UNISA ECONOMIC RESEARCH
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Working Paper 13/2016

July 2016

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AN EMPIRICAL TEST OF THE EXOGENOUS GROWTH MODELS: EVIDENCE FROM THREE SOUTHERN AFRICAN COUNTRIES

Themba Gilbert Chirwa[1] and Nicholas M. Odhiambo

Abstract

This paper aims to empirically investigate the relevance of exogenous growth models in explaining economic growth in three Southern African countries, using the recently developed ARDL bounds-testing approach. Furthermore, the relevance of the convergence hypothesis in these study countries is tested using an extended exogenous growth model. The study results reveal that the predictions of the Solow and augmented Solow growth models are consistent in the three study countries, and that the convergence hypothesis holds. However, when additional factors are taken into account in exogenous growth models, the response of income per capita due to changes in investment and human capital development is slow in economies with low income per capita, such as Malawi and Zambia, compared to South Africa, which is ranked as an economy with a high income per capita. This study has important policy implications in these study countries. These implications include the need for policy makers to ensure that macroeconomic stability is encouraged by reducing government consumption, inflation, and population growth; and by promoting trade in order to allow for the diffusion of technologies from abroad.

Keywords: Exogenous Growth Models; Autoregressive Distributed Lag Model; Economic Growth; Malawi; Zambia; South Africa

JEL Classification Code: N17, F43, O47, O55

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1. Introduction

Investigations seeking to identify the factors that promote or hinder economic growth have been some of the central pursuits amongst theoretical and empirical growth researchers – but with little consensus reached to date. Within the framework of the economic growth theory, there have been two most important new approaches that have spearheaded much of the existing discussion on economic growth. These include the neoclassical or exogenous growth theories and the endogenous growth theories. In both cases, the main focus has been on the importance of state factors such as the accumulation of physical capital, human capital development, and technology (see, amongst others, Solow, 1956; Romer, 1986; Lucas, 1988; Grossman and Helpman, 1991; Aghion and Howitt, 1992). However, there have been other equally important contributions to the economic growth literature that focus either on the role of efficiency factors on economic growth (see, among others, Easterly and Wetzel, 1989; World Bank, 1990) or the importance of fundamental sources of economic growth such as institutional, legal, demographical, geographical, socioeconomic, and political factors (see, among others, Barro, 1999, 2003; Sachs and Warner, 1997; Radelet *et al.*, 2001).

The neoclassical (Solow, 1956) economic growth theory, also known as the exogenous growth model, postulates that the accumulation of physical capital is an important driver of economic growth in the short run, while technological advancement is the key determinant of economic growth in the long run. An important extension of this neoclassical growth model was the inclusion of human capital stock as one of the key factors driving economic growth so as to complement physical capital accumulation (Mankiw *et al.*, 1992; Islam, 1995). On the other hand, the major contribution of endogenous growth theorists is based on productivity factors such as learning-by-doing (Becker, 1962; Mincer, 1962; Weisbrod, 1962; Romer, 1986; Lucas, 1988) and on the importance of useful technological knowledge (research and development) as important drivers of growth (Frankel, 1962; Grossman and Helpman, 1991; Aghion and Howitt, 1992; Stokey, 1995).

Much as there is consensus that state factors such as the accumulation of physical capital (investment) and human capital development, and productivity factors (technological growth) are important macroeconomic determinants of economic growth in almost any country, there are other proponents that postulate the key roles of the following: factors affecting the efficiency of savings and investment, such as financial repression (McKinnon, 1973; Shaw, 1973); real exchange rate misalignment (Balassa, 1964; Samuelson, 1964); inflation (Mundell, 1963; Tobin, 1965; Sidrauski, 1967; Stockman, 1981; Fischer, 1983; Bruno and Easterly, 1998); government spending (Wagner, 1892; Peacock and Wiseman, 1961; Barro, 1990; Barro and Sala-i-Martin, 1992); international trade (Dollar, 1992; Knight *et al*., 1993; Sachs and Warner, 1997); and foreign aid (Chenery and Strout, 1966; Mosley, 1980; Riddell, 1987). All of the aforesaid, among others, are arguably equally important determinants of economic growth (Easterly and Wetzel, 1989; World Bank, 1990; Fischer, 1992). These efficiency factors became prominent in the 1990s with three key outcomes being targeted, namely, the stability of the macro-economic environment; the effectiveness of the institutional framework of an economy related to political and economic governance, incentive structures, and social infrastructure; and the setting up of the right price mechanism and the regulatory environment that is necessary to clear markets (World Bank, 1990; Corbo *et al*., 1992; Snowdon and Vane, 2005). However, to our knowledge, the relevance of these factors has not been empirically investigated in exogenous growth models.

Against this backdrop, the study, therefore, seeks to investigate the relevance of exogenous growth models in explaining economic growth in three Southern African countries. In particular, the importance of efficiency factors in explaining long-run economic growth is investigated using an extension to the exogenous growth model. Three models – Solow (1956), Mankiw *et al*. (1992), and World Bank (1990) – are estimated in this study using data from three countries, namely, Malawi, Zambia, and South Africa, in order to test the importance of these factors and how they affect parameter estimates. The selection of these countries has taken into account their level of development and the fact that they belong to the same development community – the Southern African Development Community (SADC).

The rest of this paper is organised as follows: Section 2 discusses the theoretical foundations of the exogenous growth model and its challenges. Section 3 discusses the empirical model specification, as well as the estimation techniques used in the study. Section 4 presents the empirical analysis results of the estimated models. Lastly, Section 5 concludes the study and discusses some policy recommendations.

2. Theoretical Foundations of the Exogenous Growth Model

To establish linkages with the theoretical foundations, the empirical dynamic model adopted in this study is assumed to follow a Cobb-Douglas aggregate production function with labour-augmenting (Harrod-neutral) technological progress. Building on Fischer (1993); Knight *et al.* (1993); and Acikgoz and Mert (2014) methodology, the aggregate Cobb-Douglas production function is assumed to take the form:

$$Y_t = K_t^{\alpha} HC_t^{\beta} \left(A_t \{GC_t, RER_t, INF_t, TRD_t\} L_t \right)^{1-\alpha-\beta} \tag{1}$$

In equation (1), K, HC and L represent the traditional inputs used in the Solow (1956) and Mankiw *et al.* (1992) growth functions – physical capital, human capital, and labour, respectively; α represents the partial elasticity of output with respect to physical capital; and β is the partial elasticity of output with respect to human capital. When using time series data, the literature recommends that the technological change factor (A_t) should be assumed to be labour-augmenting and should follow a Harrod-neutral technical change (Uzawa, 1965; Lucas, 1988; Acikgoz and Mert, 2014). The model builds on Fischer's (1993, p. 494) approach where he assumes the labour-augmenting technology to have two multiplicative components: the level of technological progress, which is assumed to be labour-augmenting (Harrod-neutral); and the overall economic efficiency, which is dependent on institutional factors and government economic management policy. This framework has also been supported by Barro (1999, p. 445), where the empirical model of the long-run or equilibrium level of per capita output was assumed to depend on government policies, institutions, and the national population. Barro (1990) concluded that better enforcement of regulations and fewer market distortions tend to raise the long-run equilibrium level of per capita output and, hence, its growth rate.

According to the World Bank (1990) report, sustainable economic growth has three requirements, namely, a stable macroeconomic environment; an appropriate price mechanism and regulatory structure; and efficient and effective institutions that can convert national savings into productive investments (World Bank, 1990, p. 100). Fischer's (1993, p. 487) definition of a stable macroeconomic framework implies a policy environment that is conducive to economic growth. This reflects an environment where inflation is low and predictable, real interest rates are at appropriate levels to attract savings, fiscal policy is stable (distortions are sustainable), the real exchange rate is competitive and predictable, and the balance of payments position is perceived to be viable (World Bank, 1990, p. 4).

Rather than assuming economic efficiency factors to be fixed regressors, these factors have been assumed to consist of policy variables that affect the stabilisation curve of the exogenous growth model (Fischer 1992, 1993). Fischer (1993) regressed the growth rate of real GDP on inflation rate, ratio of budget surplus to GDP, black market premium on foreign exchange, and terms of trade. In Bassanini *et al.*'s (2001, p. 54) framework, using a cross-country regression, the included variables were real GDP per capita, accumulation of physical capital, human capital, growth of working age population, inflation, government consumption, government capital accumulation, tax and non-tax receipts, direct/indirect taxes, business and non-business research and development, private credit, stock market capital, and trade exposure. The rationale of taking this approach originates from three fronts, namely, the Solow residual or total factor productivity; the conditional convergence hypothesis; and macroeconomic uncertainty or the efficiency of traditional inputs of growth.

First, in the exogenous growth model, total factor productivity is defined as the portion of production and productivity that cannot be explained by the amount of traditional inputs such as the accumulation of physical capital and human capital stock. As such, the Solow residual is a source of omitted variables. Mosley *et al*. (1987) used export growth in addition to domestic savings, foreign aid, foreign direct investment, and literacy growth to isolate the components of total factor productivity that drive economic growth. In addition, Fischer (1993, p. 494) argued that the standard procedure of adding policy-induced macroeconomic variables to a growth regression implicitly assumed that policy variables affected economic growth through the productivity residual. Thus, rather than assuming that these important determinants are lumped in with the Solow residual, isolating their influence on growth is important to guide policy decision makers.

Second, the absolute convergence hypothesis of the neoclassical growth model (Solow, 1956; Cass, 1965) postulates that poorer economies grow faster and tend to catch up with richer economies. However, Barro (2003, p. 235) argued that this hypothesis did not empirically hold, and in order to understand why this is the case, the relationship between growth rates and the initial position of real GDP per capita has to be examined after holding constant some variables that are unique to each country or a set of countries. Thus, the empirical growth framework should integrate state variables that consist of the accumulation of physical and human capital stock as well as policy variables that include common characteristics driven by governments and private agents, such as the ratio of government consumption to GDP, the extent of international openness, indicators of macroeconomic stability, and political stability measures such as maintenance of the rule of law and democracy (Barro, 2003, p. 236).

Third, macroeconomic stability matters for growth through uncertainty (Fischer, 1992, p. 173). In the theoretical literature, two sources of uncertainty are described. The first is through policy-induced macroeconomic uncertainty that affects the efficiency of the price mechanism (Lucas, 1973; Froyen and Waud, 1980). The second is temporary uncertainty that affects the future potential of the rate of investment to grow and causes capital flight (Pindyck, 1988; Pindyck and Somalino, 1993). Thus, the sources of uncertainty based on the endogenous and empirical growth theorists have assumed the efficiency of capital (both physical and human) to be affected by a number of policy-related factors that include trade policy, inflation, financial repression, and real exchange rate instability, among others (Easterly and Wetzel, 1989; World Bank, 1990; Dollar, 1992; Fischer, 1993).

Growth economists that study economic growth trends have postulated that the international differences in income between developing and developed countries can be explained in part by differences in the macroeconomic policy environment. Savings and investment (both physical and human capital) are traditionally the key determinants of economic growth, and many empirical studies have found these determinants to be positively and significantly associated with economic growth. However, a stable macroeconomic environment is a necessary condition in order to maintain the efficiency of savings and investment as well as minimise capital flight (World Bank, 1990, p. 100; Fischer, 1993, 486; Bassanini *et al*., 2001, p. 5). Many endogenous empirical studies have also singled out policy distortions that affect the price mechanism and the efficient allocation of resources as the key factors that bring international differences in economic performance, especially in developing countries (Easterly and Wetzel, 1989, p. 1; Corbo, *et al*., 1992, p. 160). What the endogenous growth theories have postulated is that eliminating policy distortions can lead to a one-time increase in the output level in the long run (level effects) as well as affect the growth rate of output in the short run (growth effects). The standard neoclassical Solow (1956) growth model postulated that distortionary policies exhibit only growth effects and not level effects. The endogenous growth literature, on the other hand, has presented models where policy distortions have significant effects both on short- and long-run economic growth (Romer, 1986; Lucas, 1988; Barro, 1989, 1991; Barro and Sala-i-Martin, 1992).

The variables that are included in this study, therefore, consist of the accumulation of physical capital (investment), human capital (average years of schooling), population growth, and policy variables (efficiency factors) that include government consumption share in GDP, real exchange rate, inflation, and international trade. The distortions in these efficiency factors are assumed to affect the rate of savings and investment at certain thresholds where the relationship can either be positive or negative. Thus, these efficiency factors, just like population growth, are assumed to grow exogenously as follows (see Mankiw *et al*., 1992, Nonneman and Vanhoudt, 1996, among others):

$$L_t = L(0)e^{\eta t} \qquad (2)$$
$$A_t = A(0)e^{gt} \qquad (3)$$
$$GC_t = GC(0)e^{\theta t} \qquad (4)$$
$$RER_t = RER(0)e^{\tau t} \qquad (5)$$
$$INF_t = INF(0)e^{\pi t} \qquad (6)$$
$$TRD_t = TRD(0)e^{\delta t} \qquad (7)$$

The growth rates are represented by the exponential coefficients such as population, η; technology, g; public consumption, θ; the real exchange rate, τ; inflation, π; diffusion of knowledge (international trade), δ; as well as their initial endowments for population, $L(0)$; technology, $A(0)$; public consumption, $GC(0)$; real exchange rate, $RER(0)$; inflation, $INF(0)$; and international trade, $TRD(0)$. The theoretical model specification adopted is based on the notion that adequate levels of savings and investments are necessary but not sufficient to guarantee higher rates of economic growth in an economy. Macroeconomic stability is also essential and affects the efficiency of the factors of production at certain thresholds (World Bank, 1990; Fischer, 1993). Some of the empirical studies that support the role of macroeconomic instability include threshold effects that arise from government expenditure (Anaman, 2004), real exchange rate instability (Rodrik, 2008; Vieira *et al*., 2013), inflation (Bruno and Easterly, 1998), and trade volatility (Mendoza, 1997).

Assuming that the fraction of income invested in physical capital and human capital is given by s_k, s_h, respectively, the evolution of the economy can, therefore, be assumed to be determined by the following extended two empirical dynamic equations expressed in quantities per unit of effective labour (see Mankiw *et al*., 1992; Fischer, 1993; Barro, 2003, among others):

$$\Delta k_t = s_k y_t - (\eta + g + \theta + \tau + \pi + \delta) k_t \tag{8}$$

$$\Delta h_t = s_h y_t - (\eta + g + \theta + \tau + \pi + \delta) h_t \tag{9}$$

In equations 8 and 9, the small letters represent quantities per unit of effective labour, $A_t L_t$, and postulate that a unit of consumption can be transformed into either a unit of physical capital or a unit of human capital (Acikgoz and Mert, 2014). For the production function to converge towards its equilibrium steady state, decreasing returns to the sources of capital, $\alpha + \beta < 1$, is assumed. Therefore, the evolution towards a steady state for investment and human capital with respect to a given set of policy variables in a given country is defined by the following two equations (see Mankiw *et al*., 1992; Fischer, 1993; Barro, 2003, among others):

$$k^* = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{(\eta + g + \theta + \tau + \pi + \delta)} \right)^{1/1-\alpha-\beta} \quad (10)$$

$$h^* = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{(\eta + g + \theta + \tau + \pi + \delta)} \right)^{1/1-\alpha-\beta} \quad (11)$$

Where $(\blacksquare)^*$ = Steady state value of investment and human capital stock

Substituting equations 10 and 11 into the production function (equation 1) and expressing the variables in logarithmic form, the steady state empirical long-run growth equation can be expressed as follows (see Mankiw *et al.*, 1992, among others):

$$\begin{aligned}\ln y_t &= \ln A(0) + gt + \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) \\ &\ldots\ldots\ldots\ldots - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(\eta + g + \theta + \tau + \pi + \delta)\end{aligned} \quad (12)$$

Equation 12, therefore, reveals the structural theoretical model that shows how the long run level of income per capita is dependent on the accumulation of physical capital and human capital stock; a Harrod-neutral (or labour-augmenting) technological factor, represented by the linear trend variable, gt; and policy factors that improve their efficiency – population growth, government consumption, real exchange rate depreciation, inflation, and trade. An important aspect of the initial technological endowment factor, $In\, A(0)$, is that it represents fixed regressors that are exogenous and country-specific that may induce growth (see Mankiw *et al.*, 1992; Fischer, 1993; Barro, 2003, among others).

In summary, the efficiency factors provide the essentials and a link to how policy variables influence the aggregate production function (see World Bank, 1990; Fischer, 1993; Barro, 2003 among others). Distortions in these factors are expected to have a long lasting influence on the accumulation of savings and investment and can either prevent or induce capital flight (World Bank, 1990, p. 100). At first glance, the efficiency factors are not directly controllable by policy, and each variable optimally varies in response to shocks in the economy (Fischer, 1993, p. 487). Furthermore, significant distortions in these efficiency factors that pass a certain threshold have significant adverse macroeconomic consequences: firstly on the level of savings and accumulation of physical capital (neoclassical theory) and secondly, on growth (new growth theories).

3. Empirical Model Specification and Estimation Techniques

3.1 Empirical Model Specification

In order to test this modelling approach that takes into account efficiency factors, time series data from three study countries in SADC are used. The selected countries include a low-income economy (Malawi), a lower middle-income economy (Zambia), and an upper middle-income economy (South Africa). The three models estimated in this study are as follows: Model 1, based on Solow (1956); Model 2, based on Mankiw *et al*. (1992); and Model 3, based on an extended growth model with additional factors proposed by the World Bank (1990). The models are presented as equations 13 to 15.

Model 1 (Solow, 1956):

$$Y = f(INV, POPG) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (13)$$

Model 2 (Mankiw *et al*., 1992):

$$Y = f(INV, HC, POPG) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (14)$$

Model 3 (World Bank, 1990):

$$Y = f(INV, HC, POPG, GC, RER, INF, TRD) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (15)$$

The selected variables included in equations 13-15 comprise the following traditional factors – income per capita represented by real GDP per capita, investment (INV) proxied by gross fixed capital formation as a share of real GDP, human capital (HC) proxied by total enrolment, and population growth $(POPG)$; and the efficiency factors – government consumption (GC) as a share in real GDP, real exchange rate depreciation (RER), inflation (INF), and international trade (TRD) proxied by the ratio of exports and imports.

3.2 Estimation Techniques

The study uses the recently developed Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran *et al*. (2001). The ARDL model has numerous advantages, such as the inclusion of lags for both the dependent and regressors to investigate short- and long-run properties (Pesaran and Shin, 1999; Collier and Goderis, 2012). It can also be used to identify cointegrating relationships regardless of whether the variables are integrated of order zero or one (Odhiambo, 2013). Correction of endogeneity in the regressors (Pesaran and Shin, 1999; Acikgoz and Mert, 2014) and the provision of robust results even when the sample size is small (Narayan, 2005) are further advantages associated with the model.

The ARDL representation of models 13-15 can be expressed as follows:

Model 1:

$$\Delta lnY_t = \beta_0 + \beta_1 T_t + \sum_{i=1}^{n} \beta_{2i} \Delta lnY_{t-i} + \sum_{i=0}^{n} \beta_{3i}\, \Delta lnPOPG_{t-i} + \alpha_1 lnY_{t-1} + \alpha_2 lnINV_{t-1} + \alpha_3 lnPOPG_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (16)$$

Model 2:

$$\Delta lnY_t = \beta_0 + \beta_1 T_t + \sum_{i=1}^{n} \beta_{2i} \Delta lnY_{t-i} + \sum_{i=0}^{n} \beta_{3i}\, \Delta lnINV_{t-i} + \sum_{i=0}^{n} \beta_{4i}\, \Delta lnHC_{t-i} + \sum_{i=0}^{n} \beta_{5i}\, \Delta lnPOPG_{t-i} + \alpha_1 lnY_{t-1} + \alpha_2 lnINV_{t-1} + \alpha_3 lnHC_{t-1} + \alpha_4 lnPOPG_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots (17)$$

Model 3:

$$\begin{aligned}\Delta lnY_t = \beta_0 + \beta_1 T_t + \sum_{i=1}^{n}\beta_{2i}\Delta lnY_{t-i} + \sum_{i=0}^{n}\beta_{3i}\,\Delta lnINV_{t-i} + \sum_{i=0}^{n}\beta_{4i}\,\Delta lnHC_{t-i} + \sum_{i=0}^{n}\beta_{5i}\,\Delta lnPOPG_{t-i} \\ + \sum_{i=0}^{n}\beta_{6i}\,\Delta lnGC_{t-i} + \sum_{i=0}^{n}\beta_{7i}\,\Delta lnRER_{t-i} + \sum_{i=0}^{n}\beta_{8i}\,\Delta lnINF_{t-i} + \sum_{i=0}^{n}\beta_{9i}\,\Delta lnTRD_{t-i} \\ + \alpha_1 lnY_{t-1} + \alpha_2 lnINV_{t-1} + \alpha_3 lnHC_{t-1} + \alpha_4 lnPOPG_{t-1} + \alpha_5 lnGC_{t-1} + \alpha_6 lnRER_{t-1} \\ + \alpha_7 lnINF_{t-1} + \alpha_8 lnTRD_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (18)\end{aligned}$$

In equations 16-18, the parameters $\beta_2, \dots, \beta_9$ represent the short-run elasticities, and $\alpha_1, \dots, \alpha_8$ are the long-run elasticities, given that all variables are expressed in natural logarithm. The white noise residual term denoted by ε_t is assumed to be independent and identically distributed. The error correction models associated with equations 16-18 that measure the speed of adjustment towards the long-run equilibrium path are expressed as follows:

Model 1:

$$\begin{aligned}\Delta lnY_t = \beta_0 \Delta T_t + \sum_{i=1}^{n}\beta_{1i}\Delta lnY_{t-i} + \sum_{i=0}^{n}\beta_{2i}\,\Delta lnINV_{t-i} + \sum_{i=0}^{n}\beta_{3i}\,\Delta lnPOPG_{t-i} + \rho ECM_{t-1} \\ + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (19)\end{aligned}$$

Model 2:

$$\begin{aligned}\Delta lnY_t = \beta_0 \Delta T_t + \sum_{i=1}^{n}\beta_{1i}\Delta lnY_{t-i} + \sum_{i=0}^{n}\beta_{2i}\,\Delta lnINV_{t-i} + \sum_{i=0}^{n}\beta_{3i}\,\Delta lnHC_{t-i} + \sum_{i=0}^{n}\beta_{4i}\,\Delta lnPOPG_{t-i} \\ + \rho ECM_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (20)\end{aligned}$$

Model 3:

$$\begin{aligned}\Delta lnY_t = \beta_0 \Delta T_t + \sum_{i=1}^{n}\beta_{1i}\Delta lnY_{t-i} + \sum_{i=0}^{n}\beta_{2i}\,\Delta lnINV_{t-i} + \sum_{i=0}^{n}\beta_{3i}\,\Delta lnHC_{t-i} + \sum_{i=0}^{n}\beta_{4i}\,\Delta lnPOPG_{t-i} \\ + \sum_{i=0}^{n}\beta_{5i}\,\Delta lnGC_{t-i} + \sum_{i=0}^{n}\beta_{6i}\,\Delta lnRER_{t-i} + \sum_{i=0}^{n}\beta_{7i}\,\Delta lnINF_{t-i} + \sum_{i=0}^{n}\beta_{8i}\,\Delta lnTRD_{t-i} \\ + \rho ECM_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (21)\end{aligned}$$

3.3 Data Sources

The data used in this study are obtained from the World Bank Development Indicators (World Bank, 2015) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Institute of Statistics (UNESCO, 2015). The study uses annual time series data covering the period 1970-2013. The ARDL model estimation is computed using Microfit 5.0, while unit root tests are reported based on Eviews 9 software.

4. Empirical Results

4.1 Stationarity Tests

Table 1 reports the stationarity test results for the time series data used in this study based on the Augmented Dickey-Fuller (1979); Elliott, Rothenberg and Stock (1996) Dickey Fuller Generalized Least Squares (DF-GLS); and Perron (1990) structural break unit root tests.

Table 1: Stationarity Tests for all Variables

	Stationarity of all Variables in Levels						***Stationarity of all Variables in 1st Differences***					
	ADF		***DF-GLS***		***Perron***		***ADF***		***DF-GLS***		***Perron***	
Variable Name	***Without Trend***	***With Trend***	***Without Trend***	***With Trend***	***Without Trend***	***With Trend***	***Without Trend***	***With Trend***	***Without Trend***	***With Trend***	***Without Trend***	***With Trend***
Malawi												
Log(GDPPC)	-	-2.02	-	-1.85	-	-3.78	-	-7.42***	-	-2.91*	-	-8.00***
Log(INV)	-3.32**	-	-3.08***	-	-4.55	-	-	-	-	-	-9.18***	-
Log(HC)		-1.34	-	-1.38		-2.39	-	-6.32***	-	-5.99***	-	-6.43***
Log(POPG)	-2.67*	-	-2.71***	-	-7.32***	-	-4.82***	-	-	-	-	-
Log(GC)	-3.57***	-	-3.60***	-	-4.36*	-	-	-	-	-	-9.75***	-
Log(RER)	-	-3.08	-	-3.17*		-4.35*	-	-6.19***	-	-6.32***	-	-6.69***
Log(INF)	-4.19***	-	-4.20***	-	-5.73***	-	-	-	-	-	-	-
Log(TRD)	-4.13***	-	-4.05***	-	-4.96***	-	-	-	-	-	-	-
Zambia												
Log(GDPPC)	-	0.98	-	-0.94	-	-4.52	-	-7.26***	-	-7.42***	-	-9.86***
Log(INV)	-1.41	-	1.31	-	-2.79	-	-11.16***	-	-9.32***	-	-13.11***	-
Log(HC)	-	-1.31	-	-1.52	-	-3.37	-	-3.91**	-	-3.95**	-	-6.45***
Log(POPG)	0.26	-	-0.82	-	-1.75	-	-1.91*	-	-1.65*	-	-4.23*	-
Log(GC)	-4.18***	-	-3.14***	-	-5.04***	-	-	-	-	-	-	-
Log(RER)	-	-0.79	-	-0.95	-	-4.69	-	-5.18***	-	-5.25***	-	-10.04***
Log(INF)	-	-1.82	-	-1.25	-	-5.41**	-	-6.15***	-	-5.99***	-	-
Log(TRD)	-1.74	-	-1.62*	-	-3.39	-	-5.38***	-	-5.31***	-	-6.50***	-
South Africa												
Log(GDPPC)	-	-1.12	-	-1.38	-	-3.57	-	-4.34***	-	-4.28***	-	-5.17***
Log(INV)	-	-1.95	-	-2.05	-	-4.34	-	-6.61***	-	-6.25***	-	-7.05***
Log(HC)	-	-0.77	-	-0.96	-	-6.77***	-	-5.61***	-	-5.65***	-	-
Log(POPG)	-	-2.19	-	-1.98	-	-6.19***	-	-4.51***	-	-4.55***	-	-
Log(GC)	-	-2.21	-	-2.13	-	-5.56**	-	-5.95***	-	-5.18***	-	-
Log(RER)	-	-2.89	-	-2.83	-	-4.16	-	-5.70***	-	-5.73***	-	-6.64***
Log(INF)	-	-3.94**	-	-3.10*	-	-4.94*	-	-	-	-8.70***	-	-12.55***
Log(TRD)	-2.76*	-	-2.10**	-	-3.45	-	-6.37***	-	-	-	-7.74***	-

*Note: for all p-values: *** 1% significance level; ** 5% significance level; * 10% significance level.*

Overall, all variables in the study countries were found to be either integrated of order one or zero. Therefore, the ARDL bounds testing procedure for cointegrating relationships as suggested by Pesaran *et al*. (2001) can be employed.

4.2 ARDL Bounds Test for Cointegration

The Akaike Information Criteria (AIC) and Schwarz-Bayesian Criteria (SBC) were employed to determine the appropriate lag-length in the three models studied in this paper. In Model 1 – the Solow (1956) model – the optimal ARDL model selected for Malawi was $ARDL(1,1,2)$, for Zambia, it was $ARDL(3,1,2)$, and for South Africa it was $ARDL(1,1,0)$. In Model 2 – the Mankiw *et al*. (1992) model – the optimal ARDL models selected were $ARDL(1,1,0,2)$ for Malawi, $ARDL(2,1,2,0)$ for Zambia, and $ARDL(1,0,2,2)$ for South Africa. The selection criteria used for Models 1 and 2 were based on the AIC. In Model 3 – World Bank (1990) model – the optimal ARDL models selected were $ARDL(1,0,0,2,1,1,2,1)$ for Malawi, based on the AIC; $ARDL(2,0,0,0,0,0,0,2,0)$ for Zambia, based on the SBC; and $ARDL(1,0,0,0,0,0,1,1)$ for South Africa, based on the SBC. Table 2 reports the cointegration results for Model 1 [Solow (1956) growth model].

Table 2: Model 1 – Bounds Test for Cointegration

Country	Dependent Variable	Function	Value (F-statistic)	Co-integration Status
Malawi (Case IV)	Real GDP per capita	(***GDPPC*** **|** INV, POPG)	8.24***	Cointegrated
Zambia (Case I)	Real GDP per capita	(***GDPPC*** **|** INV, POPG)	5.28**	Cointegrated
South Africa (Case IV)	Real GDP per capita	(***GDPPC*** **|** INV, POPG)	5.11**	Cointegrated

Null Hypothesis: No long run relationships exist
Asymptotic Critical Values (Pesaran *et al*., 2001; Case I and IV, pp. 300-301)

	1%		**5%**		**10%**	
Case	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
I	3.88	5.30	2.72	3.83	2.17	3.19
IV	4.99	5.85	3.88	4.61	3.38	4.02

*Note: *** 1% significance level; ** 5% significance level; * 10% significance level.*

As illustrated in Table 2, all computed $F -$ statistics in the three study countries are statistically significant at the 1% and 5% significant levels. The growth equation in Malawi reported an F-statistic of 8.24, which is statistically significant at the 1% significance level. The F-statistic for the Zambian growth equation was 5.28, which is statistically significant at the 5% significance level, and the F-statistic for the South Africa growth equation was 5.11, which is statistically significant at the 5% significance level.

Similarly, Table 3 reports bounds-test results for Model 2 [Mankiw *et al*. (1992) growth model].

Table 3: Model 2 – Bounds Test for Cointegration

Country	**Dependent Variable**	**Function**	**Value (F-statistic)**	**Co-integration Status**
Malawi (Case IV)	Real GDP per capita	(***GDPPC*** **|** INV, HC, POPG)	6.37***	Cointegrated
Zambia (Case III)	Real GDP per capita	(***GDPPC*** **|** INV, HC, POPG)	10.28***	Cointegrated
South Africa (Case IV)	Real GDP per capita	(***GDPPC*** **|** INV, HC, POPG)	6.04***	Cointegrated

Null Hypothesis: No long-run relationships exist
Asymptotic Critical Values (Pesaran *et al*., 2001; Case I and II, p. 300)

	1%		**5%**		**10%**	
Case	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
III	4.29	5.61	3.23	4.35	2.72	3.77
IV	4.30	5.23	3.38	4.23	2.97	3.74

*Note: *** 1% significance level; ** 5% significance level; * 10% significance level.*

As illustrated in Table 3, all computed $F -$ statistics in the three study countries are statistically significant at the 1% significance level. Malawi reported a computed statistic of 6.37, Zambia reported a computed statistic of 10.28, and South African reported a statistic of 6.04.

Lastly, Table 4 reports results of the extended Model 3 [World Bank (1990) growth model].

Table 4: Model 3 – Bounds Test for Cointegration

<table>
<tr><th>Country</th><th>Dependent Variable</th><th colspan="3">Function</th><th>Value (F-statistic)</th><th>Co-integration Status</th></tr>
<tr><td>Malawi (Case II)</td><td>Real GDP per capita</td><td colspan="3">(<i>GDPPC</i> | INV, HC, POPG, GC, RER, INF, TRD)</td><td>4.14***</td><td>Cointegrated</td></tr>
<tr><td>Zambia (Case II)</td><td>Real GDP per capita</td><td colspan="3">(<i>GDPPC</i> | INV, HC, POPG, GC, RER, INF, TRD)</td><td>5.85***</td><td>Cointegrated</td></tr>
<tr><td>South Africa (Case I)</td><td>Real GDP per capita</td><td colspan="3">(<i>GDPPC</i> | INV, HC, POPG, GC, RER, INF, TRD)</td><td>5.67***</td><td>Cointegrated</td></tr>
<tr><td colspan="7">Null Hypothesis: No long-run relationships exist
Asymptotic Critical Values (Pesaran <i>et al</i>., 2001; Case I and II, p. 300)</td></tr>
<tr><td></td><td colspan="2">1%</td><td colspan="2">5%</td><td colspan="2">10%</td></tr>
<tr><td>Case</td><td>$I(0)$</td><td>$I(1)$</td><td>$I(0)$</td><td>$I(1)$</td><td>$I(0)$</td><td>$I(1)$</td></tr>
<tr><td>I</td><td>2.54</td><td>3.91</td><td>1.97</td><td>3.18</td><td>1.70</td><td>2.83</td></tr>
<tr><td>II</td><td>2.73</td><td>3.90</td><td>2.17</td><td>3.21</td><td>1.92</td><td>2.89</td></tr>
</table>

*Note: *** 1% significance level; ** 5% significance level; * 10% significance level.*

As illustrated in Table 4, all computed bounds test statistics are statistically significant at the 1% significance level. The results show that the computed $F-$statistic for the Malawi growth equation was 4.14, the reported statistic for Zambia was 5.85, while the South Africa growth equation reported a computed $F-$ statistic of 5.67. In summary, the bounds test to co-integrating relationships using the Pesaran *et al*. (2001) approach has confirmed the existence of long-run level relationships between the dependent variable, real GDP per capita, and the set of covariates in all three models adopted.

4.3 Empirical Analysis of ARDL-Based Error Correction Model

Tables 5-7 below present the short- and long-run multipliers for the estimated growth equations based on the Solow (1956), Mankiw *et al*. (1992), and World Bank (1990) models. Table 5 presents the empirical results of the Solow (1956) growth model, and the coefficients for investment and population have the predicted signs.

Table 5: Model 1 Estimated Results – Solow (1956)

Panel 1 –Long-Run Coefficients [Dependent Variable: $\log(GDPPC)_t$]						
	Malawi		**Zambia**		**South Africa**	
Regressor	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
$\log(INV)_t$	0.6050**	0.044	1.2319***	0.000	0.4178***	0.001
$\log(POPG)_t$	-0.2416	0.149	-2.4391***	0.000	-0.2446*	0.098
TREND_t	0.0074**	0.033	-	-	0.0042	0.137
C_t	5.3318***	0.000	-	-	8.1931***	0.000
Panel 2 – Estimated Short-Run Coefficients [Dependent Variable: $\Delta\log(GDPPC)_t$**]**						
	Malawi		**Zambia**		**South Africa**	
Regressor	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
$\Delta\log(GDPPC)_{t-1}$	-	-	-0.1631	0.318	-	-
$\Delta\log(GDPPC)_{t-2}$	-	-	0.0541	0.714	-	-
$\Delta\log(INV)_t$	0.0370	0.219	0.0570***	0.005	0.1520***	0.000
$\Delta\log(POPG)_t$	-0.0763*	0.066	-0.4580	0.370	-0.0691	0.152
$\Delta\log(POPG)_{t-1}$	0.1512***	0.001	0.8029	0.126	0.0597	0.249
$\Delta\mathrm{TREND}_t$	0.0013**	0.027	-	-	0.008	0.223
ECM_{t-1}	-0.1796**	0.030	-0.6377***	0.002	-0.1945***	0.009

	Malawi	Zambia	South Africa
R-Squared	0.4928	0.5703	0.5993
R-Bar Squared	0.3884	0.4764	0.5168
S.E. of Regression	0.0375	0.0312	0.0164
F-Stat	6.60[0.000]	8.49[0.000]	10.17[0.000]
Residual Sum of Squares	0.0479	0.0313	0.0091
DW-statistic	2.49	1.90	1.98
Akaike Info. Criterion	-74.70	-78.29	-109.35
Schwarz-Bayesian Criterion	-67.75	-71.53	-102.40

*Note: *** 1% significance level; ** 5% significance level; * 10% significance level.*

The computed R-squared and the adjusted R-squared, on average, support the fact that investment and population growth account for a large part of income per capita in South Africa and Zambia, which also supports the empirical results by Mankiw *et al*. (1992), but not necessarily for Malawi. The error correction terms in all three study countries are statistically significant at the 1% and 5% significant levels and are all negative, implying that all regressions converge toward their equilibrium steady path. The long-run results presented in Panel 1 show that investment is statistically significant in all three study countries at 1% and 5% significant levels. The results show that, in Malawi, a 1% increase in investment leads to a 0.61% increase in income per capita in the long run, and the results are statistically significant at the 5% significance level. In Zambia, the results show that a 1% increase in investment leads to a 1.23% increase in income per capita, while in South Africa it leads to a 0.42% increase in income per capita. Both results are statistically significant at the 1% level. These results also support the convergence principle, where economies with low levels of income, such as Malawi and Zambia, face relatively high long-run responses to income per capita compared with economies with high levels of income, like South Africa.

The short-run results in Panel 2 reveal that investment is positively and significantly associated with economic growth in Zambia and South Africa, and the results are significant at the 1% significance level. The results show that a 1% increase in the growth of investment leads to a 0.06% increase in the growth of income per capita in Zambia, while in South Africa it leads to a 0.15% increase in the growth of income per capita. The results also reveal that population growth is statistically significant only in Malawi and reveal mixed results. The results show that a 1% increase in population growth in the short run leads to a -0.08% decrease in the current period and a 0.15% increase in the growth of income per capita in the previous period.

Table 6, on the other hand, estimates the Mankiw *et al*. (1992) augmented growth model by adding human capital. Similarly, the error correction model in all three study countries is statistically significant at the 1% and 5% significance levels. The results show that the addition of human capital improves the R-squared and adjusted R-squared and reduces the overall impact of investment in all study countries, implying that human capital development is an important determinant of income per capita apart from the accumulation of physical capital. These results are also supported by Mankiw *et al*. (1992) who found similar results. It is also interesting to note that the inclusion of human capital development in the growth regressions gives mixed results. In Zambia, human capital is positively and significantly associated with long-run income per capita, and the results are statistically significant at the 5% significance level. On the other hand, the results for South Africa show that human capital development is negatively and significantly associated with long-run income per capita, and the results are statistically significant at the 1% significance level.

Table 6: Model 2 Estimated Results – Mankiw *et al.* (1992)

Panel 1 –Long-Run Coefficients [Dependent Variable: $\log(GDPPC)_t$]						
	Malawi		**Zambia**		**South Africa**	
Regressor	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
$\log(INV)_t$	0.5124**	0.039	0.5391***	0.005	0.2348***	0.000
$\log(HC)_t$	-0.3709	0.259	0.2811**	0.015	-0.2921***	0.000
$\log(POPG)_t$	-0.3093*	0.090	0.4244	0.291	-0.0907***	0.004
TREND_t	0.0282	0.147	-	-	0.0119***	0.000
C_t	9.7665**	0.016	5.0186**	0.022	12.974***	0.000
Panel 2 – Estimated Short-Run Coefficients (Elasticities) [Dependent Variable: $\Delta\log(GDPPC)_t$**]**						
	Malawi		**Zambia**		**South Africa**	
Regressor	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
$\Delta\log(GDPPC)_{t-1}$	-	-	-0.2813*	0.061	-	-
$\Delta\log(INV)_t$	0.0361	0.229	0.0633***	0.001	0.1466***	0.000
$\Delta\log(HC)_t$	-0.0742	0.255	0.0415	0.763	-0.0153	0.722
$\Delta\log(HC)_{t-1}$	-	-	-0.2749*	0.071	0.1195**	0.014
$\Delta\log(POPG)_t$	-0.0953**	0.035	-0.0774	0.404	-0.0345	0.355
$\Delta\log(POPG)_{t-1}$	0.1821***	0.001	-	-	0.0653	0.104
ΔTREND_t	0.0056	0.143	-	-	0.0074***	0.000
ECM_{t-1}	-0.2001**	0.019	-0.1825***	0.008	-0.6242***	0.000

	Malawi	Zambia	South Africa
R-Squared	0.5126	0.6634	0.7768
R-Bar Squared	0.3945	0.5818	0.7140
S.E. of Regression	0.0373	0.0281	0.0126
F-Stat	5.78[0.000]	10.84[0.000]	15.91[0.000]
Residual Sum of Squares	0.0460	0.0261	0.0051
DW-statistic	2.48	1.82	2.16
Akaike Info. Criterion	-74.53	-86.41	-119.64
Schwarz-Bayesian Criterion	-66.72	-78.59	-110.95

*Note: *** 1% significance level; ** 5% significance level; * 10% significance level.*

The response on investment is statistically significant in all three study countries. In Malawi, the results show that a 1% increase in investment leads to a 0.51% increase in income per capita, and the results are statistically significant at the 5% significance level. The results are similar in Zambia, where a 1% increase in investment leads to a 0.54% increase in income per capita, and the results are statistically significant at the 1% significance level. On the other hand, a 1% increase in investment in South Africa leads to a 0.23% increase in income per capita. Although the inclusion of human capital development in the Mankiw *et al.* (1992) model reduces the impact of the long-run response of investment on income per capita, the results still support the convergence hypothesis that economies with low income per capita are expected to experience high growth rates compared to rich ones.

The short-run results are similar to the Solow (1956) model, where investment remains positively and significantly associated with the growth of income per capita in Zambia and South Africa and statistically significant at the 1% significance level. The coefficient estimates remain the same, where a 1% increase in the growth of investment leads to a 0.06% and 0.15% increase in the growth of income per capita in Zambia and South Africa, respectively. Population growth is only significant in Malawi, where the results are also mixed with a short run response of -0.09% in the current period and 0.18% in the previous period.

In Table 7, efficiency factors such as government consumption, real exchange rate depreciation, inflation, and international trade are included as regressors in the exogenous growth models. Panel 1 presents the estimated results of the long-run coefficients, while Panel 2 presents the estimated short-run coefficients for the three countries' growth equations. The results in Panel 2 reveal that in the short run, the adjustment process measured by the error correction term (ECM) is between 0 and -1 in the three study countries and are all statistically significant at the 5% significance level. The results show that the speed of adjustment towards the long-run equilibrium path is estimated as -0.30% per annum for Malawi, -0.22% for Zambia, and -0.07% for South Africa. The speed of adjustment that monotonically converges towards the equilibrium path thus confirms the long-run equilibrium relationship between real GDP per capita and the regressors in the respective countries. The study results also reveal that the underlying ARDL models in the three study countries are a good fit, represented by an estimated $R-$squared of 67% for Malawi, 78% for Zambia, and 76% for South Africa. The high R-squared values also suggest that both the traditional and the efficiency factors account for a significant part of income per capita in these study countries.

Table 7: Estimated Results – World Bank (1990) Model

Panel 1 –Long-Run Coefficients [Dependent Variable: $\log(GDPPC)_t$]						
	Malawi		**Zambia**		**South Africa**	
Regressor	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
$\log(INV)_t$	0.2955*	0.092	0.3940***	0.012	1.0413***	0.009
$\log(HC)_t$	0.1627**	0.024	0.2697***	0.004	0.3622***	0.004
$\log(POPG)_t$	-0.2319*	0.070	0.5962	0.131	-0.4372*	0.082
$\log(GC)_t$	0.0442	0.762	-0.3275**	0.046	-0.8754**	0.042
$\log(RER)_t$	0.0474	0.832	-0.0598	0.371	0.1114	0.586
$\log(INF)_t$	-0.1611**	0.015	0.0357	0.511	-0.4216*	0.058
$\log(TRD)_t$	0.5201**	0.045	-0.1242	0.296	1.3527**	0.019
C_t	2.6194**	0.025	5.5124***	0.007	-	-
Panel 2 – Estimated Short-Run Coefficients (Elasticities) [Dependent Variable: $\Delta\log(GDPPC)_t$**]**						
	Malawi		**Zambia**		**South Africa**	
Regressor	**Coefficient**	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
$\Delta\log(GDPPC)_{t-1}$	-	-	-0.4481***	0.003	-	-
$\Delta\log(INV)_t$	0.0873**	0.022	0.0459***	0.010	0.0684**	0.030
$\Delta\log(HC)_t$	0.0481**	0.025	0.0586***	0.005	0.0238	0.122
$\Delta\log(POPG)_t$	-0.0743	0.252	0.1295	0.273	-0.0287*	0.051
$\Delta\log(POPG)_{t-1}$	0.1094	0.110	-	-	-	-
$\Delta\log(GC)_t$	-0.0716	0.232	-0.0711***	0.006	-0.0575**	0.030
$\Delta\log(RER)_t$	-0.0049	0.931	-0.0129	0.443	0.0073	0.583
$\Delta\log(INF)_t$	-0.0249**	0.011	0.0077	0.554	-0.0071	0.219
$\Delta\log(INF)_{t-1}$	0.0124	0.152	-	-	-	-
$\Delta\log(TRD)_t$	0.1329**	0.033	0.0155	0.596	-0.0371	0.297
$\Delta\log(TRD)_{t-1}$	-	-	-0.0437*	0.100	-	-
ECM_{t-1}	-0.2954**	0.034	-0.2171**	0.014	-0.0657**	0.012

	Malawi	**Zambia**	**South Africa**
R-Squared	0.6706	0.7779	0.7559
R-Bar Squared	0.4805	0.6860	0.6873
S.E. of Regression	0.0346	0.0244	0.1323
F-Stat	5.292[0.000]	10.16[0.000]	14.16[0.000]
Residual Sum of Squares	0.0311	0.0173	0.0056
DW-statistic	2.42	2.05	2.07
Akaike Info. Criterion	-75.76	-91.14	-117.77
Schwarz-Bayesian Criterion	-61.86	-79.85	-109.08

*Note: *** 1% significance level; ** 5% significance level; * 10% significance level.*

The long-run results in Table 7 reveal that investment and human capital development are positively and significantly associated with economic growth in all three study countries. In Malawi, a 1% increase in investment leads to a 0.30% increase in income per capita, and the results are statistically significant at the 10% significance level. In Zambia, a 1% increase in investments leads to a 0.39% increase in income per capita, and the results are statistically significant at the 1% significance level. On the other hand, the results show that in South Africa, a 1% increase in investment leads to a 1.04% increase in real GDP per capita, and the results are statistically significant at the 1% level. These results are consistent with empirical growth studies that found similar results in developing countries (see, among others, Bleaney, *et al*., 2001; Anyanwu, 2014).

The long-run results reveal that a 1% increase in human capital development in Malawi leads to a 0.16% increase in real GDP per capita, and the results are statistically significant at the 5% significance level. In Zambia, the results show that a 1% increase in human capital development leads to a 0.27% increase in real GDP per capita in the long run, and that the results are statistically significant at the 1% significance level. The results in South Africa show that a 1% increase in human capital development leads to a 0.36% increase in real GDP per capita in the long run, and the results are statistically significant at the 1% significance level. These results are not surprising as empirical evidence has shown that wealthier countries are likely to benefit more from innovation compared with developing economies, which benefit more from imitation than innovation. Similarly, the quality of investment and human capital development is likely to be higher in wealthier economies than in poor ones as the former are likely to support more research and development activities that improve the quality of education (see Papageorgiou, 2003, among others).

The impact of efficiency factors on economic growth can also be seen in the individual countries. Population growth was found to be negatively and significantly associated with long run economic growth in Malawi and South Africa. The long-run results showed that in Malawi a 1% increase in population growth leads to a -0.23% decrease in real GDP per capita, while in South Africa a 1% increase in population growth leads to a -0.44% decrease in real GDP per capita. These results are similar to some empirical growth studies that support a negative relationship between population growth and economic growth (see, among others, Most and Vann de Berg, 1996; Checherita-

Westphal and Rother, 2012; Anyanwu, 2014). The relationship between government consumption and economic growth was found to be negatively and significantly associated with economic growth in Zambia and South Africa. The long-run results revealed that a 1% increase in government consumption in Zambia leads to a -0.33% decrease in real GDP per capita, while in South Africa, a 1% increase in government consumption leads to a -0.88% decrease in real GDP per capita, and both results are statistically significant at the 5% significance level. These results are similar to other studies that have found a negative and significant relationship between government consumption and economic growth (see, among others, Barro, 1999, 2003; Bhaskara-Rao and Hassan, 2011).

In terms of inflation, the results revealed a negative and significant relationship between inflation and economic growth in Malawi and South Africa. The long-run results showed that a 1% increase in inflation in Malawi leads to a -0.16% decrease in real GDP per capita, and the results are statistically significant at the 5% significance level. In South Africa, the results revealed that a 1% increase in inflation leads to a -0.42% decrease in real GDP per capita, and the results are statistically significant at the 10% significance level. These results are consistent with empirical results that also found a negative and significant association between inflation and economic growth (Fischer, 1992; Barro, 1999, 2003; Burnside and Dollar, 2000; Chen and Feng, 2000; Bhaskara-Rao and Hassan, 2011; Anyanwu, 2014). The relationship between international trade and economic growth was found to be positive and significant in Malawi and South Africa and statistically significant at the 5% significance level. The long-run results in Malawi revealed that a 1% increase in international trade leads to a 0.52% increase in real GDP per capita, while in South Africa a 1% increase in international trade leads to a 1.35% increase in real GDP per capita. These results are consistent with the empirical growth literature that has revealed a positive association between trade and economic growth (see, Fischer, 1993; Barro, 1999; Anyanwu, 2014, among others).

The short-run results in Panel 2 of Table 7 reveal that the growth of investment is positively and significantly associated with the growth of income per capita in all three study countries. The results show that a 1% increase in the growth of investment leads to a 0.09% increase in the growth of income per capita in Malawi, and the results are statistically significant at the 5% significance level. In Zambia, a 1% increase in the growth of investment leads to a 0.06% increase, while in South Africa it leads to a 0.07% increase in the growth of income per capita, and the results are statistically significant at the 1% and 5% significance levels, respectively. The growth of human capital development is positively and significantly associated with economic growth only in Malawi and Zambia, where the results show that a 1% increase in the growth of school enrolment leads to a 0.05% and 0.06% increase in the growth of income per capita in the respective countries. Population growth was found to be negatively and significantly associated with economic growth only in South Africa, where a 1% increase in population growth leads to a -0.03% decrease in the growth of income per capita. Government consumption was found to be negatively and significantly associated with economic growth in Zambia and South Africa, where the results revealed a -0.07% and -0.06% decrease in the growth of income per capita in the respective countries. Inflation was found to be negatively and significantly associated with short-run economic growth only in Malawi, where a 1% increase in inflation leads to a -0.02% decrease in the growth of income per capita. Lastly, the growth of international trade was found to be negatively and significantly associated with economic growth only in Zambia, where a 1% increase in the growth of international trade leads to a -0.04% decrease in the growth of income per capita.

There are two important revelations that emerge from the results reported in Table 7. First, the convergence hypothesis no longer applies when efficiency factors are included in the exogenous growth model as predicted by Solow (1956). Second, the study results suggest that income disparities between countries can be explained better when efficiency factors are included in the exogenous growth model. The study results show that the long-run response of investment and human capital development increases from economies with low incomes, such as Malawi and Zambia, to a higher-income economy, such as South Africa. These results respond to the growth puzzle that was observed by Mankiw *et al*. (1995), who noted that the Solow's neoclassical growth model did not explain the high magnitude of income per capita when comparing income differences between countries. Macroeconomic instability in economies can significantly slow down economic growth in the long run, and these factors are more prominent in poor economies than in rich ones. This confirms that the exogenous growth model does indeed suffer from omitted variable bias.

Finally, Table 8 reports post-estimation diagnostic results for all study countries.

Table 8: ARDL-VECM Post-Estimation Diagnostic Tests

Test Statistic	**Country**		
Solow (1956) Model	**Malawi**	**Zambia**	**South Africa**
Breusch-Godfrey Test: No Serial Correlation	3.51 [0.070]	0.65 [0.423]	0.00 [0.960]
Breusch-Pagan-Godfrey Test: No Heteroskedasticity	2.59 [0.115]	0.05 [0.811]	0.00 [0.989]
Ramsey RESET Test: Functional Form	1.98 [0.168]	0.02 [0.866]	1.59 [0.215]
Normality: CHSQ (2)	2.56 [0.277]	0.59 [0.743]	0.36 [0.832]
ARCH Test: Heteroskedasticity (no ARCH terms)	2.05 [0.144]	0.11 [0.891]	0.91 [0.412]
Mankiw *et al*. (1992) Model	**Malawi**	**Zambia**	**South Africa**
Breusch-Godfrey Test: No Serial Correlation	2.88 [0.099]	0.14 [0.709]	0.55 [0.462]
Breusch-Pagan-Godfrey Test: No Heteroskedasticity	2.15 [0.150]	0.00 [1.000]	0.01 [0.924]
Ramsey RESET Test: Functional Form	0.86 [0.360]	0.01 [0.889]	0.01 [0.981]
Normality: CHSQ (2)	3.65 [0.160]	3.00 [0.223]	1.50 [0.472]
ARCH Test: Heteroskedasticity (no ARCH terms)	1.13 [0.335]	0.16 [0.852]	0.55 [0.580]
World Bank (1990) Model	**Malawi**	**Zambia**	**South Africa**
Breusch-Godfrey Test: No Serial Correlation	2.28 [0.143]	0.33 [0.568]	0.18 [0.672]
Breusch-Pagan-Godfrey Test: No Heteroskedasticity	1.75 [0.194]	0.71 [0.405]	0.02 [0.882]

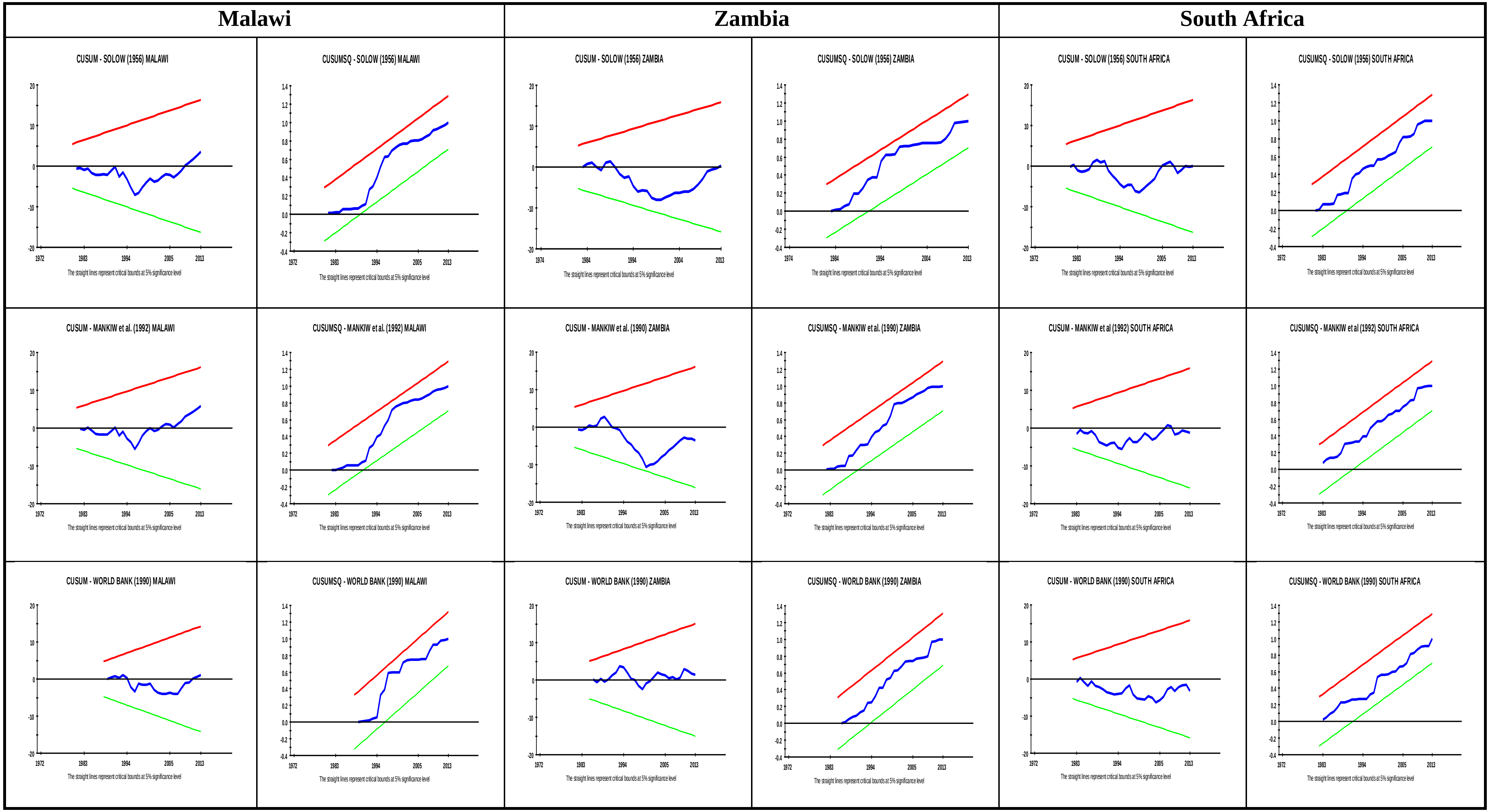
Test Statistic	**Country**		
Solow (1956) Model	**Malawi**	**Zambia**	**South Africa**
Ramsey RESET Test: Functional Form	1.32 [0.261]	0.45 [0.509]	0.00 [0.949]
Normality: CHSQ (2)	1.06 [0.589]	4.17 [0.124]	0.90 [0.636]
ARCH Test: Heteroskedasticity (no ARCH terms)	1.73 [0.199]	1.32 [0.284]	0.11 [0.743]

*Note: for all p-values: *** 1% significance level; ** 5% significance level.*

As illustrated in Table 8, the following post-diagnostic tests are reported: cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of the recursive residuals (CUSUMSQ) test; Breusch-Godfrey serial correlation test; Breusch-Pagan-Godfrey test for heteroskedasticity; Ramsey RESET test; Normality test; and ARCH test. The results reveal that the null hypotheses cannot be rejected for all post-diagnostic tests at the 5% significance level. This implies that the final ARDL model for the estimated growth equations in the study countries is well-specified, and the parameter estimates are not biased.

Figure 1 illustrates the CUSUM and CUSUMSQ results for the estimated growth equation. As illustrated in Figure 1, the CUSUM and CUSUMSQ tests reveal both parameter and variance stability, respectively, and all graphs are within the 5% critical lines.

Figure 1: CUSUM and CUSUMQ Tests



5. Conclusion

In this paper, the relevance of exogenous growth models in explaining economic growth has been investigated using data from three Southern African countries, namely: Malawi, Zambia and South Africa, during the period from 1970 to2013. The study used three exogenous growth models: the traditional Solow (1956) growth model, the augmented Solow growth model suggested by Mankiw *et al*. (1992), and an extended exogenous growth model that includes additional factors suggested by the World Bank (1990). Using the Autoregressive Distributed Lag (ARDL) modelling approach to investigate the relevance of the exogenous growth models both in the short- and long-run, the study results have shown that the predictions of the Solow and augmented Solow growth models, especially that of the convergence hypothesis, hold in the three Southern African countries. The results show that the response of income per capita to changes in investment in a low-income economy such as Malawi and low middle-income economy (Zambia) is higher than in an upper middle-income economy such as South Africa. However, when other macroeconomic factors are included in the exogenous growth model the study results reveal that the convergence hypothesis no longer holds. The results show that economies with low income per capita which are susceptible to macroeconomic instability are likely to experience slow growth compared to wealthier economies that experience macroeconomic stability. It is therefore recommended that economies studied in this paper should implement macroeconomic policies that favour the creation of a conducive macroeconomic environment for economic growth. In particular it is recommended for Malawi to implement economic policies that create incentives to reduce population growth and inflation as well as promote international trade; Zambian authorities are encouraged to reduce government spending; while in South Africa reducing population growth, government consumption, and inflation; at the same time supporting reforms that lead to the promotion of international trade are encouraged.

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