# Population Growth and Economic Growth/Development: An Empirical Investigation for Barbados

Nlandu Mamingi[1*] Justin Perch[2]
1.University of the West Indies, Cave Hill Campus, P.O. Box 64, Bridgetown, BB11000, Barbados.
2.Independent Researcher,Barbados.
* nlandu.mamingi@cavehill.uwi.edu

**Abstract**

This paper examines the nature of the relationship between population growth and economic growth/development in a small developing country, Barbados, in the period 1980-2010. Using the autoregressive distributed lag approach to cointegration, the paper yields the following main results: (i) population growth and population density positively and significantly affect economic growth; (ii) economic growth negatively and significantly affects population growth; (iii) natural increase rate positively and significantly affects population growth; (iv) net international migration negatively and significantly impacts population growth. These results have policy implications.
**Keywords**:population growth,economic growth, economic development, ARDL, cointegration, Barbados.

## 1. Introduction

While it is now well known that the economic growth or development of a given country depends on a host of factors or variables (Sala-i-Martin *et al.*, 2004), there still remains the question of the nature of the impact of population growth on economic growth/development. To the best of our knowledge, at least three schools of thought have attempted to elucidate the relationship between population growth and economic growth/development. According to the pessimists, population growth negatively affects economic growth/development to the extent that population growth, be it by natural growth or (net) immigration, puts pressure on the natural resources and the environment. This pressure hampers economic growth and development (Bongaarts, 1996; Cropper and Griffith, 1994;Yeboah *et al*., 2001). Overall, the pessimists emphasize worsening of income inequality and decrease in quality of life. On the contrary, the optimists consider population growth a bonus for economic growth and development. Indeed, by increasing mass production and specialization, population growth gives rise to improved human capital which facilitates technological advancements and by ricochet leads to economic expansion (Kuznets, 1973; Simon, 1995; Klasen and Nestmann, 2006; Barro 1991, 2001). A mitigated view is held by the revisionists or neutralists. Indeed, the latter believe that there is little evidence which indicates that population growth and economic growth are linked (Thornton, 2001; Bloom *et al.*, 2003, Bloom and Freeman, 1988; Gallup *et al*., 1998).

This study, partially based on Perch (2009), examines the impact of population growth on economic growth /development of Barbados in the period 1980-2010. At the time when Barbados is determined to build a green economy (see United Nations Environment Programme *et al.*, 2012), it is more than necessary to know the role that population growth might play. The study uses the autoregressive distributed lag (ARDL) bounds testing procedure initiated by Pesaran *et al.* (2001) to deal with the above issue.

For recall, Barbados is an island nation located in the Caribbean sea with the following key characteristics: land size of 431 square kilometer, population size of 284,714 inhabitants in 2010, population density of 664 persons per square kilometer in 2010, and GDP per capita (by purchasing power parity) of US$21,800.00 in 2010. This small open economy dominated nowadays by tourism and services has consistently been placed in the category of "very high human development" according to the United Nations Human Development Index (HDI). Although this paper concentrates more on the impact of population growth on economic growth than on economic development, it, nevertheless, acknowledges that economic growth is a necessary condition for economic development.

To the best of our knowledge, only a handful of researchers have dealt in depth with the issue of determinants of growth/development of Barbados (see the literature review in Downes, 2002). Yet, with the exception of one paper and some populist comments in the "Nation", one of the two major newspapers in the country, the relationship between population growth and economic growth has not received much attention among researchers of the Barbadian economy. In any event, Lewis and Craigwell (1998) examined the determinants of growth for Barbados using an endogenous growth model "including human capital, domestic policy and sectoral policy." The cointegration/error correction model results indicate a strong role for domestic policy and a less significant role for external forces in the country's economic growth/development. Downes (2002) looked, among others, into the key driving factors of Barbados' economic growth /development in the period 1960-2000. He clearly distinguished six factors: (i) the international environment context favorable to migrant labor and a large inflow of foreign investment; (ii) the important role of physical capital; (iii) the enhancement of human capital through "investment in health and education"; (iv) the big role of "government consumption relative to total output"; (v) the "good macroeconomic management"; (vi)the good quality of institutions. Banik and Bhaumik (2006) studied the impacts of demographic changes (aging population), the structure of labor market and youth emigration in the context of declining fertility rate on the Barbadian economic growth and development. This paper pointed out important issues that need further attention: "capital outflows from the economy, simultaneous shortage of skilled workers and high role of unemployment."

Our study contributes to the literature in three ways. First, Barbados is an interesting case per se to test the different theories concerning population growth effects on economic growth given its characteristics underlined above; in particular, high population density (one of the highest in the world), and population growth believed to be driven by an influx of immigrants. Second, apart from Banik and Bhaumik (2006), no such a study which explicitly concentrates on the linkage between population growth and economic growth has been undertaken for Barbados. Third, methodologically this study is among the few studies which use the autoregressive distributed lag approach to cointegration to examine the relationship between population growth and economic growth/development.

The study is useful to the extent that knowing and understanding the nature of the relationship between population growth and economic growth are extremely important in terms of population policy to devise in view to maintaining or boosting people's standard of living or even contemplating a harmonious development of society.

The structure of the paper is as follows. Section 2 deals with some indicators of the Barbadian economy with emphasis on population growth, population density and economic growth. Section 3 focuses on methodology and data. Section 4 deals with the empirical results. Section 5 contains the conclusions and policy implications.

## 2. Some Indicators of the Barbadian Economy

This section deals with the features of some economic and development indicators of Barbados with emphasis on economic growth, population density and population growth. The period of interest is 1980-2010.

Using 2005 US$, the real *GDP* per capita of Barbados, RCGDP, increased from $9,122 in 1980 to $10,402 in 2010. Overall, the evolution of RCGDP is characterized by some "cyclical" variations around an upward trend. In particular, the real *GDP* per capita fell in 1981-82, 1985, 1990-93, 2001-02 and 2008-2010. The fall in 1981-82 was as a result of world recession, that of 1990-93 was largely influenced by the Democratic Labor Party's (*DLP*) contractionary fiscal policy in late 1991 while the terrorists' attacks of 9/11 in 2001 were probably the cause of the decrease in 2001-02. Finally, the fall in 2008-2010 can be explained by another world recession.

The real *GDP* per capita growth, RGG, echoes more or less the "cyclical" variations alluded to above. The mean rate of growth is 0.63%. A maximum rate of 9% is registered in 1986 and a minimum rate of -5.66 % in 2009.

Among the factors that can explain the economic growth/development of Barbados are demographic factors such as population size, population density, and population growth. Population size and population density increased consistently over time in the period of investigation. Indeed, population size went from 251,970 inhabitants in 1980 to 284,714 in 2010, with an annual average growth of just less than 0.42%. Barbados's population density was approximately 586 people per square kilometer in 1980 and 664 people per square kilometer in 2010 (one of the highest in the world). The annual average density growth was less than 0.5%.

Population growth, PG, does not show a clear-cut increasing trend. The growth rate varied from 0.32% in 1980 to 0.37% in 2010. In addition, the minimum rate (0.16%) and maximum rate (0.56%) were recorded in 1981 and 1983, respectively. The mean and median rates were 0.40 % and 0.41%, respectively, over the period of interest. Overall, the data exhibit pure stationarity.

To examine the dynamics of population growth, it is important to look at, among others, the following variables: total fertility rates and the natural increase rate.

According to the UN Common Database, the Barbados' total fertility rate stood at 2.19 in 1980, 1.75 in 1990, 1.50 in 2004, 1.50 in 2005 and 1.55 in 2010. As can be seen, overall there is a decline in fertility rates. In addition, the present rate, which is below the replacement rate of two children per woman, is somewhat problematic, at least for a stable population, as it leads to an aging population and a decrease in population size.

The difference between the crude birth rate and the crude death rate gives rise to the natural increase rate (*NRI*), an important component of population growth. The natural increase rate in Barbados has been decreasing over the period of interest. Indeed, it went from 8.50 per 1,000 in 1980 to 3.36 per 1,000 in 2010; this yields on average an annual decrease of 3%. The mean *NRI* stood at 6 per 1,000 population.

Among the non demographic variables which affect economic growth, we examine the record of foreign direct investment(*FDI*) and government consumption expenditure.

Roughly, the evolution of *FDI* in Barbados in the period 1980-2010 can be divided into two sub-periods: 1980-2004 and 2005-2010. The first sub-period is rather characterized by low foreign direct investment with some level of fluctuations. Two years produced extremes in this sub-period: 2003 with a jump in *FDI* with US$58.3 million (the highest total in the sub-period) and 2004 with a fall in *FDI* of US$-12.1 million. The recent period (2005-2010) has witnessed a substantial increase in *FDI*, at least compared to the first sub-period. It is as though *FDI* has undergone a structural change in 2005.

Concerning the evolution of the raw government consumption expenditure expressed in millions of Barbados dollars (see different issues of the Central Bank of Barbados Annual Statistical Digest), it can be said that it is characterized by a clear-cut linear trend. The variable increased from 258 millions of BDS dollars in 1980 to 1,936 millions of BDS dollars in 2008.

In any case, Barbados, an economy driven by tourism and services with appreciable educational achievements, has always behaved well in every human and poverty index. Not surprisingly, according to the different annual reports of the UN Human Development Index (HDI), Barbados has consistently been classified as a very high human developed country. To corroborate, Barbados's HDI was at 0.787 in 2005, 0.790 in 2006, 0.791 in 2007, 0.792 in 2008, 0.790 in 2009 and 0.791 in 2010.

## 3. Methodology and Data

### *3.1 The Model*

The first equation of our model introduces the explicative factors of growth in real GDP per capita. Indeed,

$$RGG_t = \beta_0 + \beta_1 RCGDP_{t-1} + \beta_2 PD_t + \beta_3 PG_t + \beta_4 GOVC_t + \beta_5 CS_t + \beta_6 I_t + \beta_7 FDIC_t + \beta_8 TRADE_t + \beta_9 CLR_t + u_{1t} \quad (1)$$

where $t=1,\ldots,T$ stands for time, $RGG_t = d(RCGDP_t)$ is Real *GDP* per capita growth (%), $RCGDP_t$ is real GDP per capita or GDP per capita in 2005 US$, $RCGDP_{t-1}$ is lagged $RCGDP_t$, $PD_t$ is population density or the number of inhabitants per square kilometer, $PG_t$ is annual population growth(%), $GOVC_t$ is government consumption expenditure as a % of *GDP*, $CS_t$ is personal consumption expenditure as a % of *GDP*,$I_t$ is domestic investment as a % of *GDP*, $FDIC_t$ is foreign direct investment as a % of *GDP*, $TRADE_t$ is trade openness (exports plus imports) as a % of *GDP* and $CLR_t$ is the country's international risk measure. The latter is a composite risk score which encompasses political, financial and economic risk information. The score goes from 0 to 100 with a score of 0 to 49.9 representing a very high risk and 80 to 100 a very low risk. The error term is represented by $u_{1t}$.

Equation 1 warrants some comments. First, economic growth depends on a large number of variables (Sala-i-Martin*et al.,* 2004). Here, some variables have been left out for reason pertaining to data unavailability. Second, in terms of expected signs, the lagged real *GDP* per capita is supposed to negatively impact economic growth simulating the effect of initial real per capita *GDP* in panel data studies; domestic investment and *FDI* each positively affects economic growth. Population density impact on economic growth can be anything although many authors believe it must be positive. As pointed out above, the impact of population growth is ambiguous. Personal or household consumption expenditure negatively affects economic growth. Government consumption expenditure excluding government investment negatively affects economic growth. Trade openness is a bonus for economic growth. The riskier the country is, the lower the economic growth. Third, there is the question of the nature of the right-hand side variables that needs to be raised. Are these variables exogenous or endogenous? In the context of time series approach (VAR, cointegration and likes), all contemporaneous variables are endogenous. An appropriate framework is thus used to deal with the issue of endogeneity. Of course, in the context of a pure classical simultaneous equations model, some variables are endogenous and others, exogenous. In any case, the demographic transition theory which states that beyond a certain stage of development economic growth or development leads to low population growth, provides us with another justification for the endogeneity of population growth. At the very least, we have the following relationship:

$$PG_t = \gamma_0 + \gamma_1 PG_{t-1} + \gamma_2 NRI_t + \gamma_3 NRI_{t-1} + \gamma_4 NRI_{t-2} + \gamma_5 NRI_{t-3} + \gamma_6 RGG_t + \gamma_7 RGG_{t-1} + \gamma_8 RGG_{t-2} + \gamma_9 RGG_{t-3} + \gamma_{10} TR + u_{2t} \quad (2)$$

where $t = 1,2,3,...,T$ stands for time, $RGG_t$ is real *GDP* per capita growth, $PG_{t-1}$ is population growth lagged once, $NRI_t$ is the natural increase rate, lagged $NRI_t$ is a series of lagged $NRI_t$, lagged $RGG_t$ is a series of lagged real *GDP* per capita growth, *TR* is a trend used as a proxy to net international migration and $u_{2t}$ is the error term.

### *3.2 Data*

The data used in this study span from 1980 to 2010 and were collected from a variety of sources: Heston et al. (2006), World Bank Development Indicators database, ERS International Macroeconomic Data Set, United Nations database, Index Mundi, CIA World Factbook, International Country Risk Guide, and Central Bank of Barbados with Annual Statistical Digest. Quite a number of variables have been analyzed in the previous section. Note that for *CLR* we generated quite of number of missing values. For recall, *RCGDP* is *GDP* per capita in 2005 US$, *PD* is the number of inhabitants per square kilometer, *NRI* is the natural increase rate per thousand, *PG*,*RGG*, *GOVC*,*CS*, *I*, *FDIC*, *TRADE* are all in %. *TR* is used for net international migration since the relevant data for the latter are missing for the period 1980-1999.

Since time series data are of interest, it is worth knowing their stationarity properties. Using the Augmented Dickey-Fuller (*ADF*) test (see any decent econometrics manual for description), we find the following variables as stationary or integrated of order zero, I(0), at the 10% level of significance given the sizes of their associated *ADF* *p*-values: *RGG* with a *p*-value=0.036, *RCGDP*(with a trend) with a *p*-value=0.042, *PD*(with a trend) with a *p*-value=0.009, *CS* with a *p*-value=0.008 *NRI*(with a trend) with a *p*-value=0.030 and *CLR* with a *p*-value=0.000. The rest are integrated of order one, I(1): *TRADE* with a *p*-value=0.111, *I* with a *p*-value=0.269, *FDI* with a *p*-value=0.993 and *GOVC* with a *p*-value=0.836. *PG* is stationary by the correlogram pattern and the *KPSS* statistic with a value equals to 0.144, a value well below the critical value of 0.347.

### *3.3 Estimation Methods*

Since the data analysis reveals that the variables of the model are a mixture of I(0) and I(1) variables, an adequate framework that handles this particularity must be used. Here, we recourse to the autoregressive distributed lag approach (ARDL) to cointegration initiated by Pesaran *et al.*(2001). This method particularly targets equation 1 of the model. Note that equation 2 is a regular regression with all variables being stationary. On a second thought, this equation is also an ARDL equation.

For recall, the ARDL bounds testing procedure assumes that all variables are endogenous. In addition, unlike most cointegration techniques, the ARDL can be applied to regressors which are purely I(0), purely I(1) or mutually cointegrated. Finally, it is also suitable for cointegration analysis even if the sample size is small.

In the first instance, the bounds approach requires estimating an unrestricted error correction version of equation 1 by OLS. The unrestricted error correction model (ECM) proposed by Pesaran *et al.* (2001) follows the fundamental principles of the Johansen five error correction multi-variance VAR. Specifically (see Pesaran *et al.*, 2001; Boamah *et al.*, 2011,28-30),

Case 1: no intercepts and no trend

$$\Delta y_t = \pi_{yy} y_{t-1} + \pi_{ySS} S_{t-1} + \sum_{i=1}^{p-1} \gamma' \Delta z_{t-i} + \delta' \Delta S_t + e_t \qquad (3)$$

Case 2: Restricted intercepts and no trend

$$\Delta y_t = \pi_{yy}(y_{t-1} - \mu_y) + \pi_{ySS}(S_{t-1} - \mu_S) + \sum_{i=1}^{p-1} \gamma' \Delta z_{t-i} + \delta' \Delta S_t + e_t \qquad (4)$$

Case 3: Unrestricted intercepts and no trend

$$\Delta y_t = c_o + \pi_{yy} y_{t-1} + \pi_{ySS} S_{t-1} + \sum_{i=1}^{p-1} \gamma' \Delta z_{t-i} + \delta' \Delta S_t + e_t \qquad (5)$$

Case 4: Unrestricted intercepts and restricted trends

$$\Delta y_t = c_0 + \pi_{yy}(y_{t-1} - \alpha_y t) + \pi_{ySS}(S_{t-1} - \alpha_S t) + \sum_{i=1}^{p-1} \gamma' \Delta z_{t-i} + \delta' \Delta S_t + e_t \qquad (6)$$

Case 5: Unrestricted intercepts and unrestricted trends

$$\Delta y_t = c_0 + c_1 t + \pi_{yy} y_{t-1} + \pi_{ySS} S_{t-1} + \sum_{i=1}^{p-1} \gamma' \Delta z_{t-i} + \delta' \Delta S_t + e_t \qquad (7)$$

where $y_t$ is $RGG_t$, $S_t$= $(RCGD_{t-1}, PD_t, PG_t, GOVC_t, CS_t, I_t, FDIC_t, TRADE_t, CLR_t)$, $z_t$ is $(RGG_t, RCGD_{t-1}, PD_t, PG_t, GOVC_t, CS_t, I_t, FDIC_t, TRADE_t, CLR_t)$, $\Delta$ represents the first difference operator, $t$ captures deterministic trend, and $e_t$ is the error term.

To test for the existence of a level relationship between $y_t$ and $S_t$, in (3) – (7), the bounds procedure recourses to an *F*-test (or *Wald* test) on the joint null hypothesis that the coefficients of the level variables are jointly zero. The null hypotheses are defined as $\pi_{yy} = 0$ *and* $\pi_{ySS} = 0'$ and the alternatives as $\pi_{yy} \neq 0$ *or* $\pi_{ySS} \neq 0'$. It is the case that these *F*-statistics follow a non-standard distribution. Consequently, instead of the conventional critical values which are no longer valid, the *F*-test recourses to two asymptotic critical bounds, covering three possible classifications of the variables (all are I(0), all are I(1) or variables are mutually cointegrated). The lower bound values relate to the case of the variables being purely I(0), and the upper bound values assume that they are purely I(1). A long-run relationship or cointegration exists if the computed *F*-statistic is greater than its respective upper critical values; on the contrary, if smaller, the null of no-cointegrationis not rejected; and finally, if the value lies within the bounds, inference is inconclusive. Naturally, the existence of cointegration implies that the long-run relationship among variables and corresponding error correction models can be estimated. As a footnote, error correction models can also arise from purely raw stationary variables.

## 4. Empirical Results

At the outset, a remark is in order. Parsimonious models obtained through the Schwarz Bayesian Information Criterion (SBC) are of interest for regression models. Of course, basic econometric issues such as autocorrelation, heteroscedasticity, normality and functional misspecification are also considered in the choice of the tentative models.

For recall, stationarity is not an issue for equation 2 as all the variables are stationary. Incidentally, as pointed above the equation is also an autoregressive distributed lag model.The equation is estimated by OLS.Table 1 contains the results of the exercise. Note that we exploit the parsimonious form of equation 2 using SBC. There is no issue of endogeneity with this reformulation of equation 2 since RGG is no longer part of the equation. The latter passes the tests of autocorrelation, heteroscedasticity, functional misspecification and normality as the respective *p*-values indicate at the 10 % level of significance. Clearly, population growth is affected by its immediate past or history, the natural increase rate, the trend as a proxy to net international migration, and the history of economic growth. An increase in the natural increase rate positively affects population growth. Indeed, a 1/1,000 population increase brings about a population growth of 0.023%. The presence of a negative lagged effect means that if we permanently shock the natural increase rate by one unit then population growth will be increasing at a decreasing rate. An increase in the net international migration decreases population growth. In our view, this is only true if the net international migration in matter represents a net international emigration, that is, the number of emigrants is larger than the number of immigrants. In fact, according to the statistics from CIA World Factbook, this seems the case for Barbados. Indeed, for example, the available data from 2000 to 2010 exhibit yearly negative values meaning that on annual basis the number of emigrants has been larger than the number of immigrants. In any case, a one unit increase in the trend brings about a decrease of 0.0030% in population growth. Past economic growth negatively affects population growth. An increase of 1% in the past two-year economic growth gives rise to a decrease of 0.0044% in population growth. The theory of the demographic transition justifies this finding. Nevertheless, it is often argued that economic prosperity attracts immigrants, that is, population growth should increase. In fact, the latter only happens if the number of immigrants is larger than that of emigrants.

Table 1. Determinants of Population Growth, Barbados 1980-2010

| Dependent variable: PG | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.358065 | 0.053741 | 6.662828 | 0.0000 |
| PG(-1) | 0.285952 | 0.137122 | 2.085389 | 0.0494 |
| NRI | 0.022911 | 0.007166 | 3.197281 | 0.0043 |
| NRI(-2) | -0.011216 | 0.006297 | -1.780997 | 0.0894 |
| NRI(-3) | -0.011235 | 0.006020 | -1.866393 | 0.0760 |
| RGG(-2) | -0.004538 | 0.001723 | -2.633174 | 0.0155 |
| TR | -0.002985 | 0.001289 | -2.315288 | 0.0308 |
| R-squared | 0.770114 | | Akaike info criterion | -4.051321 |
| F-statistic | 11.72493 | | Schwarz criterion | -3.718270 |
| Prob(F-statistic) | 0.000009 | | Hannan-Quinn criter. | -3.949504 |
| BG F(4,17)=0.322 | p=0.860 | | BPG F(6,21)=1.176 | p=0.356 |
| RRT F(4,17)=1.211 | p=0.343 | | J.B. =0.116 | p=0.944 |

*Note*: Equation 2 is of interest; Method of estimation: OLS; variables are defined as in the text; heteroscedasticity-autocorrelation robust standard errors are used; Prob. < 0.10 means statistically significant at the 10% level; BG *F*: Breusch-Godfrey autocorrelation *F-statistic*; BPG *F*: Breusch-Pagan-Godfrey *F-statistic* for heteroscedasticity; RRT Ramsey Rest *F-statistic* for functional misspecification; J.B.: Jarque-Bera test for normality; prob.= *p*=probability value.

The results in Table 2 have been derived using equation 5 as a representative of equation 1. The ARDL approach is of interest. After several trials, it has been found that the ADRL( 3,0,1,0,0,0,1,1,1,1) is the parsimonious model that satisfies SBC and passes the tests of autocorrelation, heteroscedasticity, functional misspecification and normality as the respective *p*-values indicate at the 10 % level of significance. The *F*-test derived from Table 2 which deals with cointegration of the level variables in equation 5 has a value of 21.524. This value which exceeds the upper bound, that is, 2.99 at the 10% level of significance (see Pesaran *et al.*, 2001, 300), indicates that the variables in equation 5 are cointegrated. Table 3 which replicates Table 2 using a non-linear estimation confirms cointegration as the adjustment coefficient (-0.612) is largely negative ($t$ = - 4.179).

Table 2: Unrestricted Error Correction Model of the ADRL(3,0,1,0,0,0,1,1,1,1)

| Dependent variable : DRGG | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | -519.6603 | 89.33960 | -5.816686 | 0.0002 |
| RGG(-1) | -0.612201 | 0.146500 | -4.178837 | 0.0019 |
| RCGDP(-2) | -0.017150 | 0.001840 | -9.319143 | 0.0000 |
| PD(-1) | 0.652615 | 0.087567 | 7.452727 | 0.0000 |
| PG(-1) | 46.81717 | 9.320449 | 5.023060 | 0.0005 |
| GOVC(-1) | -81.07032 | 41.44735 | -1.955983 | 0.0790 |
| CS(-1) | -63.22336 | 15.56667 | -4.061456 | 0.0023 |
| FDIC(-1) | 0.076539 | 0.140006 | 0.546680 | 0.5966 |
| TRADE(-1) | -0.632406 | 0.172062 | -3.675459 | 0.0043 |
| CLR(-1) | 54.43588 | 10.73862 | 5.069169 | 0.0005 |
| DRGG(-1) | -1.252491 | 0.157802 | -7.937093 | 0.0000 |
| DRGG(-2) | -0.719481 | 0.095099 | -7.565633 | 0.0000 |
| DPD | 1.583436 | 0.465303 | 3.403024 | 0.0067 |
| DI | 0.537914 | 0.130310 | 4.127944 | 0.0021 |
| DFDIC | -0.448981 | 0.184606 | -2.432103 | 0.0353 |
| DTRADE | 0.194448 | 0.142662 | 1.363001 | 0.2028 |
| DCLR | 23.52253 | 5.112786 | 4.600726 | 0.0010 |
| Adj. R-squared | 0.9795 | | S.E.of regression | 1.0764 |
| AIC | 3.2412 | | SBC | 4.0976 |
| BG F(2,8)=1.499 | p=0.280 | | BPG F(17,10)=1.670 | p=0.206 |
| RST F(2,8)=0.964 | p=0.422 | | J.B.=0.185 | p=0.912 |

*Note:* Equation 5 is of interest; variables are defined as in the text; "*D*"as a prefix is a first difference operator, e.g., $DRGG_t=RGG_t-RGG_{t-1}$; for other details, see Note to Table 1.

Table 3 contains short-run and long-run parameter estimates. That said, in the short and long runs, population density positively and significantly affects economic growth. Concretely, a one unit increase in population density increases economic growth by 1.58% in the short run and 1.07% in the long run. Becker *et al.* (1988, 147) explain this phenomenon as follows: "At a higher level of development higher population density leads to accumulated human capital, which raises per capita income or greater population is likely to raise per capita welfare in more developed society." In the long run, population growth leads to economic growth. The size of growth in economic growth is 76% in response to a 1% shock in population growth. This response is surely inflated. In any case, the optimistic view alluded to above is vindicated here. In the long run, government consumption expenditure and private consumption expenditure negatively and significantly affect economic growth. In the short and long runs, domestic investment significantly and positively affects economic growth. In the short run, foreign direct investment has a negative impact on economic growth. The impact

Table 3. Short-run and long-run Estimates and Error Correction Model of the ADRL ( 3,0,1,0,0,0,1,1,1,1) (non-linear form of equation 5)

Dependent Variable: DRGG
Method: Least Squares
Convergence achieved after 8 iterations

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | -519.6603 | 89.33960 | -5.816686 | 0.0002 |
| C(2) | -0.612201 | 0.146500 | -4.178837 | 0.0019 |
| C(3) | -0.028014 | 0.007562 | -3.704706 | 0.0041 |
| C(4) | 1.066014 | 0.270978 | 3.933957 | 0.0028 |
| C(5) | 76.47349 | 26.18052 | 2.921008 | 0.0153 |
| C(6) | -132.4243 | 59.14048 | -2.239148 | 0.0491 |
| C(7) | -103.2722 | 31.83718 | -3.243760 | 0.0088 |
| C(8) | 1.214553 | 0.327289 | 3.710954 | 0.0040 |
| 77(9) | 0.125022 | 0.228660 | 0.546759 | 0.5965 |
| C(10) | -1.033003 | 0.359735 | -2.871568 | 0.0166 |
| C(11) | 88.91826 | 26.27338 | 3.384348 | 0.0070 |
| C(12) | -1.252491 | 0.157802 | -7.937093 | 0.0000 |
| C(13) | -0.719481 | 0.095099 | -7.565633 | 0.0000 |
| C(14) | 1.583436 | 0.465303 | 3.403024 | 0.0067 |
| C(15) | 0.537914 | 0.130310 | 4.127944 | 0.0021 |
| C(16) | -0.448981 | 0.184606 | -2.432103 | 0.0353 |
| C(17) | 0.194448 | 0.142662 | 1.363001 | 0.2028 |
| C(18) | 23.52253 | 5.112786 | 4.600726 | 0.0010 |

*Note*: DRGG=C(1)+C(2)*(RGG(-1) -C(3)*RCGDP(-2)-C(4)*PD(-1)-C(5)*PG(-1)-C(6)*GOVC(-1)-C(7)*CS(-1)-C(8)*I(-1)-C(9)*FDIC(-1)-C(10)*TRADE(-1)- C(11)*CLR(-1))+C(12)*DRGG(-1)+C(13)*DRGG(-2) +C(14)*DPD+C(15)*DI+C(16)*DFDIC+C(17)*DTRADE+C(18)*DCLR +error.
For other details, see Note to Table 2.

seems to turn positive in the long run. Trade openness is a drag to the economy, at least in the long run. This is an unexpected result. International country risk positively affects economic growth in the short and long run. This interpretation holds since the bigger the value of the variable is, the less risky the country. An increase in past output negatively affects economic growth.

## 5. Conclusions and Policy Implications

This paper examines the relationship between population growth and economic growth/development in a small developing country, Barbados, in the period 1980-2010. Using essentially the autoregressive distributed lag approach to cointegration, the paper yields the following main results: (i) population growth positively and significantly affects economic growth; (ii) population density positively and significantly affects economic growth; (iii) economic growth negatively and significantly affects population growth; (iv) natural increase rate positively and significantly impacts population growth; (v) net international migration negatively and significantly affects population growth. The other results are: (i) government consumption expenditure negatively and significantly influences economic growth; (ii) personal consumption negatively and significantly impacts economic growth; (iii) domestic investment positively and significantly affects economic;(iv) the less risky the country is, the larger the economic growth;

Concerning the main issue, as just pointed out, the paper uncovers a feedback between population growth and economic growth. That is, on the one hand, population growth boosts economic growth and, on the other hand, economic growth depresses population growth. In terms of Tietenberg (2006)'s analysis, the first finding means that the marginal product of an additional person is greater than the average product. This seems to support the optimistic view of population growth. Put differently, for Barbados the benefits of population growth outweigh the costs. Furthermore, given that in the period of investigation Barbados' economic growth did not negate the country's economic development status such as illustrated by the country's almost stable position in HDI, we can point out that conclusions drawn from economic growth can be most likely inferred to economic development.

Since population growth and economic growth are endogenous variables, economic growth or development is, among others, affected by policy variables that impact population growth. As seen above, natural increase rate and net international migration affect population growth and thus represent two good policy variable candidates.

Unquestionably, in a small island country with limited land area, caution should be exercised concerning population (growth) policy because population cannot increase indefinitely. In this connection, knowledge about the country's (physical) carrying capacity is the key framework to set up a realistic population policy. In Barbados as in many other Caribbean countries this type of knowledge is lacking. This void does not mean that Barbados should adopt a laissez-faire population policy. In any case, as just said there are at least two policy instruments that can affect population in general, and population growth in particular: the natural increase rate through the crude fertility rate or crude birth rate, and the net international migration through essentially immigration law. Since Barbados is already in the demographic transition phase characterized by a low fertility rate, it is worth examining whether the optimal fertility rate is already reached. Indeed, a fertility rate below the replacement rate of two children is always problematical in the long run. As being experienced by many western societies, an aging population can bring about a host of health and economic problems that can potentially jeopardize the country's standard of living. Immigration law should be enacted in accordance of the desired level of population growth compatible with the optimal fertility rate or the natural increase rate. In particular, there is a need for an effective immigration policy which, at the very least, takes into account the qualification and commitments of immigrants in Barbados' development endeavors.

This exploratory study has, however, some limitations. First, data unavailability for some key economic and development variables (e.g., school enrolment rates as a measure of human capital, and immigration rates as a major determinant of population growth) is the major impediment encountered in this study. Second, although the ARDL method is also suitable for small sample size, we realize that the huge number of parameters to estimate almost uses up the degrees of freedom rending the values of the estimates somewhat fragile or even difficult to interpret. Despite these limitations the study is still informative about the potential links between population growth and economic growth in Barbados.

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