epsilon_{it-1})) = -\sigma^2 \epsilon \]

The \( \delta \) are scalars, \( Y_{it} \) and \( X'_{it} \) are 1xK and \( \beta \) is KxK. We assume that the \( \epsilon_{it} \) follow a one-way error component model and \( \epsilon_{it} \sim \text{iid}(0, \sigma^2_{\epsilon_{it}}) \) and \( \epsilon_{it-1} \sim \text{iid}(0, \sigma^2_{\epsilon_{it-1}}) \) independent of each other. We denote that \( D_{1t} \) and \( D_{2t} \) are deterministic trend regressors and \( Z_{it} = (X'_{it}, D_{it})' \), the modified data \( Y'_{it} = \hat{Y}_{it} - \hat{\omega}_{12} \hat{\Omega}_{22} \hat{u}_{2} \) and estimated biased correction term \( \hat{\lambda}_{12} = \hat{\lambda}_{12} - \hat{\omega}_{12} \hat{\Omega}_{22} \hat{\Lambda}_{22} \). Assume that \( \hat{\Omega}_{22} \) and \( \hat{\Lambda}_{22} \) be the construction of long-run covariance matrix estimators using \( \hat{u}_{it} = \left( \hat{u}_{1it}, \hat{u}_{2it} \right) \).

According to the studies by Saikkonen (1992) and Stock-Watson (1993), constructing the asymptotically efficient estimator of dynamic ordinary least squares (DOLS) is to eliminate feedback in cointegrating system. Since it involves augmenting the cointegrating regression with lags in \( \Delta X_{it} \), the resulting cointegrating equation error terms become an orthogonal to the entire stochastic regressors’ innovations. Thus, the efficient estimator of the DOLS can be as

\[ \hat{Y}_{it} = X'_{it} \hat{\beta} + D'_{it} \hat{\varphi} + \sum_{j=1}^{r} \Delta X'_{it(t+j-1)} \delta \] (6)

The assumption adding \( q \) and \( r \) leads of the differenced regressor steep up all the long-run correlation between innovations over-time and estimation based on the DOLS which are efficient, have the same unbiased and mixture normal asymptotic as FMOLS (Saikkonen, 1992; Stock-Watson, 1993).

We can also express Equation (1) in terms of panel vector autoregressive (VAR) system contains a set of \( n \) variables, each of which is expressed as a linear function of the order-\( p \) lags of itself and of all others \( n-1 \) variables, plus an error term is given by

\[ \ln GDP_{it} = \eta_0 + \eta_1 \ln GDP_{it-1} + \cdots + \eta_p \ln GDP_{it-p} + \eta_1 FSD_{it-1} + \cdots + \eta_p FSD_{it-p} + \eta_3 HCR_{it-1} + \cdots + \eta_p HCR_{it-p} + \eta_3 \ln FDI_{it-1} + \cdots + \eta_p \ln FDI_{it-p} + \epsilon_{it} \] (7)

If the variables are non-stationary in their levels but stationary in differences, we take the differences and estimate short-run using vector error correction model (VECM) that allows consistent estimation of the relationships among the series. More precisely, under the specification of restricted parameters, the panel
VECM allows the interactions of short-run dynamics between cross-sections and influence of one cross-section’s temporary long-run equilibrium error on other members of the panel and the difference in cointegration ranks across cross-sections and cross-sectional cointegration (Anderson, Qian, & Rasch, 2006). If the variables in each series are cointegrated, we use the system of panel vector error correction model (VECM) instead of vector autoregressive (VAR) to estimate the short-run relationship between dependent and explanatory variables that can be set as follows

\[ \Delta \ln GDP_{it} = \lambda_0 + \Delta_{it}(\ln GDP_{lt-1} - \Phi_1 FSD_{lt-1} - \Phi_2 HCR_{lt-1} - \Phi_3 \ln FDI_{lt-1}) \]

\[ + \sum_{l=0}^{p} \Pi_l \Delta FSD_{lt-l} + \sum_{m=0}^{q} \Pi_m \Delta HCR_{lt-m} + \sum_{n=0}^{r} \Pi_n \Delta \ln FDI_{lt-n} + \theta_{lt} \]

where \( \lambda_{it} \) are parameters of the error correction terms which estimate the speed of adjustment or error-correction towards the long-run equilibrium for country \( i \) over time \( t \). If the parameter of the error correction term is negative in sign and significant, there is a long-run association, or integrated of the same order among \( \ln GDP_{lt}, FSD_{lt}, HCR_{lt} \) and \( \ln FDI_{lt} \); otherwise, no long-run relationship. \( \theta_{lt} \) is white noise random disturbances. \( \lambda_0, \Phi, \) and \( \Pi \) are parameters to be estimated and \( p, q, \) and \( r \) denote the optimal lag length. The model is flexible which provides both the short-run elasticities, in addition to being consistent in dealing with non-stationary data at level.

However, the autoregressive distributed lag (ARDL) model has gained popularity as a method of examining long-run in the panel and short-run for both panel and individual entity estimation. The cointegrating relationships among the variables exist given as ARDL \((p, q_1, \ldots, q_k)\) where \( p \) is number of lags of the dependent variable, \( q_1 \) is number of lags of the first explanatory variable, and \( q_k \) is number of lags of the \( k^{th} \) explanatory variable (Pesaran, Shin, & Smith, 1999). The model selection procedures are available for determining these lag lengths.

Therefore, we can rewrite Equation (9) in the form of dynamic panel autoregressive distributed lag ARDL model as,

\[ \Delta \ln GDP_{it} = \eta + \Pi_0 \ln GDP_{it} + \Pi_1 FSD_{lt} + \Pi_2 HCR_{lt} + \Pi_3 \ln FDI_{lt} \]

\[ + \sum_{j=1}^{q_0} \Pi_{0j} \Delta \ln GDP_{lt-j} + \sum_{j=0}^{q_1} \Pi_{1j} \Delta FSD_{lt-j} + \sum_{j=0}^{q_2} \Pi_{2j} \Delta HCR_{lt-j} + \sum_{j=0}^{q_3} \Pi_{3j} \Delta \ln FDI_{lt-j} + \lambda ECT_{it-1} \]

\[ + \varepsilon_{it} \]

Suppose the long-run matrix \( \Pi \) coefficient has reduced rank decomposition and the compact vector matrix form can be expressed in the following way as

\[ \Pi = \alpha \beta' \]

\[ \Delta Z_t = \beta_0 + \Gamma Z_{t-1} + \Pi \Delta Z_{t-1} + \varepsilon_{it} \] for \( i = 1, 2 \ldots, N \) and \( t = 1, 2 \ldots, T \).

Using the cointegrating relationship form in Equation (9), as it has been described by Pesaran, Shin, and Smith (2001), the methodology for testing whether the ARDL model contains long-run relationship of the variables. Finally, we estimate the dynamic relationship between dependent variable and regressors. In dynamic panel data regression described in Equation (9), we cannot apply the OLS, GLS, fixed effects (FE) and random effects (RE) methods because \( \ln GDP_{lt} \) is correlated with \( \lambda \) and the samples mean of \( \ln GDP_{lt-1} \) is correlated with that of \( \varepsilon_{it} \) so that the results will be inconsistent (see Baltagi, 2006).
If we assume $\varepsilon_{it}$ are uncorrelated with the other covariates, we can fit a random-effects model, which is known as variance-components or error-components model. Since variance components are unknown, consistent estimates are required to implement feasible generalized least squares (GLS). This offers two choices such as the Swamy-Arora method and simple consistent estimators to use variance-components estimators (Baltagi & Chang, 2000). These are based on the ideas of Amemiya (1971), Swamy and Arora (1972), and Baltagi and Chang (1994) derived the Swamy-Arora estimators of the variance components for unbalanced panels. The default of the Swamy-Arora method contains degree of freedom of a correction to improve its performance in small samples.

$$Z_t = \begin{bmatrix} \Delta Z_{1t} \\ \Delta Z_{2t} \\ \vdots \\ \Delta Z_{Nt} \end{bmatrix}, \quad \beta_0 = \begin{bmatrix} \beta_0' \\ \beta_1' \\ \vdots \\ \beta_N' \end{bmatrix}, \quad \Gamma = \begin{bmatrix} \Gamma_{11} & \Gamma_{12} & \cdots & \Gamma_{1N} \\ \Gamma_{21} & \Gamma_{22} & \cdots & \Gamma_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \Gamma_{N1} & \Gamma_{N2} & \cdots & \Gamma_{NN} \end{bmatrix}, \quad Z_{t-1} = \begin{bmatrix} Z_{1t-1} \\ Z_{2t-1} \\ \vdots \\ Z_{Nt-1} \end{bmatrix}, \quad \Delta Z_{t-1} = \begin{bmatrix} \Delta Z_{1t-1} \\ \Delta Z_{2t-1} \\ \vdots \\ \Delta Z_{Nt-1} \end{bmatrix} \alpha = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_N \end{bmatrix}$$

and $\Delta Z_t = \Delta \ln GDP_{it}$, $\beta_0 = \lambda_0 = \delta d_{it}$, $Z_{t-1} = \ln GDP_{it-1} + FSD_{it-1} + HCR_{it-1} + \ln FDI_{it-1}$. Matrices $\alpha$ and $\beta$ are of dimension $N_p \times r$, with rank $r \equiv r_1 + r_2 + \cdots + r_N < N_p$ and the value of $r$ determines the number of cointegration. $\Gamma$ denotes short-run coefficients. Where $\eta$ is constant intercept, $\Delta$ is the first-difference operator, $FSD_{it}, HCR_{it}$ and $FDI_{it}$ is a $1 \times k$ vector of strictly exogenous covariates in each, $\Pi$ is a $k \times 1$ vector of parameters to be estimated, $\Pi_{0i} \ldots \Pi_{4i}$ parameters to be estimated which indicate long run coefficients, $\Pi_{0ij} \ldots \Pi_{4ij}$ denote short-run coefficients, and $ECT_{it-1}$ and $\varepsilon_{it}$ are the representations error correction terms and independent identically distributed iid term which comes from a low-order moving-average process, with variance $\sigma^2_t$, respectively and $i = 1, \ldots, N$ and $t = 1, \ldots, T$. We suppose $GDP_{it}$ be a $p \times 1$ vector of cross-section $i$ in period $t$, following a non-stationary VAR ($p$) process. $\lambda_0 = \delta d_{it}$ is a $p \times 1$ vector with the $j$-th element representing the deterministic component of the model and $d_{it}$ is vector of deterministic components and $\delta_t$ is a $p \times 1$ matrix of parameters. $\delta_{it}$ are a $p \times 1$ vector of disturbances and are independent of $N(0, \Omega_{it})$ for $t = 1, \ldots, T$. Further, we assume that the number of cross-sections $N$ is fixed and the number of time periods $T$ is relatively large (see: Anderson et al., 2006).

Since an ARDL model can be estimated via least squares regression, the standard Akaike, Schwarz, and Hannan-Quinn information criteria are used for the model selection. The standard error of the long-run coefficients can be calculated from the standard errors of the original regression. The methods such as Fully modified OLS, or dynamic OLS either require all variables to be I(1) or require prior knowledge and specification of which variables are I(0) (see Johansen, 1991; 1995). To alleviate this problem, Pesaran, Shin, and Smith (1999) show that cointegrating systems can be estimated using ARDL model, with the variables in the cointegrating relationship that can be either I(0) or I(1), without pre-specify which are I(0) or I(1).

Panel data econometrics has been used for estimating and forecasting purposes (Baltagi, 2006). In dynamic panel, the short and long run estimators have increasingly used in many studies (such as Baltagi, 2006; Easterly, 1997; Islam, 1995; Arellano & Bond, 1991). These dynamic relationships are characterized by the presence of a lagged dependent variable which appears as an independent with other regressors. Based on the lagged observations used as explanatory variables, the dynamic estimators are designed to address the
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econometric problems of the unobserved specific effects and the joint endogeneity of explanatory variables (Alonso-Borrego & Arellano, 1996).

In the dynamic panel estimators, we apply the differenced equation to remove any bias and potential parameter inconsistency arising from the simultaneity bias created by the unobserved country-specific effects and the 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 & Pesaram, 2005).

The important of time scale wavelet analysis in the VAR framework is desirable local orthonormal bases consisting of small waves that dissect a function into layers of different scale (Schleicher, 2002). The segmentation of time series into different layers makes a very powerful wavelet analysis in the short, medium, and long run horizons according to studies by Ramsey and Lampart (1998), Hacker, Karlsson, and Månsson (2012), and Reboredo and Rivera-Castro (2014).

Now days, the time scale wavelet analysis has been become popular and increasingly used in economic literature according to Reboredo and Rivera-Castro (2014), Hacker, Karlsson, and Månsson (2012), Almasri and Shukur (2003), and Ramsey and Lampart (1998). The maximal overlap discrete wavelet decomposition in the methodology that we use allows 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, & 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

\[ f(x) = C_0 + \sum_{k=0}^{n} c_{k\psi}(\lambda, k, \psi) \]  

where \( C_0 \) is the overall mean of the data and along with the \( C_{k\psi} \) 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 - \( \lambda \) smooth and detail series, \( S_\lambda \) and \( D_\lambda \). Let the level-zero smooth series \( S_0 \) be 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:

\[ S_{\lambda,t} = \frac{S_{\lambda-1,t-2^{\lambda-1}} + 2S_{\lambda-1,t} + S_{\lambda-1,t+2^{\lambda-1}}}{4} \]

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 \( \Lambda \); the sum of the detail series from level 1 to level \( \Lambda \) is given by

\[ y = S_\Lambda + \sum_{\lambda=1}^{\Lambda} D_\lambda \]  

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 we have:

\[ \begin{align*}
S_{1,t} &= \frac{y_{t-1} + 2y_t + y_{t+1}}{4}, \\
D_{1,t} &= \frac{-y_{t-1} + 2y_t - y_{t+1}}{4}, \\
S_{2,t} &= \frac{S_{1,t-2} + 2S_{1,t} + S_{1,t+2}}{4}, \\
D_{2,t} &= \frac{-S_{1,t-2} + 2S_{1,t} - S_{1,t+2}}{4}, \\
S_{3,t} &= ...
\end{align*} \]
\[
S_{g,t-4} + 2S_{g,t} + S_{g,t+4} = \frac{1}{4} D_{3,t} \quad \text{and} \quad S_{h,t} = \frac{1}{4} D_{4,t} = S_{g,t-8} + 2S_{g,t} + S_{g,t+8}.
\]

The associated wavelet details, \(D_4 \) to \(D_\Lambda\) are the decompositions of the two data at different timescales and \(S_\Lambda\) represents the long-term trend at scale level \(\Lambda\), which corresponds to zooming out the camera lens and looking at the broad landscape (Hacker, Karlsson, & Månsson, 2012).

Suppose the estimation would be made not at a time, but one after another by taking others explanatory variables remain constant. This means when we make the estimation of the inter-temporal causal relationship of the growth rate of real GDP-FSD, real GNI-HCR and growth rate of real GDP-FDI are assumed to be unchanged and a like, in panel wavelet time scaling of the bivariate analysis which are jointly determined by the VAR system, from Equation (11) for the selected East African countries as

\[
\ln GDP_{it}^{D_j} = \Gamma_0 + \sum_{k=1}^{K_j} \Gamma_1^{(k)} \ln GDP_{L,t-K}^{D_j} + \sum_{k=1}^{K_j} \Gamma_2^{(k)} FSD_{L,t-K}^{D_j} + \sum_{k=1}^{K_j} \Gamma_3^{(k)} HCR_{L,t-K}^{D_j} + \varepsilon_{it}
\]

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

**Empirical Results and Discussions**

Before estimating the coefficients, we have conducted some necessary tests. These involve autocorrelation, cross-sectional dependence, and endogeneity problems. We have also identified the optimal maximum lag-length, panel unit roots, and stability conditions (results are available with the author and will be presented upon request). Prior to the estimation parameters made by the panel wavelet time scaling, we have to estimate the short-run and long-run coefficients using tradition approaches such ARDL and VECM methods. In this section, we have tried to show the empirical results and discussions using different methods and here are the results.

**Panel Cointegration Test**

Table 1

| Pedroni method | Pedroni and Kao Residual Methods of Cointegration Test |
|----------------|-------------------------------------------------------|
| Common AR coefficients with-in dimension | Individual AR coefficients between-dimension |
| Panel-statics | Statistic | p-value | Statistic | p-value | Group statistics | Statistic | p-value |
| V | 2.9505 | 0.0016** | 1.5918 | 0.0557* |
| Rho | 1.4593 | 0.9278 | 1.7563 | 0.9605 |
| PP | -1.6085 | 0.0539* | -1.6830 | 0.0462** |
| ADF | -1.5233 | 0.0638* | -1.4054 | 0.0800* |

| Kao method | Statistic | p-value |
|------------|-----------|---------|
| ADF | -4.5445 | 0.0000** |

Notes. \(H_0\): The null hypothesis: No cointegration. Automatic lag length section is based on SIC with a maximum lag of 2. ** and * denote 5% and 10% level of significance, respectively.
The results in Table 1 above are generated by the Pedroni’s method for test of panel cointegration. The method is on the basis of majority role, in which eight out of eleven outcomes confirm that the variables are integrated of the same order. The Kao method also shows there is long-run relationship among the variables. Therefore, the variables move together in the long-run or they are cointegrated and have long-run relationship.

Panel FMOLS and Panel DOLS Long-Run Estimation

Here the following are long-run estimation coefficients results obtained using the panel of fully modified ordinary least squares (FMOLS) and dynamic ordinary least square (DOLS).

Table 2
Panel FMOLS and DOLS Estimation of Long-Run Coefficients (Real lnGDP Is Dependent)

| Variable | Coeff. | t-statistic | p-value | Coefficient | t-statistic | p-value |
|----------|--------|-------------|---------|-------------|-------------|---------|
| FSDH    | 0.7125 | 2.9688      | 0.0193* | 0.5537      | 0.3021      | 0.0021* |
| HCRH    | 0.4509 | 13.350      | 0.0000* | 0.6843      | 0.0000      | 0.0000* |
| lnFDHI  | 0.0039 | 0.5689      | 0.5698  | 0.4706      | 3.8358      | 0.0001* |

Notes. * shows rejection that the insignificance of the t-statistic and real lnGDP appears as dependent variable. The long-run variances for cross sections of nine countries based on the HQIC automatic leads and lags specification of two optimum lag-length are used. The pooled estimation and the first-stage residuals using heterogeneous long-run coefficients in the panel fully modified least squares (PFMOLS) and the grouped estimation in the panel dynamic least squares (DOLS) are applied for the estimation. Note that coefficient of determination; R-squared is taken from the estimation method of the panel fully modified least squares (FMOLS). R-squared 0.9536 indicates that about 95.4% variations in real GDP are due to the facts that the change in all variables mentioned in the model.

After diagnostic testing for the residual normality distribution and serial correlation (the tests outputs are in Table A1, Appendix A), we estimate long-run parameters since number of cointegration within four series has been confirmed. Thus, panel fully modified least squares PFMOLS and panel dynamic least squares PDOLS estimation results are reported in Table 2 which indicate that as FSD increases by one unit, the real GDP growth rate increases by 0.71 and 0.55 percentage points, respectively. Similarly, a one unit increases in HCR, it increases a 0.45 and 0.68 units in real GDP growth rate using the two methods of estimation, respectively. In addition, FDI has positively significant contribution to economic growth according to PDOLS method of estimation.

Transmission Mechanism Channels in Panel VEC Model Estimation

After taking the significant independent variables along with the dependent real GDP while dropping FSD, we run the model. The results for the transmission mechanism channels in panel VECM and the two error correction term-1 and term-2, are reported in Table 3. Both the error correction terms are negative and statistically significant which indicate, there are speed of adjustment towards the long run equilibrium after the shock takes place in the short run or robust long-run relationship among gross rate of real (GDP), human capital resources (HCR), and foreign direct investment (FDI). The three years lagged in the gross rate of real GDP have significantly negative impact on the real gross rate of the current real GDP whereas that of one year lagged in human capital resources (HCR) has significantly positive contribution to the gross rate of real GDP. However, the first period lagged in the gross rate of FDI causes adverse effect to the real GDP gross rate.

The results in Table A2, Appendix A show that the joint cumulative of three years lagged in real GDP, HCR, and FDI has significantly negative, positive, and negative effects on real GDP gross rate, respectively. As you can see the diagnostic checking for the model, F-statistic (9.3501) with the probability of (0.0000) is quite
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significant which indicates the data are well fitted to the model. The model is also free from the problem of autocorrelation in which the results are reported (Table A1, Appendix A).

Table 3
Transmission Mechanism Channel in Panel VECM Using Eq. (8)

| Dep. Var. is D(lnGDP\_t) | Coefficient | Std. error | t-statistic | p-value |
|--------------------------|-------------|------------|-------------|---------|
| ε\_1ECT-1                | -0.0584     | 0.0031     | -2.6811     | 0.0088**|
| ε\_2ECT-2                | -0.0251     | 0.0036     | -6.8933     | 0.0000**|
| Γ_1D(lnGDP\_t-1)         | -0.2198     | 0.0347     | -6.3377     | 0.0000**|
| Γ_2D(lnGDP\_t-2)         | -0.1058     | 0.0341     | -3.0995     | 0.0026**|
| Γ_3D(lnGDP\_t-3)         | -0.0825     | 0.0339     | -2.4336     | 0.0170* |
| Γ_4D(HCR\_t-1)           | 0.0629      | 0.0176     | 3.5758      | 0.0006**|
| Γ_5D(HCR\_t-2)           | 0.0157      | 0.0186     | 0.8425      | 0.4018  |
| Γ_6D(HCR\_t-3)           | 0.0167      | 0.0206     | 0.8083      | 0.4211  |
| Γ_7D(lnFDI\_t-1)         | -0.0082     | 0.0026     | -3.1225     | 0.0024**|
| Γ_8D(lnFDI\_t-2)         | -0.0029     | 0.0029     | -0.9630     | 0.3382  |
| Γ_9D(lnFDI\_t-3)         | -0.0003     | 0.0028     | -0.0918     | 0.9271  |
| Constant                 | 0.0947      | 0.0055     | 17.1366     | 0.0000**|

Variance Decomposition and Impulse Response of the VECM

As we already have proved the variables are non-stationary at level, we have shown the vector error correction model (VECM) variance and impulse responses. The report results in Table A3, Appendix A show that in the year 1991, the short run-impulse innovation or shock to real GDP accounts for about 95.35 percent fluctuates variation in real GDP, while in the long-run in 2014, the own fluctuates declines to 9.50 percent.

The shock to HCR accounts for about 4.60 percent variation of fluctuates in real GDP whereas in the long-run in the year 2014, the own fluctuates increases to 11.19 percent. However, there has been a very huge fluctuation variation in real GDP for the last 25 years, because of the shock to FDI nearly about 0.04 percent in the year 1991, which becomes 79.31 percent in the year 2014. For this reason, the figures in Appendix A also indicate that the accumulated responses of the real GDP to the FDI are more immediate than to HCR for the period 1990 to 2014. As you can see in Table A4, Appendix A, the accumulated response of lnGDP\_t to HCR\_t,t and lnFDI\_t,t has not much varied between 1991 and 2014.

Random Effects and ARDL Models Estimation Coefficients

As we can see in Table 3, three different redundant fixed effects tests are employed, each in both χ² and F-test versions. For restricting the cross-section fixed effects to zero, the period fixed effects to zero and restricting both types of fixed effects to zero. In all three cases, the p-values related with the test statistics are zero or the χ² and F-tests are statistically significant at the 5 percent level, indicating that the restrictions are not supported by the data. Hence, a pooled sample data could not be employed. It is of interest to determine whether the random effects model passes the Hausman test for the random effects being uncorrelated with the explanatory variables.

We also conduct the Hausman test in order to distinguish whether random effect is an appropriate model and fit for the data or not. The chi-squared statistic χ² value of 0.1540 with the p-value of 0.9846 is greater than one percent for the test summary of the cross-section random. This leading us to fall the rejection at the one percent level of significance that the null hypothesis of the appropriate model is random effect, against the
alternative fixed effects. Thus this shows the random effects model specification is to be preferred.

In order to determine the relationship between dependent and independent variables, we choose a panel random effect over both fixed effect and pooled OLS regression models. We employ the model specified in Equation 1 for the regression estimation. Accordingly, the outputs reported in Table 4 display the basic information about the specification, including the method used to compute the component variances, the coefficient estimates and associated statistics. We estimate the specification using the cross-section seemingly uncorrelated regression (SUR) standard errors to allow for general contemporaneous correlation between the panel residuals. The cross-section designation is used to indicate a non-zero covariance, allowing across cross-sections. This portion exhibits the best-linear unbiased predictor estimates of the random effects.

Table 4
Redundant FE and the Hausman Correlated Random Effects Tests Using Eq. 1

| Effects test                  | Statistic | p-value |
|-------------------------------|-----------|---------|
| Cross-section-F               | 1,014.8   | 0.0000  |
| Cross-section-$\chi^2$        | 1,061.5   | 0.0000  |
| Period-F                      | 18.291    | 0.0000  |
| Period-$\chi^2$              | 366.51    | 0.0000  |
| Cross-section and period-F    | 212.03    | 0.0000  |
| Cross-section and period-$\chi^2$ | 1,081.8 | 0.0000  |

Hausman test summary for cross-section random-$\chi^2$

0.1540 0.9846

Table 5
Random Effects and ARDL Models Long-Run Estimation Coefficients

| Variable | Coefficient | t-statistic | p-value | Coefficient | t-statistic | p-value |
|----------|-------------|-------------|---------|-------------|-------------|---------|
| $FSD_{it}$ | 0.5181      | 0.4970      | 0.6196  | 1.4759      | 0.7953      | 0.4272  |
| $HCR_{it}$ | 1.4276      | 3.3935      | 0.0008* | 2.4803      | 2.7346      | 0.0067* |
| $lnFDI_{it}$ | 0.0589      | 2.8428      | 0.0048* | 0.3891      | 3.3650      | 0.0009* |
| Constant  | 20.427      | 53.503      | 0.0000* | 0.3658      | 3.9351      | 0.0001* |
| F-statistic | 98.943      | 0.0000*     | -3.5273 | E_{it-1}=-0.024 | -3.9351     | 0.0005* |

Notes. ** and * denote level of significance conventionally 1%. Dependent Variable: ln GDP, Panel EGLS (cross-section random effects) for a sample period 1980-2018 which includes nine cross-countries.

The Swamy and Arora estimator of the component variances and the cross-section SUR standard errors and covariance (no d.f. correction) are in the procedures. SUR, a generalization of linear regression model that consists of several regression equations, each has its own dependent variable and potentially different sets of exogenous explanatory variables (Zellner, 1962). The model selection method includes Akaike information criterion. The dynamic regressors with two lags automatic, FSD, HCR, lnFDI and number of models evaluated is four for the selected model, which is resulted in ARDL (2,1,1,1). The original data on all series were transformed into appropriate one using the demeaned method to be cross-section independent and lnGDP, FSD, and HCR were estimated by 2SLS to get rid of endogeneity.

The long-run estimations reported in Table 5 of the random effects and the autoregressive distributed lags ARDL (2,1,1,1) models indicate that human capital resource (HCR) and foreign direct investment (FDI) both have positively significant effects on economic growth (denoted by real GDP growth) for a panel of the East African countries over the period 1980-2015. More technically, an increase in HCR causes increases in the
economic growth and also a one percentage point increases in FDI that increases the economic growth by 0.06 percent for the panel countries.

The error correction terms \( E_{t-1} \) for a panel of nine countries and individual country which are available in Appendix A5 are respectively shown negatively significant. These terms measure the seed of adjustment towards the long-run equilibrium, at the seed of 2.40 percent, 5.23 percent, and 5.56 percent for panel countries and Zambia and Mauritius economies on individual basis, respectively. Out of nine countries, the Mauritian economy is the fastest one to achieve the correct disequilibrium and become on its long-run equilibrium which it takes approximately about 18 years (the absolute value reciprocal coefficient term \( 17.98 = 1/0.0556 \)).

The short-run estimated growth rates of human capital resources (HCR) and foreign direct investment (FDI) have positive and negative significant impact on economic growth rate for Burundi; negative and positive for Ethiopia; both negative for the Kenyan and Madagascar; negative and positive for Malawi; both positive for Mauritius; both negative for the Rwandan case; negative FDI and financial sector development FSD for Uganda and Zambia, respectively (see Table A5, in Appendix A).

**Panel Wavelet Time Scaling Estimation Coefficients**

Table 6

| Dependent variable | Independent variable | Combined mean coefficients of wavelet time scale horizons |
|--------------------|----------------------|----------------------------------------------------------|
| FSD-GDP growth rate model using panel | lnGDP | FSD |
| FMOLS | -1.3119 | -0.3198 | 0.3580 |
| | (14.89) | (23.32*) | (35.04*) |
| FDI-GDP growth rate using panel model | Real lnGDP | lnFDI |
| Panel ARDL (1,1) | -0.0777 | 0.0106 | 0.3584 |
| | (16.49) | (20.75*) | (21.31*) |
| Accumulated impulse-response for HCR-GNI growth rate model | lnGNI to HCR |
| HCR to lnGNI | -0.0007 | -0.0001 | 0.0117 |
| Model from | (28.06*) | (35.16*) | (52.66*) |

Notes. * denotes rejection of the null hypothesis of the explanatory which does not Granger cause of the dependent variable and the lnGDP-2SLS is equivalent to lnGDP as well as FSD-2SLS is equal to FSD. 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. We calculate the combined calculated mean coefficients and probability values from each country using the simple average method and the formula, \( \chi^2 = -2 \sum_{i=1}^{L} \ln(P_i^2) \) where \(-2\ln P_i\) which has a chi-square \( \chi^2 \) distribution and \( i \) stands for country 1, 2, 3, ..., \( L \) (see detailed in Dmitri et al., 2002; Fisher, 1932). Numbers in parenthesis denote combined calculated \( \chi^2 \) and the combined calculated \( \chi^2 \) are compared with the conventional \( \chi^2 \) which have been available in (Brooks, 2008). These conventional \( \chi^2 \) of 16.92 at the 5% level of significance for nine degrees of freedom which represents number of countries for FSD; of 14.07 at the 5% level of significance, seven degrees of freedom which represents number of countries for FDI and conventional \( \chi^2 \) of 15.98 at the 5% level of significance for nine degrees of freedom which represents number of countries for HCR. Moreover, the combined mean coefficients increase in general over-time across the short, medium, and long-run denoted by time scale of \( \beta_1, \beta_2, \) and \( \beta_3 \) of the time scale horizons. Using the optimal lag-length of two in a panel fully modified ordinary least square (FMOLS) method, of one in ARDL and three in a VEC model to the impulse-response functions because it is more appropriate method for more than two optimal lag-lengths, we are able to estimate the short-term, medium-term, and long-term effects of FSD on real GDP growth rate; FDI on GDP growth rate and HCR with the help of FMOLS, ARDL (1, 1) and VEM models.
The first raw of Table 6 shows that as one unit increases in the FSD, this causes a 32 percent decreases in the medium-term, but 3.6 percent point increases the real GDP growth in the long-term. In the meantime, however, each unit increases in the real GDP growth leads to the FSD decreases by 0.024 in the medium-term and increases by 0.1818 units in the long-term for a panel of nine East Africa economies. The indications of bi-directional dynamic causal relationship between FSD and economic growth exist in the range of time periods. These mean that the strong FSD can produce more sufficient amount of real GDP for the nations and the reverse also holds true in the long-run. However, the possible justification for the unexpected negative sign in both FSD and economic growth in the medium-term is volatile in the credit markets of the financial systems, unstable of money, and weak monetary policy probably that cause delaying in responses of monetary policy to macroeconomic performance fluctuations in the region.

The empirical results of this study is somehow related to the study in Caporale, Rault, Sova, and Suva (2009) for the EU economic growth, which shows the Granger causality runs from financial development to economic growth, but not in the opposite direction. In addition, the annual growth rate of FSD has negatively significant impact on the economic growth as a result of monetary policy in the region could unable to manage the rate of inflation. The high rate of inflation makes more difficult for households and firms to make the correct decisions in response to market signals. When prices rise, the economic agents may find it more difficult to distinguish between the changes in relative prices and the changes in the overall price level. This difficulty may interfere with the efficient operation of the price system so affects growth negatively (Howitt, 1990). Secondly, inflation may affect saving and investment decisions, thereby reducing the proportion of GDP causing the economy to accumulate less capital. The resulting reduced stocks of productive capital may; in turn, implied lower levels of the future GDP (Motley, 1994).

As we can see the results in the second raw of Table 6, the ARDL (1,1) bivariate analyze of the panel wavelet time scaling horizons indicates that there are bi-directional inter-temporal causal relationships between FDI and GDP growth rates. Both FDI and GDP cause changes significantly to each other in the short, medium, and long-terms. The FDI and GDP growth rate has significantly positive contribution to each other in the short, medium, and long-terms in the panel of the East African countries. As FDI increases by one percent, GDP growth also increases by 0.011 in the short term, 0.022 in the medium, and 0.36 percentage in the long-term; in the meantime, as GDP growth increases by one unit, FDI also increases by 4.99, 5.83, and 0.45 units in the short, medium, and long-terms, respectively.

In the third raw of Table 6 the obtained results 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 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.

The possible explanation for the unexpected negative accumulated response from HCR to GNI in the short- and medium-terms may be the low level of capacities unable to accommodate more educated and skilled people in the panel economy. The empirical results of this study are related to some previous studies such as: (1) the link between human capital and labor market of the Pakistan economy in study by Qadri and Waheed (2014) and (2) the critical unemployment high level in economic growth of the Spain and the Cyprus and the level of human capital that has been expressed as a percentage of tertiary educated in the study of Cadil, Petkovová,
and Blatnáb (2014). This possible explanation may also be related to the ideas cited in studies by Sahbi and Jaleleddine (2015), Mohsen and Maysam (2013), Ndambiri et al. (2012), Anderson, Qian, and Rasch (2006), and Freddy, Arne, Gerdie, and Lorenzo (2003).

**Conclusion**

This study investigates the main determinants of GDP growth rate in East Africa over the period 1975-2019 using various types of econometric panel data models. In this study, we have dealt with the correlation between financial sector development (FSD) and economic growth; the role of human capital resources (HCR) in economic growth and impact of foreign direct investment (FDI) on GDP growth rate.

According to the estimation made by the bivariate wavelet time scaling analysis, the FSD-GDP growth rate model using panel FMOLS confirms that the FSD dynamically causes the changes in economic growth, except in the short-term, while economic growth stimulates the change in FSD in the short, medium, and long-terms. The ARDL (1,1) bivariate analysis of the panel wavelet time scaling analysis indicates that there are bi-directional inter-temporal causal relationships between FDI and GDP growth rates. Both FDI and GDP growth rate has significantly positive contribution to each other in the short, medium, and long terms in the panel countries.

We have also shown that the obtained results of 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. Hence, we assert that more educated and skilled human capital can produce sufficient amount of real gross national income for the countries.

Therefore, the first conclusion we draw from this study entails, the reform for the financial sector is needed so as to enhance the inclusiveness of the financial system. The reform on inclusiveness can lead to a comprehensive economic beneficiary in the region. As far as strong FSD can produce more sufficient amount of goods and services that accelerate and augment the real GDP growth and vice versa, more effective and vigorous expansionary monetary policy needs to direct the economy for sustainable growth, thereby development achievement.

The second conclusion we draw is that HCR as a crucial component for economic growth, especially, well-educated and skilled persons in productive sectors, is of important determinants of economic growth. Nevertheless East Africa has the lowest level of HCR development regardless of rapid growth in the expansion of education, the issue of employment challenges that women have faced more than men. Thus, expansionary physical policy in this regard is an important element for addressing the development of HCR effectively to mobilize in addition to inequality and equity concerns. We also argue that much more attention should be given to HCR than any other economic resources for making the growth to be sustained in the process of successful economic development.

Likewise, the third conclusion is that as FDI and GDP have significantly positive contributions to one another in the short, medium, and long-run, favorable environment conditions and very conducive economic policies need to be designed for more attracting of FDI than ever before.

To the end, we only focus on the contribution of FSD, the role of HCR, and the impact of FDI on economic growth. Further studies such as the impact of corruption, the economic policy in each country, and the interaction among each country when it comes to trade are required to conduct on this area which can potentially affect the growth.
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Appendix A

Table A1

| Lags | Serial correlation LM test | Residual normality tests using Cholesky orthogonalization |
|------|----------------------------|----------------------------------------------------------|
|      | LM-statistic               | p-value | Distribution | χ²           | p-value |
| 1    | 18.52546                  | 0.0295  | Skewness     | 249.68       | 0.0000* |
| 2    | 7.522866                  | 0.5828  | Kurtosis     | 55843.5      | 0.0000* |
| 3    | 6.390804                  | 0.7003  | Jarque-Bera  | 56093.2      | 0.0000* |

Notes. * denotes rejection of the hypothesis at the 5% level of significance of Null Hypotheses: no serial correlation at lag order 3 for each. Here we do not reject at all three lags null hypotheses of autocorrelation and hence, the model is free from the problem of serial correlation. However, * denotes what are multivariate normality distributions of the residuals in the model at the 5% level of significance.
Table A2

Joint Cumulative Channels via Real GDP Using Wald Test

| Hypothesized, $H_0$: | $\chi^2$ value | p-value |
|----------------------|---------------|---------|
| 1. $\Gamma_1 + \Gamma_2 = \Gamma_3 = 0$ | 48.58982 | 0.0000* |
| 2. $\Gamma_4 + \Gamma_5 = \Gamma_6 = 0$ | 16.12213 | 0.00021** |
| 3. $\Gamma_7 + \Gamma_8 = \Gamma_9 = 0$ | 10.44713 | 0.0151** |

Notes. ** and * denote rejection of the hypothesis at the 1% and 5% level of significance. Restrictions are linear in coefficients. Dependent variable: $\Delta \ln RGDP_{lt}$.

Table A3

Variance Decompositions

| Period | S.E. | $\Delta \ln RGDP_{lt}$ | $\Delta HCR_{lt}$ | $\Delta \ln FDI_{lt}$ | S.E. | $\Delta \ln RGDP_{lt}$ | $\Delta HCR_{lt}$ | $\Delta \ln FDI_{lt}$ |
|--------|------|------------------------|-------------------|---------------------|------|------------------------|-------------------|---------------------|
| 1      | 0.02836 | 100.000 | 0.00000 | 0.0000 | 1.57851 | 1.36553 | 14.3085 | 84.3259 |
| 2      | 0.03731 | 95.3515 | 4.60350 | 0.0449 | 1.79848 | 1.34433 | 13.1814 | 85.4742 |
| 3      | 0.04437 | 91.1412 | 6.58417 | 2.2745 | 2.04552 | 1.43752 | 19.6740 | 78.8884 |
| 4      | 0.05182 | 83.3214 | 8.02720 | 8.6513 | 2.35028 | 1.42417 | 22.1119 | 76.4639 |
| 5      | 0.06044 | 74.3269 | 7.09294 | 18.580 | 2.54558 | 1.49140 | 23.6194 | 74.8892 |
| 6      | 0.06964 | 66.0972 | 6.23534 | 27.667 | 2.75374 | 1.47913 | 24.5723 | 73.9485 |
| 7      | 0.08007 | 57.8508 | 5.69750 | 36.451 | 2.93166 | 1.48087 | 25.1669 | 73.3521 |
| 8      | 0.09150 | 50.5868 | 5.48392 | 43.929 | 3.08943 | 1.48978 | 26.0214 | 72.4888 |
| 9      | 0.10417 | 44.0718 | 5.44668 | 50.481 | 3.23959 | 1.50069 | 26.8459 | 71.6533 |
| 10     | 0.11804 | 38.4058 | 5.46820 | 56.125 | 3.37529 | 1.51449 | 27.6193 | 70.8661 |
| 11     | 0.13297 | 33.5911 | 5.55159 | 60.857 | 3.50115 | 1.52600 | 28.3245 | 70.1494 |
| 12     | 0.14891 | 29.5339 | 5.71258 | 64.753 | 3.61707 | 1.53696 | 28.9611 | 69.5018 |
| 13     | 0.16577 | 26.1333 | 5.95164 | 67.914 | 3.72353 | 1.54828 | 29.5688 | 68.8828 |
| 14     | 0.18352 | 23.2759 | 6.25562 | 70.468 | 3.82197 | 1.55997 | 30.1525 | 68.2874 |
| 15     | 0.20210 | 20.8653 | 6.60642 | 72.528 | 3.91277 | 1.57214 | 30.7114 | 67.7163 |
| 16     | 0.22144 | 18.8234 | 6.99157 | 74.184 | 3.99657 | 1.58450 | 31.2441 | 67.1713 |
| 17     | 0.24148 | 17.0863 | 7.4039 | 75.509 | 4.07386 | 1.59695 | 31.7492 | 66.6538 |
| 18     | 0.26217 | 15.6015 | 7.83882 | 76.559 | 4.14505 | 1.60953 | 32.2288 | 66.1615 |
| 19     | 0.28344 | 14.3260 | 8.29189 | 77.382 | 4.21061 | 1.62225 | 32.6850 | 65.6927 |
| 20     | 0.30525 | 13.2248 | 8.75890 | 78.016 | 4.27093 | 1.63512 | 33.1186 | 65.2461 |
| 21     | 0.32754 | 12.6929 | 9.23599 | 78.494 | 4.32639 | 1.64810 | 33.5304 | 64.8214 |
| 22     | 0.35025 | 11.4360 | 9.72007 | 78.843 | 4.37732 | 1.66118 | 33.9206 | 64.4181 |
| 23     | 0.37333 | 10.7062 | 10.2086 | 79.085 | 4.42406 | 1.67434 | 34.2898 | 64.0358 |
| 24     | 0.39674 | 10.0641 | 10.6997 | 79.236 | 4.46690 | 1.68755 | 34.6384 | 63.6739 |
| 25     | 0.42043 | 9.49709 | 11.1916 | 79.311 | 4.50613 | 1.70080 | 34.9672 | 63.3319 |

Variance decomposition of $\Delta \ln FDI_{lt}$

| Period | S.E. | $\Delta \ln RGDP_{lt}$ | $\Delta \ln FDI_{lt}$ |
|--------|------|------------------------|---------------------|
| 1      | 1.57851 | 1.36553 | 14.3085 | 84.3259 |
| 2      | 1.79848 | 1.34430 | 13.1814 | 85.4742 |
| 3      | 2.04552 | 1.43752 | 19.6740 | 78.8884 |
| 4      | 2.35028 | 1.42417 | 22.1193 | 76.4639 |
| 5      | 2.54558 | 1.49140 | 23.6194 | 74.8892 |
| 6      | 2.75374 | 1.47913 | 24.5723 | 73.9485 |
| 7      | 2.93166 | 1.48078 | 25.1669 | 73.3521 |
| 8      | 3.08943 | 1.48978 | 26.0214 | 72.4888 |
### Table A4

**Impulse Response**

| Period | Accumulated response of \( \ln \text{RGDP}_{it} \) | Accumulated response of \( \ln \text{HCR}_{it} \) | Accumulated response of \( \ln \text{FDI}_{it} \) |
|--------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| 1      | 0.0283                                          | 0.0000                                          | 0.0000                                          |
| 2      | 0.0512                                          | 0.0080                                          | 0.0008                                          |
| 3      | 0.0728                                          | 0.0161                                          | 0.0074                                          |
| 4      | 0.0939                                          | 0.0253                                          | 0.0211                                          |
| 5      | 0.1157                                          | 0.0319                                          | 0.0422                                          |
| 6      | 0.1378                                          | 0.0385                                          | 0.0680                                          |
| 7      | 0.1603                                          | 0.0464                                          | 0.0995                                          |
| 8      | 0.1832                                          | 0.0561                                          | 0.1361                                          |
| 9      | 0.2066                                          | 0.0676                                          | 0.1786                                          |
| 10     | 0.2305                                          | 0.0807                                          | 0.2270                                          |
| 11     | 0.2547                                          | 0.0955                                          | 0.2812                                          |
| 12     | 0.2794                                          | 0.1124                                          | 0.3412                                          |
| 13     | 0.3046                                          | 0.1316                                          | 0.4068                                          |
| 14     | 0.3302                                          | 0.1533                                          | 0.4780                                          |
| 15     | 0.3563                                          | 0.1776                                          | 0.5578                                          |
| 16     | 0.3829                                          | 0.2046                                          | 0.6369                                          |
| 17     | 0.4100                                          | 0.2345                                          | 0.7244                                          |
| 18     | 0.4376                                          | 0.2672                                          | 0.8171                                          |
| 19     | 0.4656                                          | 0.3029                                          | 0.9148                                          |
| 20     | 0.4942                                          | 0.3416                                          | 1.0174                                          |
| 21     | 0.5231                                          | 0.3834                                          | 1.1247                                          |
| 22     | 0.5526                                          | 0.4283                                          | 1.2366                                          |
| 23     | 0.5824                                          | 0.4763                                          | 1.3528                                          |
| 24     | 0.6128                                          | 0.5274                                          | 1.4732                                          |
| 25     | 0.6435                                          | 0.5816                                          | 1.5976                                          |

**Note.** Cholesky Ordering: \( \ln \text{RGDP}_{it}, \ln \text{HCR}_{it}, \ln \text{FDI}_{it} \).
### Table A5

Cross-Section Short-Run ARDL (2,1,1,1) Coefficient Estimation Using Eq. 6

| Country   | Variable   | Coefficient | t-statistic | p-value |
|-----------|------------|-------------|-------------|---------|
| 1. Burundi| $E_{t-1}$  | -0.0042     | -134.47     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | 0.3436     | 15.615      | 0.0006* |
|           | $D(FSD)_{t}$  | -0.2267     | -50.34      | 0.6493  |
|           | $D(HCR)_{t}$  | 1.5186      | 8.6069      | 0.0033* |
|           | $D(lnFDI)_{t}$| -0.0024     | -680.42     | 0.0000* |
|           | Constant     | 0.0659      | 7.9935      | 0.0041  |
|           | $E_{t-1}$    | -0.0236     | -121.60     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | 0.0563     | 1.6340      | 0.2008  |
|           | $D(FSD)_{t}$  | -0.4991     | -39.03      | 0.7224  |
|           | $D(HCR)_{t}$  | -0.1209     | -8.4785     | 0.0165* |
|           | $D(lnFDI)_{t}$| 0.0073      | 157.39      | 0.0000* |
|           | Constant     | 0.4057      | 6.7949      | 0.0065  |
| 2. Ethiopia| $E_{t-1}$    | -0.0236     | -121.60     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | 0.0563     | 1.6340      | 0.2008  |
|           | $D(FSD)_{t}$  | -0.4991     | -39.03      | 0.7224  |
|           | $D(HCR)_{t}$  | -0.1209     | -8.4785     | 0.0165* |
|           | $D(lnFDI)_{t}$| 0.0073      | 157.39      | 0.0000* |
|           | Constant     | 0.4057      | 6.7949      | 0.0065  |
| 3. Kenya  | $E_{t-1}$    | -0.0019     | -33.910     | 0.0001* |
|           | $D(LNGDP)_{t-1}$ | 0.3498     | 10.743      | 0.0017* |
|           | $D(FSD)_{t}$  | 3.32E-06    | 1.43E-05    | 1.0000  |
|           | $D(HCR)_{t}$  | -0.1627     | -7.4745     | 0.0050* |
|           | $D(lnFDI)_{t}$| -0.0033     | -450.53     | 0.0000* |
|           | Constant     | 0.2571      | 10.535      | 0.0018  |
|           | $E_{t-1}$    | -0.0203     | -192.72     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | -0.2783    | -13.081     | 0.0010* |
|           | $D(FSD)_{t}$  | 1.4027      | 2.8260      | 0.0664  |
|           | $D(HCR)_{t}$  | -0.0321     | -7.1764     | 0.0056* |
|           | $D(lnFDI)_{t}$| -0.0015     | -124.36     | 0.0000* |
|           | Constant     | 0.3242      | 11.063      | 0.0016  |
| 4. Madagascar| $E_{t-1}$    | -0.0019     | -33.910     | 0.0001* |
|           | $D(LNGDP)_{t-1}$ | 0.3498     | 10.743      | 0.0017* |
|           | $D(FSD)_{t}$  | 3.32E-06    | 1.43E-05    | 1.0000  |
|           | $D(HCR)_{t}$  | -0.1627     | -7.4745     | 0.0050* |
|           | $D(lnFDI)_{t}$| -0.0033     | -450.53     | 0.0000* |
|           | Constant     | 0.2571      | 10.535      | 0.0018  |
|           | $E_{t-1}$    | -0.0203     | -192.72     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | -0.2783    | -13.081     | 0.0010* |
|           | $D(FSD)_{t}$  | 1.4027      | 2.8260      | 0.0664  |
|           | $D(HCR)_{t}$  | -0.0321     | -7.1764     | 0.0056* |
|           | $D(lnFDI)_{t}$| -0.0015     | -124.36     | 0.0000* |
|           | Constant     | 0.3242      | 11.063      | 0.0016  |
| 5. Malawi | $E_{t-1}$    | -0.0019     | -33.910     | 0.0001* |
|           | $D(LNGDP)_{t-1}$ | 0.3498     | 10.743      | 0.0017* |
|           | $D(FSD)_{t}$  | 3.32E-06    | 1.43E-05    | 1.0000  |
|           | $D(HCR)_{t}$  | -0.0202     | -16.379     | 0.0050* |
|           | $D(lnFDI)_{t}$| 0.0054      | 272.80      | 0.0000* |
|           | Constant     | 0.0573      | 4.9381      | 0.0159  |
|           | $E_{t-1}$    | -0.0556     | -51.052     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | 0.1070     | 7.9089      | 0.0042* |
|           | $D(FSD)_{t}$  | 0.4403      | 3.0778      | 0.0542  |
|           | $D(HCR)_{t}$  | 0.3426      | 8.0388      | 0.0040* |
|           | $D(lnFDI)_{t}$| 0.0425      | 439.52      | 0.0000* |
|           | Constant     | 0.7663      | 2.7759      | 0.0692  |
|           | $E_{t-1}$    | -0.0053     | -45.793     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | 0.2098     | 7.8061      | 0.0044* |
|           | $D(FSD)_{t}$  | -1.8181     | -1.7188     | 0.1841  |
|           | $D(HCR)_{t}$  | -0.2758     | -4.5458     | 0.0199* |
|           | $D(lnFDI)_{t}$| -0.0024     | -69.023     | 0.0000* |
|           | Constant     | 0.1045      | 5.3992      | 0.0125  |
|           | $E_{t-1}$    | -0.0356     | -41.306     | 0.0000* |
|           | $D(LNGDP)_{t-1}$ | 0.3887     | 13.322      | 0.0009* |
|           | $D(FSD)_{t}$  | 0.0608      | 6.6433      | 0.0069* |
|           | $D(HCR)_{t}$  | -0.0722     | -1.3379     | 0.2733  |
9. Zambia

| Variable     | Coefficient | T-Value | P-Value |
|--------------|-------------|---------|---------|
| D(lnFDI)_{it} | -0.0054     | -91.037 | 0.0000* |
| Constant     | 0.5436      | 2.4925  | 0.0883  |
| E_{it-1}     | 0.0523      | -91.419 | 0.0000* |
| D(LNGDP)_{it-1} | 0.0848   | 3.1310  | 0.0520  |
| D(FSD)_{it}  | 0.7184      | 4.8375  | 0.0168* |
| D(HCR)_{it}  | -0.0458     | -1.4279 | 0.2486  |
| Constant     | 0.7680      | 4.0775  | 0.0266  |

* denotes significance at the 0.05 level.

Figure A1. Combined graphs of lnRGDP_{it}, HCR_{it}, lnFDI_{it}.

Accumulated Response to Cholesky One S.D. Innovations
Impose response standard errors are not available for VECs and BVARs.

*Figure A2*. Accumulated responses.