The relation between an ageing population and economic growth in Bangladesh: Evidence from an endogenous growth model

Abstract:

This paper examines the short-run and long-run relationships between an ageing population and economic growth in Bangladesh using time series data for the period between 1972-2015. We employed a bivariate endogenous growth model to investigate the relationship between the population aged 65 years and above and per capita gross domestic product (GDP). The study found that there is a long-run positive relationship between the ageing population and per capita real GDP. The relationship runs from an ageing population to per capita real GDP, given that there is an increasing capital formation process in the economy. Therefore, the elderly population is not a matter of concern for Bangladesh as long as per capita capital formation has been greater than that of per capita ageing population.

Keywords: Bangladesh; ageing population; economic growth; time series analysis; cointegration analysis.

JEL Classification**: J01, J11, J14, C22.**

Background

The number of older people worldwide is increasing because of decreasing mortality and fertility rates [1]. It has been estimated that by the year 2050 approximately two billion people will be aged 60 years and over, and 400 million people will be aged 80 years and over [2]. Theoretically, this demographic change has three types of effects on macroeconomic growth in an economy: positive, negative, and neutral [3]. Recently, the literature has highlighted the opportunity for economic growth ascribed to demographic change- demographic dividend - through three mechanisms: labour supply, savings, and human capital (see Bloom et al., [3] for details). To the best of our knowledge, no study has investigated the relationship between an ageing population and macroeconomic growth in the countries of South Asia (Afghanistan, Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka and the Maldives), although the United Nations [2] projected that by the year 2050, the working age population in less developed countries would decline by 49%. Population ageing is already having major consequences and implications in all areas of life, and will continue to do so. In the economic area, population ageing will be expected to affect economic growth, savings, investment, consumption, labour markets, pensions, taxation and the transfer of wealth and property from one generation to another. In the context of an increasing ageing population, the time series analysis of the relationship between ageing population and per capita GDP is an interesting research agenda for a developing country like Bangladesh. This paper examines the short-run and long-run relationship between the ageing population and per capita GDP in Bangladesh based on an endogenous growth model and time series data.

The main motivation for pursuing this research, taking Bangladesh as a case study, is that the country has recently become concerned about its increasing old age population and the increasing pressure on its social safety net program – the Old Age Allowance Program. Between 2008-09 and 2017-18, the total number of beneficiaries has increased from 2.0 million to 3.5 million[1]. Consequently, there has been increasing pressure on the government's revenue budget expenditure. Between 2008-09 and 2017-18, the government budget increased from US$ 6K million to US$21K. In the given context, the government has a plan to increase retirement age for the civil servants from the current 60 years to 65 years.

As there is no definitive effect of an ageing population on macroeconomic growth (see Literature Review sub-section for detail), country-specific evidence might be a useful tool for policy makers to gain insights into the dynamics of the relationship. Most South Asian countries are highly diversified in terms of GDP, demographic structure, and law; however, unlike other South Asian countries, Bangladesh is homogeneous. Hence using time series data country-specific evidence for this study on Bangladesh is justified. The advantage of time-series analysis over panel studies is that the findings can be used to predict the future based on past data series.

Following this introductory section, the remaining parts of the paper contain the following: (i) highlights of the ageing population and capital formation in Bangladesh; (ii) review of the past literature; (iii) data description; (iv) methodology; (v) presentation and analysis of the results; and (vi) conclusion.

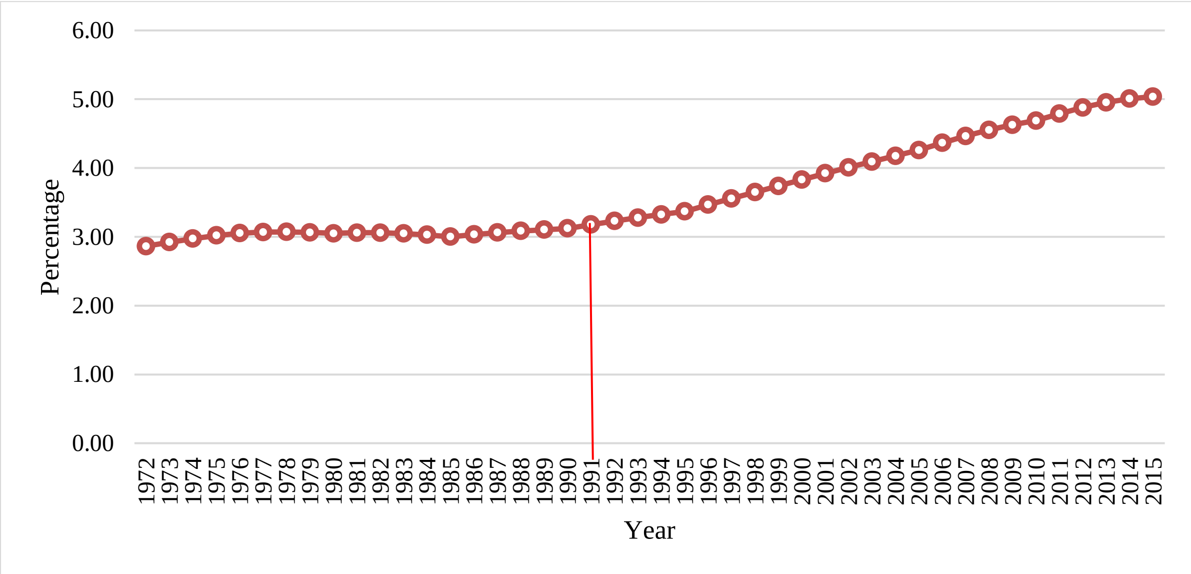
Ageing population, GDP and capital formation in Bangladesh

In the South Asian region, Bangladesh is largely enclosed by the borders of India and Myanmar (Burma). In terms of population, it is the seventh largest (with a population of 152.51million in 2011) and one of the most densely populated countries (1015 persons per sq. km) in the world. In the contexts of population and development, the country is experiencing an emerging issue of ageing [4]. The United Nation defines the cut off point for the older aged

[1] Please refer to (http://socialprotection.gov.bd/en/old-age-allowance/).

population as 60 years of age; however, in developed countries, where life expectancy is much higher, the cut off point for the older population is 65 years [5]. It is observable that the percentage of population of aged 65 and above [2] of the total population has been increasing since 1972 in Bangladesh (Figure 1). Since 1991 onwards, the line shows a steeper trend relatively.

Figure 1: Percentage of population ages 65 and above of total population in Bangladesh.



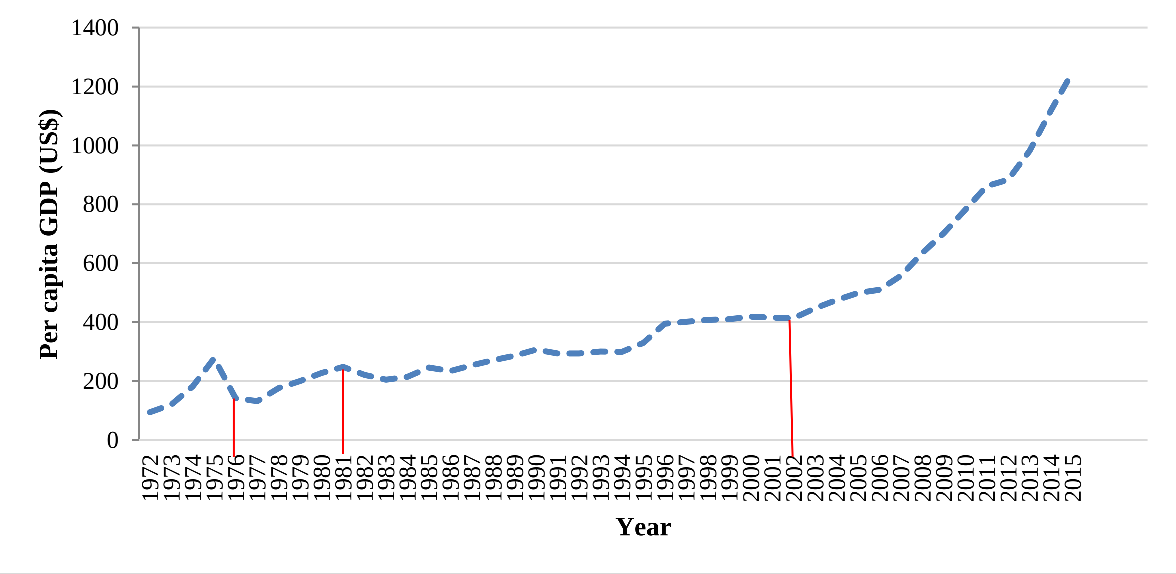
Source: World Development Indicators [6].

The increased share of the ageing population causes an increase in the dependency ratio and the ageing index (which is calculated as the ratio of population of 60+ divided by the population under 15 years). On the other hand, because of falling fertility, the ageing population is increasing, and/ or the ageing index of the population aged 60 years and above will increase more than eleven times the population aged under fifteen years in 2050 [7].

[2] In Bangladesh, the Ministry of Social Welfare has a social security program – the Old Age Monthly Allowance Program. According to the program, minimum eligibility criterion for the program is 65 years for men. Secondly, in Bangladesh, the retirement age in public sector research organizations, including public universities is 65. Although, as of 2019 civil servants retire at the age of 60, of late, the government has been contemplating extending the retirement age to 65.

Since 1972, GDP per capita (in US$) increased very steeply until 1975 with a sudden dip in 1976 due to political turmoil in August 1975 and the subsequent period until 1977 (see Figure 2). With a new government in power, the upward trend was restored and continued rising. Since 2002, there has been a steeper increasing trend in GDP per capita.

Figure 2: Trend of GDP per capita (Current US$) in Bangladesh (1972-2015)

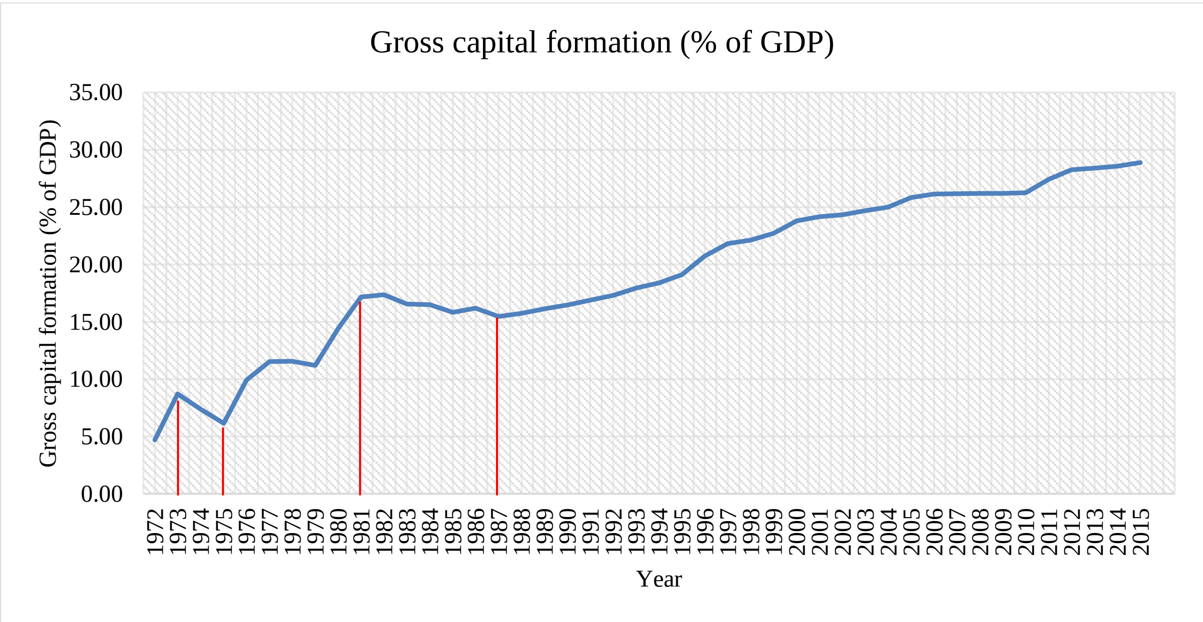


The implications of the increasing ageing population are as follows. The supply of working aged population between 24 and 60 years will decrease. This will cause an adverse effect on the supply of the working age population in Bangladesh unless countervailing initiatives are taken to increase labour productivity to substitute the decreasing supply of labour with other variables. Endogenous growth theory postulates that increasing capital formation, human capital development, and research and development are three variables that contribute to increasing labour productivity. Therefore, in the face of declining labour supply because of an increased ageing population, improving labour productivity can reverse the adverse effect on macroeconomic growth.

The variable gross capital formation (formerly gross domestic investment) consists of outlays in addition to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and essential structures, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." The trend of gross capital formation as a percentage of GDP is presented in Figure 3.

The figure shows that during the years 1972-2015, gross capital formation continued to increase with short-term dips between 1973 and 1975 and 1982 and 1986. Natural disasters like country wide floods during 1973 and 1974, and the assassination of the country's first President and his all family members in August 1975 negatively affected the capital formation. Similarly, in 1981 Bangladesh fell into political and economic crisis again due to the assassination of its second President. The crisis continued until 1986 when the newly elected government resumed its responsibility.

Figure 3: Trend of gross capital formation (% of GDP) in Bangladesh (1972-2015)



Source: http://data.worldbank.org/indicator/

In low-income countries, productive technology and technological expertise have been lacking. Recently, however, these countries have been engaged in technological changes and capital formation. If these are not hindered, current demographic changes in these countries should facilitate economic prosperity [8]. Furthermore, the increase in the retirement age [9] can lead to a transition from traditional production to new human capital oriented production that uses older workers (Elgin & Tumen, 2010). This results in replacement of labour by machines [10].

Review of literature

Empirical studies of the effect of an ageing population on macroeconomic growth are plentiful in developed countries (see Nagarajan, et al., [11] for details). In the context of Organization for Economic Cooperation and Development (OECD) countries, Bloom, et al. [9] predicted declining macroeconomic growth due to an increasing ageing population. In a separate study of OECD and 15 EU countries, Lindh and Malmberg [12] found that an aged population had a significant negative effect on the growth rate of real GDP per capita. Furthermore, in the case of the USA, Maestas, et al. [13] examined the short run relationship between the ageing population and macroeconomic growth and estimated that a 10% increase in the fraction of the population aged 60 years and above decreased per capita GDP by 5.5%. This study concluded that the declining growth could be attributed to the decreasing labour supply associated with an ageing population. Using data for the period of 1951-2001 in Taiwan, Lee and Mason [14] also found that an ageing population had a negative effect of on per capita income of families. The findings of Lisenkova et al. [15] were also similar for Scotland where the authors predicted a negative impact in output productivity for the period 2006-2016. Cardoso et al. [16] conducted a study in Portugal to explore the effect of an ageing population on productivity and wages where OLS, Fixed effect and GMM methodologies were used for the period 1986-2008, and also found a negative effect. The negative effects of ageing population on economic growth have also been confirmed by Wang et al., [17]; Hu et al., [18]; and Sun and Liu [19] for China, and by Loumrhari [20] for Morocco. Bloom, et al [21] examined the effect of an ageing population on economic growth in the selected Asian countries based on panel data. The study showed that the changes in both youth- and old- age shares over a five- year period had a negative effect on growth rate in the short run (five year), and a negative but not significant effect in the long run. The long run effect of the level of the youth - age population share was, however, negative and statistically significant. In another study based on 12 selected economies in Asia (Hong Kong, P. R. China, Republic of Korea, Singapore, India, Taipei, Thailand, Viet Nam, Indonesia, Malaysia, Pakistan and the Philippines) Park and Shine [22] predicted that Asia's growth would decline substantially (which is termed as 'demographic tax') as the region was experiencing an ageing population.

Although the empirical research findings conveyed the negative effects of an ageing population on macroeconomic growth, some studies (e.g. Blake & Mayhew [23]; Cai, [24]; Li et al., [25]) found positive or neutral effects on economic performance. For example, applying Solow's model Li and Zhang [26] examined the ageing effect on the Chinese economy for the period of 1978-2012, and found a positive effect on per capita GDP. Using the Chinese provincial panel data for the period of 1985-2005, Li et al. [25] found a positive effect of an ageing population on savings and investment that would enhance economic growth. The studies of Canari [27] and Borsch-Supan [28] found either weak or positive effects of an ageing population on private saving. Göbel and Zwick [29] conducted a study in the German metal manufacturing and service sectors using data for the period 1997-2005 and employed generalized method of moments (GMM) as an estimation strategy. They found no significant effect of an ageing population of 55-60 years on productivity in these two sectors. The neutral effects were also found by Ours and Stoeldraijer [30] in the Netherlands on the wage and productivity gap of the population aged 57 and above in the Dutch manufacturing sectors. On the other hand, Hajamini (31) examined the effects of population age structure on per capita GDP using 50 years data from 81 countries (both developed and developing) and revealed a linear relationship. He further reported weak and contradictory effects of 'old dependency' ratios on per capita GDP. Uddin et al. (32) investigated the association between the dependency ratio, savings rate and GDP growth in Australia, and indicated a negative association between dependency ratio and GDP growth.

In relation to the negative effect of the ageing population on economic growth it can be argued that the savings rate of the aged people actually decreases as they continuously spend their savings – their only source of spending [33]. Moreover, among other researchers, Hock and Weil [34], Walder and Döring [35] opine that with an increase in the ageing population the overall consumption level of the country falls, which ultimately hampers growth. Lee and Mason [14] and Nagarajan et al. [11] note that consumption falls because per capita income of all people (child, working group and retiree) falls with an increase of elderly population. Since consumption and savings/investment are important components of aggregate demand, growth will be affected with the ageing population. Furthermore, the consumption pattern of households also changes with an increase in the ageing population. As Nagarajan et al. [11] and Walder and Döring [35] noted, a country with high proportion of old people would have more consumption spending on medical care and less consumption spending on education. This has major implications for economic growth.

Economic growth may also be affected via public expenditure [36]. With the increase in the aging population, the government has to spend more on social security and medical systems, compromising the spending on productive sectors. In addition, government income decreases with an increase in the aged population because of low collection of tax revenue. Foreign direct investment is also adversely affected in a country with a high proportion of an aging population ([11]). Davies and Robert III [33] revealed that there were fewer foreign investments in a country with an ageing population because of the scarcity of workers. As a result, a negative effect on production and growth would be the likely outcome [15]. In conclusion, we have demonstrated that, firstly, past studies show inconclusive evidence about the long-run effect of an ageing population on economic growth. Secondly, the effects of an ageing population on growth differ in endogenous and semi-endogenous growth paradigms [8]. Thirdly, to the best of our knowledge, there is an absence of any single country study based on time series data. Therefore, this study is an attempt to fill this gap in the literature that will help to mitigate the current debate on the nexus between growth and the ageing population.

Data

The data used in this study are collected from the World Bank online database - World Development Indicators [6]. In order to consider the time period of the study, we consider a historical event that took place in Bangladesh in 1971. Before the year 1971, Bangladesh was a part of Pakistan, known as East Pakistan. On 25th March, 1971, a war of independence engulfed the region, and continued for nine months. After the end of the war of independence, Bangladesh emerged as an independent state on 16th December 1971. As would be expected, the war and its aftermath were both a political and an economic shock to the region, particularly to Bangladesh. In order to avoid the influence of this unexpected political event and economic shock, we consider the dataset for the period of 1972-2015.

The dependent variable of this study is the annual aggregate per capita GDP.The variable is measured in United States Dollars (US$). The variable was measured in constant price where the base year price was equal to 2010. The explanatory variable, our main variable of interest, is a stock of population aged 65 years and above. We have classified ‘ageing population’ by the population aged 65 years and above, because of the availability of data. The dataset does not contain any data about the stock of population aged 60 years and above. We have converted that stock of population into per capita labour (or aged 65 years and above) in a year by dividing the data by the total population of the corresponding year.

The other control variable used is annual stock of gross capital formation. The variable - annual stock of gross capital formation- is also measured in constant 2010 US$. The variable is used to proxy the stock of physical capital following the study by Ouédraogo (2010). The author argued that the changes in current investment are closely related to the changes of past investment if the rate of depreciation is assumed constant. The variable used in this study is per capita stock of physical capital. We convert the stock of capital formation into per capita capital formation in a year by dividing the data by the total population of the corresponding year. A summary of the statistics of the variables used in this study are presented in Table 1. Next we run a correlation study where a positive correlation between the variables of interest is also observed (lower part of the Table 1)

Table 1: Descriptive statitics and correlation coefficients between the variables of interest

	Y_t	L_t	K_t
Unit	Per capita GDP in US$ (Constant Price 2010 year)	Per capita population ages 65 and above years)	Per capita gross capital formation in US$ (Constant Price 2010 year
Mean	502.39	0.036	96.59
Min	317.78	0.020	4.72
Max	972.88	0.050	282.27
Std. Dev	179.88	0.006	73.45
Y_t	1.00		
L_t	0.95	1.00	
K_t	0.96	0.97	1.00

Preliminary examination of data

Figure 3 presents trend lines of per capita real GDP for the year 1971-2015. It also presents the trend lines of per capita capital formation and per capita population aged 65 years and above between the years 1971 and 2015. The Figure shows that in the year 1971 there is a sudden dip in the log of per capita GDP. From 1972 there is smooth upward trend of the line. The trend lines of the remaining two variables of interest also present an upward direction.

Figure 4 shows that unlike per capita real GDP, per capita population ages 65 years and above has a smooth consistent trend over the years. The movement of the three series seems cointegrated. The cointegration is an issue that will be examined in the remaining parts of the paper. If there is a cointegration, we will separate the short-run effect from the long-run effect in order to predict the effect or performance of macroeconomic variables with respect to a change in per capita ageing population in Bangladesh. However, one notable finding from Figure 4 is that we do not find the existence of (structural) breaks in the series of data after 1971 (i.e. 1972 and onward).

Figure 4: Trend lines of variables under study over the year 1972-2015.

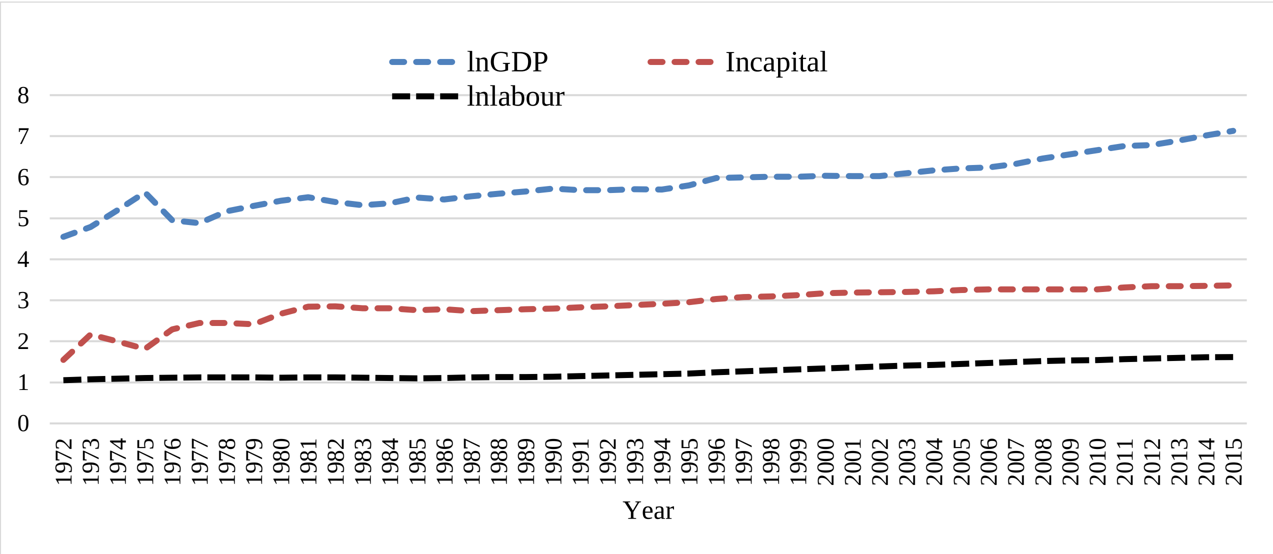
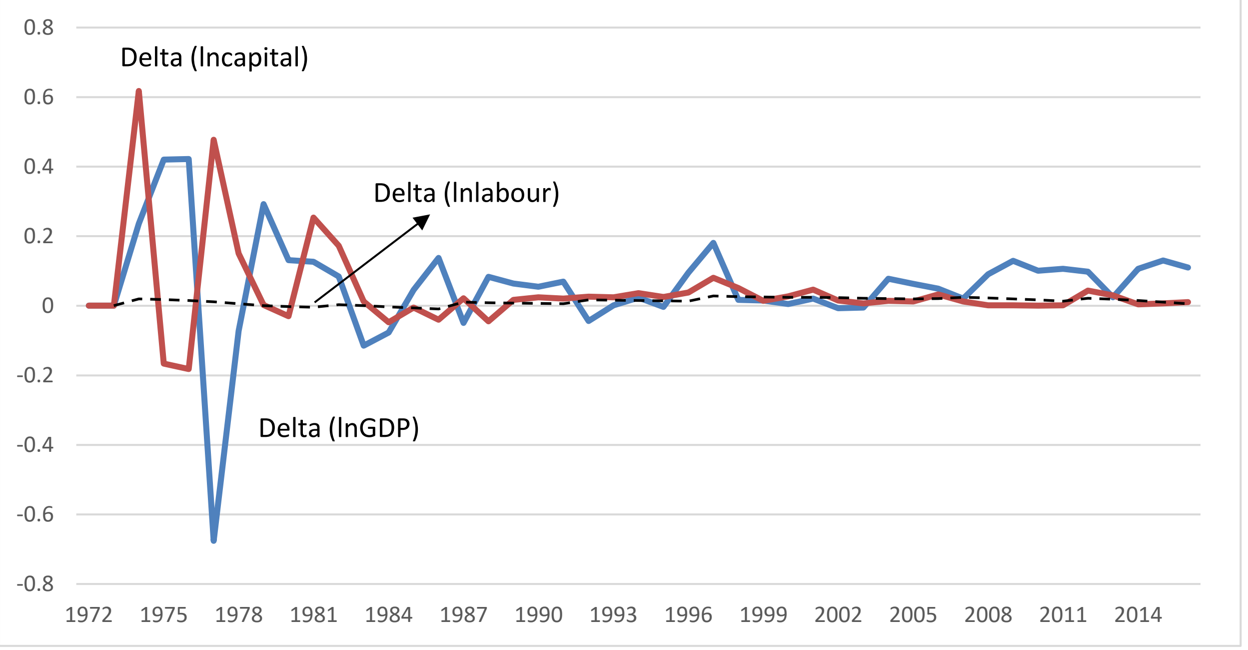


Figure 5 presents the trend lines of the changes of variables of interest. It is observed that while changes in three variables have been almost similar since 1984 onwards, there are wide variations for variables capital and GDP from 1972 to 1984.

Figure 5: Trend lines of the changes of variables of interest during 1972-2015.



Note: Delta means change of explanatory variable

Methods

The theoretical model used in this paper is the endogenous growth model. The model postulates that the rate of change in macroeconomic growth is not attributed to external factors like population growth and / or the change of population age structure; it is attributed to some internal factor(s) that is (are) affected by government policy[3]. Literature shows that there are at least ten determinants of long-run macroeconomic growth, including growth of population and stock of physical capital [37]. Based on only labour (external factor) and capital (internal factor), we can write a generic form of the endogenous growth model as follows:

$$Y = AL^{\beta_0} K^{(1-\beta_0)} \tag{1}$$

[3] In contrast, exogenous growth theory postulates that the presence of long-run growth depends crucially on exogenous technological progress.

Where Y is the gross aggregate output; L is the stock of labour and; K is the aggregate stock of capital. A is the technology factor. We transform all variables into natural logarithms because such a transformation helps us to maintain the normal properties of the dataset and the results are easily interpreted. So, equation (1) becomes (substituting α_0 for A)

$$\ln(Y_t) = \alpha_0 + \beta_0 \ln(L_t) + \beta_1 \ln(K_t) + \varepsilon_t \quad (2)$$

In order to analyse the cointegration between the variables of interest, we consider per capita output growth (Y/P) and per capita labour which consists of population aged 65 years and above (L/P) and per capita capital formation (K/P). Here P denotes total population corresponding to each year. Furthermore, time series data have a trend in the dataset, and to capture the trend in the model, we include a time (t) variable. So Eq (2) becomes

$$\ln(y_t) = \alpha_0 + \beta_0 \ln(l_t) + \beta_1 \ln(k_t) + \beta_2 t_t + \varepsilon_t \quad (3)$$

Where,

$y = (Y/P)$

$l = (L/P)$

$k = (K/P)$

It is shown that if the per capita stock of labour is held constant, growth ultimately comes to a halt because socially very little is invested and produced. If the rates of mortality and fertility remain the same, the size of the population remains the same and ultimately, growth is attributed to per capita stock of capital. In this study, we are interested in the coefficient of β_0.

Integration and cointegration analysis

The starting point of time series analysis is integration analysis of order 0 (zero) or $I(1)$ because of the expectation about a unit root process of the macroeconomic variables. For this purpose, it is necessary to test the unit root properties of all variables used in the model. We chose a model with a trend, no constant and lagged values of difference of the variable.

Literature suggests (see Rahman & Mamun [38], for example) that the Augmented-Dickey–Fuller (ADF) test has been used widely to test the unit root property of time series data. However, in the presence of structural break, the ADF test has been unable to provide reliable results. In the case of one or two unknown structural breaks in the series the Zivot–Andrews [39] (Z_A) test is a better method to test stationarity properties of time series data.

As there is no structural break in data series, we presume the ADF test is valid in this study. This is to note that we have selected the maximum lag length for the unit root tests by using a formula of $(sample-size)^{1/3}$ as suggested by Lütkepohl (1993). After removing the non-stationary property in the series used in the proposed model (equation 3), we conduct a CUSUM (cumulative sum of recursive residuals) test proposed by Brown, Durbin and Evans [40]. The test statistic is as follows.

$$CUSUM_{\tau} = \sum_{\tau=K+1}^{\tau} \hat{u}_t^{(r)} / \hat{\sigma}_u \quad (4)$$

The residuals found by the above equation reveal structural changes and are therefore plotted for $\tau = K+1,....T$ to check a model. If the CUSUM wanders too far from the zero line, this is evidence against the structural stability of the underlying model.

Next, we conduct a cointegration check. In order to check cointegration, various types of procedures are available in the literature. They are classified as a residual-based test such as the Autoregressive Distributive Lag (ARDL) bounds test proposed by Pesaran, Shin and Smith [41]; and a non-residual based test such as the Johensen test [42]. We conduct both tests in order to confirm that the obtained test results are robust for the selection of the testing method. However, the ARDL methodology has an advantage over cointegration techniques which require the underlying series to be both (0) and (1).

The ARDL test procedure involves estimating an unrestricted error correction model with the following generic form, which is as follows:

$$\Delta \ln y_t = \alpha_0 + \sum_{i=1}^{n} b_i \Delta \ln y_{t-1} + \sum_{i=1}^{n} c_i \Delta l_{t-1} + \sum_{i=1}^{n} d_i \Delta \ln k_{t-1} + \gamma_1 \ln y_{t-1} + \gamma_2 l_{t-1} + \gamma_1 \ln k_{t-1} + t_{1,t} \qquad (5)$$

The joint *F*-statistic, or Wald statistic is performed to test the null hypothesis of no cointegration, i.e. $H_0 : \gamma_1 = \gamma_2 = \gamma_3 = 0$, against the alternative hypothesis $H_0 : \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq 0$ Two sets of critical values are reported in the tests. If the calculated *F*-statistic is above the upper limit of the critical value, the null hypothesis of no cointegration is rejected. If the calculated *F*-statistic is below the upper limit of the critical value, the null hypothesis of no cointegration is accepted (not rejected). If the calculated *F*-statistic lies between the upper limit and lower limit of the critical value, a conclusive inference cannot be made. The ARDL test results remain valid irrespective of the order of integration of the explanatory variables.

The Johansen test [42] obtains the number of cointegration equations. This test requires optimum maximum lag selection. The optimum lag selection involves a single-equation setup; and lag selection is based on Akaike Information Criteria (AIC) and the Schwarz Bayesian Criterion (SBC) as suggested the past studies such as those by Rahman and Mamun [38].

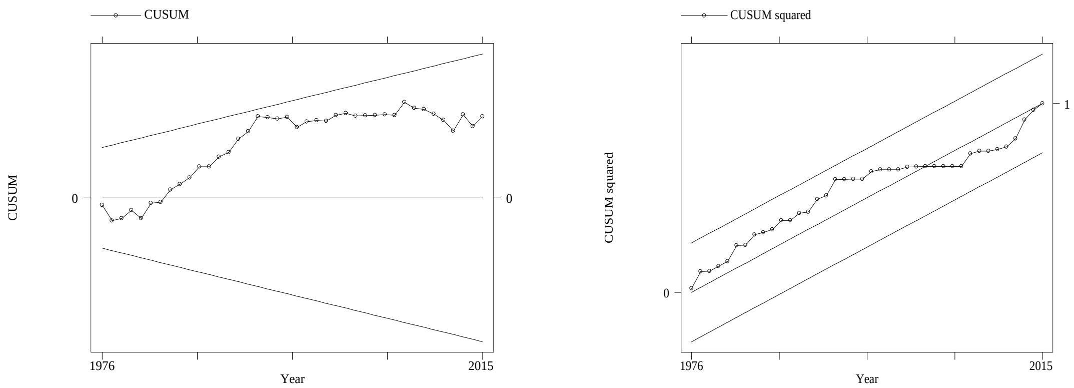
While there is evidence of a cointegration relationship between the variables of interest, the second step involves estimating the models of separate short-run and long-run effects. In the presence of cointegration, the vector error correction model (VECM) offers a strategy to separate a short-run effect from a long-run effect.

Results and Analysis

We start with the unit root test results. From the test results presented in Table 2, we conclude that three variables in the series are nonstationary at level, which is expected. After the first difference, two variables i.e. $\ln y_t$ and $\ln k_t$ in the series become stationary, so the two variables are stationary at order 1 (one) i.e. $I(1)$; and after the second difference one variable, i.e. $\ln l_t$ in the series becomes stationary, so the variable is stationary at order 2 (two), i.e. $I(2)$.

In order to check the stability of the model proposed in equation (4) we estimated the CUSUM statistic and plotted the graphs (Figure 6). The Figure demonstrates that the CUSUM statistic falls inside the critical bounds of 5% level of significance. The test confirms that the model is stable over the period of the study.

Figure 6: CUSUM and CUSUMSQ graphs



Next we check, whether the variables are cointegrated or not. The ARDL bound test results are reported in Table 3. To run the test, we require the maximum number of optimum lag. Table 4 shows that optimum maximum lag selected for the model used in this study is 2. We have run the ARDL test taking optimum lag 2 (two) as per our estimate given in Table 4. The bound test results show that the estimated F-statistic 5.57 is higher than the critical bound (2.45 to 3.63), thus implying that a null hypothesis of no long-run relationship at level can be rejected in favour of the alternative hypothesis. Hence there is a long-run relationship between the log of the dependent variable per capita GDP and the remaining explanatory variables.

Table 2: ADF unit root test results

Series	At level	First differences	Second difference	5% critical value
	t-statistic	t-statistic	t-statistic	
$\ln y_t$	3.043	-4.85**	-	- 2.94
$\ln l_t$	-0.744	-6.34**	-	- 2.94
$\ln k_t$	2.22	-2.06	-6.80**	- 2.94

N.B. ** represents 5% level of significance. MacKinnon approximate p-value is used.

Table 3: ARDL bounds tests for long-run relationship at level; Null hypothesis: no long-run relationship at level.

	$(\ln y \mid \ln l_t, \ln K_t)$	Critical value at 5%		Critical value at 1%	
		I(0)	I(1)	I(0)	I(1)
F-stat	5.57	2.45	3.63	2.01	3.10

N.B. One equation where the dependent variable is $\ln Y_t$ is reported here only because of the objective of this study.

Table 4: Optimum maximum lag selection

Lag	LL	LR	Df	p-value	AIC	HQIC	SBIC
0	218.46				-18.22	-18.22	-18.22
1	238.81	40.70	9	0.00	-18.72	-18.59	-18.36
2	265.45	53.31	9	0.00	-19.51*	-19.24*	-18.79*
3	270.259.56	9.56	9	0.39	-19.32	-18.92	-18.24

N.B. * denotes 1% level of significance.

Table 5: Johansen tests [42] for cointegration

Maximum Rank	Parms	LL	Eigenvalue	Trace Statistics	5% critical value
0	20	521.27	.	46.05	29.68
1	27	551.52	0.74	11.15*	15.41
2	32	568.51	0.53	1.07	3.76
3	35	579.77	0.39		

N.B. * denotes 1% level of significance.

Table 6: Results of short-run and long-run based of error correction model.

Dependent variable: $D.\ln y_t$	Short-run effects				
Error-correction term	$LD.\ln y_t$	$LD_2.\ln l_t$	$LD_1.\ln k_t$		Constant
-0.13	0.911	-1.12	- 0.06**		0.005
(3.36)**	(4.37)**	(1,28)	(1.97)		(1.01)
Long-run effects					
	$\ln y_t$	$\ln l_t$	$\ln k_t$	t	Constant
Cointegration of equation (1)	1	16.53**	0.86**	- 0.08**	- 8.22
		(7.81)	(10.03)	(13.98)	

N.B. One equation where the dependent variable is $\ln Y_t$ is reported only to conserve spaces.*Z-statistics* is given in the parenthesis.

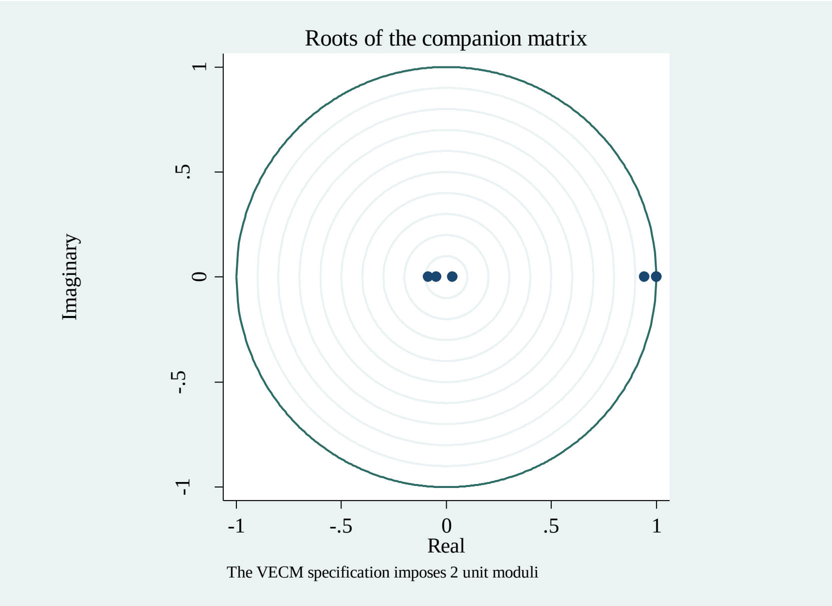
** means statistically significant at 5 % level. L*D* = lag of first-differences.*LD1* = lag of second difference.

We run the Johensen test [42] of cointegration taking the maximum optimum lag of order 2 (two). We provide Johansen test results in Table 5. In this example, because the trace statistic at r = 3 is 1.07, it is less than its critical value of 3.76. We accept the null hypothesis of 1 (one) cointegration (between change of aging population and GDP growth per capita) equation. The Johansen tests for cointegration confirm the ARDL test results too.

Given the findings that ARDL has confirmed the existence of a relationship when *lny* is considered a dependent variable, the causality test is conducted by executing a Vector Error Correction Model (VECM) within the ARDL framework [43]. To conserve space in the paper, we only focus on the relationship between the dependent variable (*lny*) and per capita ageing population (*lnl*). The results are reported in Table 6. We use statistical data analysis software STATA (command –*vec*-) to estimate the VECM. We have determined optimum lag order 2 (two), which is a lag order for the Vector Autoregressive (VAR) model. The order of lag corresponding to VECM is always 1 (one) less than the Vector Autoregressive (VAR) model. Stata command -*vec*- makes this adjustment automatically [44].

The Lagrange-Multiplier testis used to examine the stability of the model. The estimated Chi-square with degrees of freedom 9 is 14.91. The test statistic does not reject the null hypothesis of no autocorrelation at lag order 1 (one). We further check whether we have correctly specified the number of cointegrating equations by the companion matrix of $K = 2$ endogenous variables and $r = 1$ cointegrating equations which had $K\text{-}r\ (2\text{-}1) = 1$ unit eigenvalues. If the process is stable, the moduli of T in the remaining r eigenvalues is strictly less than 1 (one). We present the plot of the remaining eigenvalues in Figure 7. The graph of the eigenvalues shows that none of the eigenvalues falls very close to the unit circle. The stability check does not guarantee that our model is miss-specified.

Figure 7: Stability check of the VEC model.



The results presented in Table 6 show that the coefficient of adjustment is negative, which is less than one and statistically significant at 5% level. These results are according to our expectations. These results confirm the suitability of the model used. The results further show that, in both the short-run and long-run, there is a causal statistically significant (at 5% level) relationship running from the per capita capital to per capita GDP growth; however, in the short-run, the causal relationship is negative and in the long-run the causal relationship is positive and significant.

On the other hand, in the long-run there is a positive causal relationship running from per capita ageing population to per capita GDP growth. The relationship is statistically significant at 5% level. The finding supports the theoretical proposition by Prettner [8] that an increase in longevity has positive effects on per capita output growth empirically. These empirical research findings support the hypothesis that an ageing population is not detrimental to macroeconomic growth in Bangladesh in the long-run. The mechanisms through which the effect can take place are saving behaviour and human capital accumulation of the individuals.

Although we have found a negative effect of the ageing population of economic growth in the short-run, the effect is not statistically significant. Finally, the estimated Eq (3) can be written as follows:-

$$y_t = -8.22 + 16.53 l_t + 0.86 K_t - 0.08t$$

The estimated coefficient of β_0 is positive and equal to 16.53 in the long-run. On the other hand, the estimated effect of β_1 is 0.86. Because of differences in the units of measurements of the two explanatory variables, a direct comparative analysis of the extents of the long-term effects is not possible. In such a case, standardized coefficients are required statistically. To derive standardized comparable coefficients, we divide the values by the respective standard errors. The calculated standardized coefficient on β_0 is 7.82 and β_1 is 10.62. These findings show that in the long-run the extent of effects of per capita capital formation on per capita GDP is relatively higher than the extent of effects of per capita ageing population.

It is noted that our results contradict the results found in OECD/developed countries. The reasons for the negative relationship between ageing population and economic growth as found by Bloom, Canning and Fink (2011) with regard to OECD countries are declining labour force participation rate and diminishing stock of saving and/ or capital. According to the latest OECD data [45], in 2018, labour force participation rate among people 65 and above was on average 15.3% (of the same age group). Countries below the average were France (3.1%), Italy (4.8%), Germany (7.5%), UK (10.6%), Australia (14.0) and the country above the average was USA (19.6%).

In contrast, in Bangladesh, the labour force participation rate among the ageing population is much higher. In 2015, labour force participation rate among people 65 and above was 35.7% (of the same age group population) in rural areas, 28.6% in urban areas and 34.2% in total [46]. The cause behind the high share of ageing people's participation in the labour market might be attributed to the strong presence of the informal sector in the economy. According to BBS [46], the share of the informal sector in the economy is 86.2% where there is no legal bar for retirement. As the informal sector is usually labour intensive; there is the possibility that one can work as long as one desires to do.

Conclusions and Discussion

The major finding of this research is that there is a long-run positive relationship between ageing population and per capita GDP growth in Bangladesh; and the relationship is statistically significant at 5% level. The result provides empirical support in favour of the theoretical proposition by Prettner [8] that an ageing population does not necessarily adversely affects macroeconomic growth in the low-income countries as it does in the developed countries. The results also align with the results found by the recent empirical studies such as those of Li et al. [25] and Li and Zhang [26]. However, our finding is in stark contrast with the results found by the empirical studies conducted by Lee et al. [47], Park and Shine [22], and Van and Volkerink [48]. Our research evidence supports the hypothesis that an ageing population, in fact, fosters the long-term economic growth in Bangladesh.

Therefore, the popular theoretical proposition – that there will be decreasing growth with ageing population - does not hold true for a low-income country like Bangladesh. This differential finding may be due to the fact that our study has used data and econometric techniques that are different from the past studies. For instance, in our study we have used an endogenous growth model where capital formation is used as an explanatory variable. The increasing capital formation may accelerate labour productivity of the working age population and substitute the decreasing economic contribution of the ageing population.

In Bangladesh, the family is the basic source of care for the elderly population. In the traditional joint and /or extended family system, elderly people are accustomed to enjoying support, respect and an honourable life. Although, the scenario is now changing, the majority of people still live in a joint and/or extended family. In addition, government support (such as old age allowances) for the elderly is not huge. Therefore, with the increasing ageing population, government expenditure is unlikely to increase significantly. Hence, an ageing population is unlikely to impact on macroeconomic growth adversely.

From the policy perspective, the results indicate that fiscal policy measures will not be in crisis in Bangladesh if the ageing population increases. However, importance can be placed on investment policy. Investment policy should be such that the current rate of capital formation would be accelerated in the long-run. Fiscal measure(s) encompassing social welfare policies should be expanded adequately to cover the majority of the ageing population so that they can maintain a poverty-free healthy life-style. Appropriate policies should be put into place to build a productive labour force via more education and training where aged people can be considered as talented resources to work for a longer period of time, which will enable the Bangladesh government to increase the retirement age.

The main contribution of this research is that we have initiated and explored the relationship between an ageing population and economic growth in Bangladesh, an emerging country of South Asia, for the first time and found an interesting impact of the ageing population on economic growth contrary to the conventional findings. Our findings can be used as a reference point to carry out further research in this area in the South Asian region and beyond.

A notable point of this study is that we have used a bi-variate growth model, including capital formation as a proxy variable only due to lack of data on human capital formation. It would be more useful to extend the endogenous growth model by including human capital formation and thereafter to examine the issue in the context of low-income countries (e.g. other South Asian countries). This will remain an avenue for further research in the future.

Declaration of Competing Interest

The authors confirm that they do not have any conflict of interest that needs to be declared.

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