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# Is there any Long Run Relationship between Dependency Ratio and Economic Growth? Evidences from Bangladesh

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**Abstract:** While utilizing time series data for the period of 1972 to 2018, this paper attempts to provide empirical evidences of the long-run relationship between dependency ratio and economic growth. The analyses involve standard time series methods of Johansen cointegration analysis. Our empirical analysis reveals a negative and significant long-run impact of dependency ratio on per capita growth-a reduction in dependency ratio is expected to have a positive impact on per capita growth of Bangladesh. Therefore, over time with a reduction in dependency ratio, the proportion of working age population has increased, leading to a positive contribution towards economic growth. Thus, given the significance of demographic composition on economic growth, our estimated results emphasized the importance of policies related to greater public investment in human resources and skill development.

**Key Words:** dependency ratio, demographic dividend, economic growth, Johansen cointegration analysis, Bangladesh

## Background

For achieving higher economic growth, the population structure of an economy plays a crucial role. An educated and skilled work force of population, if engaged in productive employment can contribute significantly towards growth process of a country. The global experience of demographic profile is however quite heterogeneous with the developed world, due to its low fertility have been facing a scenario of increased aged population, which is in contrast to the proportional increase of working age population in developing countries. For developing countries like Bangladesh, which is scarce in land area and capital equipment, it is primarily the abundance of labor on which the growth momentum of the country is dependent upon. From an initial high fertility-high mortality rate, the country has succeeded to reduce its total fertility rate (TFR) close to the replacement level and over the course of time has also been able to reduce mortality rate substantially (NIPORT, 2016). This structural change in population has resulted in an eventual reduction in the proportion of dependent population (children and older age population) and a corresponding increase in working age population: from 45.33 percent in 1991, the percentage of population belonging to 0 to 14 years has come down to 31.59 percent in 2011 and such a change has resulted in a shift towards increase in the proportion of working age population (15 to 64 years) from 54.66 percent to 68.41 percent in the corresponding period (GoB, 2015). This increased working age population, if coupled with effective investment in human resource development can argued to be translated into productive labor force and through higher

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savings and greater investment in growth enhancing activities, it can lead the country towards higher growth trajectory. Here theoretically, with an increase in economically active population there can be a number of direct as well as indirect effects. For example, over time with better health care facilities, safe drinking water and improved maternal health, we can expect a reduction in infant and child mortality. This reduction in mortality is expected to result in an increase in the size of working age population and with such an expansion, there will be a boost in per capita income as the proportion of working age to non-working age population rises. In addition, lower mortality may influence the choice of family size due to higher probability of child survival and lower child mortality and consequential fall in fertility can also change the composition of work force as greater proportion of women are enabled to devote more time to participate in the labor market. Greater participation of females in labor force can contribute positively towards economic growth (National Transfer Accounts, 2012).

There exists a number of literature on how population growth and demographic transition affects economic growth for a variety of economies (Bloom et al. 2001; Mason 1988; Lee et al. 2003; Lee, 2003). Bloom et al. (2001), attempted to understand the relationship between the changes in population structure and economic growth for different regions of the world and found evidences of positive contribution of the increase in working age population on economic growth. Lee (2003) in this context, analyzed the changes in demographic structures in last three centuries and attempted to explain its implication on economic development.

As for Bangladesh, Baltagi and Datta (2001) utilized a micro data set (Matlab Household Survey) primarily attempted to understand the effect of contraceptive use on fertility and found that, instead of contraceptive use alone, with economic development, improved education, along with positive changes in socio-economic status play the determining role in fertility. Based on their analysis, the authors concluded that, in order to attain greater reduction in fertility, in addition to family planning services, changes in people's attitude towards sex preference and desired family size are quite crucial factors. Islam, Abdullah and Hossain (2019), Khondker and Rahman (2016) and Islam (2016), with the help of data of age composition, analyzed the demographic transition in Bangladesh and concluded that the opportunity from this demographic dividend that has begun in 1990s, reaching its peak in 2020s will be available only till 2030s. Based on such analysis, the author emphasized on the importance of supportive government policies for harnessing the benefits.

In case of the linkage between demographic transition and growth, there are at least three clear school of thoughts: one believes that population growth enhances economics growth while the other treats it as one which hinders growth and another one considers population growth as a neutral factor for economic growth. Nonetheless, whenever it comes to the issue of quantifying the impact of demographic transition on growth there are very few studies which have analyzed it from a dynamic point of view (Coale and Hoover, 1958; Kuznets, 1960; Kuznets, 1967; Kuznets, 1975). Also, surprisingly for Bangladesh which is the 8$^{th}$largest countries in the world in terms of population, currently passing the third stage of demographic transition, the literature based on quantitative analysis is rather limited.

As for other developing countries, Thuku, Paul, and Almadi (2013) have exploited annual time series data for Kenya for the period 1963 to 2009 and estimated a VAR model to examine the relationship between population growth and economic growth. The findings suggested that there is a long run positive relationship between these two variables-it therefore supported the hypothesis that population growth drives growth of the economy. The impact of demographic transition on economic growth in Pakistan has been examined by Iqbal, Yasmin, and Yaseen (2015). The study used annual time series data from 1974 to 2011 and applied ARDL model and Bound Testing approach for cointegration for analyzing the long run relationship. It was found that growth of working age population had positive and significant impact on economic growth and in particular demographic transition was found to be incremental to growth. Earlier Ali, Ali, and Amin (2013) have also found that the direct impact of population growth on economic development in Pakistan was positive and as a policy recommendation, they suggested to efficiently use this workforce for achieving higher growth. Choudhry and Elhorst (2010) have used Solow–Swan model for scrutinizing the impact of demographic transition on economic growth. Their analysis revealed that during 1961 to 2003,46 per cent of per capita GDP growth in China, 39 per cent in India and 25 per cent in Pakistan could be explained through population dynamics. The study argued that for India and Pakistan population dynamics was expected to carry a positive effect on growth while for China the effect could be rather negative.

Nakibullah (1998) have tried to identify whether population growth is endogenous or exogenous in relation to economic development in the context of Bangladesh, By estimating an unrestricted VAR model and performing Granger causality test it was found that real GDP per capita tend to Granger cause population growth in Bangladesh but the reverse causality was not found to be valid. Thus, population growth was concluded to be endogenous in the economic development process of the country. Ali et al. (2015) have used annual time series data of Bangladesh for the period of 1981 to 2014 and have estimated a simple growth model using OLS while analyzing the relationship between the population growth and economic development. They have found a negative impact of Bangladesh’s population growth on her economic development and hence suggested enhancing the family planning services. Nonetheless, their findings have been criticized as it did not take into account the time series properties of the variables and applied OLS as estimation method in an ad hoc manner. Similar findings can be found in Abdullah et al. (2015). While using similar methodology and exploiting the time series data of Bangladesh during the period of 1980 to 2005 the authors found that population growth had a significant negative association with GDP growth. Their findings were however questionable due to the ignorance of the time series properties of the variables of interest.

It is interesting to note that, despite the importance of demographic transition in the context of Bangladesh, there is limited academic literature focusing on the critical linkage of demographic composition and economic growth with macro level data. This is particularly important because despite required shift in demographic composition, there is inadequacy in terms of essential supporting policy instrument and public investment in education and health services and as a consequence the resulting ‘dividend’ is argued not to be attained at its fullest (Bidisha et al. 2020; UNFPA 2019, Islam, Abdullah and Hossain, 2019). In the context of low level of education and skill composition of its labor force, despite of favorable demographic composition, the country may ‘miss’ the opportunity of reaping such benefits. Therefore, it is crucial to understand whether the positive linkage between demographic composition and economic growth holds valid for Bangladesh. Thus, this study has attempted to understand the long run consequences of changed demographic composition on economic growth of Bangladesh by examining the relationship exploiting macro data over the period of last 46 years (1972 to 2018). Based on the results, it can be concluded that the composition of population (in our analysis dependency ratio) have important implication towards the economic growth of the country, emphasizing the significance of policy instruments directed towards human capital development.

## Methods and Data:

### *Basic Methodological Framework:*

Based on the conceptual framework as well as the anecdotal evidences provided in other countries, it can be inferred that, an eventual reduction in dependency ratio can contribute positively towards economic growth through a number of channels as discussed in Section 1. In the context of Bangladesh, with the help of time series data from 1972 to 2018 this paper attempts to examine whether there exist a cointegrating relationship among a number of variables promoting growth, particularly taking into consideration the dependency ratio of the country. The World Development Indicators (WDI) database from World Bank has been accessed as data source. A simple growth model has been developed and estimated using human capital along with physical capital as the accelerator. Standard time series econometric method was carried out to detect the long run equilibrium relationship among the concerned variables. More specifically, the paper has given effort to find the long run equilibrium relationship between the per capita income growth and dependency ratio of the country by using the following growth function:

$$PCDGPG = f(GDPSGFCF, GDPSPSE, SGER, GDPSTRADE, DR)$$

Here, the variables can be labeled as per capita GDP growth (*PCGDPG*), GDP share of public spending on education (*GDPSPSE*); Secondary gross enrolment rate (*SGER*); GDP share of gross capital formation (*GDPSGFCF*); GDP share of trade (*GDPSTRADE*) and Dependency ratio (*DR*).

### *Dealing with Stationarity of the Variables*

Regression models that include non-stationary variables are not appropriate for making inference because of being spurious. Hence, it is of sheer importance to check the stationarity of the variables before ensuing into any estimation involved with time series data. In the literature of conventional time series econometrics, a series would be characterized as stationary (well behaved) whenever the first two moments, mean and variance becomes independent of time and magnitude of auto-covariances depends on the depth of lag. Following mathematical derivation, it can be argued that testing for the existence of unit root in a stochastic difference equation is the approved way to test the stationarity of a series. In application if the characteristic root of a stochastic difference equation of a time series process happens to be equal to unity it would be categorized as non-stationary. Differencing the non-stationary series is the most common way of transformation followed by the researches across the areas to regain the stationarity property. A non-stationary time series process would be characterized as first difference stationary and consequently integrated of order one i.e. I(1) whenever differencing it for once make it stationary. Therefore, to find the exact integration order of each variable it is required to diagnose their stationarity property. Although there are a number of different testing procedures available to do the task, in this analysis Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1979) method has been used to test the stationarity due to its simplicity and wide application in the similar field of literature. In particular, the following test regression has been estimated for each of the variables:

$$\Delta x_t = \alpha_0 + \alpha_1 t + \beta x_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta x_{t-i} + u_t \quad (1)$$

Here, $x_t$ is the variable of concern for which stationarity would be tested, $\alpha_0$ and $\alpha_1$ are the drift and trend coefficients respectively, *t* is the trend variable and $u_t$ is assumed to be white noise error term. The coefficient of lagged variable, $\beta = (\rho - 1)$ and $\rho$ is the autoregressive coefficient in a standard autoregressive regression model for $x_t$. The differenced lagged variable, $\Delta x_{t-i}$ has been used to address the problem of autocorrelation that might potentially present in the model. The unit root hypothesis can be written as:

$$H_0: \beta = 0 \ implies\ \rho = 1,\ \ x_t\ is\ Non\ Stationary \quad 2(a)$$
$$H_1: \beta < 0\ implies\ |\rho| < 1, x_t\ is\ Stationary \quad 2(b)$$

Thus, ADF by construction is a one tail test . The Dickey-Fuller test statistic is the usual *t* statistic for $\beta$ presented using $\tau$ as follows:

$$\tau = \frac{\hat{\beta}}{Se(\hat{\beta})} \quad (3)$$

In order to take decision the Dickey-Fuller critical values have been utilized.

***Determining the Depth of Lag:***

Subject to the condition that all the variables under consideration becomes first difference stationary and hence have common order of integration, they might conceive cointegrating relationship among themselves. Following the existence of cointegration a Vector Error Correction Model (VECM) is possible to estimate revealing the short run and long run dynamics among the variables. The aforementioned method in practice requires identification of appropriate depth of lag for the variables. This issue is crucial as researchers do not want to make compromise between *degrees of freedom* and *autocorrelation* resulting from misspecification while modeling time series data. Here, the depth of lag has been selected minimizing a multivariate version of Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC). For lag length *p* the relevant equation is as follows:

$$BIC(p) = ln\left(det(\hat{\Sigma})\right) + \frac{k(kp+1)ln(T)}{T} \quad (4)$$

Where, $det(\hat{\Sigma})$ is the determinant of $\hat{\Sigma} = \frac{\sum_{t=1}^{T} \hat{\varepsilon}_t \hat{\varepsilon}_t'}{T}$. Replacing $ln(T)$ by 2 in the above formula would help obtaining AIC.

***Examining the Existence of Cointegration:***

It is established that when a set of variables are correlated an error correction representation will remain present in the data. Two commonly explored methods for examining the existence of cointegration are Engle – Granger approach (Engle and Granger, 1987) and Johansen approach (Johansen, 1988). The underlying difference between these two procedures is on the number of cointegrating relationship they intend to test. The former one diagnose the presence of *single* cointegrating relationship, in contrast the later one allows for the presence of *multiple*. Since we have multiple independent variables resulting in probable existence of the multiple cointegrating vectors the Johansen approach was chosen to be applied. The said approach depends on the association among the rank of matrix for the coefficient of lagged dependent variable and its characteristic roots. Following the representation by Enders, 2008, it can be presented as a multivariate generalization of Dickey-Fuller procedure. Consider the following general autoregressive process:

$$x_t = B_0 + B_1 x_{t-1} + \varepsilon_t \qquad (5)$$

The above expression can be further presented following first difference transformation as follows:

$$\Delta x_t = B_0 + \theta x_{t-1} + \varepsilon_t \qquad (6)$$

where, $x_t$ is $(x_{1t}, x_{2t}, \ldots \ldots, x_{nt})'$, a vector with dimension (n*1), $B_0$ is $(b_{10}, b_{20}, \ldots \ldots, b_{n0})'$, a vector of constants with dimension (n*1), $\varepsilon_t$ is $(\varepsilon_{1t}, \varepsilon_{2t}, \ldots \ldots, \varepsilon_{nt})'$, vector of errors with dimension (n*1)and with mean zero and variance $\Sigma_\varepsilon$ and $\theta = (B_1 - I)$ with I as identity matrix with dimension (n*n) and $B_1$ as matrix of parameters also with dimension (n*n). Augmenting the model with lagged difference variable will control for potential autocorrelation problem when exists. Thus, the generalization of the above model can be presented as follows:

$$\Delta x_t = B_0 + \theta x_{t-1} + \sum_{i=1}^{p-1} \theta_i \Delta x_{t-i} + \varepsilon_t \qquad (7)$$

Where, $\theta = -\left(I - \sum_{i=1}^{p} B_i\right)$ and $\theta_i = -\sum_{j=i+1}^{p} B_j$. Here the exact number of independent cointegrating vectorswould be determined by rank of matrix for $\theta$. It is due to the fact that mathematically the number of non zero characteristic roots of a matrix happens to be equal to its rank. For instance, when $rank(\theta) = 1$, a single cointegrating vector would exist and $\theta x_{t-1}$ would be the speed of adjustment term. As a generalization of the argument, there will be multiple cointegrating vector under the condition, $1 < rank(\theta) < n$. Thus, the attempt would be made to estimate the matrix of autoregressive coefficient i.e. $\theta$ and its corresponding characteristics roots. The following two test statistics (trace and maximum eigen value) would be used for testing purpose:

$$\omega_{trace}(r) = -T \sum_{i=r+1}^{n} ln(1 - \widehat{\omega}_i) \qquad (8)$$
$$\omega_{max}(r, r+1) = -T ln(1 - \widehat{\omega}_{r+1}) \qquad (9)$$

Here $T$ indicates number of observations used and $\widehat{\omega}_i$ is the estimated values of characteristics roots or the eigen values obtained from $\theta$ matrix. Among two test statistics, $\omega_{trace}$ is used to test null arguing that the number of distinct cointegrating vector is less than or equal to $r$ against a general alternative. In contrast, $\omega_{max}$ test the same null against the alternative saying that there is *(r+1)* cointegrating vectors.

***Estimation of Long Run Relationship with Vector Error Correction Model:***

In order to analyze long run relationship involving multiple variables, the conventional method is to use Vector Error Correction Model (VECM) which takes into account the cointegrating relationship among variables. The VECM model considers cointegrating relationship by using a Vector Autoregressive (VAR) model with first difference variables (here the variables are I(1)) augmented with a vector of error correction terms, the length of which is equal to the number of cointegrating vectors among variables.

Assuming that the $\theta$ matrix in the above VAR model has reduced rank (i.e. $1 < rank(\theta) < n$), it can be factorized into two rank $m$ matrices for instance, $\lambda$ and $\mu'$ ($rank(\lambda) = rank\ (\mu) = m$, where both $\lambda$ and $\mu$ are of dimension $(n * m)$) as $\theta = \lambda\mu' \neq 0$. The VECM can be correspondingly written as follows:

$$\Delta x_t = B_0 + \eta t + \lambda\mu' x_{t-1} + \sum_{i=1}^{p-1} \theta_i \Delta x_{t-i} + \varepsilon_t \tag{10}$$

In the above expression $\mu$ would be characterized as a matrix of cointegrating parameters here a single cointegrating vector can be written as $(1,\ \mu_2, \mu_3, \dots\dots, \mu_n)'$ and $\lambda$ can be characterized as matrix of speed of adjustment parameters which is a kind of weight matrix that helps the cointegrating vectors to enter into the VAR system where $\lambda = (\lambda_1, \lambda_2, \dots\dots, \lambda_n)'$. Therefore $\lambda\mu' x_{t-1}$ would be the error correction term which determine $\Delta x_t$ such that $x_t$ moves in the correct direction for bringing the equilibrium back.

## Results Estimation

### *Descriptive Analysis of Principal Variables:*

Table 1 contains the summary statistics and the value of correlation coefficient of the two key variables of current analysis for the full sample period and as well as different sub sample periods. It can be observed that during the early years of the emergence of Bangladesh the average *PCGDPG* was negative with a high standard deviation. The average *DR* in those periods was also higher with a value of around 93 with low standard deviation (0.131) implying that the high value of DR remained consistent. The correlation coefficient of these two variables during that time was found to be 0.348 with a negative sign but insignificant. The average value of *PCGDPG* has increased while that of *DR* is decreased in the second decade. However, the sign of correlation coefficient is altered but remained insignificant as before. During the third decade *PCGDPG* experienced an average value of 2.463 with standard deviation of 0.676. So, consistency of *PCGDPG* has also been improved along with the average value. In the same decade average *DR* has decreased further to become 78.095. The sign of correlation coefficient again found to be negative though insignificant. The increase in average *PCGDPG* along with decrease in *DR* continues in the next decades as well. The correlation between the variables is found to be significant with a negative sign during 2001 to 2010. Nevertheless, if we consider the full sample then the average *PCGDPG* and *DR* has been found to be 2.510 and 75.948 respectively. The correlation coefficient between them was found to be 0.560 with a negative sign and statistically significant. Thus, it can be argued that decrease in average *DR* might cause increase in average *PCGDPG* given everything else constant. Also, though in sub periods the correlation was observed to be insignificant in some cases, most of the time the coefficient contained a negative sign. However, while full sample is considered the coefficient was negative and significant indicating that the impact of change in *DR* on *PCGDPG* might subject to the perspective of long run analysis.

### *Testing Stationarity of Variables:*

As the correlation coefficient between the *PCGDPG* and *DR* has been observed to be negative and statistically significant with a continuous decrease in average DR coupled with a regular increase in average value of *PCGPDG*, effort was given to answer whether demographic transition of Bangladesh (that leads to decrease in *DR*) helps her to improve the *PCGDPG* from a log run perspective. In case of time series analysis, the first step of conducting any econometric exercise is to check whether the series are stationary and in order to check stationarity, conventional ADF test procedure has been followed. Testing stationarity is important as regression with non stationary variables could result in spurious outcome. In Table 2, results of stationarity test is shown. Particularly, the test has been performed under two different specifications; one with drift only while the other with a trend term along with drift. As suggested by the results of Table 2, *PCGDPG* was found to be nonstationary in both level and as well as in first difference when test regression allows only drift term. It was however found to be difference stationary and hence I (1) when both drift and trend term was considered in test regression. *DR* was another variable which was found to be difference stationary in one specification-the test statistic for DR was insignificant both at level and in first difference specification where both drift and trend are considered. In contrast, the test statistic for first difference of DR was significant at 10 percent significance level when specification included only drift term. Hence this variable could also be considered as I (1). Since for the rest of the variables the ADF test statistics for their first difference have been found to be statistically significant at both specifications of test regression, they can also be argued as difference stationary and thus, I (1).

***Testing for Cointegration and Estimation of Long Run Relationship:***

As all the six variables in the model was diagnosed as difference stationary resulting in common order of integration, formulation of long run equilibrium relationship among them would be a rational expectation. With a view to check the presence of cointegrating relationship, Johansen (1988) cointegration test has been applied following the rationale of having multiple cointegrating relationship. An unrestricted VAR model with all the variables has been estimated beforehand and by minimizing the multivariate version of Bayesian and Akaike information criteria, depth of lag was determined. Table 3 contains the selection criteria for VAR lag structure.

From the estimation result, we could argue that BIC and AIC were minimized at depth of lag as 2 4 respectively. However, in large samples BIC is considered more consistent than AIC and the penalty with BIC is greater than that with AIC. Therefore, relying with BIC it can be argued that a maximum of two lags would be enough to capture the dynamics for variables in VAR and hence in VECM. After identifying that the VECM will contain two lags, Johansen cointegration test procedure has been followed. The null hypothesis arguing $H_0$*: Zero Cointegrating Rank (alternatively, No Cointegrating Vector)* was tested using Trace as well as Maximum Eigen Value method under Johansen procedure. Table 4 contains the test results which discloses that the *p* - values of the trace test of the hypothesis that *'Cointegrating Rank is Zero'* was as low as rejection level while that is 0.0725 (not significant at 5 per cent level) when the null hypothesis was argued to be *'Cointegrating Rank Equals 3'*. Evidence thus, suggest that at most 3 cointegrating equations might remain present there. Following the maximum eigenvalue approach the conclusion also persisted.

Table 1: Summary statistics of the Principal variables

| Year | PCGDPG | | DR | | Correlation (P – Value) |
|---|---|---|---|---|---|
| | Mean | Std. Deviation | Mean | Std. Deviation | |
| **1972 – 80** | -0.512 | 6.800 | 92.720 | 0.131 | -0.348 (0.358) |
| **1981 – 90** | 1.307 | 1.514 | 89.464 | 2.266 | 0.118 (0.743) |
| **1991 – 2000** | 2.463 | 0.676 | 78.095 | 4.554 | -0.543 (0.104) |
| **2001 – 10** | 4.071 | 1.189 | 63.632 | 3.841 | -0.650** (0.041) |
| **2011 – 18** | 5.520 | 0.695 | 52.897 | 2.761 | -0.795** (0.018) |
| **Full Sample: 1972 - 2018** | 2.510 | 3.625 | 75.948 | 15.170 | -0.560*(0.000) |

Note: * and ** indicates 1 per cent and 5 percent level of significance

Table 2: Stationarity Diagnosis of the Variables

ADF Test Results, Null Hypothesis: Series Contains a Unit Root

| Variables | Drift | | | Drift and Trend | | |
|---|---|---|---|---|---|---|
| | Test Statistic | Prob. | Stationarity | Test Statistic | Prob. | Stationarity |
| **PCGDPG** | 6.843 | 1.000 | Non Stationary | 1.038 | 1.000 | Non Stationary |
| **D(PCGDPG)** | -1.949 | 0.308 | Non Stationarity | -8.602* | 0.000 | Stationarity: I(1) |
| **GDPSPSE** | -1.640 | 0.454 | Non Stationary | -2.467 | 0.341 | Non Stationary |
| **D(GDPSPSE)** | -3.127** | 0.031 | Stationarity: I(1) | -8.218* | 0.000 | Stationarity: I(1) |
| **SGER** | 0.984 | 0.995 | Non Stationary | -2.755 | 0.220 | Non Stationary |
| **D(SGER)** | -4.249* | 0.000 | Stationarity: I(1) | -4.691* | 0.000 | Stationarity: I(1) |
| **DR** | 0.830 | 0.993 | Non Stationary | -2.517 | 0.319 | Non Stationary |
| **D(DR)** | -2.877*** | 0.057 | Stationarity: I(1) | -2.613 | 0.276 | Non Stationary |
| **GDPSGFCF** | -0.926 | 0.771 | Non Stationary | -2.593 | 0.284 | Non Stationary |
| **D(GDPSGFCF)** | -4.854* | 0.000 | Stationarity: I(1) | -4.812* | 0.001 | Stationarity: I(1) |
| **GDPSTRADE** | -1.010 | 0.742 | Non Stationary | -2.693 | 0.243 | Non Stationary |
| **D(GDPSTRADE)** | -7.223* | 0.000 | Stationarity: I(1) | -7.139* | 0.000 | Stationarity: I(1) |

Note: * indicates 1 per cent level of significance, ** indicates 5per cent level of significance and *** indicates 10 per cent level of significance.

Table 3: Depth of lag Identification using VAR

| **Lag** | **AIC** | **BIC** |
|---|---|---|
| **Endogenous Variables: PCGDP, DR, SGER, GDPSPSE, GDPSGFCF, GDPSTRADE** | | |
| **0** | 26.0045 | 26.2578 |
| **1** | 12.536 | 14.3095 |
| **2** | 6.7792 | 10.0725* |
| **3** | 6.7422 | 11.5555 |
| **4** | 3.8295* | 10.1628 |

Note: * Indicates lag order selected by respective criterion

Table 4: Testing Existence of Cointegration following Johansen Approach

| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
|---|---|---|---|---|
| **Unrestricted Cointegration Rank Test (Trace)** | | | | |
| **None*** | 0.9143 | 221.5655 | 95.7536 | 0.0000 |
| **At most 1*** | 0.7690 | 118.3692 | 69.8188 | 0.0000 |
| **At most 2*** | 0.4920 | 56.8115 | 47.8561 | 0.0058 |
| **At most 3** | 0.3329 | 28.3606 | 29.7970 | 0.0725 |
| Trace test indicates 3 cointegrating eqn(s) at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values | | | | |
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Max - Eigen Statistic** | **0.05 Critical Value** | **Prob.**** |
| **Unrestricted Cointegration Rank Test (Maximum Eigenvalue)** | | | | |
| **None *** | 0.9143 | 103.1962 | 40.0775 | 0.0000 |
| **At most 1*** | 0.7690 | 61.5576 | 33.8768 | 0.0000 |
| **At most 2*** | 0.4920 | 28.4509 | 27.5843 | 0.0387 |
| **At most 3** | 0.3329 | 17.0057 | 21.1316 | 0.1717 |

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values

Establishing the existence of cointegration among the variables, the long run equilibrium relationship has been estimated with the help of VECM. More specifically, effort was given to estimate the long run impact of dependency ratio (*DR*) on per capita GDP growth (*PCGPG*). It is evident from the results presented in Table 5 that in the long run not all the variables in the chosen model specification had significant impact on *PCGDPG*. Nevertheless, the long-run coefficient attached with DR is found to be significant at 1 percent level implying that there exists a long run equilibrium relationship between *DR* and *PCGDP*. In particular, the findings reveal that a fall in dependency ratio will lead to a rise in per capita GDP growth in the long run. Thus, it can be argued with evidence that the demographic transition which is continuously taking place in Bangladesh for last more than four decades, helped her to improve wealth accumulation as well as saving in family level that further transmit to enhancement in domestic investment to lead to increase in *PCGDPG* to reach at present level. Also, this transition stages helped Bangladesh to have increase participation from women in the labor force. This in turn again helped the country to receive a higher domestic saving that further boost the *PCGDPG* following the channel of investment. So, it is imperative for the country to complete the further stages of transition in proper manner and take appropriate policy initiative to reap the benefit at its highest potential level.

Table 5: Estimation of long run coefficients

**Cointegrating Equation: Long Run Coefficients**

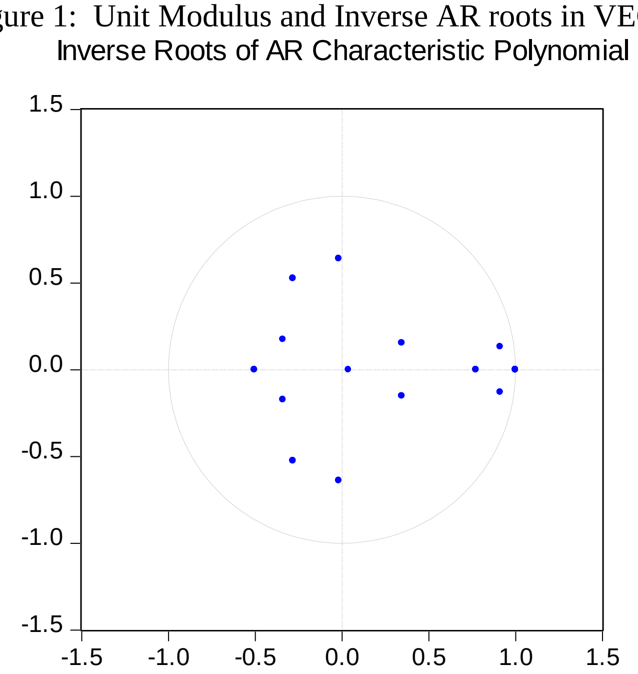
| **PCGDP** | **DR** | **GDPSGFCF** | **GDPSPSE** | **GDPSTRADE** | **SGER** | **Trend** | **Constant** |
|---|---|---|---|---|---|---|---|
| 1.000 | 0.993* | -0.723* | 1.800** | 0.012 | 0.298* | 1.160* | -106.388 |
| - | (0.153) | (0.140) | (0.708) | (0.062) | (0.066) | (6.084) | - |

Note: Standard Errors are in Parenthesis, * and ** indicates 1 per cent and 5 per cent level of significance respectively

***Testing VECM Residual Characteristics and Stability:***

The stationarity of the estimated cointegrating equation is of vital importance for the reliability of using the estimated coefficients. Figure 1 contains the plot of inverse AR roots presenting a visual diagnostic of VECM stability. In a VECM when all the inverted roots lie inside the circle of unit modulus, its characterized as stable. The figure reveals that none of the inverted roots are outside the unit circle indicating that the model is correctly specified. The number of inverted roots along the unit modulus in the figure indicate the number of cointegrating restriction imposed while estimating VECM.

Figure 1: Unit Modulus and Inverse AR roots in VECM




VECM with no specification bias would have appropriate depth of lag for variables so that residuals become white noise. Table 6 contains the Portmanteau test for autocorrelation in the VECM residuals. As the used depth of lag for variables in VECM was two, the test ignored the first two lags. The test result provided evidence that because of high $p$ – values, the null saying *“there is no autocorrelation”* could not be rejected even up to lag length of 10. Hence the estimated VECM model is free of autocorrelation problem and the residuals would remain as white noise.

**Table 6: Autocorrelation in VECM Residuals**

| Lag Order (h) | Q – Stat. | Prob. |
|---|---|---|
| **Null Hypothesis: No Residual Autocorrelation up to lag h** | | |
| **1** | 20.28 | - |
| **2** | 43.509 | - |
| **3** | 77.46 | 0.179 |
| **4** | 115.973 | 0.180 |
| **5** | 150.274 | 0.242 |
| **6** | 169.796 | 0.596 |
| **7** | 194.925 | 0.779 |
| **8** | 234.206 | 0.710 |
| **9** | 251.859 | 0.908 |
| **10** | 275.703 | 0.961 |

Along with the autocorrelation the characteristics of the distribution of VECM residuals summarized by its variance is of another importance. The residuals in a VECM should be homoscedastic. Table 7 contains the Lagrange Multiplier (LM) test results in this regard. Since, the test is not statistically significant, it can be concluded that there was not enough evidence against the null arguing *“VECM residuals are Homoscedastic*”.

Table 7: LM test for Spreadness of VECM residuals

| Test Statistic ($\chi^2$) | Prob. |
|---|---|
| **Null Hypothesis: No Heteroscedasticity in VECM Residuals** | |
| 572.407 | 0.209 |

The long run relationship between *DR* and *PCGDPG* in Bangladesh has therefore been identified by estimating a VECM which satisfies all the required properties implying the establishment of the consistency of the estimates. The change in demographic composition resulting in fall in *DR* will hence help the country to stimulate the *PCGDPG* in the long run. However, the statement is condition upon appropriate policy formulation related to different issues such as education, health and labor market.

## Discussion and Conclusion

This study has made an attempt to provide empirical evidences in favor of long run impact of demographic composition due to changes in population age structure, on economic growth of

Bangladesh. It has utilized time series macro level data of 46 years and adopted standard time series econometric techniques to perform cointegration as well as vector error correction (VECM) analysis among a number of relevant macro variables, including per capita GDP growth and dependency ratio, where the later variable represents the ratio of 'dependent' population (aged below 15 and above 65 years) to 'working age' population (aged 15 to 64 years). Our estimations reveal negative and statistically significant long run impact of dependency ratio on per capita growth-therefore a reduction in dependency ratio is expected to have a positive impact on per capita growth. The analysis suggests that, over time changes in the age structure with a reduction in fertility and mortality, the proportion of working age population has increased and that has resulted in a positive contribution towards economic growth in the long run. This is worth mentioning that, the positive linkage between age structure and economic growth though appears quite straight forward with labor being a crucial component of growth, with low endowment of education and skill, there remains question whether a country will be able to reap the benefits of demographic transition. With as high as 29 percent of youths within the age range of 15 to 29 as NEET (not in employment, education and training) and 8.8 percent of youth labor force without any education, there remains substantial challenges in realizing the benefits of its demographic transition. It is therefore crucial to understand the linkage between the demographic structure and economic growth of the country and our analysis has contributed to this end.

As suggested in empirical literature, converting demographic transition into demographic dividend requires productive and skilled labor force (UNFPA, 2014). There is no denying the fact that, despite having favorable composition of population, low level of education of labor force as well as low public investment in education, health and skill development maypose threat in attaining demographic dividend. In the context of Bangladesh, the labor force is characterized by low education and lack of involvement in medium and high skill jobs. Over time although the trend has improved, still a large proportion of employed population possesses no education (31.9 percent) and very small percentage have tertiary education (5.3 percent) (GoB, 2018). In terms of technical and vocational training, similar scenario can be found as well. Therefore, age structure of the population- the demographic composition of the country though is favorable for demographic dividend, it is not yet supported by required human resources to take advantage of it. Against this backdrop, with a view to attaining demographic dividend for Bangladesh, the most crucial area is that of public investment in human resource development and it is extremely important to increase public spending in educationto a significant extent. In the context of Bangladesh, increasing emphasis should particularly be attached to tertiary education as the proportion of high skilled labor force, required for transitioning towards higher growth trajectory is alarmingly low. On the other hand, transforming the low skilled workforce to a semi skilled one entails specific policy focus on technical and vocational training. In this context, encouraging the youths to increasingly get involved in different skill training program can proved to be an effective policy tool for the government. This requires, in addition to budgetary allocation towards establishing skill training centers, specific attention towards designing innovative and demand based courses, trainings and informational support can be instrumental. Redesigning the existing curriculum in favor of technical education at secondary level in particular can also prove to be beneficial in this regard. There is no denying the fact that education and skill training programs should necessarily be complemented with suitable job opportunities, which in turn depends on both public and private investment programs. In addition to education and skill training, it is also crucial to emphasize on primary and reproductive health care facilities and programs. Without controlling the fertility and reducing infant, child and maternal mortality, it is not possible to maintain favorable demographic composition.

Finally, given that demographic dividend is crucially dependent on healthy and nourished work force with high level of productivity, increasing budgetary allocation to basic health care services and increasing importance to meet nutritional requirement of children can be considered as instrumental in eventually transforming the working age population into a 'dividend' for the economy. As suggested from the trend of our demographic profile, Bangladesh is eventually proceeding to the later stage of availing demographic dividend and has not yet invested sufficiently in human resources to take maximum advantage of its demographic profile. Lack of investment for creating suitable job opportunities and human capital development coupled with proper policy support for savings mobilization during 90's is often argued to have affected the early phase of demographic opportunities for Bangladesh (Khondker and Rahman 2016). It is therefore of paramount importance to prioritize the relevant policies and allocations in taking the best possible advantage of demographic composition of the country.

The contribution of the study is actually three folds; firstly, it has given effort to lend empirical support that fall in dependency ratio does beneficial for the per capita income growth in the long run; secondly, it has used the largest possible data series for the study country Bangladesh where previously no such attempt has been made and finally, it has used the appropriate econometric technique to quantify the impact. Nevertheless, the current study is not free of flaws, hence findings should be considered with caution. The applied econometric methodology is strongly dependent on the assumption that there is no structural break. Results and conclusion may vary should there be any instability of the parameters. However, incorporating these features into the model while analyzing the long run impact of dependency ratio on economic growth could be a further area of research.

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