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Savings, investment and economic growth in Ethiopia: Evidence from ARDL approach to co-integration and TYDL Granger-causality tests

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This paper examines the causal relationship among savings, investment and economic growth in Ethiopia using annual time series data from 1969/70-2010/11 in a multivariate framework. Results from the PP unit root test shows that all variables under consideration are I(1). Result from the ARDL Bounds Testing indicates that there exists co-integration among gross domestic savings, gross domestic investment, real gross domestic product, labor force and human capital when RGDP is taken as dependent variable. Labor and investment have significant positive effect on economic growth of Ethiopia both in the short-run and long-run while GDS and human capital are statistically insignificant. Moreover, Toda-Yamamoto and Dolado-Lutkepohl as well as Innovative Accounting Techniques (i.e., IRFs and FEVD) approach to Granger causality analysis shows that there exists bidirectional causality between gross domestic investment and economic growth as well as between gross domestic savings and gross domestic investment. Granger causality running from investment to savings and from investment to growth is stronger as witnessed from impulse responses and variance decompositions. Although there is unidirectional Granger causality running from economic growth to gross domestic savings, it is weak. To attain high and sustained growth in the country, increased savings and especially investment are required due to its dual effect.

Key words: Economic growth, Ethiopia, Granger causality, savings, investment.

INTRODUCTION

Promoting economic growth through savings and investment has received considerable attention in many countries around the world (Verma, 2007). This is because high investment and saving rates are crucial for growth as a result of their strong positive correlation with GDP growth rates enunciated by endogenous growth theory (Agrawal, 2000).

The conventional perception through which investment, savings and economic growth are related is that savings contribute to higher investment and hence higher GDP growth in the short run (Mohan, 2006). However, there are different thoughts regarding linkages among these variables and how they affect one another.

The central idea of Lewis's (1955) traditional theory

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was that increasing savings would accelerate growth, while the early Harrod-Domar models specified investment as the key to promoting economic growth. In contrast, the neoclassical Solow (1956) model argues that increase in the savings rate boosts steady-state output by more than its direct impact on investment because the induced rise in income raises savings, leading to a further rise in investment (Jangili, 2011). This higher investment in turn accelerates economic growth by increasing aggregate demand in the economy. The relationship among economic growth, savings and investment works also in the other way round according to some recent studies which contradict with the conventional axiom that savings stimulate economic growth (Ahmad and Anoruo, 2001). For instance, studies by Jappelli and Pagano (1994), Gavin et al.(1997), Sinha and Sinha (1998), and Carrol and Weil (1994, 2000) argue that it is economic growth that promotes savings and not vice versa.

In the Keynesian and post-Keynesian traditions investment plays a critical role both as a component of aggregate demand as well as a vehicle of creation of productive capacity on the supply side. In post Keynesian demand-driven models investment still plays a crucial role in determining medium run growth rates (Wondwesen, 2011).

Savings and investment have been considered as two critical macro-economic variables with micro-economic foundations for achieving price stability and promoting employment opportunities thereby contributing to sustainable economic growth. However, inadequate savings and investment are common problem in developing countries.

For instance, Ethiopian average gross domestic savings to GDP ratio has been lower than that of the SSA average in real terms (Dawit, 2004). The average GDS to GDP ratio in real terms for the Ethiopia had been 9.7% in the 1990s and 6.4% for the period 2000-08 which is lower than the corresponding average GDS to GDP ratio for SSA (Tasew, 2011).Poor performance of the economy, high unemployment level, engagement of a large proportion of the population in the informal sector and low wages are factors responsible for low domestic savings in small developing states.

Empirical findings about the causal relationship among savings, investment and economic growth are mixed and controversial across countries, data and methodologies. Some empirical studies support the classical growth theory[1] while some agree with the Carroll-Weil hypothesis[2] and some do not support either of these[3]. Development and growth theories are replete with examples of how savings and investment play a critical role in promoting economic growth. However, most studies in Ethiopia look at the relationship between investment, savings and growth by commonly testing for bi-variate Cointegration and Granger causality separately between investment and growth, or between savings and growth. This study therefore investigates the possibility of saving investment led growth and growth driven saving investment hypothesis by testing for Granger causality, under a multivariate framework, between gross domestic savings, gross domestic investment and growth in Ethiopia.

Moreover, most empirical works on the relationship between savings, investment and economic growth are based on panel or cross-country regressions and may be criticized in view of the fact that they impose cross-sectional homogeneity on coefficients that in reality may vary across countries because of differences in institutional set up, domestic policy measures, political, social and economic structures. The overall result obtained from panel or cross-section regressions represents only an average relationship, which may or may not be appropriate to individual countries in the sample.

Actually, several time series studies have been conducted in the area. However, they treat causal relationship between savings, investment and economic growth bi-variately by looking into the causal relationship either between savings and economic growth or between investment and economic growth. The main objective of this paper is, therefore, to examine the causal relationship among savings, investment and economic growth in Ethiopia in a multivariate framework using data from 1969/70-2010/11. Moreover, the paper tries to examine the existence of long run relationship among savings, investment and economic growth in Ethiopia.

The remainder of the paper proceeds as follows: section two furnishes the literature review. In section three, the data type and source, and methodology are discussed. Section four presents the empirical results and the last section provides the summary and conclusions of the study.

LITERATURE REVIEW

A lot of empirical researches have been done on savings, investment and economic growth (in a multivariate framework) in recent years. The motivation for these empirical studies is the growing divergence in saving and investment rates between the developing countries, the growing concern over the falling savings rates in the major OECD countries, and the increasing emphasis of the vital role of investment in the more recent economic growth literature (Verma and Wilson, 2005). This section, therefore, tries to present some of these empirical studies.

Jangili (2011) examined the direction of the relationship between saving, investment and economic growth in India at both aggregate level and sectoral level for the period 1950/51 to 2007/08 by using Granger causality test through VAR/VECM framework. Besides, cointegration test based on Johansen and Julius (1990) method

[1] See Jappelli and Pagano (1994)
[2] See Verma (2007), Sinha and Sinha (2008)
[3] See Sinha (1996)

was used in order to test the long-run relationship among the variables. The cointegration test result suggests that there exists co-integration relationship among all series with GDP except private corporate saving. Study found that the direction of causality runs from saving and investment to economic growth collectively as well as individually and there is no causality from economic growth to saving and (or) investment. However, there exists reciprocal causality from saving and investment of the private sector to economic growth. This reciprocal causality comes from the household sector where saving and investment led growth and growth driven saving and investment were observed. Empirical evidence also reveals that private corporate sector saving does not cause Granger economic growth.

The study conducted by Verma and Wilson (2005) on savings, investment, foreign inflows and economic growth of the Indian economy using the annual time series data from 1950 –2001 shows little evidence that sectoral per worker's savings and investment affect GDP in the long run while per worker GDP has significant but small effects on per worker household savings and investment in the short run. The feedbacks of GDP are absent in the long run and only small and not precise in the short run. Whilst savings certainly influence investment, there are only weak links from investment to output. Generally, their findings do not support the Solow and endogenous growth policy prescriptions that it is desirable to increase household savings and investment so as to encourage economic growth in India.

Verma (2007) empirically examined the relationship between savings, investment and economic growth in India using annual time series data for the period 1950/51 to 2003/04. The study applied the Autoregressive Distributed Lag (ARDL) Bounds Testing technique to test for Cointegration. The ARDL Cointegration result revealed that GDP, GDS and GDI have long-run relationship except when GDP is the dependent variable. The author also estimated the long-run and short-run elasticities of the correlation between GDS, GDI and GDP growth which exposes three conclusions. Firstly, the econometric evidence corroborates the Carroll-Weil hypothesis that savings do not cause growth, but growth causes savings. Secondly, the results obviously support the view that savings drive investment both in the short-run and in long-run. Lastly, there is no evidence that investment is the driver of economic growth in India during the sample period.

Attanasio et al. (2000) analyzed the short-run and long-run relationship among savings, investment and growth rate for 123 countries over the period 1961– 94. By applying techniques such as OLS, Granger causality and impulse response functions, the study found the following results which are vigorous across data sets and estimation methods: i) lags of saving rates are positively related to investment rates; ii) investment rates Granger cause growth rates with a negative sign; iii) growth rates Granger-cause investment with a positive sign.

Budha (2012) examines the relationship between the gross domestic savings, investment and growth for Nepal using annual time series data for the period of 1974/75 to 2009/10. The study employed the Autoregressive Distributed Lag (ARDL) approach to test for Cointegration and error correction based Granger causality analysis for exploring the causality between the variables of interest. Empirical results show that Cointegration exists between gross domestic savings, investment and gross domestic product when each of them is taken as dependent variable. Granger causality analysis shows that there is short-run and long-run bidirectional causality between investment and gross domestic product as well as between gross domestic savings and investment. Nevertheless, no short-run causality is found between gross domestic savings and gross domestic product.

To come to the point, it is evident from the above theoretical and empirical literature review that the direction of causality between savings, investment and economic growth is mixed. Most of these empirical studies are cross section and cross country studies and fail to use long period data. The problem with such studies is the homogeneity assumption throughout the countries, which is unlikely because of differences in social, economic and institutional conditions. This necessitates country specific studies to shed more light on the causality issue of savings and investment and the related policy issues.

Moreover, most of the existing country specific empirical studies, including those conducted for the Ethiopian case; look into the relationship between savings, investment and economic growth by normally testing for bi-variate Cointegration and Granger causality separately between investment and growth, or between savings and growth which can result in specification bias. Stern (2011) claimed that multivariate Granger tests are advantageous over bi-variate Granger tests in that they can help avoid spurious correlations and can aid in testing the general validity of the causation test which can be done through adding additional variables that may be responsible for causing y or whose effects might obscure the effect of x on y. There may also be indirect channels of causation from x to y, which VAR modeling could be find out as suggested by Stern (2011). Therefore, this paper tries to fill these gaps by examining the causal relationship between savings, investment and economic growth in Ethiopia through a multivariate Granger causality framework.

MATERIALS AND METHODS

Sources and type of data

This paper used annual time series data ranging from 1969/70-2010/11 obtained from different publications of National Bank of Ethiopia (NBE), Ministry of Finance and Economic Development (MoFED), Statistical data base of Ethiopian Economic Association (EEA), African Development Indicator (ADI) and WB CD-ROM.

Model specification

To explain the possible association between the savings, investment and growth based on Ethiopian data, this study has postulated the following specification based on Budha (2012) and Verma (2007), with some modifications. Budha (2012) and Verma (2007) suggest that gross domestic product is positively related with the gross domestic savings and gross domestic investment, all other things being equal. Thus, GDP is an increasing function of gross domestic savings and gross domestic investment which can be given as below:

$$\ln GDP = f(\ln GDS, \ln GDI) \quad (1)$$

Where: GDP, GDS, and GDI are gross domestic product; gross domestic savings as a percentage of GDP and gross domestic investment as a percentage of GDP respectively. Gross domestic investment is proxied by gross capital formation as a percentage of GDP. Here, gross domestic savings and gross domestic investment rather than their net are taken for the analysis. The reason, according to Feldstein and Horioka (1980), is that the accounting definitions of depreciation are very imperfect, especially when there is significant inflation; errors of measurement in the depreciation estimates would cause a bias in the estimated coefficients.

Human capital plays a special role in a number of models of endogenous economic growth (Barro, 1991). In Romer (1990), human capital is the key input to the research sector, which generates the new products or ideas that underlie technological progress thereby leads to faster growth. According to Lucas (1988), human capital is an important source of long -term growth because of its positive policies that enhance public and private investment in human capital, therefore, promote long-run economic growth. In this setting, increases in the quantity of human capital per person tend to lead to higher rates of investment in human and physical capital, and hence, to higher per capita growth. Moreover, Solow (1956)'s growth model suggests that labor plays a crucial role in determining economic growth. Based on these arguments, therefore, Equation (1) is augmented by including these two variables in the equation. Accordingly, Equation (1) becomes:

$$\ln GDP = f(\ln GDS, \ln GDI, \ln LF, \ln HC) \quad (2)$$

An econometric expression of Equation (2) is:

$$\ln RGDP_t = \alpha + \beta_1 \ln GDS_t + \beta_2 \ln GDI_t + \beta_3 \ln LF_t + \beta_4 \ln HC_t + \varepsilon_t \quad (3)$$

Where LF is labor force measured by share of population aged 15-64, ln stands for natural logarithmic transformation and ε_t is error term. HC represents human capital proxied by total capital expenditure on health and education (Adelakun, 2011; Asghar and Aswan, 2012; Adawo, 2011; Eigbiremolen and Anaduaka, 2014; Oluwatobi and Ogunrinola, 2011). The basic premise in this approach is that increase in workers' quality through improved education improves output. This affirms the human capital theory which suggests that education and healthcare of workers ensure greater productivity (Adawo, 2011). The variables are transformed to their natural logarithm form to remove or educe considerably any heteroskedasticity in the residuals of the estimated model.

Method of Data Analysis and Estimation Techniques

Unit root test

The first step in building dynamic econometric models entails a thorough investigation of the characteristics of the individual time series variables involved. Such an analysis is essential as the properties of the individual series have to be taken into account in modeling the data generation process of a system of potentially related variables (Lutkepohl and Kratzig, 2004).

When discussing stationary and non-stationary time series, the need to test for the presence of unit roots in order to avoid the problem of spurious regression should be stressed. Unit root test should be conducted in order to determine whether individual variables are stationary or not. To this end, the Phillips Perron (1989) (PP) tests was applied since it has greater power than standard ADF test.[4]

Cointegration Test: ARDL Bounds Testing Approach

There are various techniques for conducting the Cointegration analysis among time-series variables. The well-known methods are: the residual-based approach proposed by Engle and Granger (1987) and the maximum likelihood-based approach proposed by Johansen and Julius (1990) and Johansen (1992).

This paper adopts the so-called autoregressive distributed lag (ARDL) bounds which appear to be applied in recent empirical investigations. This method has certain econometric advantages as compared to other Cointegration procedures. First, it is applicable irrespective of the degree of integration of the variables (i.e. whether the underlying variables are Purely I(0), I(1) or mixture of both) and thus avoids the pre-testing of the order of integration of the variables. Second, the long-run and short-run parameters of the model are estimated simultaneously since it takes into account the error correction term in its lagged period. Third, the ARDL approach is more robust and performs better for small sample sizes.

The ARDL approach requires estimating the conditional error correction version of the ARDL model for variables under estimation. Arising from the above, the augmented ARDL version of the model specified earlier is expressed as:

$$\Delta \ln RGDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta \ln RGDP_{t-i} + \sum_{i=0}^{q_1} \eta_i \Delta \ln GDS_{t-i} + \sum_{i=0}^{q_2} \gamma_i \Delta \ln GDI_{t-i} + \sum_{i=0}^{q_3} \theta_i \Delta \ln LF_{t-i}$$
$$+ \sum_{i=0}^{q_4} \pi_i \Delta \ln HC_{t-i} + \delta_1 \ln GDP_{t-1} + \delta_2 \ln GDS_{t-1} + \delta_3 \ln GDI_{t-1} + \delta_4 \ln LF_{t-i}$$
$$+ \delta_5 \ln HC + \varepsilon_{1t} \quad (4)$$

The parameters δ_i where i= 1, 2, 3, 4, 5 are the corresponding long-run multipliers, while the parameters β_i, $\eta_i, \gamma_i, \theta_i, \pi_i$ are the short-run dynamic coefficients of the underlying ARDL model.

From Equation (3), we first test the null hypothesis of no Cointegration, H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ against the alternative using the F-test with upper and lower critical values that are calculated automatically and reported after the ARDL regression estimates. To this end, the order of the lag distribution function should be selected using one of the standard information criteria such as Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC). Pesaran and Shin (1995) argue that the Schwartz-Bayesian Criteria (SBC) is preferable to other model specification criteria because it often has more parsimonious specifications. Therefore a more parsimonious model is selected

[4] See for example, Choi (1992)

using the SBC criteria with the maximum lag order of two.[5]

The Error Correction Models (ECM)

Estimating a dynamic equation in the levels of the variables is problematic and differencing the variables is not a solution; so any information about the long run is removed. The more suitable approach is to convert the dynamic model into an error correction model (ECM). It is shown that this contains information on both the short-run and long-run properties of the model, with disequilibrium as a process of adjustment to the long-run model (Harris and Sollis, 2003).

The error correction (EC) representation of the ARDL model can be expressed as:

$$\Delta \ln RGDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta \ln RGDP_{t-i} + \sum_{i=0}^{q_1} \eta_i \Delta \ln GDS_{t-i} + \sum_{i=0}^{q_2} \gamma_i \Delta \ln GDI_{t-i} + \sum_{i=0}^{q_3} \theta_i \Delta \ln LAB_{t-i} + \sum_{i=0}^{q_4} \pi_i \Delta \ln HC_{t-i} + \Psi ECM_{t-1} \quad (5)$$

Where Ψ is the speed of adjustment and ECM_{t-1} is error correction term lagged by one time period.

The existence of an error-correction term among a number of cointegrated variables implies that changes in the dependent variable are a function of both the level of disequilibrium in the Cointegration relationship (represented by the ECM) and the changes in other explanatory variables. This tells us that any deviation from the long-run equilibrium will feed back on the changes in the dependent variable in order to force the movement towards the long-run equilibrium (Faras and Ghali, 2009).

Granger Causality Test: The TYDL Approach

There are three approaches to implement the Granger causality test depending on time-series properties of variables; a VAR model in the level data (VARL), a VAR model in the first-differenced data (VARD), and a vector error correction model (VECM). However, Phillips and Toda (1993, 1994) argue that VAR estimation often involves nuisance parameters and then no satisfactory basis for mounting a statistical test of causality test applies as the F-test statistic does not have a standard distribution when variables are integrated. The VECM approach which involves pre-testing through unit root and cointegration tests suffers from size distortions and can often lead to mistaken conclusions about causality.[6]

As a result, this study adopted the TYDL approach of Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996). This approach has many advantages over other methods of testing Granger non-causality. TYDL approach is applicable irrespective of integration and cointegration properties of model. The TYDL method better controls the type I error probability than other methods based on the VARL, VARD, and VECM. The simulation results by Yamada and Toda (1998) indicate that among three causality procedures, TYDL is the most stable approach when compared to VAR and VECM. The basic idea behind the TYDL is to artificially augment the correct VAR order, k, with d_{max} extra lags, where d_{max} is the maximum likely order of integration of the series in the system. The lag augmented VAR representation of Equation (2) is given as below:

$$\ln RGDP_t = \beta_{10} + \sum_{i=1}^{p} \theta_{1i} \ln RGDP_{t-i} + \sum_{i=p+1}^{p+d_{max}} \Omega_{1i} \ln RGDP_{t-i} + \sum_{i=1}^{p} \delta_{1i} \ln GDS_{t-i} + \sum_{i=p+1}^{p+d_{max}} \phi_{1i} \ln GDS_{t-i} + \sum_{i=1}^{p} \gamma_{1i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \psi_{1i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \eta_{1i} \ln LF_{t-i} + \sum_{i=1}^{p} \vartheta_{1i} \ln HC_{t-i} + \sum_{i=p+1}^{p+d_{max}} \omega_{1i} \ln HC_{t-i} + \varepsilon_{1t} \quad (6)$$

$$\ln GDS_t = \beta_{20} + \sum_{i=1}^{p} \theta_{2i} \ln RGDP_{t-i} + \sum_{i=p+1}^{p+d_{max}} \Omega_{2i} \ln RGDP_{t-i} + \sum_{i=1}^{p} \delta_{2i} \ln GDS_{t-i} + \sum_{i=p+1}^{p+d_{max}} \varphi_{2i} \ln GDS_{t-i} + \sum_{i=1}^{p} \gamma_{2i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \Psi_{2i} \ln GDI_{t-i} + \sum_{i=1}^{p} \phi_{2i} \ln LF_{t-i} + \sum_{i=p+1}^{p+d_{max}} \eta_{2i} \ln LF_{t-i} + \sum_{i=1}^{p} \vartheta_{2i} \ln HC_{t-i} + \sum_{i=p+1}^{p+d_{max}} \omega_{2i} \ln HC_{t-i} + \varepsilon_{2t} \quad (7)$$

$$\ln GDI_t = \beta_{40} + \sum_{i=1}^{p} \theta_{4i} \ln RGDP_{t-i} + \sum_{i=p+1}^{p+d_{max}} \Omega_{4i} \ln RGDP_{t-i} + \sum_{i=1}^{p} \delta_{4i} \ln GDS_{t-i} \sum_{i=p+1}^{p+d_{max}} \phi_{4i} \ln GDS_{t-i} + \sum_{i=1}^{p} \gamma_{4i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \psi_{4i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \eta_{4i} \ln LF_{t-i} + \sum_{i=1}^{p} \vartheta_{4i} \ln HC_{t-i} + \sum_{i=p+1}^{p+d_{max}} \omega_{4i} \ln HC_{t-i} + \varepsilon_{4t} \quad (8)$$

$$\ln LF_t = \beta_{40} + \sum_{i=1}^{p} \theta_{4i} \ln RGDP_{t-i} + \sum_{i=p+1}^{p+d_{max}} \Omega_{4i} \ln RGDP_{t-i} + \sum_{i=1}^{p} \delta_{4i} \ln GDS_{t-i} \sum_{i=p+1}^{p+d_{max}} \phi_{4i} \ln GDS_{t-i} + \sum_{i=1}^{p} \gamma_{4i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \psi_{4i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \eta_{4i} \ln LF_{t-i} + \sum_{i=1}^{p} \vartheta_{4i} \ln HC_{t-i} + \sum_{i=p+1}^{p+d_{max}} \omega_{4i} \ln HC_{t-i} + \varepsilon_{4t} \quad (9)$$

$$\ln HC_t = \beta_{50} + \sum_{i=1}^{p} \theta_{5i} \ln RGDP_{t-i} + \sum_{i=p+1}^{p+d_{max}} \Omega_{5i} \ln RGDP_{t-i} + \sum_{i=1}^{p} \delta_{5i} \ln GDS_{t-i} \sum_{i=p+1}^{p+d_{max}} \phi_{5i} \ln GDS_{t-i} + \sum_{i=1}^{p} \gamma_{5i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \psi_{5i} \ln GDI_{t-i} + \sum_{i=p+1}^{p+d_{max}} \eta_{5i} \ln LF_{t-i} + \sum_{i=1}^{p} \vartheta_{5i} \ln HC_{t-i} + \sum_{i=p+1}^{p+d_{max}} \omega_{5i} \ln HC_{t-i} + \varepsilon_{5t} \quad (10)$$

Where $\theta_i s$, $\Omega_i s$, $\delta_i s$, $\varphi_i s$, $\gamma_i s$, $\psi_i s, \eta_i s, \vartheta_i s$ and $\omega_i s$ are parameters of the model; p is the true lag length; ε_{1t}, ε_{2t} and ε_{3t} are the residuals of the model; ln represents natural logarithm. Equations (6) - (10) will be estimated to determine the direction of causality between the variables under consideration.

From (6), Granger causality from $\ln GDS_t$ to $\ln GDP_t$ implies

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[5] Pesaran and Shin (1997) and Narayan (2004) suggested two as the maximum order of lags in the ARDL approach for the annual data series.

[6] Such possibilities are demonstrated by a number of simulation studies (e.g., Yamada and Toda, 1998; Clarke and Mirza, 2006).

$\delta_{11} = \delta_{12} = \ldots \delta_{1p} \neq 0$; Granger causality from $\ln GDI_t$ to $\ln GDP_t$ implies $\gamma_{21} = \gamma_{22} = \ldots \gamma_{2p} \neq 0$. From (7), Granger causality runs from $\ln GDP_t$ to $\ln GDS_t$ if $\theta_{21} = \theta_{22} = \ldots$ and from to if. Similarly, from (8), Granger causality from $\ln GDP_t$ to $\ln GDI_t$ shows that $\theta_{31} = \theta_{32} = ... = \theta_{3p} \neq 0$ and Granger causality from $\ln GDS_t$ to $\ln GDI_t$ implies $\delta_{31} = \delta_{32} = ... = \delta_{3p} \neq 0$.

Then, Granger causality is tested using the modified Wald (MWald) test which is theoretically very simple, as it involves estimation of a VAR model augmented in a straightforward way.

Impulse response function (IRF) and variance decomposition

In empirical research, it is often necessary to know the response of one variable to an impulse in another variable in a system that involves a number of further variables as well. Thus, one would like to investigate the impulse response relationship between two variables in a higher dimensional system (Lutkepohl, 2005). To this end, generalized impulse response[7] which is invariant to the ordering of the variables in the VAR has been used.

To infer the degree of exogeneity of the variables beyond the sample period, the decomposition of variance which measures the percentage of a variable's forecast error variance that occurs as the result of a shock from a variable in the system should be considered (Narayan and Symth, 2004). As the orthogonalized forecast error variance decompositions are not invariant to the ordering of the variables in the VAR, the generalized forecast error variance decomposition which is invariant to the ordering of the variables in the VAR (Pesaran and Pesaran, 2009) is used in this study.

ESTIMATION AND DISCUSSION OF RESULTS

Descriptive statistics

Before directly going to the econometric estimation, it is better to have a look at the descriptive statistics of the variables under consideration. This is vital because these statistics summarize the statistical properties of the series in the model such that some explanations about the behavior of the series can be offered at a glance (Table 1).

Unit root testing

The null hypothesis for the test (in both ADF and PP) depicts that the data series under consideration has unit root while the alternative hypothesis claims that the series is stationary.

As can be seen from Table 2, PP test witnessed that GDI in natural log at level is non-stationary under both options (i.e. with constant and trend, and with constant only) since we cannot reject the null hypothesis of unit root at 1 and 5% level of significance. On the other hand, when the first difference of natural log of GDI is considered it becomes stationary at 1 and 5% level of significances (when only constant is included) and at 1% level of significance (when both constant and trend are considered). Coming to the PP test, the result reveals that the first difference of lnGDI is stationary at 1% level of significance under all specifications. However, lnGDI at level is not stationary.

The PP test shows that none of the variables is stationary at level. However, taking the first difference of the variables makes them stationary since the null hypothesis of unit root is rejected at 1 and 5% level of significance.

In general, the PP test from Table 2 shows that all variables are integrated of order one, I (1). Thus, the determination of cointegration relationships using the ARDL technique does not face a problem from the existence of I(2) or beyond variables in the model specified.

Co-integration test and estimation of long-run relationship

A two-step procedure is used in estimating the long-run relationship: an initial examination of the existence of a long-run relationship among the variables in Equation (2) is followed by an estimation of the short-run and long-run parameters.

The results in Table 3 show that lnRGDP, lnGDS, lnGDI, lnLF and lnHC are co-integrated when lnRGDP is taken as dependent variable since F-statistic, also written as F_{lnRGDP} (lnRGDP| lnGDS, lnGDI, lnLF, lnHC) = 9.4448 [with lag order of (1,0,0,1,0) selected by the SBC] is greater than both the 95% Upper Bound critical value of Narayan (2004) and Pesaran et al. (2001) which is 4.000 and 4.4778 respectively. However, taking each of the remaining four variables (i.e. lnGDS, lnGDI, lnLF and lnHC) as a dependent variable never establishes co-integration since the calculated F-statistic is less than the 95% Lower Bound critical value in all cases.[8] The existence of single co-integrating equation, according to Pesaran et al. (2001) indicates that there is unique long-run relationship among the variables under consideration.

Before estimating the long-run relationship and the short-run dynamics of the model, it is important to analyze performance of the ARDL estimates through the diagnostic tests. As can be seen from the result, R-squared is 99 percent and it is statistically significant (with P-value = 0.000) at 1% level of significance implying that the model fits well. Moreover, the model (ARDL estimates) is free from the problem of serial correlation, functional form, heteroskedasticity and normality as revealed in LM version of tests because we cannot reject

[7] The approach is also used in the construction of order-invariant forecast error variance decompositions.

[8] See Appendix II for details.

Table 1. Descriptive Statistics of variables in the model (EViews 6 output)

Statistics	lnGDI	lnGDS	lnHC	lnLF	lnRGDP
Mean	8.364595	7.813345	6.392825	3.827325	10.91619
Median	7.721755	7.637657	6.112890	3.822098	10.77609
Maximum	11.77887	10.71401	9.423067	3.987131	12.04144
Minimum	6.627380	6.215688	4.228293	3.718438	10.37658
Std. Dev.	1.532191	1.139270	1.428327	0.049412	0.443089
Skewness	0.651298	0.656988	0.442306	1.085338	1.002417
Kurtosis	2.224956	2.533091	2.252189	5.403382	3.070663
Jarque-Bera	4.020534	3.402943	2.348078	18.35414	7.042617
Probability	0.133953	0.182415	0.309116	0.000103	0.029561
Sum	351.3130	328.1605	268.4987	160.7476	458.4801
Sum Sq. Dev.	96.25195	53.21535	83.64483	0.100102	8.049459
Observations	42	42	42	42	42

Table 2. Result for the PP Unit Root Test (EViews 6 output)

Variables at level									
	Intercept				Intercept and trend				
Variables	Test Statistic	1% CV	5% CV	P-value	Test Statistic	1% CV	5% CV	P-value	Decision
lnGDI	7.407	-3.600	-2.935	1.0000	-0.264	-4.199	-3.524	0.9892	I(1)
lnRGDP	5.642	-3.600	-2.935	1.0000	1.755	-4.198	-3.523	1.0000	I(1)
lnGDS	0.457	-3.600	-2.935	0.9831	-3.019	-4.198	-3.523	0.139	I(1)
lnLF	-0.988	-3.600	-2.935	0.7484	-2.444	-4.198	-3.523	0.3526	I(1)
lnHC	2.817	-3.600	-2.935	1.0000	0.820	-4.198	-3.523	0.9997	I(1)
Variables at the first difference									
DlnGDI	-6.734	-3.605	-2.936	0.0000	-9.480	-4.205	-3.526	0.0000	
DlnRGDP	-4.841	-3.605	-2.936	0.0003	-5.935	-4.205	-3.526	0.0001	
DlnGDS	-9.075	-3.605	-2.936	0.0000	-9.817	-4.205	-3.526	0.0000	
DlnLF	-9.703	-3.605	-2.936	0.0000	-10.232	-4.205	-3.526	0.0000	
DlnHC	-4.710	-3.605	-2.936	0.0005	-5.528	-4.205	-3.526	0.0003	

Note: CV represents critical value and P-value < 5% shows that the variable is stationary.

the null hypothesis of each test statistic. See appendix III: A and B for details.

Table 3 presents the estimated coefficients of the long-run relationship along with the diagnostic tests of the model. Based on the results given in Table 3, the long-run growth equation is given as below:

$$\ln RGDP = -7.3464 + 4.2666 \ln LF + 0.33434 \ln GDI + 0.026485 \ln GDS$$

P-value (0.051) (0.000) (0.001) (0.664)

$$-0.15569 \ln HC \quad (10b)$$

(0.120)

The estimated coefficients show that gross domestic investment and labor force have a statistically significant positive impact on economic growth, which is in line with theoretical argument that investment and labor force positively contributes to economic growth. More specifically, the elasticity of labor indicated that a 1% increase in labor force leads to 4.2666% increase in economic growth on average, keeping other variables constant. Similarly, the long-run elasticity of gross domestic investment is 0.33434 which implies that a 1% rise in gross domestic investment results in about 0.33434 percent increase in economic growth. The result coincides with the findings of Were (2001) for the case of Kenya and Iyoha (1999) for the case of SSA countries.

However, human capital (lnHC) has an insignificant effect on economic growth. This result is in line with the findings of Wondwessen (2011), Pritchett (1996), Pritchet (2001) and World Bank (1995). The reason why human capital is insignificant in explaining the Ethiopian economic growth is due to the fact that, firstly, the returns to schooling appear to differ sharply by economic activity.[9] Evidences show that the estimated returns to schooling

[9] See for example, Pritchett, 1996

Table 3. Estimated Long Run Coefficients using the ARDL Approach (Output obtained from Microfit 5.2 version).

Estimated Long Run Coefficients using the ARDL Approach ARDL (1,1,0,0,0) selected based on Schwarz Bayesian Criterion			
Dependent variable is lnRGDP			
Regressor	**Standard Error**	**Coefficient**	**T Ratio[Prob]**
$lnLF_t$	4.2666	.97564	4.3731[.000]**
$lnGDI_t$	.33434	.095876	3.4872[.001]**
$lnGDS_t$	.026485	.060355	.43882[.664]
$lnHC_t$	.15569	.097673	1.5940[.120]
Constant	7.3464	3.6299	2.0238[.051]
R Squared	.97740	R Bar Squared	.97561
S.E. of Regression .	.069192	F Stat.F(3,38)	547.7733[.000]
Diagnostic Tests			
Test Statistics	**LM Version**		
A: Serial Correlation	$\chi^2_{auto}(1) =$ .35302[.552]		
B: Functional Form	$\chi^2_{RESET}(1) =$ .019774[.888]		
C: Normality	$\chi^2_{Norm}(2) =$ .74315[.690]		
D: Heteroscedasticity	$\chi^2_{Het}(1) =$ .41234[.521]		

Dependent variable is lnRGDP. Notes: ** and * indicate significance at 1% and 5% level of significances. Figures in parenthesis are p-values. A: Lagrange multiplier test of residual serial correlation, B: Ramsey's RESET test using the square of the fitted values, C: Based on a test of skewness and kurtosis of residuals, D: Based on the regression of squared residuals on squared fitted values.

(human capital) are higher in manufactured exports (Ross and Sabot, 1995). But, Ethiopian economy which is dominated by agricultural sector contributes a lion's share both in terms of GDP, and employment does not respond this much to change in human capital, according to this argument. Secondly, technological progress in agricultural sector is low in Ethiopia. Foster and Rosenzweig (1995) argue that the returns to schooling of farmers are very low where technological progress is low.

Moreover, the long-run model suggests that gross domestic savings has statistically insignificant effect on economic growth. This result is coherent with the findings of Budha (2012) for Nepal. This could be due to low level of savings which resulted from lack of continuous saving behavior in Ethiopia over time which is in turn primarily attributable to the subsistence nature of the economy where output is barely enough for consumption.

The short run dynamic modelling (Error Correction Model)

After estimating the long-run coefficients, we obtain the error correction representation (see Equation 4) of the ARDL model.

The results of the short-run dynamic growth model and the various diagnostic tests are presented in Tables 4. About 67 percent of the variation growth is explained by explanatory variables included in the model. R-squared which is 66.9 is statistically significant at 1% level of significance implying that the model fits well since the explanatory variables are jointly significant at 1% level of significance.

Based on the results given in Table 4, the short-run dynamics of growth equation is given as:

$$\begin{aligned} \Delta \ln RGDP &= .79235\Delta \ln LF + .12875\Delta \ln GDI + \Delta.010199 \ln GDS \\ P-value &\quad (0.005) \qquad (0.001) \qquad (0.656) \\ &- .059956\Delta \ln HC_t - .38509 ECM_{t-1} \\ &\quad (0.065) \qquad (0.000) \end{aligned} \tag{11}$$

The result reveals that the estimated coefficients of lnLF and lnGDI are statistically significant with the positive sign. In line with the postulates of growth theories, labor and investment have a positive effect on real gross domestic product of Ethiopia in the short-run. However, gross domestic savings (lnGDS) and human capital (lnHC) do not have any impact on the economic growth of Ethiopia in the short-run. The reason is that it can take a long time before benefits from human capital arrive, as it takes time to build human capital.

The estimated coefficient of the ECM $_{t-1}$ is equal to -0.38 which states that departure from the long-term growth path due to a certain shock is adjusted by 38 percent over the next year, significant at the 1% level of significance and complete adjustment will take about three years.

Table 4. Short Run Dynamics Result for the Selected ARDL Model.

Error correction representation for the ARDL Approach ARDL (1,1,0,0,0) selected based on Schwarz Bayesian Criterion			
Dependent variable is ΔLNRGDP			
Regressor	**Coefficient**	**Standard Error**	**T Ratio[Prob]**
$\Delta lnLF_t$	.79235	.26355	3.0065[.005]**
$\Delta lnGDI_t$	12875	.036201	3.5565[.001]**
$\Delta lnGDS_t$	.010199	.022716	.44898[.656]
$\Delta lnHC_t$	-.059956	.031455	.9061[.065]
ECM_{t-1}	-.38509	.086777	-4.4377[.000]**
R Squared	.66926	R Bar Squared	.61089
S.E. of Regression .	.039245	F Stat.F((5,35)	13.7597[.000]
Diagnostic Tests			
Test Statistics	**LM Version**		
A: Serial Correlation	χ^2_{auto} (1) = .32617[.568]		
B: Functional Form	χ^2_{RESET} (1) = 3.4656[.063]		
C: Normality	χ^2_{norm} (2) = .68080[.711]		
D: Heteroscedasticity	χ^2_{Het} (1) = .041579[.838]		

Notes: Figures in parenthesis are p-values. Δ represents the first difference. ** and * means the coefficients are significant at 1% and 5% level of significance respectively. A: Lagrange multiplier test of residual serial correlation, B: Ramsey's RESET test using the square of the fitted values, C: Based on a test of skewness and kurtosis of residuals, D: Based on the regression of squared residuals on squared fitted values.

The model passes all the diagnostic tests. The diagnostic tests applied to the error correction model point out that there is no evidence of serial correlation and heteroskedasticity. Besides, the RESET test implies the correctly specified ARDL model. Skewness and kurtosis of residuals based normality test shows that the residuals are normally distributed.

The stability of the regression coefficients is tested using the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) of the recursive residual test for structural stability (Brown et al., 1975). Plots of CUSUM and CUSUMSQ of the growth equation in its short-run version are given in Appendix III: C and D. As can be seen from the graphs, the regression equation seems stable given that neither the CUSUM nor the CUSUMSQ test statistics go beyond the bounds of the 5% level of significance.

Granger Causality Test: Toda-Yamamoto and Dolado-Lutkepohl (TYDL) Approach

As can be seen from Table 5, the optimal lag length is one. Since all variables become stationary after the first differencing, it implies that d_{max} is also one. We then estimate a system of VAR in levels with a total of (d_{max} +k=1+1) which is 2 lags where k is the lag length selected by information criteria. Using this information, the system of equations (i.e. Equations 5-9) is jointly estimated as a "Seemingly Unrelated Regression Equations" (SURE)[10] model.

A range of formal diagnostic tests such as autocorrelation, non-normality, heteroskedasticity and stability tests are conducted for checking the adequacy of VAR model before using the model for Granger causality and related tests. The test results show that the model passed all diagnostic tests except that of non-normality[11]. However, Lutkepohl (2007) argued that normality is not a necessary condition for the validity of many of the statistical procedures related to VAR models. Thus, the VAR model is adequate and can be used for Granger causality test as well as for formulating the impulse response functions and the variance decomposition.

Following the TYDL approach, the augmented VAR of order 2 is estimated and the Wald test is performed only on the coefficients of the first lag. The result of five variables VAR model was estimated using SUR regression technique;

Table 6 shows that the null hypothesis that 'Granger

[10] Zellner (1962) suggests that the regression coefficient estimators obtained by the SUR are at least asymptotically more efficient than those obtained by an equation-by-equation application of least squares. Moreover, Rambaldi and Doran (1996) show that SUR regression makes the computation of modified Wald test statistic too simple.

[11] VAR diagnostic test result is not presented here to save space. However, it is available upon request.

Table 5. VAR lag order selection criteria**.**

	LogL	LR	FPE	AIC	SC	HQ
0	69.56111	NA	2.51e-08	-3.310826	-3.097549	-3.234304
1	235.8193	281.3599*	1.82e-11*	-10.55483*	-9.275171*	-10.09570*
2	254.2704	26.49403	2.71e-11	-10.21900	-7.872949	-9.377255
3	278.6671	28.77557	3.35e-11	-10.18806	-6.775624	-8.963706

Notes:* indicates lag order selected by the criterion.LR: sequential modified LR test statistic.

Table 6. Estimates of long-run Granger causality based on TYDL approach.

Dependent variables	Sources of Causation (Long-run)				
	lnRGDP	lnGDS	lnGDI	lnLF	lnHC
	χ^2 (1)	χ^2 (1)	χ^2 (1)	χ^2 (1)	χ^2 (1)
lnRGDP	-	2.3469	11.4169***	17.3323***	1.0928
lnGDS	3.1669*	-	7.2279**	11.8651***	0.0332
lnGDI	7.1825**	6.4726**	-	4.8342**	1.3805
lnLF	3.1985*	0.0309	0.0204	-	0.0119
lnHC	0.6351	2.6784	6.5711**	0.2373	-

Notes: *, **and *** indicates that significance at 10, 5 and 1% respectively.

no-causality from gross domestic savings to economic growth' cannot be rejected even at 10% level of significance. However, there is an evidence to support the reverse even though it is weak (significant at 10% level). That is, growth is found to Granger cause savings. This result is consistent with the Carrol-Weil (1994)'s hypothesis which states that it is growth that causes savings but savings does not cause Granger growth. Moreover, the result is in line with the findings of Abu (2004) for the case of Ethiopia, Khan and Shahbaz (2010) for the case of Pakistan, Sinha and Sinha (2007) for the case of Mexico, Attanasio et al. (2000) for 123 countries' case, Abu (2010) for the case of Nigeria, and Elbadawi and Mwega (1998) for the case of Sub-Saharan Africa.

The result also reveals that the Granger causality between gross domestic savings and gross domestic investment is bi-directional. That is, gross domestic savings Granger causes gross domestic investment and there is a feedback from gross domestic investment. This result supports the empirical finding of Budha (2012) for the case of Nepal. However, it contradicts the finding of Abu (2004) for the case of Ethiopia.

Similarly, Granger causality between gross domestic investment and economic growth is bi-directional. The implication is that the data can be viewed either through the Keynesians/ neoclassical glasses or with an accelerator model in mind. This result corroborates the empirical findings of Tang et al. (2008) for the case of China, Alfa and Garba (2012) for the case of Nigeria, and Elbadawi and Mwega (1998) for the case of Sub-Saharan Africa.

Labor force precedes and Granger causes both economic growth and gross domestic investment. Moreover, it Granger causes gross domestic savings suggesting that economic growth increases the income of workers relative to that of non-workers (children and retirees).Hence workers' saving could rise. There is no Granger causality between human capital and the remaining other variables except gross domestic investment in which Granger causality runs from gross domestic investment to human capital.

Impulse Response Functions and Variance Decompositions

Table 7 illustrates the estimated generalized impulse response functions of variable lnRGDP for ten years. In response to a one standard deviation disturbance in current economic growth (Table 7), future economic growth increases by 4.8 percent in the first year, by 3.59 percent in the fifth year and gradually reduce to 3 percent in the 10^{th} year.

A one standard deviation disturbance originating from economic growth results in an approximately 4.8 percent increase in gross domestic investment in the first period. But it continuously declines to about 3.65 percent in the third period and starts increasing after the third period and reaches about 6.5 percent in the 10^{th} period implying that the impact of growth on gross domestic investment is permanent.

Table 7. Generalized impulse responses to one SE shock in the equation for lnRGDP.

Horizon	lnRGDP	lnLF	lnGDI	lnGDS	lnHC
0	.047048 .	0095923	.057428	.099884	-.0093927
1	.048689	.0066556	.048201	.072994	.0049663
2	.044466	.0062991	.037725	.035628	.016623
3	.040776	.0061394	.036527	.026656	.026324
4	.038062	.0057860	.039486	.029033	.034307
5	.035905	.0053597	.043468	.032838	.040926
6	.034130	.0049557	.047667	.036150	.046540
7	.032714	.0046035	.051978	.039199	.051435
8	.031651	.0043070	.056363	.042220	.055826
9	.030921	.0040645	.060776	.045258	.059870
10	030496	.0038731	.065186	.048300	.063687

A one standard deviation disturbance originating from economic growth results in more or less 7.3 percent increase in gross domestic savings in the first period. However, this figure declines to about 2.7 percent in the third period but starts rising afterwards. Accordingly, it reaches about 4.8 in the 10th period implying that the impact of economic growth on gross domestic savings is not dying out.

The impact of economic growth on labor force is very small (about 0.7 percent in 1st period and declined to 0.4 percent in the 10th period). This shows that the impact of economic growth on labor force in temporarily lived phenomenon.

The generalized impulse response output for lnGDS and lnGDI is not presented here to save space.[12] The result shows that a one standard deviation shock arising from gross domestic investment results in about 12.3 percent rise in gross domestic investment itself in the first period which decreases to about 9.4 percent in the 6th period and starts increasing afterwards. The response of natural log of gross domestic savings to one SE shock in natural log of gross domestic investment is relatively stronger as compared to that economic growth as it leads to approximately 10.5 percent increase in gross domestic investment in the first period while economic growth increases only by about 2.5 percent during the same period. The impact of gross domestic investment on economic growth and gross domestic savings never dies out as the impact increases to 3.9 percent in the 10th period in case of economic growth and the impact on gross domestic savings follows rising pattern since the 4th period. The implication is that the impact (due to shock) of gross domestic investment on economic growth and gross domestic savings is permanent one.

The result for the generalized impulse responses to one SE shock in the equation for LNGDS shows that the gross domestic savings shocks have larger and permanent effects on gross domestic savings itself which fluctuate in the whole period followed by its impacts on gross domestic investment. On the other hand, the impulse response of economic growth, human capital and labor force to one SE shock in gross domestic savings is very small.

Despite the fact that impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. However, it must be noted that unlike the orthogonalized forecast error variance decomposition the total variance in case of the generalized forecast error variance decomposition does not sum to 100 percent since the covariance between the original shocks is non-zero as suggested by Tang and Lean (2009). Tables 8-10 present the generalized variance decompositions of variables of interest (i.e. lnRGDP, lnGDS and lnGDI) for ten year time horizon.

The results in Table 8 point out that disturbance arising from lnRGDP itself imposed the greatest variability to future lnRGDP: it contributes up to 78.26 percent variability one year ahead and approximately 50 percent four quarters ahead. This result indicates that current change in economic growth heavily determines future changes in economic growth. LnLF dominates over all other three variables (i.e. lnGDS, lnGDI and lnHC) in influencing economic growth. It accounts for approximately 46.3 and 41.8 percent of the total variance in economic growth two year and three year ahead respectively.

The third largest source of variation in economic growth appears to be from lnGDI, which describes for approximately 15.6 percent of the variance in lnRGDP one year ahead and increases to 35.3 percent ten year ahead. The remaining two variables (i.e. lnGDS and lnHC) account for very little percentage of variations in lnRGDP. This result is in line with the result obtained from the TYDL approach to Granger causality that the natural logarithm of labor force, lnLF, and the natural logarithm of gross domestic investment, lnGDI, cause

[12] However, it can be obtained upon request.

Table 8. Generalized forecast error variance decomposition for variable lnRGDP.

Horizon	lnRGDP	lnLF	lnGDI	lnGDS	lnHC
0	.1.0000	.14763	.13764	.093131	016593
1	.78267	.43216	.15673	.049200	.0067165
2	.70245	.46322	.18114	.031315	.0045814
3	.65949	.44486	.20965	.023474	.0047034
4	.62657	.41874	.23780	.019071	.0059821
5	.59737	.39302	.26354	.016243	.0082316
6	.57044	.36900	.28637	.014336	.011376
7	.54538	.34682	.30644	.013035	.015309
8	.52200	.32640	.32405	.012156	.019899
9	.50013	.30762	.33951	.011580	.025009
10	.47966	.29034	.35313	.011224	.030504

Table 9. Generalized forecast error variance decomposition for variable lnGDI.

Horizon	lnRGDP	lnLF	lnGDI	lnGDS	lnHC
0	.075776	.015284	1.0000	.24330	.0027923
1	.10886	.028821	.89995	.15839	.0030344
2	.069766	.038175	.82020	.092736	.0021076
3	.071803	.033263	.79192	.078630	.0021871
4	.078504	.044348	.74055	.075432	.0026312
5	.10464	.040423	.68890	.077713	.0078832
6	.11945	.038696	.65024	.080989	.010003
7	.14713	.035661	.61623	.077240	.013376
8	.17357	.032424	.58207	.074227	.014853
9	.19616	.029435	.56116	.069033	.015004
10	.21714	.026572	.54193	.064144	.014094

Table 10. Generalized forecast error variance decomposition for variable lnGDS.

Horizon	lnRGDP	lnLF	lnGDI	lnGDS	lnHC
0	.15173	.2951E-5	.30551	1.00000	.011697
1	.15902	.091922	.26225	.80595	.061629
2	.12289	.073538	.37931	.61098	.057608
3	.11556	.077920	.41635	.58166	.056722
4	.10327	.098960	.38310	.54588	.058725
5	.10232	.098026	.36711	.53709	.058475
6	.10038	.10193	.36112	.53234	.057249
7	.10036	.10067	.35469	.52757	.059997
8	.10569	.099650	.34972	.52000	.060631
9	.11189	.098397	.35001	.51330	.061667
10	.11396	.097229	.35216	.50178	.062914

economic growth.

Table 9 presents the generalized forecast error variance decomposition for variable lnGDI. The result shows that the largest source of variation in the forecast error of lnGDI goes to its own innovations. In the second period, for example, about 82% of the variation in lnGDI is explained by the innovations of lnGDI itself which gradually declined to about 54% in the 10th period.

LnRGDP is the second largest source of variation in lnGDI followed by lnGDS, suggesting that both gross domestic savings and economic growth Granger cause gross domestic investment which corroborates the result obtained from TYDL approach.

Table 10 shows that the largest variation in the forecast error of gross domestic savings, lnGDS, arises from its own innovations which account for about 80.6 percent the first period and 50 percent even in the 10th period; while gross domestic investment (i.e. lnGDI), which is the second largest source of variation in lnGDS, contributes 37.9 and 35.4 percent in the second and seventh period respectively. The variation of forecast error of lnGDS due to lnGDI is relatively strong that it contributes about 35.2 percent of the variation in lnGDS even in the 10th period. LnRGDP is the third largest source of variation in lnGDS contributing about greater than 10 percent of forecast error variance of lnGDS. The results tend to confirm the conclusion found by within sample TYDL causal analysis which states that lnRGDP and lnGDI Granger cause lnGDS even though Granger causality from economic growth of gross domestic savings is relatively weak.

CONCLUSION AND POLICY IMPLICATIONS

As determinants of growth, the long-run coefficients of the natural logarithm of gross domestic investment and labor force are both positive and statistically significant at 1% percent level of significance, implying that these two variables have a significant and positive impact on growth in the long-run. However, the long-run coefficients of gross domestic savings and human capital are both statistically insignificant.

Besides, ARDL based short-run dynamic modeling (Error Correction Model) for growth shows that labor and investment have statistically significant positive effect on growth in the short-run. Furthermore, the stability of the estimated parameters of both short-run and long-run relationships is supported by CUSUM and CUSUMSQ stability tests.

The direction of causal relationship among the gross domestic savings, gross domestic investment and economic growth using the Granger causality tests based on the TYDL framework suggests that the direction of Granger causality is from savings to investment and then to economic growth which is in line with the conventional wisdom. Additionally, the Granger causality runs from economic growth to investment and then to savings. This implies that there is two-way causal relationship between gross domestic savings and gross domestic investment and between gross domestic investment and economic growth. However, Granger causality running from investment to savings and economic growth is the strongest as suggested by impulse response and variance decompositions. The result also shows that there is unidirectional Granger causality running from economic growth to gross domestic savings which is consistent with the Carrol-Weil hypothesis.

Labor Granger causes savings, investment and economic growth. However, human capital does not Granger cause any the variables of interest. Similarly, only investment Granger causes human capital.

The most important mechanism for spurring growth is investment since it helps savings and economic growth. Thus, the country is required to set an encouraging environment such as adequate access to credit in order to stimulate domestic investment. Therefore, the government should reduce lending rate through monetary policy in order to boost so as to bring high and sustained economic growth.

Savings should be increased for two main reasons. Firstly, investment has to be financed some way or the other and therefore savings should be considered. Ensuring an adequate level of gross domestic savings is vital in closing the gap between savings and investment and reducing an extreme dependence on foreign capital which can be a risk due to its volatility. Secondly, it stimulates investment thereby economic growth and this higher growth reinforces savings and investment. Therefore, the government is required to set a sound and fertile environment in order to foster domestic saving that is adequate enough to finance investment and to realize sustainable economic growth. To do this, the government should:

1. Create stable and predictable economic atmosphere that honors savers for thrift and decreases the fear that inflation or a collapsing of financial system will lead to confiscation of their savings. Specifically, the government should stabilize inflation, strengthen domestic financial institutions, give savings incentives such as tax breaks and increase the role of market signals to create competitive environment in the sector, i.e. eliminating financial repression.
2. Make strong improvement on the fiscal balance, particularly the revenue balance to render public savings positive. Moreover, the government should develop long-term savings instruments to mobilize household savings which in turn enhances public savings.
3. Expand microfinance institutions and banks to far flung areas of the country to mobilize domestic savings from the small depositors.
4. Increase the deposit rate of the commercial banks through monetary policy at the disposal of the Central Bank.

Conflict of Interests

The author have not declared any conflict of interests.

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Appendix I. Result of Bounds Test for Cointegration.

Dependent Variable (intercept included)	**Order of ARDL**	**F-statistic**	**Decision**
F_{LnRGDP}(lnRGDP|(lnGDS,lnGDI, lnHC,lnLF)	(1,0,0,0,1)	9.4448*	Cointegration
F_{lnGDS}(lnGDS|(lnRGDP,lnGDI, lnHC, lnLF)	(1,0,1,0,0)	2.2021	No cointegration
F_{lnGDI}(lnGDI|(lnGDS,lnRGDP, lnHC, lnLF)	(1,1,0,0,0)	1.5523	No cointegration
F_{lnHC}(lnHC|(lnGDS,lnGDI, lnRGDP, lnLF)	(1,1,1,0,0)	2.6799	No cointegration
F_{lnLF}(lnLF|(lnGDS,lnGDI, lnRGDP, lnHC)	(0,0,0,0,0)	Not applicable as lag of dependent variable is zero	
Critical Values			
Type	95% Lower Bound	95% Upper Bound	
Pesaran et al. (2001)	3.2055	4.4778	
Narayan (2004)	2.893	4.000	

Note: * means it is greater than the 95% Upper Bound critical value.

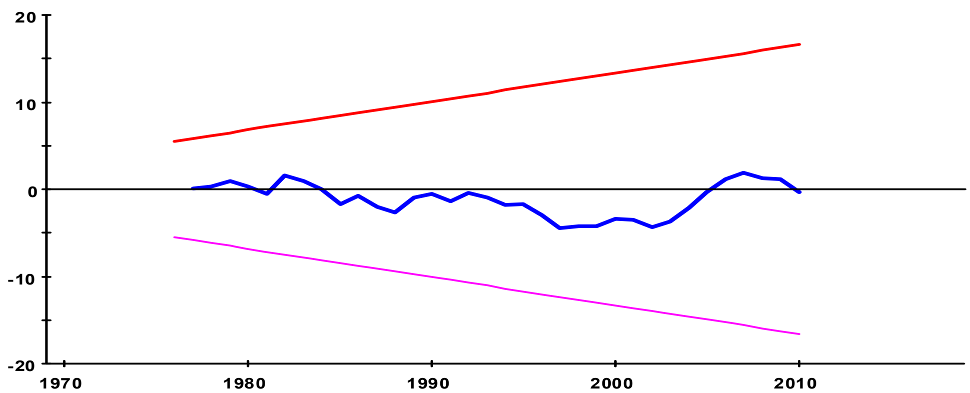
Appendix II. Results of ARDL Estimates and Diagnostic Tests. Results of Autoregressive Distributed Lag Estimates.

Autoregressive distributed lag estimates ARDL(1,0,0,1,0) selected based on Schwarz Bayesian Criterion				
R-Squared	.99377	R-Bar-Squared	99244	
S.E. of Regression	.038268	F-Stat. F(7,33)	751.3990[.000]	
Mean of Dependent Variable	10.9294	S.D. of Dependent Variable	.44020	
Residual Sum of Squares	.048328	Equation Log likelihood	80.0616	
Akaike Info. Criterion	72.0616	Schwarz Bayesian Criterion	65.2073	
DW statistic	1.9119	Durbin's h statistic	34819[.728]	4.4312
Testing for existence of a level relationship among the variables in the ARDL model				
F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
7.2181*	3.9343	5.2128	3.3148	
W-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
36.0904*	19.6716	26.0638	16.5738	22.1559

Notes: * means F-statistic and W-statistic are greater than 95% Upper Bound critical value. Dependent variable is LNRGDP 41 observations used for estimation from 1970 to 2010

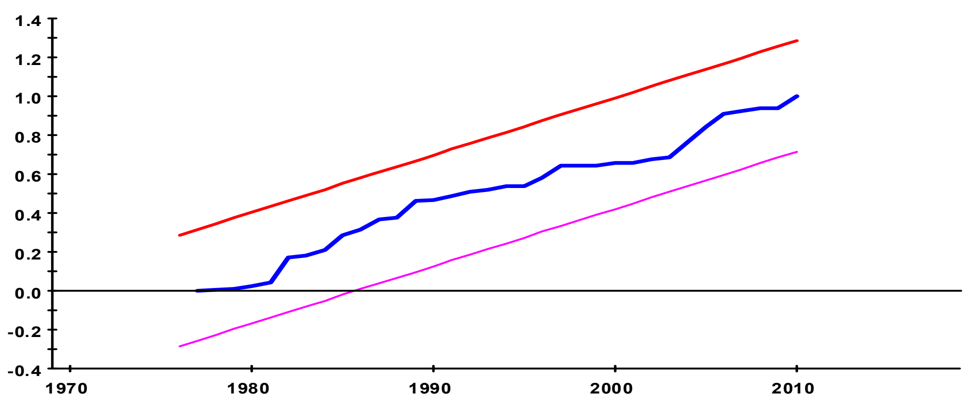
Appendix III. Plots of CUSUM and CUSUMSQ.

A) Plot of Cumulative Sum of Recursive Residuals (Short-run)



The straight lines represent critical bounds at 5% significance level

B) Plot of Cumulative Sum of Squares of Recursive Residuals (Short-run)



The straight lines represent critical bounds at 5% significance level