

# The Impact of Population Growth on Botswana's Economic Growth

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**Abstract:** This paper explores the long run relationship between economic growth and population growth for Botswana. Specifically, the study uses cointegration analysis and the vector error correction models to abstract simultaneously the short and long run information in the modeling process. Results from the study do not support the conventional wisdom, which stipulates that population growth has an adverse effect on economic growth. The results suggest that there is a long run relationship between economic growth and population growth for Botswana. In addition, population growth is found to Granger-cause economic growth. It appears though, that a carefully formulated population growth strategy coupled with institutional and policy changes could engender economic growth, especially for a country with nascent economy, such as Botswana.

## Introduction

The impact of population on economic growth has been under discussion following the seminal work of Malthus in 1798.<sup>1</sup> The debate on this issue centers on the question as to whether or not population growth promotes or retards economic growth. Some economists including, Coale and Hoover (1958) argue that population growth diverts resources from savings and capital accumulation to current consumption of goods and services. Similarly, McNicoll (1984), Hammer (1986) and Kelley (1988) suggest that population growth redirects resources from education and health services to current consumption. The diversion of resources from capital accumulation, education, and health services will inhibit economic growth, *Ceteris paribus*. This has serious consequences especially for less developed countries (LDCs) because population growth in the face of lagging economic growth creates a phenomenon known as “*population trap*” or *low-level equilibrium trap* (Pearce, 1983). James (2002) blames rapid population growth and urbanization for unsustainable economic development, the socio-cultural and ecological problems and the failures of political systems among Sub-Sahara African countries.

Empirical studies on the long-run relationship between economic and population growth rates have produced mixed results in the extant literature. For instance, Easterlin (1967), Kuznets (1967), Simon (1992), Thirlwall (1972), Coale and Hoover (1958), and Blanchet (1991) found weak or insignificant relationship between population and economic growth rates. However, Kelly and Schmidt (1994),

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<sup>1</sup> Malthus published his famous book titled *An Essay on the Principles of Population as it Affects the Future Improvement to Society* in 1789.

Coale and Hoover (1958), Blanchet (1991) found that economic and population growth rates are negatively related with respect to less developed countries. Dawson and Tiffin (1998) using cointegration analysis found that economic growth rate and population growth rate do not have long-run relationship in the case of India. Thornton (2001) using cointegration analysis and the one-step error correction model found that there is no long run relationship between population growth rate and economic growth rate in the cases of Latin American countries including, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela. The National Research Council (1986) using time-series and cross-regional data from poor countries found that population size and its growth have both negative and positive effects on economic growth.

The current study adds to the extant literature in four basic ways. First, the time frame under consideration is the largest of any study known to the authors. The data set covers the time period 1961 through 1999. Second, the authors are not aware of any other study that investigated the relationship between economic growth and population growth relative to Botswana. Third, unlike most previous studies on the relationship between economic growth and population growth that applied the standard OLS,<sup>2</sup> the present study implements cointegration procedure and the vector error correction models (VECM). Fourth, the application of the VECM enables the authors to control for both the long run and short-run dynamics of the economic growth and population growth, thus presenting a clearer picture on their relationship.

The structure of the paper is as follows: section II presents the data and the summary statistics. Section III furnishes the methodology. Section IV discusses the empirical results while section V presents the summary and policy implications of the study.

### **Data and Summary Statistics**

The data for the study consist of annual observations on economic growth and population growth for Botswana. The data were collected from the World Development Indicators, published by the World Bank, CD-Rom edition, 2002. The sample spans from 1961 to 1999.

Table 1 presents the summary statistics for economic and population growth rates and the Pearson Correlation. The mean values of economic and population growth are respectively, 9.74 and 3.07 percent. The standard deviations suggest that economic growth (5.65%) varied more than population growth (0.51%) for the period under study. The correlation coefficient (0.614) between economic and population growth is positive and statistically significant at the 1 percent level.

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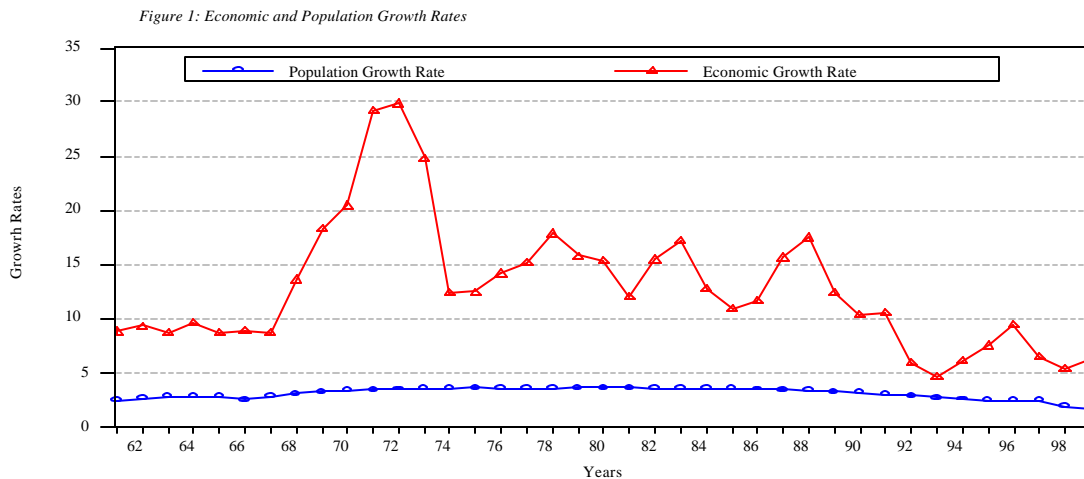
<sup>2</sup> Nelson and Plosser (1982) suggest that most macroeconomic time series data are first-difference stationary. Studies that applied the OLS without ascertaining the time series properties of economic growth and population growth are likely to lead to spurious inferences.

Table 1: Summary Statistics (1961 - 1999)

Series	Mean	Max	Min	STD	COR
GP	3.07	3.56	1.68	0.51	0.614**
GY	9.74	26.36	1.98	5.65	0.614**

\*\* indicates correction is statistically significant at the 1% level of significance. GP = population growth rate, GY = GDP growth rate, Max = maximum, Min = minimum, STD = standard deviation, and COR = correlation between GP and GY.

Figure 1 plots both the economic and population growth rates. The graph corroborates the facts presented in Table 1. It can be observed that Botswana's economic growth is erratic for the study period. On the other hand, population appears to grow at a modest rate for the period under consideration. The graph reveals that economic growth outpaced population growth for the sample period. Botswana's population is projected to grow at an average rate of 2.10 percent between 2000 and 2030.<sup>3</sup> Urbanization in Botswana stood at 14.7, 25.2 and 37.2 percent, respectively for 1950, 1975 and 2000. It is however expected to reach 52.9 percent in 2030.<sup>4</sup>



The population growth in Botswana follows similar pattern as those of the other countries of Sub-Saharan Africa. The population growth in Sub-Saharan Africa is higher than those of most other regions. The average annual growth rate for the region was 2.7 percent compared to 1.4, 0.5, 1.8, 2.6,

<sup>3</sup> The projected average growth rate was obtained from the World Bank, *World Development Indicators*, 2002.

<sup>4</sup> The figures on urbanization were obtained from the United Nations' Population Division, *World Urbanization Prospects*, 2001.

and 2.0 percent, respectively for East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, and South Asia.

## Methodology

Although the preceding section has provided some cursory evidence relative to the relationship between economic growth and population growth, the issue at hand requires the formulation of more rigorous econometric models. To this end, the standard augmented Dickey-Fuller (Dickey and Fuller, 1981) (ADF) unit root procedure is applied to ascertain the order of integration for economic and population growth rates. The equation estimated for the ADF test is as follows:

$$\Delta X_t = \alpha_0 + \beta_1 X_{t-1} + \delta t + \sum_{i=1}^n \theta_i \Delta X_{t-i} + \varepsilon_t \quad (1)$$

where  $\Delta$  represents the first-difference operator,  $t$  is the time trend, and  $\varepsilon$  is the stationary random error, and  $n$  is the optimal lag length. The null and alternative hypotheses under ADF unit root test are as follows:

$$H_0: \beta = 0 \quad H_a: \beta < 1.$$

The rejection of the null hypothesis indicates that the series under consideration has unit root. To attain stationarity, the series must be differenced to avoid spurious inferences. However, Perron (1989) suggests that the conventional ADF has low power in the presence of structural breaks. This study mitigates this flaw by employing the Perron (1997) unit root procedure that allows for structural break in the data. The following regression equation is utilized for the unit root test:

$$Y_t = \alpha + \phi DU_t(\lambda) + \beta t + \gamma DT_t(\lambda) + \theta_1 Y_{t-1} + \sum_{i=1}^n \psi_i \Delta Y_{t-i} + \omega_t \quad (2)$$

where  $\alpha$  is a constant,  $t$  represents the time trend,  $D(T)$  captures the change in slope,  $DU$  is a dummy variable,  $DU_t(?) = 1$  for  $t > T?$ , and  $DU_t(?) = 0$  for  $t = T?$ ;  $? = T_B/T$  is the location of the structural break;  $T$  is the total sample size; and  $T_B$  represents the break date. The term  $\sum_{i=1}^n \psi_i \Delta Y_{t-i}$  represents the additional lags necessary to remove serial correlation. The model in equation (2) allows for both changes in the intercept and the slope. The null and alternative hypotheses under Perron (1997) unit root test are as follows:

$$H_0: \lambda = 0 \quad H_a: \lambda < 1.$$

The study next applies the Gregory and Hansen (1996) cointegration test procedure that allows for structural break in the mean to ascertain the long run relationship between economic and population growth rates. The Gregory-Hansen framework involves two steps. The first step involves the estimation of the following multiple regression equation:

$$Y_t = \alpha + \beta TR + \gamma DU_t(\lambda) + \theta_i X_t + \varpi_t \quad (3)$$

where  $DU$  is a dummy variable,  $Du_t(\lambda) = 1$  for  $t > T\lambda$ , and  $Du_t(\lambda) = 0$  for  $t \leq T\lambda$ ;  $\lambda = T_B/T$  is the location of the structural break;  $TR$  is the time trend,  $T$  is the total sample size;  $T_B$  represents the break date and  $X$  consists of a vector of independent variables.

The second step involves testing the residual from equation (3) for stationarity. The recovered residual is used to formulate the following regression equation:

$$\Delta \varpi_t = \alpha \varpi_{t-1} + \sum_{i=1}^n \beta_i \Delta \varpi_{t-i} + \mu_t \quad (4)$$

The ADF or Phillips-Perron unit root test procedure is applied to equation (4). The null and alternative hypotheses are as follows:

$$H_0: a = 0 \quad H_a: a < 1.$$

We reject the null hypothesis of no cointegration in equation (4) if  $\alpha$  is statistically significant and negative. The study next investigates the causal relationship between economic growth and population growth by employing both the one-step error correction model and the VECM of Engle and Granger (1987); provided that economic growth and population growth are cointegrated (Kremers, Ericsson, and Dolado 1992). These procedures are adopted to avoid spurious inferences resulting from differencing economic growth and population growth variables.<sup>5</sup> Under the one-step error correction framework, the levels of the dependent and independent variables (lagged by one period) are included in the regression equations to capture the long run relationship between the series in the system. The following equations are implemented for the one-step error correction model:

$$\Delta GY_t = \alpha + \sum_{i=1}^a \theta_i \Delta GY_{t-i} + \sum_{i=1}^b \varphi_i \Delta GP_{t-i} + GY_{t-1} + GP_{t-1} + \varepsilon_{it} \quad (5)$$

<sup>5</sup> Engle and Granger (1987) suggest that differencing nonstationary variables may result in a loss of useful information pertaining to the long run relationships between dependent and independent variables.

$$\Delta GP_t = \alpha + \sum_{i=1}^a \theta_i \Delta GY_{t-i} + \sum_{i=1}^b \phi_i \Delta GP_{t-i} + GY_{t-1} + GP_{t-1} + \varepsilon_{2t} \quad (6)$$

where  $\Delta$  represents difference operator,  $a$  and  $b$  are the maximum lags;  $\varepsilon_{1t}$  and  $\varepsilon_{2t}$  are the error terms.  $GY$  and  $GP$  stand for economic and population growth, respectively. In equation (5), population growth is said to Granger-cause economic growth if the regression coefficients on  $\Delta GP$  (i.e.  $\phi_i$ ) are jointly statistically significant. Similarly, in equation (6), economic growth is said to Granger-cause population growth if the sum of the regression coefficients on  $\Delta GY$  (i.e.  $\theta_i$ ) is statistically different from zero. Feedback causality is indicated if both  $\phi_i$  and  $\theta_i$  are statistically significant.

In addition to the one-step error correction model, the study also applies the VECM proposed by Engle and Granger (1987) to ascertain the short-run and long run relationship between economic growth and population growth. The VECM is based on the following regressions:

$$\Delta GY_t = \alpha + \sum_{i=1}^a \theta_i \Delta GY_{t-i} + \sum_{i=1}^b \phi_i \Delta GP_{t-i} + EC_{t-1} \quad (7)$$

$$\Delta GP_t = \alpha + \sum_{i=1}^a \theta_i \Delta GY_{t-i} + \sum_{i=1}^b \phi_i \Delta GP_{t-i} + EC_{t-1} \quad (8)$$

where  $EC_{t-1}$  represents the error correction term from the cointegrating equation. The variables remain as defined in equations (5) and (6). Under the VECM, causality emerges from two channels namely — lagged coefficients of the independent variables and the error correction term (Engle and Granger 1987). Statistically significant error correction term indicates the abilities of the series in the system to adjust to past equilibrium.

Table 2: Unit Root Tests

Series	Level	Difference	Lag(s)
Panel A: Standard ADF			
GP	-0.55	-5.04**	1
GY	-3.03	-4.62**	2
Panel B: Sequential Minimum ADF			
GP	-1.11	-4.01**	1
GY	-2.35	-3.74**	2
Panel C: Perron (1997)			
GP	-3.56	-6.20**	1
GY	-0.68	-6.67**	2

\*\* indicates significant at the 5 percent level. The critical value at the 5% significance level is -3.50

GP = population growth, GY = economic growth; GP = population growth rate. The 5% critical value for the Perron's unit root test is -5.33.

## Empirical Results

The first step of the empirical investigation involves the use of the standard ADF, the sequential minimum ADF, and the Perron's unit root tests to determine the order of integration for economic and

population growth rates.<sup>6</sup> Since unit root test procedures are sensitive to lag lengths, we compute and report results using the optimal lags determined by the Akaike Information Criterion (AIC). Table 2 presents the unit root test results. The results indicate that both economic and population growth rates have a unit root in their levels. However, they are first difference stationary at the 5 percent significance level. Taken together, the results indicate that the series have the same order of integration (i.e. I(1)).

Given that economic and population growth rates have the same order of integration, we next use the Gregory-Hansen cointegration procedure to examine the long run relationship between them. Table 3 reports the Gregory-Hansen cointegration test results and the structural break points. The Gregory-Hansen cointegration test results suggest that economic and population growth rates are cointegrated, since the test statistics from the Phillips-Perron and ADF tests (-4.84 and -5.24, respectively) are greater than the critical value (-4.61) at the 5 percent significance level. This finding indicates that there is a long run relationship between economic and population growth rates. We check the robustness of the cointegration result by employing the Johansen and Juselius procedure. Table 4 reports the bivariate cointegration test results. The results from both the maximum eigenvalue ( $\lambda_{\max}$ ) and the trace tests reject the null hypothesis of no cointegration at the 5 percent level of significance. These results corroborate the results obtained from the Gregory-Hansen cointegration procedure that there is a long run equilibrium relationship between economic and population growth rates.

Table 3: Gregory-Hansen Cointegration Results

Model	Z( $t_{\tau}^*$ )	ADF
C/T	-4.84(0.31)**	-5.24(0.38)**

\*\* indicates rejection of the null hypothesis of no cointegration at the 5% level of significance. The 5% critical value for ADF and Z( $t_{\tau}^*$ ) is -4.61. The critical values are taken from Table 1 of Gregory and Hansen (1996). C/T indicates that the model included constant and trend. The numbers in parentheses are the break points expressed as percentage of the sample size.

Table 4: Bivariate Cointegration Tests



<sup>6</sup> To avoid arbitrary selection of break point ( $\tau$ ) and the additional lags ( $\sum_{i=1}^n \psi_i \Delta Y_{t-i}$ ), equation (2) is estimated using a RATS' procedure written by Colletaz and Serranito.

Null Hypothesis	Maximum Eigenvalue Test		Trace Test		
	Test Statistic	Critical Value	Null Hypothesis	Test Statistic	Critical Value
$r \leq 0$	35.46**	18.33	$r \leq 0$	36.01**	23.83
$r \leq 1$	0.55	11.54	$r \leq 1$	0.55	11.54

\*\* indicates the rejection of the null hypothesis at the 5% level of statistical significance.

Order of VAR = 3.

Table 5 presents the bivariate Granger-causality test results from the one-step error correction model. The results reveal that economic growth does not Granger-cause population growth, since neither the error correction term, nor the sum of the regression coefficient on economic growth, is statistically significant. However it can be seen from Table 5 that population growth Granger-causes economic growth in Botswana, since the sum of the regression coefficients on population growth is statistically significant. In addition, the error correction term is negative and statistically significant in relation to the equation for economic growth.

Table 6 presents the Granger-causality from the VECM. The results suggest that economic growth does not cause population growth; since neither the error correction term nor the sum of the lagged regression coefficient on  $\Delta GY$  is statistically significant. On the other hand, the results show that population growth Granger-causes economic growth. The error correction term is statistically significant relative to the economic growth equation. This confirms the existence of long run relationship between economic and population growth rates. The results from the VECM are consistent with those obtained from the one-step error correction model.

Table 5: Bivariate Causality Test Based on the One-Step ECM: F-Statistics

Dependent Variable

Explanatory Variable	Dependent Variable	
	$\Delta GP$	$\Delta GY$
$ECT_{t-1}$	1.71	9.26 <sup>***</sup>
$\Sigma \Delta GP$	1.30	2.45 <sup>*</sup>
$\Sigma \Delta GY$	0.60	3.83 <sup>**</sup>

<sup>\*\*</sup>, <sup>\*\*</sup> and <sup>\*</sup> represent rejection of the null hypotheses of non-causality at the 1% , 5% and 10% levels of significance. The results from this table are obtained by estimating equations (5), (6), and (7). The estimated  $ECT_{t-1}$  represents the error correction term lagged by one period. The level of significance for the error correction term ( $ECT_{t-1}$ ) is determined by the standard  $t$ -statistics.

Table 6: Bivariate Causality Test Based on the Engle-Granger VECM: F-Statistics

Explanatory Variable	Dependent Variable	
	$\Delta GP$	$\Delta GY$
$ECT_{t-1}$	2.46	10.48 <sup>***</sup>
$\Sigma \Delta GP$	2.23	2.96 <sup>*</sup>
$\Sigma \Delta GY$	1.88	8.32 <sup>***</sup>

<sup>\*\*</sup>, <sup>\*\*</sup> and <sup>\*</sup> represent rejection of the null hypotheses of non-causality at the 1% , 5% and 10% levels of significance. The results from this table are obtained by estimating equations (5), (6), and (7). The estimated  $ECT_{t-1}$  represents the error correction term lagged by one period. The level of significance for the error correction term ( $ECT_{t-1}$ ) is determined by the standard  $t$ -statistics.

## Summary and Policy Implications

This paper has examined the long run relationship between economic growth and population growth in Botswana using annual data for the period 1961 through 1999. The empirical investigation consists of: (1) the application of cointegration analysis to ascertain the long run relationship between economic growth and population growth; and (2) the determination of the direction of causality among the variables in the context of error correction models.

The unit root test results suggest that economic growth and population growth are first-difference stationary. The results from both the Gregory-Hansen and Johansen-Juselius cointegration tests reveal that there is a long run relationship between economic and population growth in Botswana. The results obtained from both the one-step error correction model and the VECM indicate that population growth Granger-causes economic growth for the period under consideration. This implies that population growth engenders economic growth in Botswana.

Population growth can influence economic growth through two essential channels including technical progress and economies of scale. Simon (1981) suggests that an increase in population leads to innovations. Technological advances in turn promote productivity and economies of scale, hence the national output. According to Smith (1937), the size of the market has important implications for specialization. As the population grows, the size of the market increases. The increase in market size promotes specialization, which in turn leads to the attainment of economies of scale and thus an improvement in the national output.

The finding that population growth promotes economic growth in the long run contradicts those of Thornton (2001) and Dawson and Tiffin (1998). A number of factors could account for the inconsistencies. The sample could be one of the possible explanations. For instance, Dawson and Tiffin (1998) examined the impact of population growth on economic development in the context of India. Thornton (2001) on the other hand, examined the long run relationship between economic growth and population growth for Latin American Countries. In addition, methodological differences could have contributed to the contradiction. These studies used the Johansen and Juselius cointegration procedures to examine the long run relationship between economic growth and population growth. In addition to the Johansen and Juselius cointegration test, the present study also considers the Gregory-Hansen framework that allows for structural break in the data.

The results have important implications especially for developing countries. Although the paper is not advocating unsustainable population expansion, it appears though, that a carefully planned population growth strategy coupled with institutional and policy changes could be beneficial to countries with nascent economies, such as Botswana. A skeptic might wonder why one would advocate population expansion in developing countries given the famines that have engulfed most of their economies. Lele

and Meyers (1980) and Williams (1984) suggest that inadequate government policies, rather than population growth, are responsible for the woes including, famines that besiege most developing nations.

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