BIGD Working Paper
No. 36 | September 2016

The Long Run Relationship between Population Growth and Economic Growth: Empirical Evidence from Bangladesh

Iffat Zahan

BRAC Institute of Governance and Development
BRAC University

The Long Run Relationship between Population Growth and Economic Growth: Empirical Evidence from Bangladesh

Iffat Zahan

BRAC Institute of Governance and Development
BRAC University

BRAC Institute of Governance and Development (BIGD)
BRAC University, Dhaka

BIGD Working Paper Series
No. 36, September 2016

The Long Run Relationship between Population Growth and Economic Growth: Empirical Evidence from Bangladesh

By
Iffat Zahan, Research Associate, BIGD

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect the views of BRAC Institute of Governance and Development (BIGD), BRAC University. This volume is a product of the BIGD, BRAC University. The findings, interpretations and conclusions presented in this document do not necessarily reflect the views of BRAC University authorities.

Terms of use

BDT 50
USD 5
Cover: Md. Parvej

Published by

BRAC Institute of Governance and Development (BIGD)
BRAC University

SK Centre (Basement, 3rd - 7th & 9th Floor), GP, JA-4, TB Gate
Mohakhali, Dhaka 1212, Bangladesh

Tel : (+88 02) 5881 0306, 5881 0326, 5881 0320, 883 5303
Fax : (+88 02) 883 2542
Email : info@bigd.bracu.ac.bd
Website: bigd.bracu.ac.bd

Table of Contents

List of Tables

List of Figures

Acknowledgement

I am grateful to Professor M. Ismail Hossain for his immense support, guidance and scholastic advice. I would also like to show gratitude to Dr. Sultan Hafeez Rahman for his valuable insight and enthusiasm.

Abstract

Does population growth induce or depress economic growth? Or, does economic growth encourage or discourage population growth? This is a long existing debate which has sustained throughout the centuries. This paper investigates the causal relationship between GDP per capita and population growth in Bangladesh. Using the Johansen cointegration test, we find evidence of a long run relationship between population growth and GDP per capita. Next with a Vector Error Correction model, we find a causal direction between the two, which suggests that in Bangladesh population growth actually negatively affects GDP per capita, but not vice versa. Therefore, to some extent Bangladesh is in the Modern Growth regime stage. Hence, the policy implication is very clear: appropriate measures should be taken in order to arrest population growth.

Key Words:

Economic growth, Population growth, Demographic transition, Malthusian regimes, GDP per capita, Cointegration, Causality

1. Introduction

"Animals can be driven crazy by placing too many in too small a pen. Homo sapiens are the only animal that voluntarily does this to himself" (Heinlein, 1973). The quote above sheds some light on the desire of the human race to increase its numbers without knowing that they are endangering themselves in a crowded world. Ever since Malthus put forward his celebrated model, there has been considerable debate on the relationship between population growth and economic growth. Does population growth induce economic growth? Or does economic growth discourage population growth? Is population growth merely an exogenous variable or is it endogenous? Does the relationship remain positive or negative over time? The relationship, as complex as it is, is still an issue. There seems to be no standard theory describing the relationship between population growth and economic growth that is applicable to all countries. Rather reality differs across the countries and hence requires alternative models to test the nature of the relationship.

The aim of this study is to investigate the relationship between population growth and economic growth i.e. GDP per capita. Specifically it attempts to identify the direction of the causality in the relationship, using annual data for the 55 years period from 1960 to 2015.

In the first section, we discuss the existing theory of the relationship between population growth and economic growth and the past empirical studies analysing this relationship. The second section discusses the population and GDP trend of Bangladesh over the decades. The third section focuses on the methodology of this paper, the fourth section analyses the empirical result and the final section finishes with concluding remarks followed by some policy recommendations.

2. Theoretical Approach

Economists Allen Kelly and Robert Schmidt (1995) explained that population growth acted as a brake on GDP per capita growth during the 1980s. According to the UN Development Programme (1996), "in many cases [in the developing world] lots of employment were being created, but not fast enough to match the rapid growth in the labour force." However, during the 1960s and 1970s the adverse effect of population growth was not very visible. It could be suggested that the 1980s effect was the delayed outcome of previous decades' growth or the result of global debt burden or recession. In fact, debate still on-going regarding the relationship between GDP growth and population growth: whether it existed in the 1980s, or continues to exist presently, or will exist in future. Thirwall (1972) illustrated in a theoretic model to explain both the positive and negative effects that large population growth can have on economic conditions. According to them, on the one hand a large population can be detrimental due to diminishing returns if land is used more intensively; on the other hand, it can also encourage the economy to generate specialisation and increases returns to scale. Therefore, the relationship between population growth and GDP growth needs to be examined.

This paper will mainly look into the relationship between population growth and income per capita, along with analysing which of the Malthusian regimes Bangladesh would fall in. Galor and Weil (2000) assumed that the ancient history was in line with the Malthusian concept; with slow technological progress and low productivity, higher population growth depressed income per capita. This stage was named as the Malthusian regime. Basically, the relationship between income per capita and growth in population is positive at this stage. Subsequently, an era came with

technological progress during the industrial revolution, which helped to save a greater portion of economic growth from rapid population growth. This phase was named as the post-Malthusian regime. Finally, a regime introducing faster technological advancement and large accumulation of human capital will cause a demographic transition and slower population growth rate, which leads to increased output per capita. This is called the Modern Growth regime. In this regime there exists a negative relationship between the output level and growth rate of population. It is clear that whereas in the Post-Malthusian and Modern Growth regime population growth rate is higher but balanced with growth in per capita output, in the Malthusian regime though population growth is low, economic development is largely hindered.

There is a wide range of theories around the different relationships between GDP per capita and population growth. Smith (1776) in his popular book An Inquiry into the Nature and Causes of the Wealth of Nations (generally referred to by its short name The Wealth of Nations) said: "The most decisive mark of the prosperity of any country is the increase in the number of its inhabitants." In his view, population growth is not the cause, rather the consequence of lower productivity. Although his position has a Malthusian basis in structure, policy recommendation is completely different. According to Smith, population is not supposed to follow an uncontrolled pattern, but be controlled by an "invisible hand". Therefore population control policies need not be implemented.

In his famous pamphlet named "An Essay on the Principles of Population", Thomas R. Malthus (1798) came up with a classic economic theory, which also successfully influenced scientists in natural evolution (Malthus, 1798, as cited in Landreth and Colander, 2002). His fundamental argument for this book was that population growth will eventually collide with diminishing returns – since the term "diminishing return" implies that adding more labour to a fixed amount of land can increase output – however at a point of time the increasing additional labour would yield progressively diminishing increases in output. Therefore, the result would be in future increase in food production would not increase related to the population because the world has a fixed quantity of land. This stage, according to Malthus is called Malthusian Trap. According to Malthus, whereas population has the tendency to grow geometrically, food supply actually grows only arithmetically. Thus although population growth is supposed to increase output per capita as there will be more people added to labour force, it does not really happen because of limitations to physical capital availability and diminishing marginal return to labour. Malthus suggested some preventive and positive measure should be taken to keep the balance between consumption and production (Malthus, 1826).

Over the past few centuries, population in developed nations is believed to pass through three stages, a process called demographic transition. In the first stage of this transition, there is slow population growth due to high birth rates and high death rates. The second stage is characterised by decreasing death rates and increasing birth rates, resulting in an increase in population. In the third and final stage, low mortality rate is combined with low fertility rates resulting in low or no population growth. A general explanation for this stage is that the improvement of economic conditions, more particularly of public health, eventually decreases the death rate as well as the birth rate. Being a reflector of technology, education and health, income per capita is considered to be a good indicator for economic conditions and this suggests that there is a strong relationship between per capita income and population size.

After World War II, neo-Malthusian theorists came to dominate the already existing research on population growth. Contrary to Malthus, Solow (1956) said that population growth does not follow a geometrical pattern, but rather an arithmetical pattern. He divided the impact of population

growth rate on the output growth rate. First, an increase in population growth rate increases the amount of labour a thusnd the absolute level of output and the steady state output growth rate, Second, it reduces physical capital per worker and thus productivity and steady state output per worker. In this way, Solow showed that population growth can be detrimental for economic development.

Coaled and Hoover (1958) voiced the same fear illustrating that more people means less savings as money needs to be spent on more infrastructure such as schools and medical facilities for the growing population as well as on creating more capital for additional labour. Moreover, a higher population means a higher youth dependency ratio, which requires the nation to invest more on education, infrastructure and jobs, thus forcingit to undercapitalize its existing labour force (Bloom and Freeman,1988). In his note on population and poverty, Meier (1989) wrote that population growth creates constraints not only on saving but also on foreign exchange and human resources. Even though additional people depress the savings rate and increase public expenditure, few people still might not get access to adequate public services which in turn hinders the quality of the population as a public agent (Meier, 1989, as cited in Nakibullah and Rahman, 1996).

Two groups have opposite views about the growing population: neo-liberals and distributionalists. In a seminal paper, Simon (1985) took an exact opposite position of the well-known phenomenon that population growth is detrimental to economic growth. Population control seems to be “an inhuman coercion and the denial of personal liberty in one of the most valued choices a family can make.” Discussion about the growth of population as a problem actually distracts us from the real problems, which can be created by economic and political systems. The institutions backed by the technological progress and creativity provide all the means to adjust with the growing population (Simon, 1985). Distributionalists, too, argued the same notion that population growth is not the problem and poverty alleviation and equity are the conditions for better adjustment.

Subsequently, a new group emerged in the 1980s to support this side: the revisionists. According to them, a densely populated country should have smoothly functional markets to make the initial adverse effect of population growth “ameliorated or even reversed in the long run” (National Research Council, 1986).Another positive effect of population growth that leads to an expansionary economic cycle is the stable demand for consumption and investment goods (Simon 1992). According to Crenshaw, Ameen and Christenson (1997), many nations such as Kenya, Burundi and Honduras have managed to achieve higher economic growth with higher youth dependency ratios. “Baby Boom” may slow the economic growth initially; however it does not necessarily halt or reverse economic growth. In the long run, this population growth may become the gear of economic development. However, this population ‘boom” or “blast” can be made weaker by some socioeconomic changes such as female labour ratio to total working population or urban population. Dawson and Tiffin (1998) examined the long run relationship of population and economic growth in India for the time period 1950-1993. They concluded that population growth neither causes economic growth nor can it be caused by it. Tsen and Furuoka (2005) said that a larger population provides a larger domestic and more competitive market, which demands technological advancement and innovations, and therefore economic growth. A large population can also encourage greater specialisation and increase returns to human capital and knowledge. According to them, the relationship between population and economic growth depends on the strength of technological advancement and knowledge expansion compared to diminishing returns to natural resources.

Some economists prefer the Marxist theory to be named as transitionary. Marx considered overpopulation as a consequence of capitalism, meaning that it is not a natural cycle. In his view a "reserve army" of labour is necessary in order to preserve wages at the minimal level; technological advancement is exploitation in one form, which leads to further population growth and drives the population to collapse (Landreth and Colander, 2002).

Later, Mason (1988) demonstrated using both theoretical and empirical points of view that population growth reduces propensity to save, thereby lowering potential investment. This would result in further decrease in per capita physical capital per worker and per capita steady state output. This phenomenon eventually constrains economic growth. However, Hasan (2001) found exactly opposite results in the case of India, which showed that an increase in per capita income lowers population growth.

In addition, Thorton (2001) conducted research on the seven Latin American countries: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela, taking the population growth and GDP per capita over the period 1900-1994. For all seven countries, it showed there is no long run causal relationship between these two variables.

Taking the data for real GDP per capita and population growth of Bangladesh for the period 1959-1990, a similar relationship status has been examined (Nakibullah& Rahman, 1996). Though this particular study is somewhat misleading as they show the GDP per capita as indicator of poverty, it is still an insightful study about the relationship. This paper shows population growth does not cause changes in GDP, but instead it is the other way around. They emphasised the fact on the basis that the major proportion of the population of Bangladesh is poor (they are low income) and the population is increasing. They have not provided any reason as to why less GDP growth is a stimulus to the population. They rather preferred to align with the neo-liberals, saying that population control measurements taken by Government of Bangladesh are not the correct ones.

Hasan (2002) examined the relationship between GDP per capita and population in Bangladesh using data spanning over the period 1973 to 1997. In his study it has been found that both the variables are cointegrated, hence resulting in a long run relationship. He also concluded that there was a bi-directional negative causality between the two variables, which means increase in population depresses the GDP while increase in GDP also helps reduce population. However, he failed to connect this result with any of the existing theories. It seems that Bangladesh, in that time, was in both a post-Malthusian and Modern Growth regime. He also advocated some policies based on sound macro and micro-economic management, such as good governance and the realization of economies of scale by utilising additional labour through promoting human capital, technological advancement and so on.

3. Trend of Population and GDP in Bangladesh

The People's Republic of Bangladesh is located in South Asia between 20o.34¢ and 26o.38¢latitude and between 880.01¢& 920.41¢east longitude. With an estimated population of 13,92,52,683 in 2011 and the area of 1,47,570 sq.km, Bangladesh is the 8th most populous country in the world. However, the number of population estimated by Bangladesh Bureau of Statistics in their Population and Housing Census 2011 report was immediately disputed by United Nations, which is why a 156,186,882 (July 2016 est.) population reported by CIA(Central Intelligence Agency), the World Factbook, seems more accurate. On the other hand, 156,826,000 (2014 est.) is the estimated population according to Encyclopaedia Britannica.

Population Trend of Bangladesh

As we see from Figure 1, the total population has evidently increased to more than 150 million over approximately two decades. However, the population growth rate decreased until 2008 and again faced a slight increase from 2009 onwards (Figure 2). This declining population growth is actually slower slowing down the increasing rate of the total population; however there is a long way to go to attain complete stability in population growth.

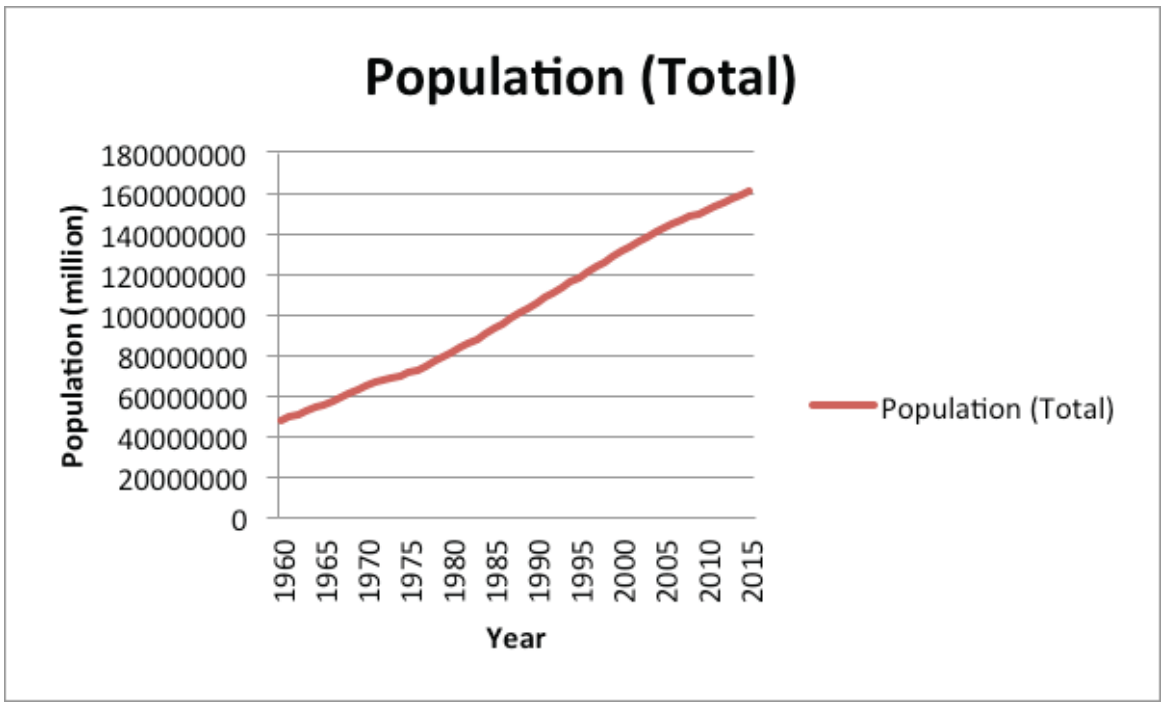


Figure 1: Total population over the time period of 1960-2015

Population density has been rising for more than the last two decades, which means that more people reside in small areas. While it was around 844.5 per sq.km, it had become 1203 per sq.km by 2013 (Figure 3). This increase demonstrates why fewer people are getting access to land for living on, and it is not even arable land.

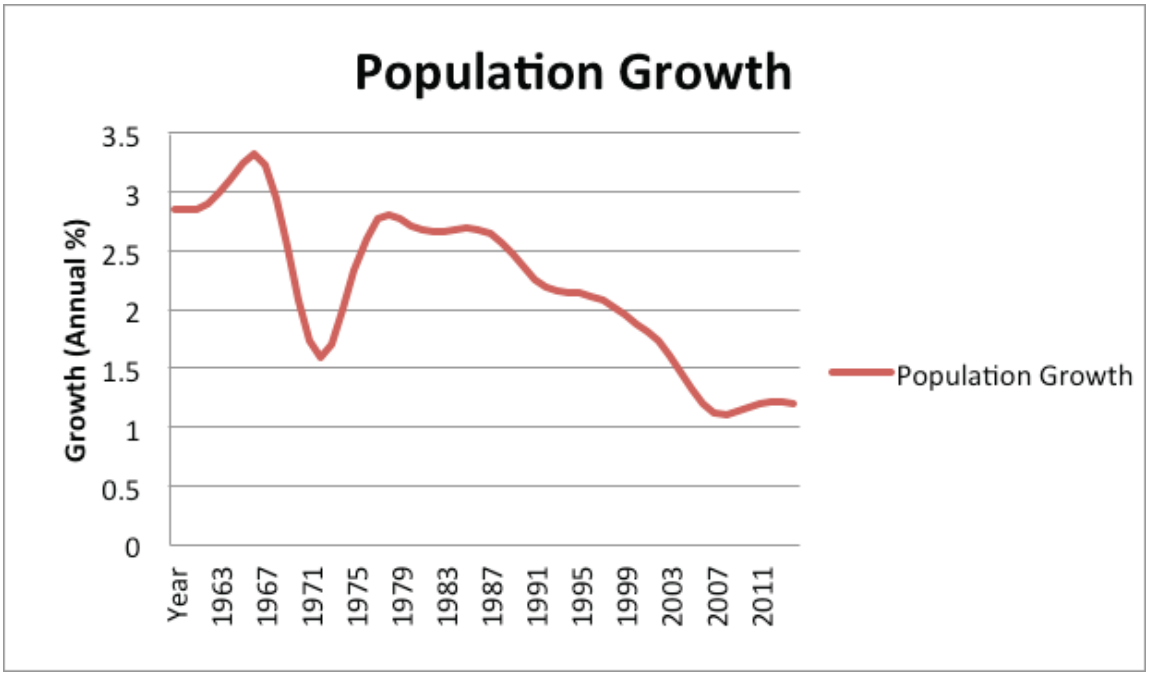


Figure 2: Population growth over the time period of 1960-2015

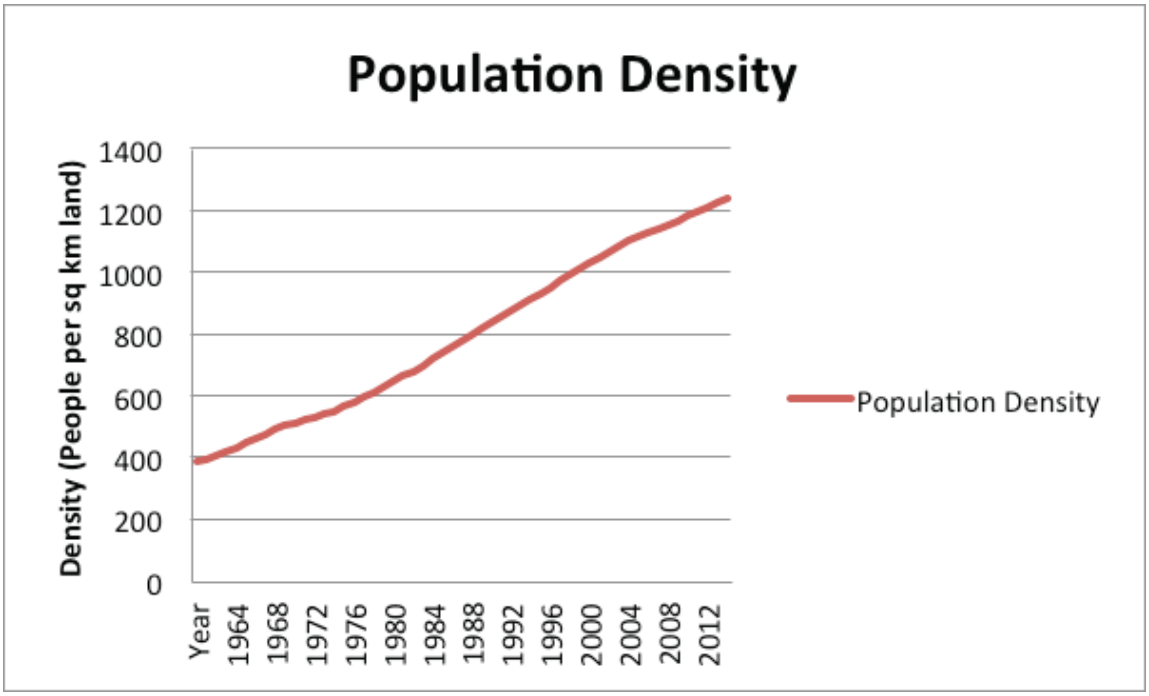
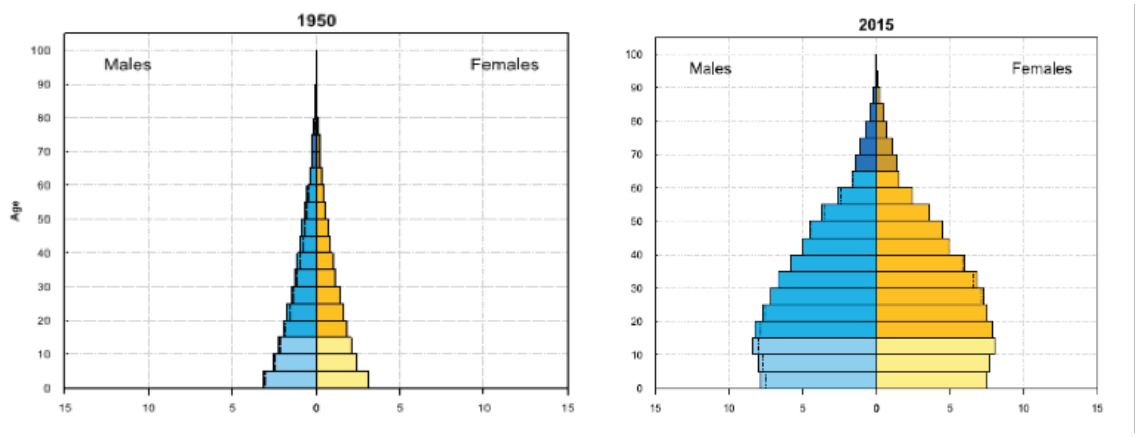


Figure 3: Population density (1960-2015)

Population by age groups and sex has shown drastic changes from 1950 to 2015. We can see that in following graph:



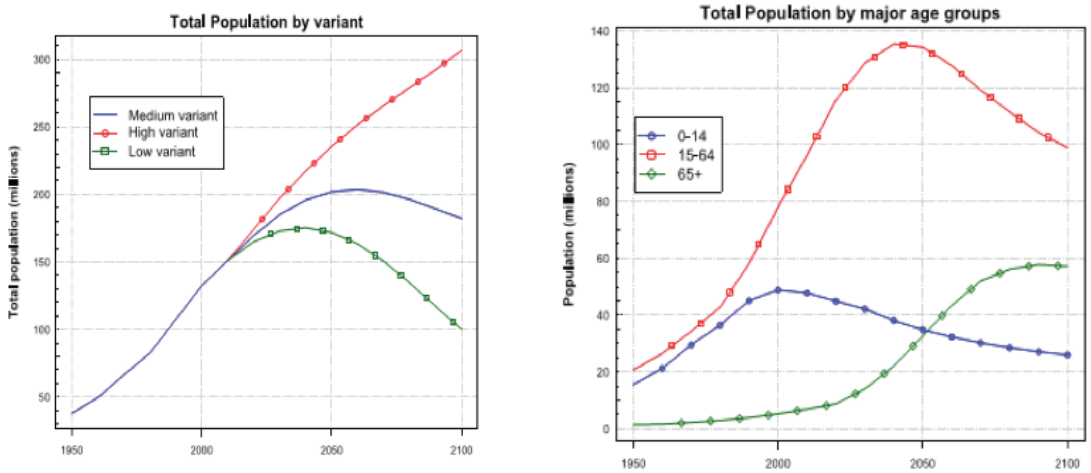
Source: World Population Prospects: The 2015 Revision, Volume II: Demographic Profiles, UN

Figure 4: Population by age group and sex (1950 and 2015)[1]

The data is in thousands or millions. From the graph we can see that the on male side there are excessive number of males between ages 10-20, which means the dependent group is higher. At the same time, the age group 40-60 also consists of excessive numbers. However, this is an improved situation compared to 1950,when all age groups consisted of xcessive males. In the case of the female group, whereas the 1950 data shows no excessive number of females in any group, the 2015 data shows excessive females in the 25-40 age group.

Future Projection of the Population

The UN discloses their projected population through variants and expected future population for Bangladesh. The following graphs depict these two:



Source: World Population Prospects: The 2015 Revision, Volume II: Demographic Profiles

Figure 5: Future projection of population by variant and by major age groups

[1] The dotted line indicates the excess male or female population in certain age group

Gross Domestic Product Trend and Pattern

Although Bangladesh is a densely populated country, it has been considered as one of the "Next Eleven" developing countries with potential for massive growth. It has been successful in sustaining its positive economic growth for more than three decades. The indicator for this economic growth is mainly GDP (Gross Domestic Production). In Bangladesh, GDP is mainly calculated taking three sectors into account: agriculture, services and industry.

GDP growth since 1960

Following the War of Liberation in 1971, Bangladesh faced a slowdown in its economy. However, the economy has accelerated since the 1980s. Economic growth has also been less volatile. The contribution of the different sectors to GDP has changed drastically. Whereas the agricultural sector had about 31 percent contribution to GDP in 1991, it has come down to only around 16 percent within two decades. On the other hand, the contribution of the service sector has increased by around 10 percent and that of industry has increased around 6 percent from 1991 to 2013. Growth within the service sector has consistently been broad-based, with wholesale and retail trade, transport, storage and communication consistently leading the way. Figure 6demonstrates this more clearly.

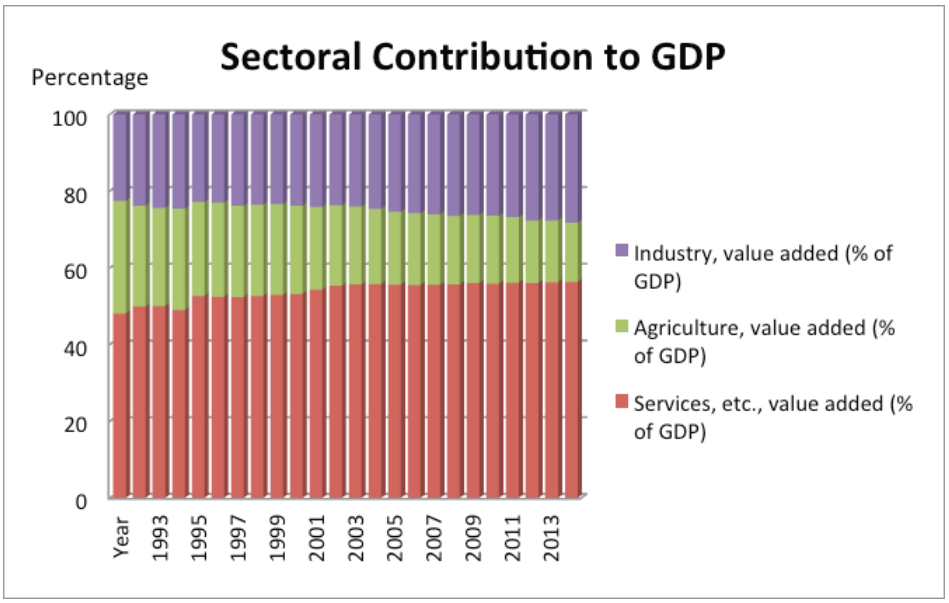


Figure 6: Sectoral Contribution to GDP (in percentage) during 1991-2015

Although the share of consumption in total expenditure appears to have decreased due to growth in export and investments, it still accounts for more than 80percent of Bangladesh's GDP.

Sources of GDP Growth

According to the World Bank (2012), in recent decades Bangladesh has been passing through the third phase of demographic transition with its declining birth rates and death rates. With decreasing dependency ratio during the last three decades, the savings rate has been increasing, which has helped to achieve an efficiency growth. The World Bank has attributed the steady growth to the slow

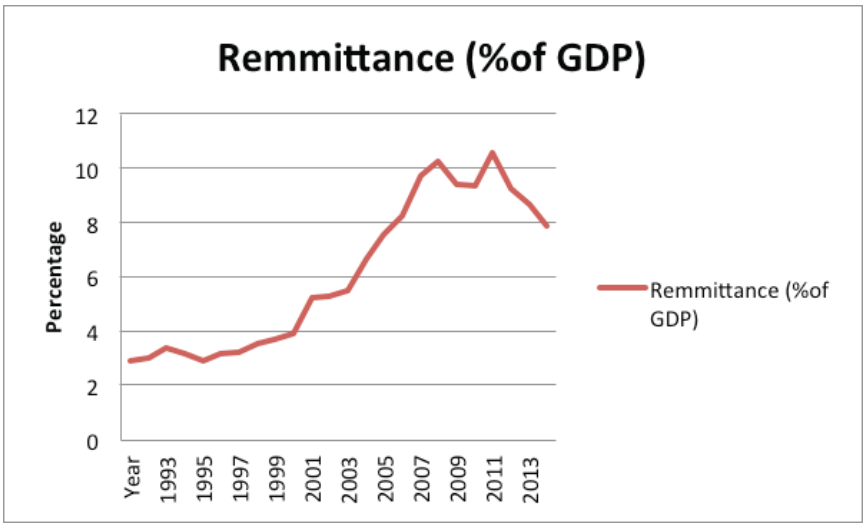
rate of population growth, because with declining population growth, alarger number goods and services (minus that needed for reinvestment purposes) becomes available to improve living standards. Thus according to World Bank, slow population growth in Bangladesh encourages a higher rate of investment, followed by higher capital per worker, resulting in higher income per capita.

Also according to Rahman and Yusuf (Not dated), an increase in GDP per working-age person, demographic changes and population growth increases GDP growth. Though Bangladesh has shown a faster population growth decrease, GDP growth has been considered to be driven by labour productivity as well. A widely known theory about Bangladesh is that since the 1980s with the slow pace of population growth, the working age population had contributed to faster economic growth, which led to the conclusion that change in ratio of working age to population had been contributing to economic growth since the 1980s.

However, Rahman and Yusuf found out using World Bank's labour force data (1980-2006) that falls in labour force participation rate, particularly during the 1990s when female share of the labour force fell, offset the contribution of demographic changes to GDP growth. So it can be concluded that the same demographic change that caused GDP to rise actually slightly offset the very same contribution as it lowers the participation rate. According to Rahman and Yusuf, the GDP growth has been mostly driven by growth in GDP per working age person. It also shows that after 1990s the growth was entirely due to change in labour productivity.

For many other economists, the contribution for increasing GDP should be attributed to other factors like the emergence of the RMG (Ready-made garments) sector and remittances. The emergence of the RMG sector has been another driving force behind increasing GDP. Moreover, Bangladesh has also been successful in upgrading its export-plus-import-to-GDP ratio from 16 percent in the 1980s to over 40 percent in the 2010s.

Kynge (2014) said Bangladesh is the 8th biggest recipient of remittances, which covers 80 percent of domestic GDP. Moody's projected that the remittance inflows will push GDP growth above 6 per cent this fiscal year, up from 5.8 per cent in 2013. Figure 7 shows the remittance contribution to GDP over the years.



4. Methodology

For this study, the relationship between population growth and income per capita over the years in Bangladesh is tested. The annual data of GDP per capita and population growth of Bangladesh over the time period of 1960 to 2015 has been taken. The data is in logarithms and taken from the data bank of the World Bank's website. The population growth variable is defined by logarithms of population growth (denoted by P) and the GDP per capita growth is defined by the logarithms of GDP per capita growth (denoted by g).

First stage: Check for Stationarity and Unit Root

First of all, as the data of two variables is time series data, stationarity of the data is to be checked. Variables are first analysed graphically before moving on for Autocorrelation Function (ACF). Determining the lags for the data, the autocorrelation coefficient, which has to be very high at first and gradually falling with increasing lag for the data set being non stationary or vice versa, is estimated for the both of the variables.

For being more confident about the stationarity or non stationarity of the data, the data was tested using Augmented Dickey Fuller (ADF) unit root test. From the graphical analysis, population growth has a deterministic trend whereas the GDP per capita growth has a stochastic trend. Thus the following model for both the variables is taken:

$$\ln Y_t = \beta_1 + \beta_3 \ln Y_{t-1} + u_t \quad \text{.....(1)}$$

Here Y denotes both the variable

Second Stage: Selection of Lag Order

Tsay First of all, as the data of two variables is time series data, stationarity of the data is to be checked. Variables are first analysed graphically before moving on for Autocorrelation Function (ACF). Determining the lags for the data, the autocorrelation coefficient, which has to be very high at first and gradually falling with increasing lag for the data set being non stationary or vice versa, is estimated for the both of the variables.

For being more confident about the stationarity or non stationarity of the data, the data was tested using Augmented Dickey Fuller (ADF) unit root test. From the graphical analysis, population growth has a deterministic trend whereas the GDP per capita growth has a stochastic trend. Thus the following model for both the variables is taken:

(1984), Paulsen(1984) and Nielsen(2001) have shown the method to select lag order for VAR model with I (1). In order to select the lag, Hannan–Quinn information criterion (HQIC) method, Schwarz Bayesian information criterion (SBIC) method, and sequential likelihood-ratio (LR) were used.

Third Stage: Cointegration

Engle and Granger (1987) observed that the economic data that spans through time have non stationary characteristics and might have linear combination with each other that converges to a long run relationship eventually. Only after the two time series are stationary individually after the first differencing, it can be assumed that there can be a relationship between two such variables and this phenomenon is called cointegration. Hence GDP per capita and population might have some linear combination. To investigate this, the maximum likelihood test procedure is used, which was introduced by Johansen (1991). The form of cointegration model is:

$\Delta \ln Y_t = a + \beta_1 \Delta \ln Y_{t-1} + \ldots\ldots\ldots\ldots\ldots + \beta_{k-1} \Delta \ln Y_{t-k} - 1 + \Gamma \ln Y_{t-1} + Z_t$

The focal point is to find out the rank of p*p matrix. In the present application, there might be two possible ranks. For rank zero the null hypothesis is that there is no relationship. For rank one the null hypothesis is that there is one or fewer cointegrating equation.

Fourth Stage: Causality Test

If we find a linear relationship or cointegration between the two variables, then we would want to see the direction of the relationship: whether population growth causes GDP growth or vice versa. Causality inferences in the bi-variate framework are made by estimating the parameters of the following VECM equations:

$\Delta \ln Y_t = \alpha + \sum^{n}_{i=1} \beta i \Delta \ln Y_{t-i} + \sum^{n}_{j=1} \theta_j \Delta \ln X_{t-j} + f Z_{t-1} + u_t$

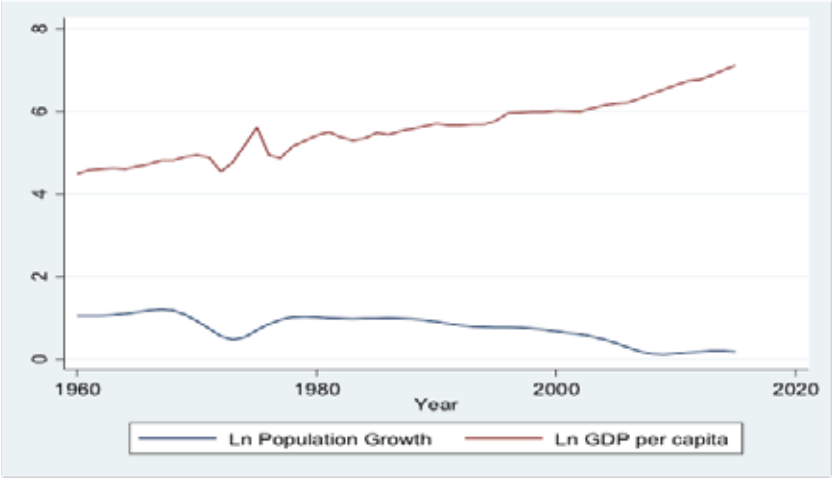
Hence Z is the error correction term.

5. Empirical Analysis

As discussed in the previous chapter, the data for the two variables of GDP per capita (current USD dollar) and population growth of Bangladesh for the time span of 1960 to 2015 has been collected. Variables are transformed to the log because log transformation can reduce the problem of heteroskedasticity (Gujarati, 2004).

Graphically Checking forStationarity

First of all, stationarity of the data has been checked. The graphical analysis (Figure 8) shows that GDP per capita increases over the years with a stochastic trend, which also increases. The population growth (Pt) decreases over the years, then around the year 2009 it slightly increases.



Data Source: World Bank

Figure 8: Trend line for log of population growth and GDP per capita

Thus both the variables can be assumed to be non-stationary, meaning they are changing over time.

Correlogram Check

To further check for the stationarity of the variables, a correlogram test has been run taking 26 lags for population growth variable. The coefficient of autocorrelations started at a very high value

at lag 1 (0.947) and declines slowly, though not very slowly (figure 9). Thus it seems to be non stationary.

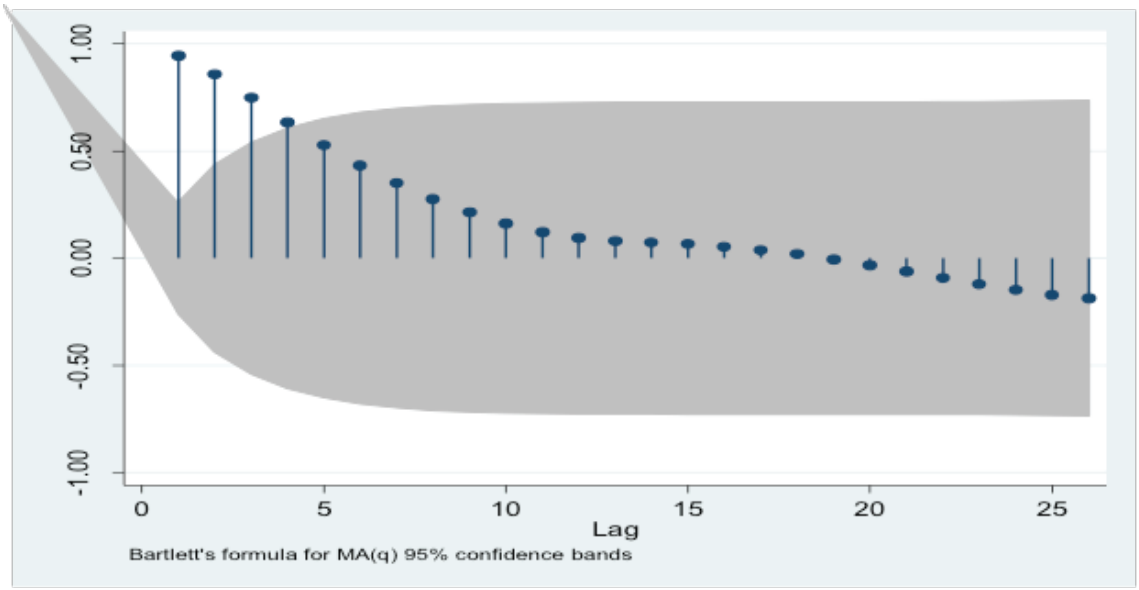


Figure 9: Correlogram check for Population Growth (lnPt)

Similarly, taking 26 lags for growth in GDP per capita, the coefficient autocorrelation(Figure 10) shows that it started at a medium value at lag 1 (0.9098) and declines slowly, which seems to be non stationary, suggesting it to be stationary with the earliest difference.

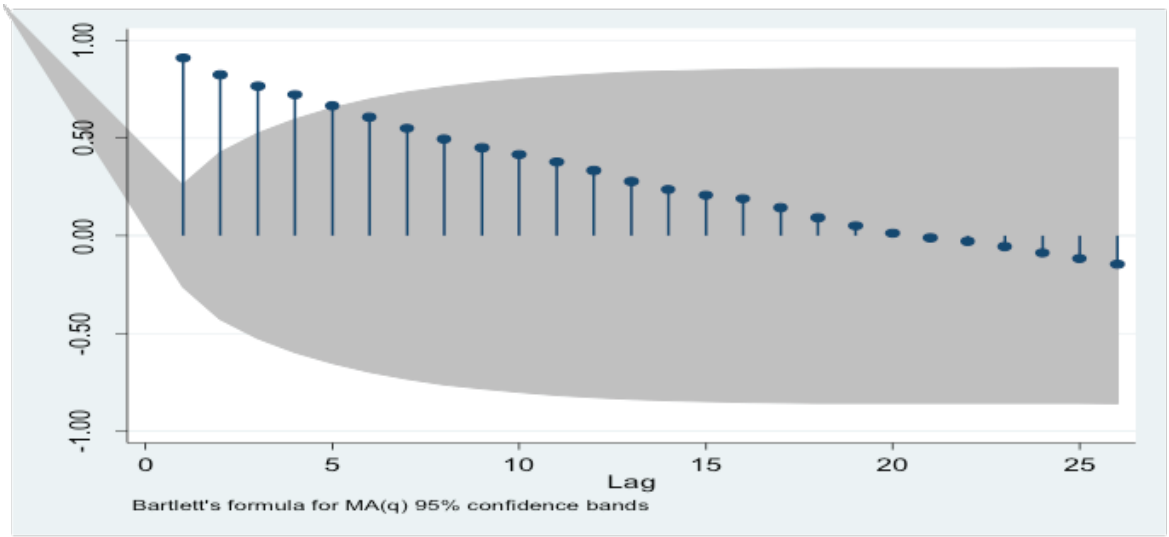


Figure 10: Correlogram check for GDP per capita Growth (lngt)

Unit Root: Augmented Dickey Fuller (ADF) Test

As the graphical analysis shows that both the variables are either increasing or decreasing over the period, a Random Walk Model with drift will be appropriate for a unit root test.

$\ln P_t = \beta_1 + \beta_2 \ln P_{t-1} + u_t$ ……(6.1)

$\ln g_t = \beta_1 + \beta_2 \ln g_{t-1} + u_t$ ……..(6.2)

Hence Pt is population growth and gt is GDP per capita.

Table 1: Unit Root Test

Ho: Variables have unit root or non stationary		
	Population Growth t-stat	GDP per capita t-stat
L (level)	-2.574 (0)	-0.031 (0)
Δ (first difference)	-7.902(1)***	-8.340 (1)***

Notes: The rejection of null hypothesis is based on the significance of t-stat. Values in parentheses are optimal lag lengths according to the Schwarz Information Criteria. Asterisk (***) shows the test statistic is significant at 1%, 5% and 10% significant level and p-value is 0.000.

From Table1, it can be seen that both the variables of population growth and GDP per capita have a unit root, as we cannot reject the null hypothesis. If the first difference of both the variables is taken, the null hypothesis can be rejected. Therefore, the variable becomes stationary if it is integrated once.

Lag Order Selection

Following Hannan–Quinn information criterion (HQIC) method, Schwarz Bayesian information criterion (SBIC) method, sequential likelihood-ratio (LR), Table 5 shows that * is on the lag rank 4. So lag 4 is taken for further analysis.

Table 2: Lag Order Selection for Cointegration test

Lag	FPE	AIC	HQIC	SBIC
4	2.3e-06*	-7.29637*	-7.03742*	-6.62094*

Cointegration Test

As the variables are integrated of order 1, they might be cointegrated. The examination of the linear combination between two leads to the following tentative VEC model:

$\Delta \ln P_t = \alpha + \beta_1 \Delta \ln P_{t-1} + \ldots\ldots\ldots\ldots + \beta_{k-1} \Delta \ln P_{t-k-1} + \Gamma \ln P_{t-1} + z_t$

$\Delta \ln g_t = a + b_1 \Delta \ln P_{t-1} + \ldots\ldots\ldots\ldots + b_{k-1} \Delta \ln g_{t-k-1} + \Gamma 1 \ln g_{t-1} + z_t$

In Johansen's method the test for cointegration is implemented in vecrank. Here (Table 3) line (1) with maximum rank of zero gets the null hypothesis of having no co integration, whereas line (2) with maximum rank of one get the null hypothesis of having one or fewer co integration equations.

Table 3: Johansen tests for cointegration between lnPt and lngt

Hypothesis	Max Rank	Trace Statistics	Max Statistics
Ho=No co integration at r	r=0	17.2415	15.3347
Ho= One co integration at r	r=1	1.9068	1.9068

Note: Both the ranks are not significant at 5% critical value for trace statistics and Max statistics

For maximum rank 0, we cannot accept the null hypothesis, so we reject that there is no cointegration at rank zero. Then at rank 1, we fail to reject the null hypothesis that the variables have one cointegrating equation.

There is a long run relationship between population growth and GDP per capita.

Causality Test through Vector Error Correction Model

Now a VECM model is developed for both the variables which catches up both the short run and long run effects of the variables on each other and also adds an error correction feature. As there is one or few cointegrating equation, the direction of the causality of the two variables is tested here.

$$\Delta \ln P_t = \alpha + \sum_{i=1}^{n} \beta_i \Delta \ln P_{t-i} + \sum_{j=1}^{n} \theta_j \Delta \ln g_{t-j} + MZ_{t-1} + u_t$$

$$\Delta \ln g_t = a + \sum_{i=1}^{n} b_i \Delta \ln g_{t-i} + \sum_{j=1}^{n} c_j \Delta \ln P_{t-j} + fZ_{t-1} + z_t$$

Ztis the error correction term which is the lagged residual series of the cointegrating vector; it measures the deviations of the series from the long run equilibrium relation.

Table 4: Causality from GDP per capita growth to population growth

Null Hypothesis	Short Run Coefficients			Error Correcting term
	LD	L2D	L3D	Z_{t-1}
GDP per capita causes population growth	-.0268462 (0.047)	-.0332565 (0.009)	.0260895 (0.078)	—0.0048755 (0.057)
Population growth causes GDP per capita	-4.71*** (0.00)	-7.874*** (0.00)	-4.79*** (0.00)	-0.0637933*** (0.004)

Notes: The rejection of null hypothesis is based on the significance of Zt-1, error correcting term. Values in parentheses are the p-values. Asterisk (***) shows the coefficient is significant.

Table 4 shows that causality running from GDP to population has no evidence of a long run relationship. The coefficients of lagged error correction term are not significant as it does not have

the expected sign, and p-value is larger than 5%. No short run coefficients is also significant. Therefore, it can be concluded that there is no causality created by GDP per capita on population.

Next, we move on to the other direction of causality, which is population growth to GDP.

Causality running from population to GDP has evidence of a long run relationship. The coefficients of lagged error correction term are significant as it does have the expected sign and p-value is less than 5%. Short run coefficients are also significant (Table 4). In both the long run and the short run, there is a negative relationship from population growth to GDP per capita. Coefficients of error correction term [Z(t)] also measures the speed at which GDP per capita adjusts to the changes in population growth before converging to the equilibrium level. It takes GDP more than 15years to adjust with the growing population, i.e. 6.3 percent of the disequilibria of the previous year's shock adjusts back to the long run equilibrium in the current year, and as a result it took more than 15years for the whole adjustment.

Diagnostic test

We run Autocorrelation test to see whether the correlation coefficients for residuals are significantly different from zero.

Table 5: Autocorrelation Test

H_0: There is no auto correlation at lag order		
Lag	Chi square	Probability
1	17.9982	0.00124
2	12.8973	0.01179
3	1.4066	0.84305
4	9.0550	0.05974

Note: None of the p value is greater than 5%. We accept the null hypothesis

The null hypothesis can be accepted; there is no auto correlation among the residuals. Hence, this indicates that the model is good enough.

As discussed in the theoretical framework section, there are supposed to be three regimes in the case of the relationship between GDP and population and it seems from the above analysis that Bangladesh is currently in the Modern Growth regime as it shows negative relationship between population growth and GDP growth. Although the direction is from population to GDP, and not vice versa, it can be said that Bangladesh is on its way to reach the stage where a small increase in GDP will decrease population growth. For now, it is visible that increase in population is degrading Bangladesh's economic growth as well as lowering the environmental and ecological conditions.

6. Concluding Remarks

Conclusion

The findings from this study somewhat resemble the study using similar data for 1973-1997 by Hasan (2002). However, he found a bi-directional negative causal relationship between GDP per capita and population growth in Bangladesh, which suggested Bangladesh at that time was in the Modern Growth regime stage of demographic transition. On the contrary, the present analysis shows that there is a uni-directional negative causality from population growth to GDP per capita in the long run, which also means Bangladesh is now in the stage of Modern Growth regime, but is yet to attain the influence of GDP on population. In general, population increases the youth dependency ratio, which in turn lowers GDP per capita. Furthermore, the additional labouris not being used efficiently, economies of scale have not yet been attained: this is worsening the economic condition with the growing population.

Policy Recommendations

This study clearly shows that Bangladesh cannot go ahead in developing its economy, more particularly its GrossDomestic Product, without addressing the problems of rapid population growth. Policies should be more focused on controlling population growth. The following details some recommended steps:

- First of all, Bangladesh should focus more on population control than on poverty alleviation. Poverty amelioration is equally important, but without controlling population it will never be achieved fully. Therefore, controlling population should be the priority;

- Although some policymakers suggest adopting China's one child policy, it will not be feasible for Bangladesh given its traditional background and religious emotions. Policy should be adopted keeping religious and social barriers in mind as in the rural areas family planning is considered a prohibited matter;

- Although Bangladesh's family planning programme has shown great success rate over the period, given its recent inadequacy some supervision is needed for these programmes in the most remote areas;

- Government should aim to bring in less expensive and relatively safer methods of birth control;

- As Bangladesh has already made great advancement in technology, and has been successful in reaching a stage where even the lower-middle-income part of the population can afford to buy a television or mobile phone, more promotional activities concerning family planning should be introduced;

- In rural areas, importance of family planning can be taught in a special course in high school;

- Although Bangladesh has introduced the minimum age for marriage, it should also encourage people not to get married without being able to earn money. More youth-based programmes to create awareness among the youth, especially girls, needs to be introduced by the Government and NGOs with a view to make them understand the consequences of getting married and procreating without an earning source;

• It has also been reported that many women in rural areas are in favour of family planning. However they do not get any means to do so. It is time for the Government to focus more on how contraceptives can reach remote areas and which agents should be used to introduce them.

7. References

1. Bloom, D.E. and Freeman, R.B., 1988. Economic Development and the timing and components of population growth. Journal of Policy Modelling, 10(1), pp. 57-81.

2. Coale, A. J. and Hoover E.M., 1958. Population growth and economic development in low-income countries: A Case study of India's prospects. Princeton University Press, New Jersey.

3. Crenshaw, E. M., Ameen, A. Z. and Christenson, M., 1997. Population dynamics and economic development: Age-specific population growth rates and economic growth in developing countries, 1965 to 1990. American Sociological Review, 62(6), pp. 974-984.

4. Dawson, P.J. and Tiffin, R., 1998. Is there a long-run relationship between population growth and living standards? The case of India. Journal of Development Studies, 34(5), pp. 149-156.

5. Ehrlich, I. and Lui, T.F., 1997. The problem of population and growth: A review of the literature from Malthus to contemporary models of endogenous population and endogenous growth. Journal of Economic Dynamics and Control, 21(1), pp. 205-242.

6. Engle, R. F., and Granger, C. W. J., 1987. Co-integration and error correction: Representation, estimation, and testing. Econometrica, 55(2), pp. 251–276

7. Galor, O. and Weil, D. N., 2000. Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and beyond. The American Economic Review, 90(4), pp. 806-828

8. Gujarati, D.N., 2004. Basic Econometrics. 4th. McGraw Hill Companies, New York.

9. Hasan, M.S., 2001. Is there a long run relationship between population growth and living standards? The case of India-a re-examination. Indian Economic Journal, 48(4), pp. 27-34

10. Hasan, M.S., 2002. The long relationship between population growth and per capita income in Bangladesh. The Bangladesh Development Studies, 28(3), pp.65-84

11. Heinlein, R. A., 1973. Time Enough for Love. G. P. Putnam's Sons, New York.

12. Johansen, S. 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica. 59. 1551–1580

13. Kelly A.C and Schmidt R.M., 1995. Aggregate population and economic growth correlations: The role of the components of demographic change. Demography, 32(4), pp.543-555

14. Kelly A.C and Schmidt R.M., 2005. Evolution of recent economic-demographic modeling: A synthesis. Journal of Population Economics. 18(2). 275-300

15. Kynge, J., 2014. Record remittance inflows boost Bangladesh GDP outlook. Financial Times, August 12, 2014. Available at: [http://blogs.ft.com/beyond-brics/2014/08/12/record-remittance-inflows-boost-bangladesh-gdp-outlook/]

16. Landreth, H. and Colander, D. C., 2002. History of Economic Thought. 4th. Hughton Mifflin, Boston.

17. Malthus, T. R., 1826. An Essay on the Principle of Population. 6th. John Murray, London.

18. Mason, A., 1988. Saving, Economic Growth, and Demographic Change. Population and Development Review, 14 (1), pp.113-144.

19. Nakibullah A. and Rahman A., 1996. Poverty-led higher population growth in Bangladesh. The Bangladesh Development Studies, 24(1/2),pp. 151-164

20. National Research Council, 1986. Population Growth and Economic Development: Policy Questions. Washington, D.C: National Academy Press

21. Nielsen, B., 2001. Order determination in general vector auto regressions. Working paper, Department of Economics, University of Oxford and Nuffield College.

22. Paulsen, J., 1984. Order determination of multivariate autoregressive time series with unit roots. Journal of Time Series Analysis, 5(2), pp. 115–12

23. Rahman, J. And Yusuf, A., Not Dated. Economic Growth in Bangladesh: Experience and Policy Priorities. Availableat:[http://www.learningace.com/doc/1479044/6c0f410934b7bbd28bcf839d24007065/economic-growth-in-bangladesh-experience-and-policy-priorities]

24. Simon, J. L., 1985."Why Do We Still Think Babies Create Poverty?"Washington Post, 12 October, 1985.

25. Simon, J. L., 1992. Population andDevelopment in Poor Countries.. Princeton University Press, New Jersey.

26. Smith, A., 1776. The Wealth of Nations. 5th. Methuen & Co., Ltd , London.

27. Solow, R. M., 1956. A Contribution to the Theory of Economic Growth. The Quarterly Journal of Economics, 70 (1), pp. 65-94

28. Thirwall, A.P., 1972. A cross-section study of population growth and the growth of output and per capita income in a production function framework. The Manchester School, 40, pp. 339-359

29. Thornton, J., 2001. Population growth and economic growth: long-ran evidence from Latin America. Southern Economic Journal, 68(2),pp. 464-468

30. Tsay, R. S., 1984. Order selection in nonstationary autoregressive models. Annals of Statistics,12(4), pp. 1425–1433.

31. Tsen, W.H. and Furuoka, F., 2005. The relationship between population and economic growth in Asian economies. ASEAN Economic Bulletin, 22(3), pp. 314-330

32. The World Fact Book, 2016. South Asia: Bangladesh. Central Intelligence Agency. Available at: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/bg.html [Accessed on: 19th November, 2016]

33. United Nations, Department of Economic and Social Affairs: Population Division, 2015. World Population Prospects: The 2015 Revision, Volume II: Demographic Profiles. New York: United Nation

34. United Nations Development Program, 1996. Human Development Report. New York: UNDP, (89)

BRAC Institute of Governance and Development (BIGD), BRAC University is a centre of policy and academic excellence. BIGD is devoted to research on a range of governance and development concerns, as well as the nexus between the two. BIGD's research is aimed at contributing to public policy as well as supporting its academic and training programs. It does not limit knowledge creation to being an end itself but rather to advance the pursuit of a just and prosperous society. It also plays an advocacy role to give voice to contemporary governance, political and economic issues. As an institute of BRAC University, BIGD works closely with the university motivated by its motto: 'inspiring excellence'. BIGD also has the unique advantage of being associated with BRAC, the world's largest NGO through its work. It is inspired by BRAC's values in shaping its institutional work and professional standards.

BRAC Institute of Governance and Development (BIGD)
BRAC University
SK Centre (Basement, 3rd - 7th & 9th Floor), GP, JA-4, TB Gate
Mohakhali, Dhaka 1212, Bangladesh

BRAC UNIVERSITY
Inspiring Excellence

http://bigd.bracu.ac.bd facebook.com/BIGDBRACUniversity twitter.com/BIGD_BRACU BIGD, BRAC University