

Ageing population and economic growth nexus in Bangladesh: Evidence from an endogenous growth model

Shamsul Arifeen Khan Mamun¹

Mohammad Mafizur Rahman^{2†}

Rasheda Khanam³

Abstract:

This paper examines short-run and long-run relationship between ageing population and economic growth in Bangladesh using time series data for the period of 1972-2015. We employ bivariate endogenous growth model, ARDL bounds test and Johansen test to investigate the relationship between the population aged 65 years and above, and per capita gross domestic product (GDP). The study has found that there is a long-run positive relationship between the aging population and per capita real GDP. The relationship runs from aging population to per capita real GDP, given that, there is an increasing capital formation process in the economy. Therefore, 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.

¹ American International University - Bangladesh & Higher Education Quality Enhancement Project, Ministry of Education, Government of Bangladesh. Email: sakmamun@aiub.edu

² School of commerce, University of Southern Queensland, Australia. Email: mafiz.rahman@usq.edu.au

³ School of commerce, University of Southern Queensland, Australia. Email: rasheda.khanam@usq.edu.au

† Corresponding author.

1. Introduction

Ageing population is growing worldwide because of increasing longevity and decreasing mortality and fertility rates (Harper & Leeson, 2009). It has been estimated that by the year 2050 approximately two billion people will be aged 60 years and over globally, and 400 million people will be aged 80 years and over (United Nations, Department of Economic and Social Affairs, Population Division, 2013). Theoretically, this demographic change makes three types of effects on macroeconomic growth in an economy - positive, negative, and neutral effect (Bloom et al., 2003). Recently, the literature highlights the opportunity for economic growth ascribed to demographic changes - demographic dividend through three mechanisms: labour supply, savings and human capital (please see Bloom et al., 2003 for details). To the best of our knowledge, no study has investigated the relationship between aging population and macroeconomic growth in the South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Pakistan, and Nepal, Sri Lanka and Maldives), although the United Nations (2009) 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 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 increasing aging population, the time series analysis of the relationship between aging population and per capita GDP should be an interesting research agenda for a developing country like Bangladesh. This paper examines the short-run and long-run relationship between aging population and per capita GDP in Bangladesh based on endogenous growth model and time series data.

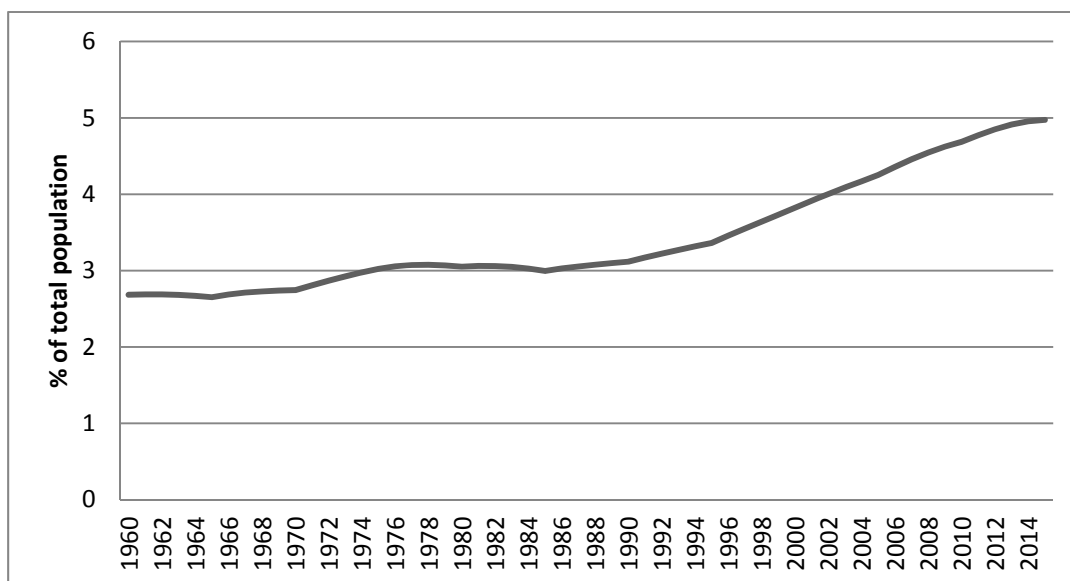
The remaining parts of the paper are structured in the following ways. Section 2 highlights the ageing population and capital formation in Bangladesh; section 3 reviews the

past literature; section 4 describes the data; section 5 explains the methodology, and section 6 presents and analyses the results. Finally, conclusion is presented in section 7.

2. Ageing population & capital formation in Bangladesh

In the South Asian region, Bangladesh is largely enclosed by Indian and Myanmar (Burma) border. It is the seventh largest (with a population of 152.51 millions in 2011) and one of the most densely populated countries (1015 persons per sq. km) in the world. The country has started to experience an emerging issue of population ageing in its highly vulnerable population and development context (BBS, 2011). United Nation defines the cut off point for the older aged population is 60 years of age; however, in the developed countries, where life expectancy rate is very high, the cut off point for the older population is 65 years (WHO, 2016). It is observable that the percentage of population of aged 65 and above of the total population has been increasing since 1960 in Bangladesh (Fig 1). After 1990, the line shows a relatively a steeper trend.

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



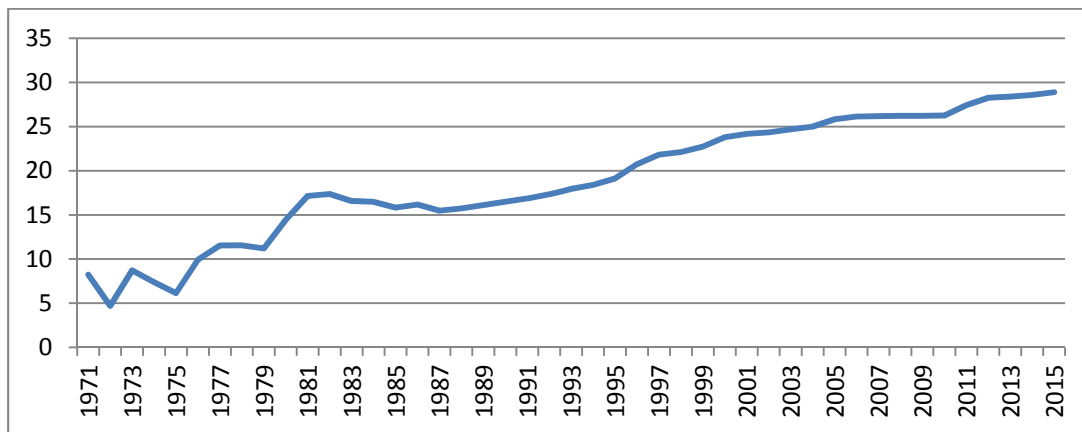
Source: World Development Indicators, 2017.

The increased share of ageing population causes an increase in the dependency ratio and the ageing index (which is calculated as the ratio of population 60+ divided by the population under 15 years); on the other hand, because of the falling fertility ageing population is increasing, and the ageing index of population aged 60 years and above will increase more than eleven times than the population aged under fifteen years in 2050 (Kabir et al., 2013).

The implications of the increasing ageing population are as follows. The supply of working aged population between 24 and 60 years old will decrease. This causes an adverse effect on the supply of working age population in Bangladesh unless countervailing initiatives to increase labour productivity are not taken timely to substitute the decreasing supply of labour. Endogenous growth theory postulates that increasing capital formation, human capital development, and research and development are three variables that contribute to the increasing labour productivity. Therefore, in the face of declining labour supply, an increasing labour productivity can revoke the adverse effect on macroeconomic growth, although aging population is increasing.

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 the like, 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." Trend of gross capital formation in Bangladesh is presented in Fig 2. The figure shows that over the years between 1971-2015 gross capital formation remains increasing with a short-term dip between 1981 and 1986.

Figure 2: Trend of gross capital formation (% of GDP) in Bangladesh (1971-2015)



Source:

<http://data.worldbank.org/indicator/NE.GDI.TOTL.ZS?end=2015&locations=BD&start=1960&view=chart>

In the low-income countries, productive technology and the technological know-how were very primitive. Recently, these countries have been engaged in technological changes and capital formation. If the capital formation and technological changes are not hampered, current demographic changes in these countries would not hamper economic prosperity (Prettner, 2013). Further argument is that, with the ageing population retirement age is increased (Bloom et al., 2010), as a result a switch is made from traditional production to new human capital oriented production that uses old aged workers (Elgin & Tumen, 2010). This results in replacement of labour by machines (Elgin & Tumen, 2012).

3. Review of literature

Empirical studies of the effect of ageing population on macroeconomic growth are voluminous in the developed countries (see Nagarajan, et al., 2016 for detail). In the context of OECD (Organization of Economic Cooperation and Development) countries, Bloom, et al. (2010) projected declining macroeconomic growth due to increasing ageing population. In a separate study on OECD and 15 EU countries, Lindh and Malmberg (2009) found a significant negative

effect of aged population on the growth rate of real GDP per capita. Furthermore, in the case of the USA, Maestas, et al. (2016) examined the short run relationship between the ageing population and macroeconomic growth and estimate that a 10% increase in the fraction of the population ages 60 years and above decreases per capita gross domestic product (GDP) by 5.5%. This study concluded that the declining growth has been attributed to the decreasing labour supply associated with ageing population. Using data for the period of 1951-2001 in Taiwan, Lee and Mason (2007) also found a negative effect of ageing population on per capita income of families. The findings of Lisenkova et al., (2012) were also similar for Scotland where the authors predict negative impact in output productivity for the period of 2006-2106. Cardoso et al. (2011) conducted a study in Portugal to explore the effect of ageing population on productivity and wage where OLS, Fixed effect and GMM methodologies were used for the period of 1986-2008, and found a negative effect as well. The negative effects of ageing population on economic growth have also been confirmed by Wang et al., (2004); Hu et al., (2012); and Sun and Liu (2014) for China, and by Loumrhari (2014) for Morocco. Bloom, Canning, and Finlay, (2010) examined the effect of 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 have a negative effect on growth rate in the short run (five year), 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 the Asia (Hong Kong, P. R. China, Republic of Korea, Singapore, India, Taipei, Thailand, Viet Nam, Indonesia, Malaysia, Pakistan and the Philippines) Park and Shine (2012) predicted that Asia's growth will decline substantially as the region is experiencing with ageing population.

Although the foregone empirical research findings conveyed negative effects of ageing population on macroeconomic growth, some studies (e.g. Blake & Mayhew 2006; Cai, 2010;

Li et al., 2012) found positive or neutral effect on economic performance. For example, applying Solow model Li and Zhang (2015) examined the ageing effect on the Chinese economy for the period of 1978-2012, and found a positive effect on per capita income. Using the Chinese provincial panel data for the period of 1985-2005, Li et al. (2012) found a positive effect of ageing population on savings and investment that would enhance economic growth. The studies of Canari (1994) and Borsch-Supan (1996) also found either weak or positive effect of ageing population on private saving. Göbel and Zwick (2012) conducted a study in German metal manufacturing and service sectors where they used data for the period of 1997-2005 and employed generalized method of moments (GMM) as an estimation strategy; They found no significant effect of ageing population ages 55-60 on productivity in these two sectors. The neutral effects were also found by Ours and Stoeldraijer (2011) in the Netherlands on wage productivity gap of the population aged 57 and above.

In relation to the negative effect of the ageing population on economic growth it is argued that savings rate of the aged people actually decreases as they continuously spend their savings-only source of spending (Davies and Robert III, 2006). Moreover, Hock and Weil (2012), Walder and Döring (2012) and others opined that with the increase of ageing population overall consumption level of the country falls which ultimately hampers growth. Lee and Mason (2007) and Nagarajan et al (2016) noted 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 is also changed with the increase of ageing population. As Nagarajan et al. (2015 and 2016) and Walder and Döring (2012) noted, a country with high proportion of old people will have more consumption spending on medical care and less consumption spending on education. This has implication for economic growth as well.

Economic growth may also be affected via public expenditure (Meijer et al., 2013). With the increased aged population, the government has to spend more on social security and medical system compromising the spending on education and other productive sectors. In addition, the government income decreases with an increase of aged population because of low collection of tax revenue. Foreign direct investment is also adversely affected in a country with a high proportion of aged population (Nagarajan et al., 2016). Davies and Robert III (2006) revealed that foreign investments do not go in a country of ageing population because of scarcity of workers. As a result, a negative effect on production and growth is the likely outcome (Lisenkova et al., 2012). In conclusion, we find that, the past literature show an inconclusive evidence about the long-run effect of aging population on economic growth. Secondly, the effect of aging population on growth differ from each other in endogenous and semi-endogenous growth paradigm (Prettner, 2013). Thirdly, to the best of our knowledge, any single country study based on time series data is absent. Therefore, this study is an attempt to fill up this gap in the literature which will help to mitigate the current debate on growth-ageing population nexus.

4. Data

The data used in this study are collected from the World Bank online database - World Development Indicators (World Bank, 2017). 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, and it was known as East Pakistan. On 25th March, 1971, an outbreak of war of independence engulfs the region, and the war continued for nine months. After the end of the war of independence, Bangladesh was emerged as an independent state on 16th December 1971. The political event made an economic shock to the region, particularly to

Bangladesh substantially. In order to avoid the influence of the unexpected political event and economic shock, we consider dataset for the period of 1972-2015.

The dependent variable of this study is annual aggregate per capita GDP. The variable is measured in United States Dollar (US\$). The variable was measured in constant price where the base year price was equal to 2010. The variable was available in the dataset. The explanatory variable, our main variable of interest, used in this study is stock of population ages 65 years and above. We have classified ageing population by the population ages 65 years and above, because of the availability of data. The dataset does not contain any data about the stock of population ages 60 years and above. We convert the stock of population ages 65 years and above into per capita labour (or ages 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- was measured in constant 2010 US\$ too. The variable is used to proxy the stock of physical capital following the past study by Ouédraogo (2010). The author argued that the changes in current investment were closely related to the changes of past investment if the rate of depreciation was 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 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 statistics 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

4.1. Preliminary examination of data

Figure 2 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 ages 65 years and above between the years 1971 and 2015. The Figure shows that in the year 1971 there is 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 present an upward direction too.

Figure 2 presents that unlike per capita real GDP, per capita population ages 65 years and above has a very smooth consistent trend over the years. The movement of the three series

seems co-integrated. 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 variable with respect to a change in per capita ageing population in Bangladesh. However, one notable finding from the figure 3 is that we do not find the existence of (structural) break in the series of data after 1971 (i.e 1972 and onward).

Figure 3: Trend lines of variables under study over the year 1972-2015.

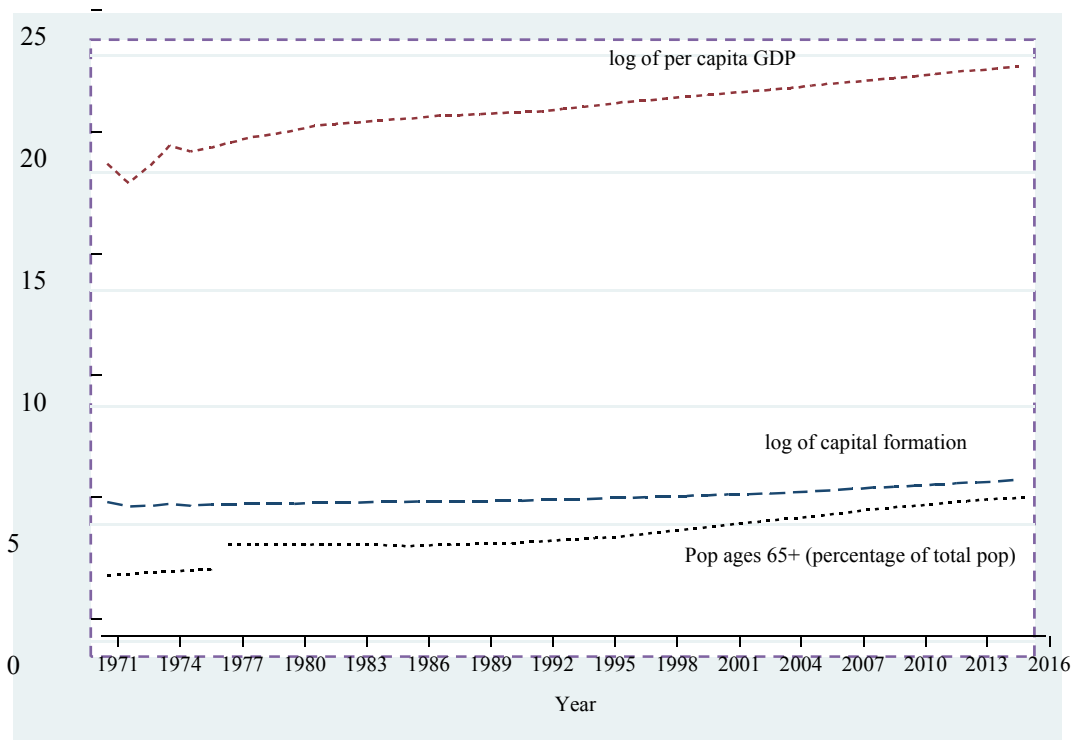
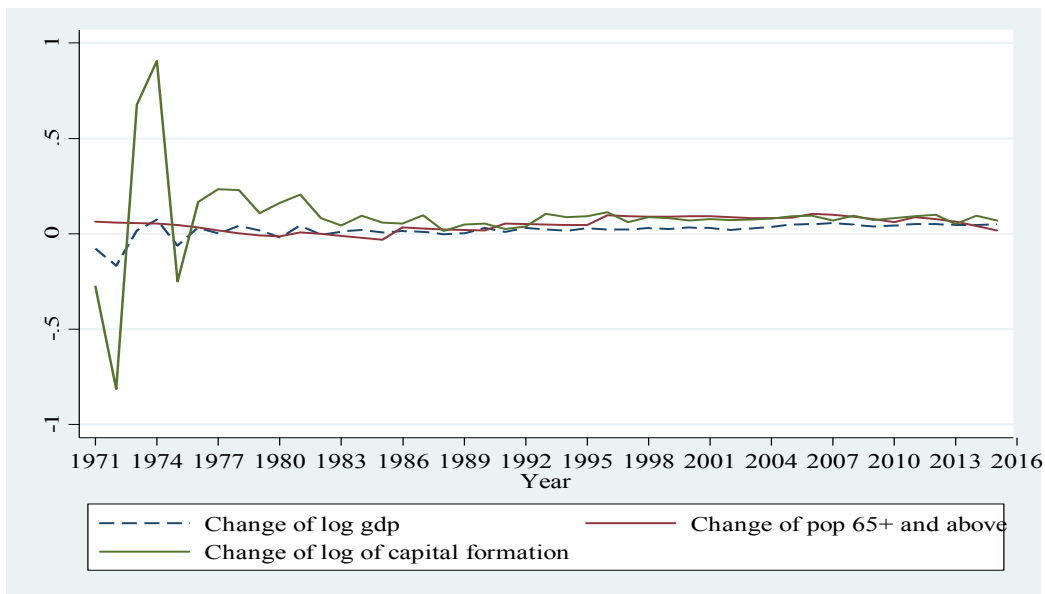


Figure 4: Trend lines of the changes of variables of interest during 1971-2015.



5. Methodology

The theoretical model used in this paper is Endogenous growth model. The model postulates that the rate of change in macroeconomic growth is not attributed to external factor 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 policy⁴. Literature show that there exists at least ten determinants of long-run macroeconomic growth, including growth of population and stock of physical capital (Jones, 1995). Based on only labour (external factor) and capital (internal factor), we can write a generic form of the endogenous growth model as follow:

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

⁴ 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 logarithm because such transformation helps us to maintain normality properties of the dataset. It is easy to interpret the results too. 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 is consisted of population of ages 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 has a trend in the dataset, and to capture the trend in the model, we include a time (t) variable. So the Eq (2) becomes

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

Where,

$$y = (Y / P)$$

$$l = (L / P)$$

$$k = (K / P)$$

It is showed that if per capita stock of labour is held constant, growth ultimately comes to a halt because socially very little is invested and produced. If the rate of mortality and fertility remain the same, the size of 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 .

5.1. 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 choose a model with a trend, no constant and lagged values of difference of the variable.

As literature suggest (see Rahman & Mamun, 2016 for example) that 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 has been unable to provide reliable results. In case of one or two unknown structural breaks in the series Zivot–Andrews (1992) (Z_A) was a better method to test stationarity properties of time series data.

As there is not structural break in data series, we presume ADF test is a very 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 (1975). The test statistic is as follows.

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

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

Next, we conduct cointegration check. In order to check cointegration, various types of procedures are available in the literature. They are classified as residual-based test such as

Autoregressive Distributive Lag (ARDL) bounds test proposed by Pesaran, Shin and Smith (2001); and non-residual based test such as Johansen test (Johansen, 1991). We conduct both tests in order to confirm that the test results found are robust to the selection of 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:

$$\Delta \ln y_t = \alpha_0 + \sum_{i=1}^n b_i \Delta \ln y_{t-1} + \sum_{i=1}^n c_i \Delta l_{t-1} + \sum_{i=1}^n d_i \Delta \ln k_{t-1} + \gamma_1 \ln y_{t-1} + \gamma_2 l_{t-1} + \gamma_3 \ln k_{t-1} + t_{1,t} \quad (5)$$

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 $H_1 : \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq 0$. 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 remains valid irrespective of the order of integration of the explanatory variables.

Johansen test (1991) finds out 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 Schwarz Bayesian Criterion (SBC) as suggested by the past studies such as Rahman and Mamun (2016).

While there is evidence of cointegration relationship between the variables of interest, the second step involves estimating the models of separate short-run and long-run effects. In

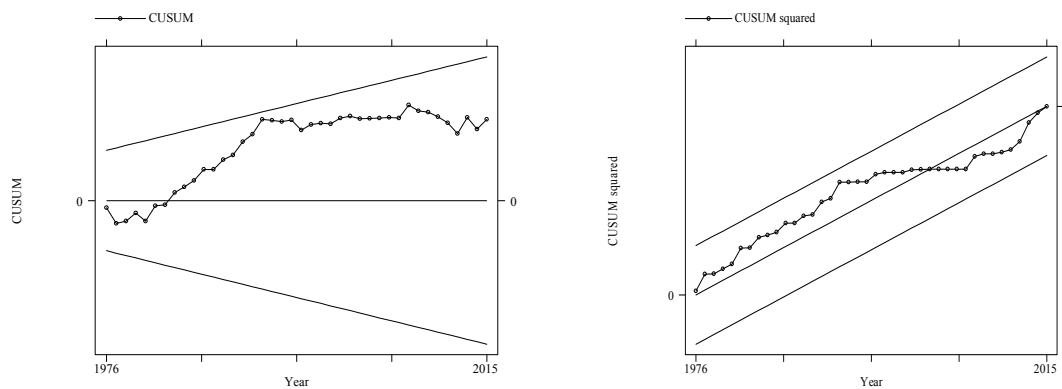
the presence of cointegration, the vector error correction model (VECM) offers a strategy to separate a short-run effect from a long-run effect.

6. 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 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 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 CUSUM statistic and plotted the graphs (Figure 5). The Figure presents 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 5: CUSUM and CUSUMSQ graphs



Next we check, whether the variables are cointegrated or not. ARDL bound test results are reported in Table 3. To run the test, we require the maximum number of optimum lag. The

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 that 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
	<i>t</i> -statistic	<i>t</i> -statistic	<i>t</i> -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.

	$(\ln y \ln l_t, \ln K_t)$	Critical value at 5%		Critical value at 1%	
		I(0)	I(1)	I(0)	I(1)
<i>F</i> -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	<i>p</i> -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 (1991) 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				Constant
Error-correction term	$LD.\ln y_t$	$LD_2.\ln l_t$	$LD_1.\ln k_t$		
-0.13	0.911	-1.12	- 0.06**		0.005
(3.36)**	(4.37)**	(1,28)	(1.97)		(1.01)
Long-run effects					
Cointegration of equation (1)	$\ln y_t$	$\ln l_t$	$\ln k_t$	t	Constant
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. *LD* = lag of first-differences. *LDI* = lag of second difference.

We run Johansen test (Johansen, 1991) of cointegration taking maximum optimum lag of order 2 (two). We provide Johansen tests results in Table 5. In this example, because the trace statistic at $r = 3$ is 1.07, which is less than its critical value of 3.76. We accept the null hypothesis of 1 (one) cointegration equation. The Johansen tests for cointegration confirm ARDL test results too.

Given the findings that ARDL has confirmed the existence of relationship when *lny* is considered dependent variable, the causality test is conducted by executing a Vector Error Correction Model (VECM) within the ARDL framework (Ouédraogo, 2010). To conserve space in the paper, we only focus on the relationship between the dependent variable (*lny*) and per capita ageing population (*I*). 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 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 (Baum, 2005).

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 as per our expectation. 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 Prettnner (2013) that increases in longevity have positive effects on per capita output growth empirically. These empirical research findings support that ageing population is not a 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 negative effect of 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:-

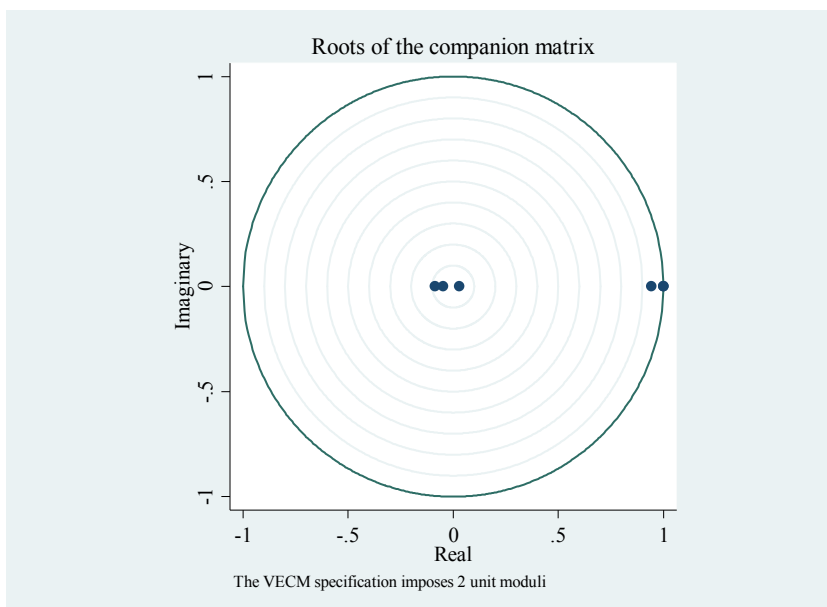
$$y_t = -8.22 + 16.53I_t + 0.86K_t - 0.08$$

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 coefficients 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.

Now we run the Lagrange-Multiplier test 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).

Now we check whether we have correctly specified the number of cointegrating equation by the companion matrix of $K = 2$ endogenous variables and $r = 1$ cointegrating equations had $K-r (2-1) = 1$ unit eigenvalues. If the process is stable, the moduli of T in the remaining r eigenvalues strictly less than 1 (one). We present the plot of the remaining eigenvalues in Figure 5. 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 misspecified.

Figure 6: Stability check of the VEC model.



7. Conclusion 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 theoretical proposition by Prettnner (2013 that aging population not necessarily adversely affect macroeconomic growth in the low-income countries as it is found in the developed countries.

The results are also aligned with the results found by the recent empirical studies such as Li et al. (2012) and Li and Zhang (2015). However, our finding is stark contrast with the results found by the empirical studies conducted by Braun et al (2009), Bloom et al. (2011), Lee et al. (2011), Park and Shine (2012), Van Ewijk and Volkerink (2012), and Thiébaut et al. (2013). Our research evidence supports that aging population, in fact, fosters the long-term economic growth in Bangladesh.

Therefore, the popular theoretical proposition - there will be a decreasing growth with ageing population - does not hold true for a low-income country, Bangladesh. This differential finding may be due to the fact that our study has used data and econometric technique that are different from the past studies. For instance, in our study we have used 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 family is the basic source of care for the elderly population. In traditional joint and /or extended family system, elderly people used to enjoy support, respectable and honourable life. Although, the scenario is now changing, majority people still live in joint and/or extended family. In addition, government's support (such as old age allowances) for the elderly is not huge. Therefore, with the increasing aging population, the government expenditure is less likely to increase significantly. Hence, aging population is less likely to impact macroeconomic growth adversely.

From the policy perspective, the results indicate that fiscal policy measure will not be in crisis in Bangladesh if aging population increases. However, there is an importance of investment policy. Investment policy should be such that the current rate of capital formation be accelerated in the long-run. Fiscal measure(s) encompassing social welfare policies should

be expanded adequately to cover majority of the ageing population, so that they can maintain a poverty-free healthy life-style. Appropriate policies should be taken to build a productive labour force via more education and training where aged people can be considered as talented resources to work for longer period of time which will enable the Bangladesh government to increase the retirement age.

A notable covet of this study is, 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 the low-income countries. This will remain an avenue for further research in the future.

References:

- Bangladesh Bureau of Statistics (BBS) (2011). *Population & Housing Census Report 2011: Socioeconomic and demographic report*. Ministry of Planning. Government of Bangladesh.
- Baum, C. F (2005). Stata : The language of choice for time-series analysis? *The Stata Journal*, 5 (1), 46-63.
- Blake, D. and Mayhew, L. (2006). System in the light of population ageing and declining fertility. *The Economic Journal*, 116, 286-305.
- Bloom, D. E., Canning, D., and Finlay, J. E. (2010). Population ageing and economic growth in Asia. In Ito, T. and Rose, A, K. (Eds.). *The Economic Consequences of Demographic Change in East Asia*, (pp. 61-89). UDSA: The University of Chicago Press.
- Bloom, D. E., Canning, D. and Fink, G. (2010). Implications of population ageing for economic growth. *Oxford Review of Economic Policy*, 26 (4), 583–612.

- Bloom, D. E., Börsch-Supan A., McGee, P. and Seike, A. (2011). Population aging: Facts, challenges, and responses, PGDA Working Paper No. 71. Retrieved from https://www.hsph.harvard.edu/program-on-the-global-demography-of-aging/WorkingPapers/2011/PGDA_WP_71.pdf
- Bloom, D.E., Canning, D., and Sevilla, J. (2003). *The demographic dividend: A new perspective on the economic consequences of population change*. A RAND program of Policy Relevant Research Communication. Retrieved from https://www.rand.org/content/dam/rand/pubs/monograph_reports/2007/MR1274.pdf
- Borsch-Supan, A. (1996). The Impact of Population Aging on Savings, Investment and Growth in the OECD Area. Future Global Capital Shortages: Real Threat or Pure Fiction?.
- Brendan, L. R., & Sek, S. K. (2016). The relationship between population ageing and the economic growth in Asia. In S. Salleh, N. A. Aris, A. Bahar, Z. M. Zainuddin, N. Maan, M. H. Lee, & Y. M. Yusof (Eds.), *AIP Conference Proceedings* (Vol. 1750, No. 1, p. 060009). AIP Publishing
- Brown, R. L., Durbin, J. and Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society*, 37, 149– 192.
- Cai, F., (2010). Demographic transition, demographic dividend and lewis turning point in China. *China Economic Journal*, 3(2), 107-119.
- Canari, L. (1994). Do Demographic Changes Explain the Decline in the Saving Rate of Italian Households? In A. Ando, L. Guiso, & I. Visco (Eds.), *Saving and the Accumulation of Wealth*. Cambridge University Press. <http://dx.doi.org/10.1017/CBO9780511664557.005>
- Cardoso, A.R., Guimarães, P. and Varejão, J. (2011). Are older workers worthy of their pay? An empirical investigation of age-productivity and age-wage nexuses. *De Economist*, 159, 95-111.

- Davies, R.B. and Robert III, R.R. (2006). Population aging, foreign direct investment, and tax competition. Retrieved from http://www.sbs.ox.ac.uk/sites/default/files/Business_Taxation/Docs/Publications/Working_Papers/Series_07/WP0710.pdf
- Elgin, C. and Tumen, S. (2010). Can sustained economic growth and declining population coexist? Barro-Becker children meet Lucas. *Economic Modelling*, 29, 1899-1908.
- Göbel, C. and Zwick, T. (2012). Age and productivity: sector differences. *De Economist*, 160, 35-57.
- Harper, S. and Leeson, G. (2009). Introducing the journal of population ageing. *Journal of Population Ageing*, 1, 1-5.
- Hock, H. and Weil, D.N. (2012). On the dynamics of the age structure, dependency and consumption. *Journal of Population Economics*, 25, 1019-1043.
- Hu, A., Liu, S., & Ma, Z. (2012). Population aging, population increase and economic growth-empirical evidence from Chinese provincial panel data. *Population Research*, 5, 14-26.
- Jones, C.I. (1995). Time series tests of endogenous growth models. *The Quarterly Journal of Economics*, 10 (2), 495-525.
- Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review*, 2, 163–172.
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12 (2–3), 231–254.
- Johansen, S. (1991) Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, 1551–1580.
- Kabir, R., Khan, H., Kabir, M., and Rahman, M. T. (2013). Population ageing in Bangladesh and its implication on health care. *European Scientific Journal*, 9(33), 34-47.

- Kelley, A. C., and R. M. Schmidt. 2005. Evolution of recent economic- demographic modeling: A synthesis. *Journal of Population Economics* 18: 275– 300.
- Lee, H. S., Mason, A. and Park, D. (2011). Why does population aging matter so much for Asia? Population aging, economic security and economic growth in Asia. *ERIA Discussion Paper Series*, ERIA-DP-2011-04.
- Lee, S.H. and Mason, A. (2007). Who gains from the demographic dividend? Forecasting income by age. *International Journal Forecast*, 23, 603-619
- Lindh, T. and Malmberg, B. (2009). European union economic growth and the age structure of the population. *Economic Change and Restructuring*, 42, 159-187.
- Lisenkova, K., Mérette, M. and Wright, R. (2012). Population ageing and the labour market: modelling size and age-specific effects. *Economic Modelling*, 35, 981-989.
- Li, X., Li, Z. and Chan, M. W. L. (2012). Demographic change, savings, investment and economic growth, a case from China. *The Chinese Economy*, 45(2), 5 – 20.
- Li, H. and Zhang, X. (2015) Population ageing and economic growth: The Chinese experience of Solow model. *International Journal of Economics and Finance*, 7, (3), 199-206.
- Loumrhari, G. (2014). Ageing, longevity and savings: The case of Morocco. *International Journal of Economics and Financial Issues*, 2, 344-352.
- Lütkepohl, H. (1993). *Introduction to multiple time series analysis*. Springer, Netherland.
- Maestas, N., Mullen, K., & Powell, D. (2016). The effect of Population Ageing on economic Growth, the Labor Force and Productivity. *RAND Working paper*, WR-1063-1. Available at: http://www.rand.org/pubs/working_papers/WR1063-1.html
- Mason, A. and Lee, R. (2013). Labor and consumption across the lifecycle. *The Journal of the Economics of Ageing*, 1-2, 16-27.
- Meijer, C., et al. (2013). The effect of population aging on health expenditure growth: a critical review. *European Journal of Ageing*, 10, 353-361.

- Nagarajan, R., Teixeira, A. A., & Silva, S. (2016). The impact of population ageing on economic growth: An exploratory review of the main mechanisms. Available at: <http://wps.fep.up.pt/wps/wp504.pdf>
- Navaneetham, K. & Dharmalingam, A. (2012). A review of age structural transition and demographic dividend in South Asia: opportunities and challenges. *Journal of Population Ageing*, 5, 281-298.
- Ouédraogo, I. M. (2010). Electricity consumption and economic growth in Burkina Faso: A cointegration analysis. *Energy Economics*, 32(3), 524-531.
- Ours, J.C.V. and Stoeldraijer, L. (2011). Age, wage and productivity in Dutch manufacturing. *De Economist*, 159, 113-137.
- Park, D. & Shine, K. (2012). Impact of population ageing on Aisa's future growth. In Park, D., Lee, S.-H., and Manson, A., (Eds.). *Ageing, economic growth, and old-age dependency security in Aisa* (pp.:83-202). USA: Edward Elgar
- Prettner, K. (2013). Population ageing and endogenous economic growth. *Journal of Population Economics*, 26 (2), 811-834.
- Pesaran, M.H., Shin, Y. and Simth, R. (2001) Bound testing approaches to the analysis of level relationships. *Journal of Applied Economics*, 16, 289-326.
- Rahman, M. M. & Mamun, S.A. K. (2016) Energy use, international trade and economic growth nexus in Australia: New evidence from an extended growth model. *Renewable and Sustainable Energy Review*, 64, 806-816.
- Sun, A., & Liu, S. (2014). Analysis of economic growth effect caused by population structural transition. *Population & Economics*, 1, 37-46.
- Thiébaud, S.P., Barnay, T. & Ventelou, B. (2013). Ageing, chronic conditions and the evolution of future drugs expenditure: a five-year micro-simulation from 2004 to 2029. *Applied Economics*, 45, 1663-1672.

- United Nations (2013). *World Population Ageing*. United Nations Department of Economic and Social Affairs, Population Division, The United Nations.
- Van Ewijk, C and M Volkerink (2012). Will ageing lead to a higher real exchange rate for the Netherlands? *De Economist*, 160, 59-80.
- Wang, D., Cai, F., & Zhang, X. (2004). Saving effect and growth effect of demographic transition. *Population Research*, 5, 2-11. Retrieved from <http://dx.chinadoi.cn/10.3969%2fj.issn.1000-6087.2004.05.001>
- World Health Organisation (WHO). *Health statistics and information system: Definition of an older or elder person*. Retrieved from: <http://www.who.int/healthinfo/survey/ageingdefnolder/en/>
- Walder, A.B. and Döring, T. (2012). The effect of population ageing on private consumption – a simulation for Austria based on household data up to 2050. *Eurasian Economic Review*, 2, 63-80.
- World Bank (2015). *World Development Indicators*. Washington DC, USA. Available at: <http://data.worldbank.org/data-catalog/world-development-indicators>
- Zivot, E., & Andrews, K. (1992). Further evidence on the great crash, the oil price shock, and the unit root hypothesis. *Journal of Business, Economics & Statistics*, 10, 251–270.