



EXTENDED EXOGENOUS GROWTH MODEL: APPLICATION AND INVESTIGATION THE LONG-TERM GROWTH DETERMINANTS OF BANGLADESH



 **Imrul Hossain Chowdhury**

Department of Economics, Jagannath University, Dhaka, Bangladesh.
Email: cmimrul@gmail.com Tel: +880-1741538828



ABSTRACT

Article History

Received: 26 September 2019
Revised: 8 November 2019
Accepted: 12 December 2019
Published: 22 January 2020

Keywords

Growth theory
Exogenous growth model
Long-term growth
Autoregressive distributed lag (ARDL)
Error correction model (ECM)
Bangladesh.

JEL Classification:

C19, C32, F43, O40.

This study explored various exogenous growth theories and investigated the determinants of the long-term economic growth of Bangladesh. The study estimated the extended exogenous growth model to find the factors of long-term economic growth by exploring the macroeconomic choice variables. The study analyzed the determinants of long-term economic growth by using the annual time-series data from the World Development Indicators (WDI) database from 1985 to 2018. The Autoregressive Distributed Lag (ARDL) and Bounds Test were applied to find the long-term cointegration relationship between the variables, and the Error Correction Model (ECM) identified a stable long-term relationship. The results showed a long-term positive and negative cointegration relationship between economic growth and its estimated determinants. The results found that economic growth has a positive relationship with government consumption expenditure, fertility rate, inflation rate, and agricultural sector growth, and a negative association with population growth. The overall findings of the study contradict the empirical results of the extended exogenous growth model. The study suggests that the Bangladesh government should promote the research and development sector and give importance to technological improvement, stock of human capital growth, capital stock expansion, and governmental actions.

Contribution/ Originality: This study is one of very few studies to have investigated the extended exogenous growth model to identify the long-term growth determinants. The paper's primary contribution is investigating the determinants of the long-term economic growth of Bangladesh.

1. INTRODUCTION

Growth is an indicator to determine the economic condition of a country. For any country willing to make progress and develop, economic growth is indispensable. The nations with predominant economic growth for elongated periods, have always made it possible to increase the overall size of the economy, substantiated their democratic moralities and political permanence, tapered conflict, crime and violence, and improve the overall condition of their environment (Barro, 1996; Easterly, 1999; Barro, 2002; Dollar and Kraay, 2004). Hence, there should be a fundamental objective for policymakers of every country to comprehend the contributing factors of former progression while eradicating the elements limiting present development and make the best use of the visions for future growth. The exogenous and endogenous growth theory provides insightful factors to determine

economic growth. The exogenous growth theory has convergence properties which predict a balanced growth path (Chirwa and Odhiambo, 2019). The exogenous growth theory helps to find the determinants of long-term economic growth by exploring cross-country panel data (Barro, 1991a; Barro, 1991b; Islam, 1995; Barro, 1996; Chirwa and Odhiambo, 2019).

Economists are always interested in the factors that create wide gaps in economic development and output per capita between countries. Several variables are taken into account when considering the significant elements of modern economic growth (Snowdon and Vane, 2005). As a result, economists become more interested in determining the fundamental factors enabling these developments.

To identify such cases, productivity, and human capital have been used in numerous models to apprehend economic growth (La Torre and Marsiglio, 2010). The neoclassical exogenous growth theory provides a paradoxical solution (Domar, 1946). The relationship between full employment and capital accumulation was developed where the capital stock was the only component of the output (Harrod, 1939; Domar, 1946). Later, Solow (1956) and Swan (1956) criticized the Harrod-Domar exogenous growth model and reintroduced labor as an essential factor to determine economic growth. Solow (1956) discovered that physical capital has a short-term impact on economic growth, and technological development has a long-term effect on economic growth. The human capital stock inclusion works as the major component to determine economic growth (Mankiw *et al.*, 1992; Islam, 1995).

According to the neoclassical exogenous growth theory, run by Solow (1956); Swan (1956); Cass (1965) and Koopmans (1965) accretion of physical capital has been considered as a significant factor in elucidating emerging economies. They have also suggested that conditional convergence of economic growth rates and GDP per capita will take place between many nations of the world. On the other hand, Arrow (1962); Romer (1986); Lucas (1988) and Rebelo (1991) and others formed endogenous growth models where the evolution of human capital, ideas, and knowledge have been marked as the main contributing element in triggering long-term economic growth. They also contended that balanced growth could easily be spawned endogenously, where the need for exogenous technical movement is not crucial. It has been noted by Huh and Kim (2013) that trying out the difference between exogenous and endogenous growth models is an essential step in discovering the causes of long-term growth.

Apart from that, there are also numerous variables used to depict long-term growth. Investment and output are considered to be at the core of both exogenous and endogenous growth models (Huh and Kim, 2013). The developing nations that have undergone such growth speed have shown distinguishing determinants of this progression (Breisinger *et al.*, 2009).

According to Boakye (2012) these economic models tend to classify countries by similarities in social and political environments. It is a significant drawback of these models. Different nations have different degrees of socio-political advancement and maturity which directly create an immense impact on their economic growth. As a result, these models fail to provide a complete outcome and deliver less precise extrapolations. To give a broader idea, Acemoglu (2012) stated that economic growth cannot be defined by aggregate output only, rather it also involves the ultimate revolution of an economy. It includes the entire social and institutional infrastructure, sectoral assemble, and its demographic and geographic temperament too.

Bangladesh is listed amidst the top five fastest emerging economies of the world, with a GDP growth of 7.3% in fiscal year 2018, although the private sector investment is not remarkable (Bangladesh Economic Review, 2019). Bangladesh will also uphold the position of the fastest growing economy in Asia-Pacific by taking its GDP growth to 8% in 2019 and 2020. This economic growth is a significant milestone for the country since it has happened in a time when growth among most of the developing Asian countries is at 5.7% in 2019 and 5.6% in 2020 with a continuous perplexing economic stance all over the globe. Hence, Bangladesh has become a benchmark of economic growth during this harsh economic condition.

Behind this spectacular growth of Bangladesh, lies the agricultural sector and its continuous growth. The growth rate of the agricultural sector rose from 3.06% in 2017 to 4.19% in 2018 (BER, 2019). The consumption spending of the government also experienced a rise in 2018. Compared to the Government consumption expenditure of 504,370 BDT million in 2017, it recorded an increased amount of 582,107 BDT million in 2018 (BER, 2019).

The inflation rate also contributed to the growth by remaining stable in 2016, 2017, and 2018. The inflation rates were 5.9%, 5.4%, and 5.8%, respectively (BER, 2019). It has also been anticipated that the inflation rate will tend to stay stable for the rest of the year of 2019 with a value of 5.5% and will slightly rise to 5.8% in 2020. Adding to these factors, the fertility rate and population growth of the country have also been decreasing over time. The fertility rate dropped from 2.09% in 2016 to 2.06% in 2017, and further fell to 2% in 2018 (Statistical Year Book, 2019). Likewise, the population growth rate also fell gradually in 2016, 2017, and 2018. The growth rates of the population were 1.05%, 1.04%, and 1%, respectively (SYB, 2019).

To find out the significance of the exogenous economic growth model in defining long-term growth, the majority of the firsthand studies have concentrated on cross-country differences. In this study the focus was only on Bangladesh to identify the variables of exogenous growth that are essential for long-term economic growth.

The objective of this study was to explore numerous exogenous growth models and identify the contributing elements of long-term economic growth from the extended exogenous growth models. The study explored and tested the macroeconomic choice variables of the extended exogenous growth theory which were developed by Barro (1996). Since this study will also aid in policy exploration and design, it will encourage further research in the field.

The rest of the paper is organized as follows: Section 2 explores a brief review of the empirical literature, Section 3 presents the theoretical model and data of the empirical study, Section 4 describes methodology and empirical results, and Section 5 provides some policy implications.

2. LITERATURE REVIEW

Harrod (1939) and Domar (1946) are classical Keynesian scholars. The growth theory in economic development was explored by using the Harrod-Domar exogenous economic growth model. The growth rate was a function of output and capital stock. This model indicated the capital stock as a significant component of economic growth, also specified that the saving rate equals the investment. But the long-term economic growth was unstable in the Harrod-Domar growth model.

Later, Solow (1956) and Swan (1956) extended the Harrod-Domar model by adding labor as a very crucial factor of production, and also justified that the capital-output ratios fluctuate. In this model, the saving rate, population growth, capital depreciation, and technological level are supposed to be fixed positive constants, but these variables vary in different forms in the long-term. The model solved stable steady state economic growth.

Tobin (1955) presented a growth model similar to the Solow-Swan economic growth model. The model focused on money growth in the economy but failed to solve the long-term stability. Other researchers, Cass (1965) and Koopmans (1965) who extended and improved the Ramsey (1928) mathematical model, found similar long-term stability as Solow (1956) and Swan (1956). The model is known as the Ramsey-Cass-Koopmans model. The model also identified a stable long-term economic growth by exploring an aggregate production function.

Solow (1956); Swan (1956); Cass (1965) and Koopmans (1965) developed the exogenous neoclassical growth theory. The theory is based on a group of long-term economic models that are established under the framework of neoclassical economics. The variables like the output, capital accretion, productivity, growth rate of population, and technological advancement are explored to determine the growth rate in the long-term of an economy. A continuous production function is employed to find out the long-term relationship between the output (per capita GDP) and input (labor, capital, technology, population growth) of the study.

The model indicates that in the steady state, the output of the growth theory will be exogenous and act independently. When savings increase, the output per worker also increases as a result of increasing capital per worker but that does not affect the growth rate of output. Growth in per capita is the result of increase in savings or decrease in population. If there is no technological progress, growth per worker will halt with the resulting diminishing returns to capital. The uniqueness of the theory was the introduction of the concept of conditional convergence. The concept postulates that in the long-term the countries who have similar characteristics such as savings, population, technological progress will ultimately reach the same steady state of growth rate.

The major identifying characteristic of the exogenous model developed by Solow (1956); Swan (1956); Cass (1965) and Koopmans (1965) is the convergence property. The property provides evidence of a higher level of predicted growth rate due to the lower level of real per capita GDP in the starting point. The convergence property can be applied in an absolute form. This property says that the poor countries can have a faster per capita GDP than the rich countries. But the convergence property can be applied in the conditional form if the economic condition is different based on government policy, technological progress, population growth, or working willingness of the people.

In the steady state, if the per capita GDP is lower at the starting point then the growth rate will be higher. In the neoclassical model, the convergence property acts as a diminishing return to capital. The higher rate of growth is possible due to lower the capital per work in steady state. The elements of human capital, such as education, experience, and health are the primary neoclassical model concept for physical capital (Lucas, 1988; Barro, 1996). In the initial stage, the countries that have higher human to physical capital will grow faster because physical capital is more responsive than human capital.

Barro (1996) provided strong evidence for the determination of long-term economic growth. His theory is the extension of the neoclassical growth theory. He estimated the exogenous growth model by using the cross-country panel data which supported the conditional convergence property of Solow (1956); Swan (1956); Cass (1965) and Koopmans (1965). Many external factors were explored to determine the long-term economic growth by using the extended exogenous growth model.

The Solow-Swan model was found to be one of the key models to explore the economic growth in various studies (Knight *et al.*, 1992; Lee *et al.*, 1997; Dowrick, 2002; Fankhauser and Tol, 2005; Guerrini, 2006; Morley, 2006). Ding and Knight (2009) provided an empirical study using the augmented Solow model. The study tested the neoclassical growth model proposed by Solow (1956) with the analysis of cross-country panel data including China. The model found the gap in the growth rate between China and the other 145 countries. The study suggested that the augmented Solow model is useful for measuring the human capital and structural change in an economy. The results showed that the higher growth in China is only due to the higher investment in physical capital, gain in conditional convergence, lower population growth, and employment opportunity in the economy.

Alhassan *et al.* (2012) explored the determining factors of long-term economic growth in Ghana. The study adopted a Cobb-Douglas economy-wide production function from Solow (1956) exogenous growth model to explore the long-term growth. In this study, the authors used the cointegration approach and error correction model to find the long-term association by anticipating the time series data. The results showed that factors like government consumption, growth and inflation, export and human resource expansion have a long-term association. The results also showed that export and human resource expansion had a positive impact on economic growth, whereas inflation and government consumption had a negative effect. Hence, by reducing public spending and readjusting expenditure primacies, the government should directly handle macroeconomic disparities. The monetary policies should be made more stringent, inflation should be reduced, exports diversified, and value addition should be exhilarated. Finally, the overall human capital should be developed by providing quality education and health.

By exploring quarterly data, another researcher Ahiakpor and Akapare (2015) observed the long-term association concerning inflation and economic growth in Ghana. The study adopted the neoclassical growth model

of Solow (1956) to explore the long-term growth relationship. The ARDL and ECM were used in their research. The study found that the GDP of a country is positively affected by components such as government spending, capital, labor force, and money supply. On the other hand, inflation and interest rate has a negative effect on economic growth. The outcome of the study has suggested that inflation targeting would be the best monetary policy for economic growth. The study pointed out that the government needs to escalate its spending in the fields of infrastructure development and human capital to expand output.

Saidu *et al.* (2018) also explored the determinants of Nigerian economic growth in the long-term. The study used the per capita GDP, government consumption expenditure, inflation, and population growth rate to identify the long-term cointegrations relationship among the variables by using annual time series data. The ARDL model was applied to find the long-term cointegration relationship between the variables. The ECM from the ARDL model discovered that the promptness of modification to reestablish equilibrium is 0.85 which put forward the notion that there is a steady long-term association. The study verified the results with Barro (1996) extended exogenous growth theory. The findings of this study postulated that the government of Nigeria should be more concerned about developing its technological fields and capitalize on research and development. To trigger economic growth, the country should also improve its standard of human capital and increase its capital stock.

Numerous studies explored the relationship between the long-term growth and its determinants of Bangladesh's economy using empirical analysis (Al Mamun and Nath, 2005; Love and Chandra, 2005; Ahmed and Uddin, 2009; Adhikary, 2010; Bristy, 2014; Kumar and Stauvermann, 2014). Rao and Hassan (2011) analyzed the determinants of the economic growth of Bangladesh in the long-term. The study estimated total factor productivity (TFP), which was introduced by Solow (1957). The study assessed the TFP to find the long-term growth relationship with trade openness, foreign direct investment, development of the financial sector, current government spending, and inflation. The ARDL and ECM model were used to estimate the long-term cointegration relationship between variables. The empirical study showed that in the long-term trade openness, foreign direct investment, development of financial sector increases economic growth.

Another study based on the long-term growth analysis and determinants of Bangladesh economy was made by Rao and Hassan (2012). The study explored the Solow (1957) growth model which was extended by Mankiw *et al.* (1992) to estimate the TFP to show the long-term growth components. A growth accounting exercise (GAE) was analyzed to explore the finding of the economic growth. The study observed that the remittance of the workers was not improving the economic growth in Bangladesh.

In the above empirical literature, most of the studies explored the long-term growth determinants by using a single exogenous growth model. The studies provide steady state growth results without exploring all the significant exogenous growth models. This research examined the paramount exogenous growth theory of Ramsey (1928); Harrod (1939); Domar (1946); Solow (1956); Swan (1956); Cass (1965); Koopmans (1965) and Barro (1996) and found the long-term growth determinants of Bangladesh economy from the extended exogenous growth model.

3. THEORETICAL MODEL AND EMPIRICAL STUDY

3.1. Harrod-Domar Exogenous Growth Model

The classical Keynesian exogenous economic growth model was developed by Harrod (1939) and Domar (1946). A very similar exogenous economic growth model was developed by Cassel (1967).

The model is defined as follows where “Y” denotes output/income, “K” denotes capital stock, “S” denotes total saving, “s” denotes saving rate, “I” denotes investment, “ δ ” denotes capital stock's depreciation rate, “c” denotes constant and “t” denotes time.

A prior assumption:

$$Y = f(K) \quad (1)$$

$$\frac{dY}{dK} = c \Rightarrow \frac{dY}{dK} = \frac{Y}{K} \quad (2)$$

$$f(0) = 0 \quad (3)$$

$$sY = S = I \quad (4)$$

$$\Delta K = I - \partial K \quad (5)$$

Here, Equation 1 shows the output as a function of capital stock, Equation 2 tells the constant marginal product of the capital with a constant return to scale, and marginal products and average products of the capital are equal. Equation 3 indicates capital is important for the output, Equation 4 states saving equals investment, and Equation 5 says the change in the capital stock equals investment less the depreciation of the capital stock.

Derivation of output growth rate:

$$c = \frac{dY}{dK} = \frac{(Y(t+1) - Y(t))}{K(t) + sY(t) - \delta K(t) - K(t)} \quad (6)$$

$$c = \frac{Y(t+1) - Y(t)}{sY(t) - \delta \frac{dK}{dY} Y(t)} \quad (7)$$

$$c \left(sY(t) - \delta \frac{dK}{dY} Y(t) \right) = Y(t+1) - Y(t) \quad (8)$$

$$cY(t) \left(s - \delta \frac{dK}{dY} \right) = Y(t+1) - Y(t) \quad (9)$$

$$cs - c\delta \frac{dK}{dY} = \frac{Y(t+1) - Y(t)}{Y(t)} \quad (10)$$

$$s \frac{dY}{dK} - \delta \frac{dY}{dK} \frac{dK}{dY} = \frac{Y(t+1) - Y(t)}{Y(t)} \quad (11)$$

$$sc - \delta = \frac{\Delta Y}{Y} \quad (12)$$

Here, Equation 6 states the derivation of output with respect to capital stock with the prior assumption of Equation 2, Equation 7 indicates the transformation of Equation 6, Equation 8 shows the equation of exchange, Equation 9 indicates the transformation of Equation 8, Equation 10 applies the equation of exchange, Equation 11 shows the application of the prior assumption of Equation 2, and Equation 12 shows the constant saving rate less the depreciation equal output growth.

The first assumption Equation 1-3 indicates the linear relationship between output and capital as follows:

$$Y = cK \Rightarrow \log(Y) = \log(c) + \log(K) \quad (13)$$

Since the marginal product of capital “c” is constant, then-

$$\frac{d \log(Y)}{dt} = \frac{d \log(K)}{dt} \Rightarrow \frac{Y^*}{Y} = \frac{K^*}{K^*} \quad (14)$$

Here, Equation 13 shows the linear relationship between two variables by taking log. Equation 14 indicates the first differentiation.

Now, the capital growth rate by taking the assumption Equation 4-5 as follows:

$$\frac{K^*}{K} = \frac{I}{K} - \delta = s \frac{Y}{K} - \delta \Rightarrow \frac{Y^*}{Y} = s c - \delta \quad (15)$$

The final result in Equation 15 indicates the growth rate of output will be increased by rising saving rate and marginal product of capital, and reducing the depreciation rate.

3.2. Solow–Swan Exogenous Growth Model

The neoclassical growth model, which came after the Harrod-Domar growth model was developed by Solow (1956) and Swan (1956). This model extended and superseded the Harrod-Domar growth model by adding labor as an essential element of economic growth, which was missing in the classical Keynesian exogenous economic growth model. Solow (1956) and Swan (1956) explored the growth model by applying the similar Cobb-Douglas (Cobb and Douglas, 1928) production function. The model is defined as follows where “Y” denotes output, “K” denotes capital, and “L” denotes labor.

The Solow growth model was developed by combined labor and capital as follows:

$$Y = F(K, L) \quad \text{for } K, L > 0 \quad (16)$$

$$Y = Lf(k) \quad \text{for } k = \frac{K}{L} \quad (17)$$

$$\frac{dK}{dt} = K^* = sY \quad (18)$$

$$K^* = k^*L + kL^* \quad (19)$$

$$\frac{dL}{dt} \cdot \frac{1}{L} = \frac{L^*}{L} = \lambda \quad \text{for } \lambda > 0 \quad (20)$$

$$k^*L + k\lambda L = sLf(k) \quad (21)$$

$$k^* = sf(k) - (\lambda + \delta)k \quad (22)$$

Here, Equation 17 represents the intensive form per effective labor, Equation 18 tells the rate of change for capital over time, Equation 19 applies product rule, Equation 20 explains the labor function where the labor force grows exponentially, Equation 21 is substituting Equations 17, 19 & 20 into Equation 16 and Equation 22 represents a fundamental equation of the Solow growth model, which is found by dividing Equation 21 by L and solving for k^* .

In the Solow growth model, the intersection point is $sf(k) = (\lambda + \delta)k$ that is called an optimal growth path where the output, consumption, and capital are maximized. In a closed economy, the exogenous elements are taken to determine the long-term growth rate.

Solow (1957) provided an aggregate production function by adding total factor productivity. This model is known as the Solow model in the real world. The aggregate function is as follows:

$$Y = zF(K^\alpha L^{1-\alpha}) \quad (0 < \alpha < 1) \quad (23)$$

$$z = Y/(K^\alpha L^{1-\alpha}) \quad (24)$$

In Equation 23, “z” denotes total factor productivity (TFP). TFP is called as “Solow residual,” which represents in Equation 24. TFP can capture various macroeconomic variables to show the impact on economic growth in the long-term.

The Solow-Swan model explored a set of continuous-time without government intervention and international trade. The aggregate production function is applied as follows:

$$Y(t) = K(t)^\alpha (A(t)L(t))^{1-\alpha} \quad [0 < \alpha < 1] \quad (25)$$

In Equation 25, “A” denotes knowledge, “AL” denotes effective labor, “t” denotes time, “(0 < α < 1)” denotes elasticity of output respect to capital. In this model, “A” is a function set of various macroeconomic variables. Different macroeconomic variables can be selected for knowledge to show the impact on economic growth in the long-term.

3.3. Ramsey–Cass–Koopmans Exogenous Growth Model

Ramsey’s neoclassical exogenous economic growth theory was developed at the first stage by Ramsey (1928) and later improved by Cass (1965) and Koopmans (1965). This model explored the long-term economic growth instead of the fluctuation in the business cycle. This model is different from the Solow-Swan due to the implication of consumer choice and Pareto efficient outcome (Cass, 1965; Koopmans, 1965). The growth model is shown as follows:

$$F(K, L) = L \cdot F\left(\frac{K}{L}, 1\right) = L \cdot f(k) \quad [L = L_0 e^{nt}, L_0 > 0] \quad (26)$$

$$k^* = \frac{dk}{dt} = f(k) - (n + \delta)k - c \quad (27)$$

In Equation 26, $F(K, L)$ specifies Cobb-Douglas production function where “K” denotes capital, “L” denotes labor. The function is explored by assuming homogenous of degree 1. In Equation 27, “k” denotes capital intensity, “k*” denotes change in capital intensity, “c” denotes consumption per work, “f(k)” denotes output per work, “δ” denotes depreciation rate. Equation 27 states that a rise in capital per worker is that part of output which is not consumed, minus the rate of depreciation of capital.

3.4. Extended Exogenous Growth Model

After Solow (1956); (Swan, 1956); Cass (1965) and Koopmans (1965) the extended form of exogenous growth model was developed by Barro (1996) by exploring numerous macroeconomic choice and environmental variables which correctly supports the conditional convergence property of Ramsey (1928); Solow (1956); (Swan, 1956); Cass (1965) and Koopmans (1965). The long-term determinants of economic growth are explored by using an extended version of the neoclassical exogenous growth model of Barro (1996) as follows:

$$Dy = f(y, y^*) \quad (28)$$

In Equation 28, “Dy” denotes the growth rate of per capita output, “y” denotes the current level of per capita output, “y*” indicates steady state or long-term of per capita output. Dy is diminishing in y for given y* and increasing in y* for given y. For the long-term economic growth study, the targeted value y* provides the opportunity to take numerous macroeconomic choices and environmental variables for the study. The economic growth of a country, in the long-term, will be increased by increasing the target of choice and environmental variables y*.

This research examined the macroeconomic choice and environmental variables y* to find the long-term or steady state economic growth of Bangladesh economy. The macroeconomic choice variables which were used for this research included the Government Consumption Expenditure (GCE), Fertility Rate (FTR), Inflation Rate (INF), Population Growth (PPG), and Agricultural Sector Growth (AGR). The study used the macroeconomic time series data from 1985 to 2018, and the data was taken from the World Development Indicators (WDI) database. All the econometric tests were conducted by applying EViews software. All the variables and summary statistics are displayed in Table 1.

The relationship between the dependent variable Per capita Gross Domestic Product (RGDP) and independent variables (GCE, FTR, INF, PPG, and AGR) are expressed in Equation 29. Saidu *et al.* (2018) also established the same model without the Agricultural Sector Growth (AGR). The transformation of the Econometric model to be estimated in Equation 30.

$$RGDP_t = f(GCE_t, FTR_t, INF_t, PPG_t, AGR_t) \quad (29)$$

$$LRGDP_t = \beta_0 + \beta_1 LGCE_t + \beta_2 LFTR_t + \beta_3 LINF_t + \beta_4 LPPG_t + \beta_5 LAGR_t + \varepsilon_t \quad (30)$$

In Equation 30, “LRGDP” denotes Natural Logarithm of Per capita Gross Domestic Product, “LGCE” denotes Natural Logarithm of Government Consumption Expenditure, “LFTR” denotes Natural Logarithm of Fertility rate, “LINF” denotes Natural Logarithm of Inflation rate, “LPPG” denotes Natural Logarithm of Population growth, “LAGR” denotes Natural Logarithm of Agricultural Sector Growth, “ ε ” denotes Error Term, and “t” denotes trend variables.

Table-1. Descriptive statistics of the variables.

Descriptives	LRGDP	LGCE	LFTR	LINF	LPPG	LAGR
Mean	6.182320	21.81609	1.145241	1.684736	0.532183	23.30533
Median	6.028361	21.69939	1.121678	1.837160	0.634610	23.19104
Maximum	7.354998	23.42952	1.704930	2.951948	0.968881	24.23471
Minimum	5.453859	20.61564	0.723676	-1.860993	0.067887	22.67602
Std. Dev.	0.539551	0.792542	0.306184	0.782488	0.328609	0.431342
Observations	33	33	33	33	33	33

4. METHODOLOGY AND EMPIRICAL RESULTS

For the methodology part, stationary checking for all variables was crucial for the empirical analysis. The method of unit root test was used, including the Augment dickey fuller (ADF), Dickey and Fuller (1979) Phillips–Perron (PP), Phillips and Perron (1988) and Ng-Perron (NP) tests (Ng and Perron, 2001) for the empirical analysis. After checking the stationary of all variables, the Bounds Test approach was used to investigate the cointegration existence between variables. This test was developed and improved by Pesaran *et al.* (1999) and Pesaran *et al.* (2001) which is more effective than other cointegration approaches (Narayan and Narayan, 2004) because of its better application for small sample sizes. The autoregressive distributed lag (ARDL) model was applied to identify the short-term and long-term elasticity relationships between the variables (Engle *et al.*, 1987; Johansen and Juselius, 1990; Pesaran and Shin, 1999). The ARDL model was preferred for its advantage compared to other conventional models (Hassler and Wolters, 2006; Afzal *et al.*, 2010; Shrestha and Bhatta, 2018). It helps to provide the simultaneous analysis of both the short-term and the long-term impact between variables. The ARDL is the best method to deliver superior results for small or finite samples (Engle *et al.*, 1987; Johansen and Juselius, 1990; Pesaran and Shin, 1999). The ARDL model can identify the impact of independent variables on the dependent variable and eliminate the serial correlation and endogeneity problem from the model. Engle *et al.* (1987) argued that in the long-term if the cointegration exists between the variables, the ECM should be applied to investigate the causal relationship between the variables.

4.1. Unit Root Test

ADF, PP, and NP tests were employed to check the unit root problem. The regression model is impossible to estimate if the data suffers from unit root problem. Unit root tests confirmed that the variables were integrated of I (0) or I (1), and that none of the variables were integrated of I (2) or more. The critical value for the order of integration either I(0) or I(1) was used from the Pesaran *et al.* (2001). Therefore, the ADF and PP test was applied to check the stationary of the variables and the outcomes are shown in Table 2. Hence, the variables for the ADF test of LFRT, LINF, and LAGR were integrated I(0), and of LRGDP, LGCE, and LPPG were integrated I(1). The variables for the PP test of LFRT, LINF, and LPPG were integrated I(0), and of LRGDP, LGCE, and LAGR were integrated I(1). The results of NP tests found that all the variables were integrated I(1). The stationary test outcomes in Table 2 show that ARDL was the best method for this study.

Table-2. Stationary test.

ADF (Augmented Dickey–Fuller) Test result

Variables	In Level: I(0)		In First Difference: I(1)		Order of integration
	t-Statistic	Probability	t-Statistic	Probability	
LRGDP	-0.190390	0.9906	-4.493673	0.0059	I(1)
LGCE	0.415721	0.9985	-4.749667	0.0031	I(1)
LFTR	-2.224194	0.0275	-	-	I(0)
LINF	-4.301645	0.0109	-	-	I(0)
LPPG	-2.912556	0.1749	-3.019683	0.0462	I(1)
LAGR	-2.224194	0.0275	-	-	I(0)

Note: The lag length has selected by Schwarz information criterion (Schwarz, 1978).

Table-2. Continue.

PP(Phillips–Perron) Test result

Variables	In Level: I(0)		In First difference: I(1)		Order of integration
	t-Statistics	Probability	t-Statistic	Probability	
LRGDP	-0.348888	0.9855	-4.553258	0.0051	I(1)
LGCE	0.280652	0.9977	-4.732981	0.0033	I(1)
LFTR	-5.955797	0.0000	-	-	I(0)
LINF	-4.350746	0.0081	-	-	I(0)
LPPG	-2.473967	0.0150	-	-	I(0)
LAGR	-0.527438	0.9769	-4.568052	0.0049	I(1)

Note: The lag length has selected by Newey–West bandwidth (Newey and West, 1994).

Table-2. Continue.

NP (Ng-Perron) Test result					
Variables	MZa	MZt	MSB	MPT	Order of integration
LRGDP	1.40803	0.74787	0.53114	26.0153	-
D(LRGDP)	-10.1542	-2.20960	0.21761	2.58063	I(1)
LGCE	1.211728	0.64126	0.52680	24.9830	-
D(LGCE)	-13.6995	-2.53438	0.18500	2.09982	I(1)
LFTR	0.16078	0.09706	0.60366	25.4394	-
D(LFTR)	-12.08678	-1.99086	0.13966	2.03562	I(1)
LINF	0.03557	0.10630	0.98848	24.8730	-
D(LINF)	-10.80200	-2.32608	0.18065	3.01412	I(1)
LPPG	-5.17770	-1.41824	0.27391	5.19182	-
D(LPPG)	-14.63973	-2.52252	0.12815	2.28165	I(1)
LAGR	1.71389	1.00159	0.58439	31.4819	-
D(AGR)	-12.3080	-2.45033	0.19908	2.10740	I(1)

Note: The lag length has selected by Schwarz information criterion (Schwarz, 1978).

The null hypothesis is rejected if calculated t statistics for MZa, MZt tests are greater and the calculated t statistics for MSB and MPT tests are less than the critical values.

Ng-Perron critical values for LRGDP, LGCE, LFTR, LINF, LPPG, and LAGR; MZa, MZt, MSB, MPT are respectively; 1% Significance level -23.80, -3.42, 0.14 and 4.03., and 5% significance level for -17.30, -2.91, 0.17 and 5.48. Ng-Perron critical values for D(LRGDP), D(LGCE), D(LFTR), D(LINF), D(LPPG), and D(LAGR); MZa, MZt, MSB, MPT are respectively; 1% significance level -13.80, -2.58, 0.17 and 1.78., and 5% significance level for -8.10, -1.98, 0.23 and 3.17.

4.2. Determination of Lags Number

The determination of the optimal lags is essential for every study before the estimation of the ARDL model. The criteria and results of the optimal lag length selection are displayed in Table 3. The result showed that the optimal lag number should be 2 according to FPE, AIC, and HQ criterion. The AIC criterion (Akaike, 1974) was selected for the optimal lag length where lagged values (1, 1, 0, 1, 2, 0) were chosen as shown in Figure 1.

Table-3. Lag Selection from VAR.

Lag	FPE	AIC	SIC	HQ
0	0.000425	-4.931870	-4.651630*	-4.842219
1	0.000419	-4.947700	-4.620754	-4.843107
2	0.000393*	-5.016155*	-4.642503	-4.896621*
3	0.000401	-5.003453	-4.583094	-4.868977

FPE: Final prediction error.
 AIC: Akaike information criterion.
 SIC: Schwarz information criterion.
 HQ: Hannan-Quinn information criterion.

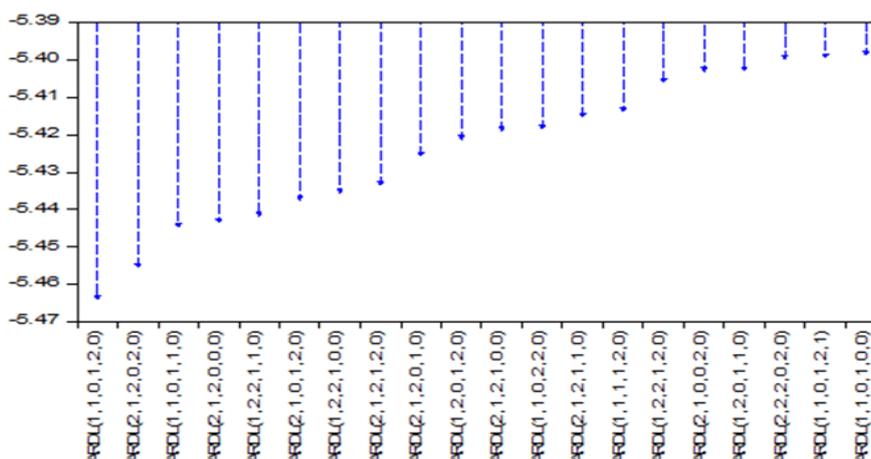


Figure-1. Akaike information criteria (top 20 models).

4.3. Bound Test for Cointegration

The bound test method by Pesaran *et al.* (2001) was applied to show the long-term relationship between the variables of the study. The Error Correction Model (ECM) was formulated for the bounds test approach. For the study, the ECM specification was shown in Equation 31.

$$\begin{aligned} \Delta LRGP_t = & \gamma_0 + \sum_{i=1}^m \gamma_{1i} \Delta LRGP_{t-i} + \sum_{i=0}^m \gamma_{2i} \Delta LGCE_{t-i} + \sum_{i=0}^m \gamma_{3i} \Delta LFTR_{t-i} + \sum_{i=0}^m \gamma_{4i} \Delta LINF_{t-i} \\ & + \sum_{i=0}^m \gamma_{5i} \Delta LPPG_{t-i} + \sum_{i=0}^m \gamma_{6i} \Delta LAGR_{t-i} + \gamma_7 LRGP_{t-1} + \gamma_8 LGCE_{t-1} + \gamma_9 LFTR_{t-1} \\ & + \gamma_{10} LINF_{t-1} + \gamma_{11} LPPG_{t-1} + \gamma_{12} LAGR_{t-1} + u_t \end{aligned} \quad (31)$$

In the ECM model in Equation 31 “m” denotes number of lags, and “t” means trend variables. The existence of a cointegration relationship between the variables was measured by the Wald Test or F-statistics. The null and alternative hypothesis was established for the F test as follows:

$$H_0 = \gamma_7 = \gamma_8 = \gamma_9 = \gamma_{10} = \gamma_{11} = \gamma_{12} = 0$$

$$H_1 \neq \gamma_7 \neq \gamma_8 \neq \gamma_9 \neq \gamma_{10} \neq \gamma_{11} \neq \gamma_{12} \neq 0$$

The F statistics was compared with the table bottom and upper critical values of Pesaran *et al.* (2001). If the result of F statistics was larger than upper critical value, the null hypothesis would be rejected, and it provides evidence of the existence of the cointegration relationship between the variables. The bound test result is displayed in Table 4. The value of F-statistics in Table 4 was 6.16 which is larger than the upper critical value of 4.68 at 1%, 3.79 at 5%, and 3.35 at 10% level of significance. The result revealed a long-term cointegration relationship between the variables from 1985 to 2018.

Table-4. Bound test results.

F-Bounds test		Null Hypothesis: No levels relationship		
Test statistic	Value	Sig.	I(0)	I(1)
F-statistic	6.160888	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68

Note: p-value incompatible with t-Bounds distribution.

4.4. Estimation with ARDL Model

This part estimated the ARDL model after selecting the optimal lag length by AIC and bound test for checking the cointegration relationship. The ARDL and ECM provided the evidence of long-term cointegration relationship between the variables.

The ARDL model specification is introduced in Equation 32:

$$\begin{aligned} \Delta LRGP_t = & \gamma_0 + \sum_{i=1}^m \gamma_{1i} \Delta LRGP_{t-i} + \sum_{i=0}^m \gamma_{2i} \Delta LGCE_{t-i} + \sum_{i=0}^m \gamma_{3i} \Delta LFTR_{t-i} + \sum_{i=0}^m \gamma_{4i} \Delta LINF_{t-i} \\ & + \sum_{i=0}^m \gamma_{5i} \Delta LPPG_{t-i} + \sum_{i=0}^m \gamma_{6i} \Delta LAGR_{t-i} + u_t \end{aligned} \quad (32)$$

In the ARDL model in Equation 32, the model estimates $(m + 1)^k$ where k is the number of variables, and $(m + 1)$ is the optimal lag length.

The results of ARDL Error Correction Regression are shown in Table 5, which was a short-term effect. The results showed that LGCE, LFTR, LINF, and LAGR were statistically significant at 1%. In the short-term, these variables have a positive impact on RGDP. The coefficient value of ECM was negative (-0.7635) and statistically significant at 1% level of significance. The coefficient value revealed that there were a speed adjustment and the existence of a long-term cointegration relationship between the variables. The coefficient of ECM revealed that 76.35% of the short-term errors needed to be corrected each year automatically to achieve the long-term equilibrium for the model.

The results of the ARDL long-term form are represented in Table 6. The results showed the long-term cointegration positive and negative relationship between the variables. The results also showed that the variables such as LGCE, LFTR, LINF, and LAGR have a positive and statistically significant relationship with LR GDP at 1%, and LPPG has a negative and statistically significant association with LR GDP at 1% level of significance. All the variables support the prior expectation.

The positive relationship between the LGCE and LR GDP suggested that more government consumption expenditure helps the economic growth to expand by increasing the production level output. The LFTR and LR GDP also have a positive relationship, which indicated that the higher fertility rate is still positive for economic growth if the resource can be used in the productive sectors. The positive association between the LINF and LR GDP suggested that a higher inflation rate helps to lower the interest rate which helps to expand the economic growth by creating more investment opportunities in the financial market. The LAGR was positively related to LR GDP which suggested that more agricultural sector growth is helping the economic growth to expand by increasing the export opportunity of agricultural products. The negative relationship between LPPG and LR GDP indicated that a higher rate of population growth is harmful to the economy due to the adverse effect on per capita income and unemployment problems.

Table-5. ARDL error correction regression.

Dependent variable: D(LRGDP)				
Selected Model: ARDL (1, 1, 0, 1, 2, 0)				
ECM Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGCE)	0.522285	0.055164	9.467786	0.0000
D(LFTR)	0.333011	0.102822	3.238708	0.0041
D(LINF)	0.014881	0.004147	3.588195	0.0018
D(LPPG)	-0.281596	0.283595	-0.992952	0.3326
D(LPPG(-1))	0.411071	0.310867	1.322338	0.2010
D(LAGR)	0.404147	0.078193	5.168553	0.0000
CointEq(-1)*	-0.763506	0.115654	-6.601629	0.0000
R-squared	0.9999542	Mean dependent var		6.221327
Adjusted R-squared	0.999313	S.D. dependent var		0.524715
S.E. of regression	0.013755	Akaike info criterion		-5.463436
Sum squared resid	0.003784	Schwarz criterion		-4.954602
Log likelihood	95.68326	Hannan-Quinn criter.		-5.297569
Durbin-Watson stat	2.109076			
Included observations: 31				

Table-6. ARDL long-term form.

Levels equation				
Selected model: ARDL (1, 1, 0, 1, 2, 0)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGCE	0.467516	0.059396	7.871145	0.0000
LFTR	0.436161	0.110739	3.938633	0.0008
LINF	0.029483	0.008739	3.373627	0.0030
LPPG	-0.227952	0.069453	-3.282098	0.0037
LAGR	0.529330	0.071555	7.397474	0.0000
C	-16.77151	0.754653	-22.22411	0.0000

EC = LRGDP - (0.4675*LGCE + 0.4362*LFTR + 0.0295*LINF -0.2280*LPPG + 0.5293*LAGR -16.7715)

4.5. Robustness Test for the Estimated Model

The ARDL model for this study passed all the robustness tests. The robustness tests are represented in Table 7. The results of robustness tests showed that the model has no serial correlation, heteroscedasticity, mis specification and normality problem. All tests accepted the null hypothesis at 5% level of significance.

Also, over the sample period, the coefficients of ARDL model were found to be stable based on the cumulative sum of recursive residuals (CUSUM) and CUSUM-square tests. The CUSUM and SUSUM tests were proposed by Brown *et al.* (1975). The results of the CUSUM and SUSUM tests are displayed in Figure 2 and Figure 3. The results showed that both the graphs of CUSUM and CUSUM-square do not exceed the critical boundaries at 1% significance level. It proved that the parameters of the ARDL model were stable in the long-term.

Table-7. Diagnostic test for the ARDL models.

Heteroskedasticity test: ARCH			
F-statistic	0.369392	Prob. F(1,28)	0.6974
Obs*R-squared	0.801260	Prob. Chi-Square(1)	0.6699
Breusch-Godfrey Serial Correlation LM test:			
F-statistic	1.734777	Prob. F(2,18)	0.2047
Obs*R-squared	5.009706	Prob. Chi-Square(2)	0.0817
Normality Test			
Jarque-bera	0.800113		
Probability	0.670282		

Note: H_0 : No Heteroskedasticity, H_0 : No Serial Correlation, and H_0 : Normally Distributed.

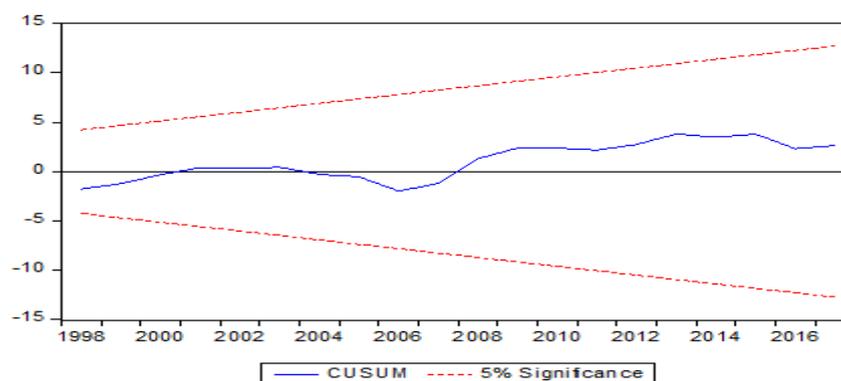


Figure-2. CUSUM test results for ARDL (1, 1, 0, 1, 2, 0) model.

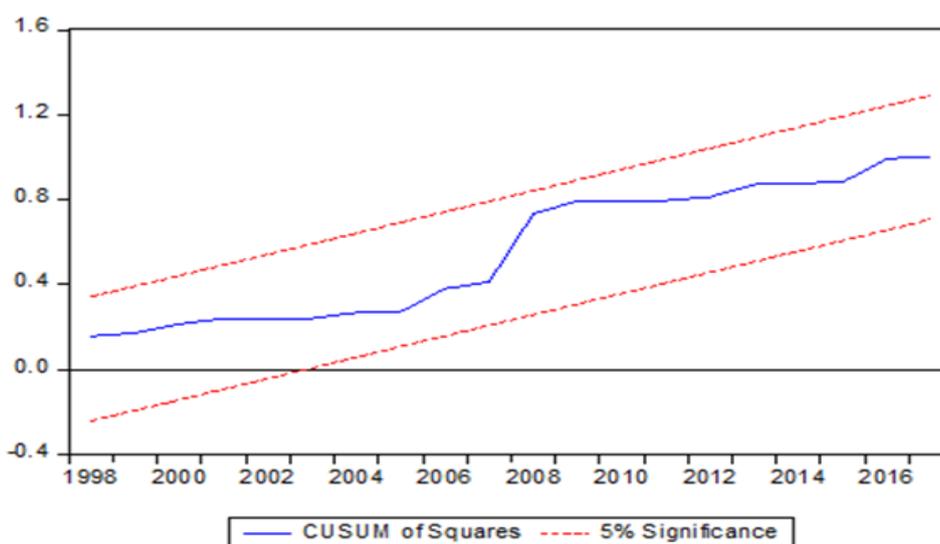


Figure-3. CUSUM test of Squares results for ARDL (1, 1, 0, 1, 2, 0) model.

5. CONCLUSION AND POLICY IMPLICATION

The study analyzed various exogenous growth models and investigated the long-term determinants of economic growth from the extended exogenous growth model. The study used the macroeconomic choice variables with the annual time series data of Bangladesh economy from 1985 to 2018 by exploring the World Development Indicators (WDI) database. The results of the study showed the long-term impact on economic growth.

The investigation of the stationary properties for all the variables was applied for the empirical analysis. The unit root test by including ADF, PP, and NP was used to check the stationary for all the variables.

Then, the ARDL and Bound Test approaches were used to find out the long-term cointegration relationship between the variables. The coefficient (-0.7635) result of the ECM from ARDL indicated a speed adjustment and a stable long-term relationship. The ARDL long-term form suggested that all the variables were statistically significant at 1%.

The results showed that the government consumption expenditure, fertility rate, inflation rate, and agricultural sector growth have a positive effect on economic growth in the long-term. The population growth has only a negative relationship with economic growth in the long-term.

The empirical findings of this research contradict the results of the extended exogenous growth model by Barro (1996). The findings of the study based on the Bangladesh economy do not support the empirical findings of Barro (1996).

A more robust model with the missing variables needs to be estimated to find out more appropriate results. For this part, a reasonable policy implication is required for the Bangladesh economy.

The government of Bangladesh should prioritize developing the research and development sector. The government should be careful about the technological improvement, stock of human capital expansion, and capital stock development.

The long-term growth of a country, according to Barro (1996) depends on proper governmental actions such as law and order, tax policy, infrastructure development, regulation on international trade, financial market, and intellectual property rights. The government of Bangladesh can follow these actions for better adjustment of the economic growth in the long-term.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Acknowledgement: The author wishes to thank Dr. Md Mahmud Hasan Shah (Assistant Professor, Department of Economics, Jagannath University) for his useful suggestions during the planning and development of this research.

REFERENCES

- Acemoglu, D., 2012. Introduction to economic growth. *Journal of Economic Theory*, 147(2): 545-550.
- Adhikary, B.K., 2010. FDI, trade openness, capital formation, and economic growth in Bangladesh: A linkage analysis. *International Journal of Business and Management*, 6(1): 16-28. Available at: <https://doi.org/10.5539/ijbm.v6n1p16>.
- Afzal, M., M. Farooq and H. Ahmad, 2010. Relationship between school education and economic growth in Pakistan: ARDL bounds testing approach to cointegration. *Pakistan Economic and Social Review*, 48(1): 39-60. Available at: <https://doi.org/10.2307/41762413>.
- Ahiakpor, F. and I.A. Akapare, 2015. Short-term and long-term inflation and economic growth nexus in Ghana. *Ghana Journal of Development Studies*, 11(2): 32-49.
- Ahmed, H.A. and G.S. Uddin, 2009. Export, imports, remittance and growth in Bangladesh: An empirical analysis. *Trade and Development Review*, 2(2): 79-92.
- Akaike, H., 1974. A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, 19(6): 716-723. Available at: <https://doi.org/10.1109/TAC.1974.1100705>.
- Al Mamun, K.A. and H.K. Nath, 2005. Export-led growth in Bangladesh: A time series analysis. *Applied Economics Letters*, 12(6): 361-364. Available at: <https://doi.org/10.1080/13504850500068194>.
- Alhassan, H., S.A. Donkoh and Y. Asante, 2012. The determinants of long-term economic growth in Ghana from 1960-2007. *Journal of Research in Economics and International Finance*, 1(5): 141-149.
- Arrow, K.J., 1962. The economic implications of learning by doing. *The Review of Economic Studies*, 29(3): 155-173. Available at: <https://doi.org/10.2307/2295952>.
- Bangladesh Economic Review, 2019. Dhaka: Finance division, ministry of finance. Available from <https://mof.gov.bd/site/page/44e399b3-d378-41aa-86ff-8c4277eb0990/BangladeshEconomicReview>.
- Barro, R.J., 1991a. A cross-country study of growth, saving, and government. In *National saving and economic performance*. University of Chicago Press. pp: 271-304.
- Barro, R.J., 1991b. Economic growth in a cross section of countries. *The Quarterly Journal of Economics*, 106(2): 407-443. Available at: <https://doi.org/10.2307/2937943>.
- Barro, R.J., 1996. Determinants of economic growth: A cross-country empirical study (No. w5698). National Bureau of Economic Research.
- Barro, R.J., 2002. Education as a determinant of economic growth. In: *Lazear EP Education in the Twenty-First Century*. Hoover Institution Press. pp: 9-24.
- Boakye, S., 2012. Theory of social transformation, political transition and economic growth. *Economic Systems*, 36(3): 411-425. Available at: <https://doi.org/10.1016/j.ecosys.2012.07.002>.
- Breisinger, C., X. Diao and J. Thurlow, 2009. Modeling growth options and structural change to reach middle income country status: The case of Ghana. *Economic Modelling*, 26(2): 514-525. Available at: <https://doi.org/10.1016/j.econmod.2008.10.007>.
- Bristy, H.J., 2014. Impact of financial development on exchange rate volatility and long-term growth relationship of Bangladesh. *International Journal of Economics and Financial Issues*, 4(2): 258-263.
- Brown, R.L., J. Durbin and J.M. Evans, 1975. Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society: Series B (Methodological)*, 37(2): 149-163. Available at: <https://doi.org/10.1111/j.2517-6161.1975.tb01532.x>.
- Cass, D., 1965. Optimum growth in an aggregative model of capital accumulation. *The Review of Economic Studies*, 32(3): 233-240. Available at: <https://doi.org/10.2307/2295827>.

- Cassel, G., 1967. Capital and income in the money economy. The theory of social economy (reprint). New York: Augustus M. Kelley.
- Chirwa, T. and N.M. Odhiambo, 2019. An empirical test of exogenous growth models: Evidence from three Southern African Countries. *Economic Annals*Ekonomski Anali, 64(220): 7–38. Available at: <https://doi.org/10.2298/eka1920007c>.
- Cobb, C.W. and P.H. Douglas, 1928. A theory of production. *The American Economic Review*, 18(1): 139-165.
- Dickey, D.A. and W.A. Fuller, 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366a): 427-431. Available at: <https://doi.org/10.1080/01621459.1979.10482531>.
- Ding, S. and J. Knight, 2009. Can the augmented Solow model explain China's remarkable economic growth? A cross-country panel data analysis. *Journal of Comparative Economics*, 37(3): 432-452. Available at: <https://doi.org/10.1016/j.jce.2009.04.006>.
- Dollar, D. and A. Kraay, 2004. Trade, growth, and poverty. *The Economic Journal*, 114(493): 22-49. Available at: <https://doi.org/10.1111/j.0013-0133.2004.00186.x>.
- Domar, E.D., 1946. Capital expansion, rate of growth, and employment. *Econometrica*, 14(2): 137-147. Available at: <https://doi.org/10.2307/1905364>.
- Dowrick, S., 2002. Classical and technological convergence: Beyond the Solow-Swan growth model. *Oxford Economic Papers*, 54(3): 369-385. Available at: <https://doi.org/10.1093/oenp/54.3.369>.
- Easterly, W., 1999. Life during growth. *Journal of Economic Growth*, 4(3): 239-276.
- Engle, R.F., C.W.J. Granger and C.W.J. Granger, 1987. Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, 55(2): 251-276. Available at: <https://doi.org/10.2307/1913236>.
- Fankhauser, S. and R.S. Tol, 2005. On climate change and economic growth. *Resource and Energy Economics*, 27(1): 1-17.
- Guerrini, L., 2006. The Solow-Swan model with a bounded population growth rate. *Journal of Mathematical Economics*, 42(1): 14-21. Available at: <https://doi.org/10.1016/j.jmateco.2005.05.001>.
- Harrod, R.F., 1939. An essay in dynamic theory. *The Economic Journal*, 49(193): 14-33. Available at: <https://doi.org/10.2307/2225181>.
- Hassler, U. and J. Wolters, 2006. Autoregressive distributed lag models and cointegration. *Autoregressiv. Modern Econometric Analysis: Surveys on Recent Developments*, 90(1): 59-74. Available at: https://doi.org/10.1007/3-540-32693-6_5.
- Huh, H.-s. and D. Kim, 2013. An empirical test of exogenous versus endogenous growth models for the G-7 countries. *Economic Modelling*, 32: 262-272. Available at: <https://doi.org/10.1016/j.econmod.2013.02.012>.
- Islam, N., 1995. Growth empirics: A panel data approach. *The Quarterly Journal of Economics*, 110(4): 1127-1170. Available at: <https://doi.org/10.2307/2946651>.
- Johansen, S. and K. Juselius, 1990. Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and statistics*, 52(2): 169-210. Available at: <https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x>.
- Knight, M.D., D. Villanueva and N. Loayza, 1992. Testing the neoclassical theory of economic growth: A panel data approach. *Journal Issue*, 1992(106): 1-38. Available at: <http://dx.doi.org/10.5089/9781451947052.001>.
- Koopmans, T.C., 1965. On the concept of optimal economic growth, *Pontificia Academia Scientiarum. The econometric approach to development planning*. Amsterdam: North-Holland. pp: 225-287.
- Kumar, R.R. and P.J. Stauvermann, 2014. Exploring the nexus between remittances and economic growth: A study of Bangladesh. *International Review of Economics*, 61(4): 399-415. Available at: <https://doi.org/10.1007/s12232-014-0199-3>.
- La Torre, D. and S. Marsiglio, 2010. Endogenous technological progress in a multi-sector growth model. *Economic Modelling*, 27(5): 1017-1028. Available at: <https://doi.org/10.1016/j.econmod.2010.04.008>.
- Lee, K., M.H. Pesaran and R. Smith, 1997. Growth and convergence in a multi-country empirical stochastic Solow model. *Journal of Applied Econometrics*, 12(4): 357-392. Available at: [https://doi.org/10.1002/\(sici\)1099-1255\(199707\)12:4<357::aid-jae441>3.3.co;2-k](https://doi.org/10.1002/(sici)1099-1255(199707)12:4<357::aid-jae441>3.3.co;2-k).

- Love, J. and R. Chandra, 2005. Testing export-led growth in Bangladesh in a multivariate VAR framework. *Journal of Asian Economics*, 15(6): 1155-1168. Available at: <https://doi.org/10.1016/j.asieco.2004.11.009>.
- Lucas, J.R.E., 1988. On the mechanics of economic development. *Journal of Monetary Economics*, 22(1): 3-42.
- Mankiw, N.G., D. Romer and D.N. Weil, 1992. A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107(2): 407-437.
- Morley, B., 2006. Causality between economic growth and immigration: An ARDL bounds testing approach. *Economics Letters*, 90(1): 72-76. Available at: <https://doi.org/10.1016/j.econlet.2005.07.008>.
- Narayan, P.K. and S. Narayan, 2004. The J-curve: Evidence from Fiji. *International Review of Applied Economics*, 18(3): 369-380. Available at: <https://doi.org/10.1080/0269217042000227088>.
- Newey, W.K. and K.D. West, 1994. Automatic lag selection in covariance matrix estimation. *The Review of Economic Studies*, 61(4): 631-653. Available at: <https://doi.org/10.2307/2297912>.
- Ng, S. and P. Perron, 2001. Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69(6): 1519-1554. Available at: <https://doi.org/10.1111/1468-0262.00256>.
- Pesaran, M.H. and Y. Shin, 1999. An autoregressive distributed lag modelling approach to cointegration analysis. In *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Cambridge: Cambridge University Press. pp: 371-413.
- Pesaran, M.H., Y. Shin and R. Smith, 1999. Bounds testing approaches to the analysis of long-term relationships, Cambridge WP in Economics 9907. Cambridge: Faculty of Economics, University of Cambridge.
- Pesaran, M.H., Y. Shin and R.J. Smith, 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3): 289-326. Available at: <https://doi.org/10.1002/jae.616>.
- Phillips, P.C. and P. Perron, 1988. Testing for a unit root in time series regression. *Biometrika*, 75(2): 335-346. Available at: <https://doi.org/10.1093/biomet/75.2.335>.
- Ramsey, F.P., 1928. A mathematical theory of saving. *The Economic Journal*, 38(152): 543-559. Available at: <https://doi.org/10.2307/2224098>.
- Rao, B.B. and G. Hassan, 2011. Determinants of the long-term growth rate of Bangladesh. *Applied Economics Letters*, 18(7): 655-658. Available at: <https://doi.org/10.1080/13504851003800760>.
- Rao, B.B. and G.M. Hassan, 2012. An analysis of the determinants of the long-term growth rate of Bangladesh. *Applied Economics*, 44(5): 565-580. Available at: <https://doi.org/10.1080/00036846.2010.510466>.
- Rebelo, S., 1991. Long-term policy analysis and long-term growth. *Journal of Political Economy*, 99(3): 500-521. Available at: <https://doi.org/10.1086/261764>.
- Romer, P.M., 1986. Increasing returns and long-term growth. *Journal of Political Economy*, 94(5): 1002-1037. Available at: <https://doi.org/10.1086/261420>.
- Saidu, B.M., B.A. Ahmed and A.H. Jakada, 2018. The determinants of long-term economic growth in Nigeria. *Asian Economic and Financial Review*, 8(1): 1-7. Available at: <https://doi.org/10.18488/journal.aefr.2018.81.1.7>.
- Schwarz, G., 1978. Estimating the dimension of a model. *The Annals of Statistics*, 6(2): 461-464. Available at: <https://doi.org/10.1214/aos/1176344136>.
- Shrestha, M.B. and G.R. Bhatta, 2018. Selecting appropriate methodological framework for time series data analysis. *The Journal of Finance and Data Science*, 4(2): 71-89. Available at: <https://doi.org/10.1016/j.jfds.2017.11.001>.
- Snowdon, B. and H.R. Vane, 2005. *Modern macroeconomics: Its origins, development and current state*. Edward Elgar Publishing.
- Solow, R.M., 1956. A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1): 65-94.
- Solow, R.M., 1957. Technical change and the aggregate production function. *The Review of Economics and Statistics*, 39(3): 312-320.
- Statistical Year Book, 2019. Bangladesh Bureau of Statistics. Available from <http://www.bbs.gov.bd/site/page/29855dc1-f2b4-4dc0-9073-f692361112da/Statistical-Yearbook>.

Swan, T.W., 1956. Economic growth and capital accumulation. *Economic Record*, 32(2): 334-361.

SYB, 2019. Bangladesh Bureau of Statistics. Available from <http://www.bbs.gov.bd/site/page/29855dc1-f2b4-4dc0-9073-f692361112da/Statistical-Yearbook>.

Tobin, J., 1955. A dynamic aggregative model. *Journal of political Economy*, 63(2): 103-115.

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