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Can population growth contribute to economic development? New evidence from Singapore

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Abstract

This paper chose Singapore as a case study to investigate whether population growth can contribute to economic development. It employed four different single-equation tests for cointegration, namely, 1) ordinary least squares, 2) fully modified ordinary least squares, 3) canonical cointegration regression, and 4) dynamic ordinary least squares. The empirical findings indicated a mutually reinforcing bilateral causality between population and economic development in the island-state. This highlights a dynamic nature of the population-development relationship in the country. In other words, Singapore's population growth did contribute to the nation's economic development, which in return stimulated population expansion in the country.

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1. Introduction

Recent global demographic trends have attracted attention and scrutiny of researchers, policymakers, and the mass media. Economic performance in any country is, to a substantial degree, affected by the country's demographic situation. In recent decades, the developed countries have been experiencing declining fertility rates that caused serious shortages of the workforce. Besides, the plunging fertility rates have led to the phenomenon called "ageing population" which has become a socio-economic reality in many developed countries and which has put a big strain on their pension systems. The importance of the relationship between population growth and economic development has been well recognized by development economists. As Dawson and Tiffin (1998: 149) have pointed out, "most textbooks on economic development include a section on population and development".

Despite the fact that there are numerous research studies on the relationship between population and economic development, there is no universal consensus as to whether population expansion is beneficial or detrimental to economic growth. Thirlwall (1994: 143) has observed that "the historical evidence is ambiguous, particularly concerning what is cause and what is effect" in the relationship between a country's population and its economic growth. On the one hand, the relationship between population growth and economic performance could be regarded as *positive* when the upward demographic trends stimulate the economic development and lead to a rise in living standards. In this situation, the population growth promotes competition in business activities because it leads to market expansion, which in its turn encourages entrepreneurs to set up new businesses. On the other hand, the relationship between population growth and economic performance could be described as *negative* when the increase in population becomes an impediment to the country's economic development because the rapid expansion of population increases dependency burden (i.e., the number of people who are considered to be economically unproductive, such as children and the elderly).

The seminal book on the relationship between population expansion and development written by Thomas Malthus was published in the year 1798, under the title "*An Essay on the Principle of Population"* (Malthus 1798). Malthus' theory was based on the "law of diminishing returns" which regarded the quantity of available land as fixed. The author claimed that there existed a tendency for population growth to surpass production growth because the former increases in the geometric progression while the latter increases in the arithmetic progression. Malthus concluded that an unencumbered population growth would plunge a country into the state of acute poverty. According to Kelley and Schmidt (1996), since the publication of Malthus' treatise the pessimist views about the impact of growing population were prevalent among population analysts. This position is reflected in several publications and research studies (Meade 1961, Meadows *et al*. 1972, Samuelson 1975, Tinbergen 1985, Buchholz 1999).

However, many economists and researchers disagree with such pessimistic views. Robert Repetto (1985) has pointed out that many of the empirical studies that claimed that a rapid population growth impeded economic development could not be considered reliable. This is because the statistical correlation between population expansion and economic growth has not addressed the causal relationship between the two (Repetto

1985). A prominent population economist, Julian Simon, regards human capital as the crucial element for economic growth. As he has succinctly put it, "The ultimate resource is people – skilled, spirited, and hopeful people who will exert their will and imaginations for their own benefit, and inevitably they will benefit not only themselves but the rest of us as well" (Simon 1996: 589). Simon described programs aimed at curbing population growth in developing countries as downright harmful. As he argued, "Some aspects of U.S. Foreign Aid Programmes for 'family planning' are not just wasteful, not just fraudulent, not even just politically dangerous for the United States, but they may well be extremely damaging on net balance by offering a palliative that distracts from all-important issues of economic system of the country receiving the aid" (Simon 1987: 160).

Recently, the availability of reliable time-series data sets that are extensive enough to allow conducting time-series regression analyses has revived the interest in research on the relationship between population growth and economic development. For example, Dawson and Tiffin (1998) have employed time-series data to analyse the long-run relationship between population growth and economic development in India. According to the researchers, no long-run *equilibrium relationship* between the population growth and economic development in India could be established; in other words, these pairs of variables did not seem to move jointly. As Dawson and Tiffin (1998: 154) concluded, "population growth neither causes per capita income growth nor is caused by it". John Thornton (2001) has conducted a research on the long-run relationship between population growth and economic development in seven developing countries in Latin America, namely, Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela. According to Thornton (2001: 466), "A long-run relation between population and real per capita GDP does not appear to exist; hence, population growth neither causes growth of per capita GDP nor is caused by it". Fumitaka Furuoka (2009) has examined the long-run relationship between population growth and economic development in Thailand. He found out that there was a long-run equilibrium relationship between population growth and economic development in that country; also, the findings showed that there existed a unidirectional causality from the population growth to economic development. This means that population growth in Thailand had a positive impact on the country's economic performance. These findings support the population-driven economic growth hypothesis which states that population growth promotes per capita income growth.

Considering the fact that there exist different opinions regarding the impact of population growth on economic development, this paper chose Singapore as a case study to empirically examine whether population growth can contribute to economic development. The island-state offers an interesting setting for a case study. This is because the quality of population in Singapore, or human capital, is said to play an important role in maintaining a high economic growth since the country had gained independence from Britain in 1963.[1] Singapore's economic achievements are impressive. According to the data from the Centre for International Comparisons (CIC) at the University of Pennsylvania, Singapore's real per capita Gross Domestic Product (GDP)

[1] For a detailed discussion on the importance of human capital in economic development in Singapore please refer to Lucas (1993).

was US$774 in 1960. In one decade, this figure doubled and reached US$1,545 by the year 1970 (see Figure 1). During the 1970s, Singapore's per capita GDP quadrupled and, in 1980, it amounted to US$6,660. During the 1980s, GDP in Singapore continued to grow and reached US$17,753 in the year 1990. Singapore suffered the first economic decline in its economic history in 1998, which caused real per capita GDP to drop to US$25,764 from US$28,010 in the previous year. The second economic downturn occurred in 2001, when Singapore's real per capita GDP decreased from US$30,988 in 2000, to US$28,961 in 2001. This was followed by economic recovery and, in 2005, Singapore's real per capita GDP reached new heights at US$38,441 before increasing spectacularly to US$48,489 in 2007 (CIC 2010).

Compared to the big leaps in the economic performance, Singapore's population was increasing in a steady pace. As Figure 2 shows, in 1960, the country's population was 1.646 million people. By the end of the decade, in 1968, it was recorded at 2.012 million people. By 1970, Singapore's population expanded to 2.074 million. There was a further increase and, in 1975, there were 2.262 million people living in Singapore. In 1980, the figure was reported as 2.413 million people. In 1990, the country's population reached 3.047 million people; it increased over the decade to 4.036 million in 2000. There were further expansions in Singapore's population, which was reported as being 4.425 million people in 2005, and 4.553 million people in 2007 (CIC 2010).

A basic research question that arises is whether the relationship between Singapore's population and economic development is positive or negative? To answer this question, the present study examined the long-run equilibrium relationship between the population expansion and economic development in Singapore. It employed single-equation tests for cointegration while the previous research studies had used a more standard procedure by running the Johansen cointegration test (Dawson and Tiffin 1998, Thornton 2001, Furuoka 2009). The novelty of the present study is that it used four different single-equation tests for cointegration, namely, 1) ordinary least squares (Engle and Granger 1987), 2) fully modified ordinary least squares (Phillips and Hansen 1990), 3) canonical cointegration regression (Park 1992), and 4) dynamic ordinary least squares (Saikkonen 1992, Stock and Watson 1993). This paper consists of five sections. Following this introductory section, Section Two outlines the research method, Section Three reports the findings, and Section Four offers a conclusion.

2. Data and Method

In this study, several econometric methods were employed to examine the relationship between two variables, i.e. *GDP* (Singapore's real per capita Gross Domestic Product) and *POP* (Singapore's total population) over the period 1960-2007. The data were obtained from the Penn World Table 6.3 (CIC 2010). All the data were transformed into a log form for the purpose of the analysis.

As Phillips (1986) has observed, a regression analysis that contains non-stationary variables may produce misleading results. Therefore, the empirical analysis in the present study was done in three stages. In the first stage, unit root tests were used to determine whether the time series data were stationary.[2] In the second stage, cointegration tests were carried out in order to analyse whether the pairs of variables were cointegrated or moved jointly in the long-run.[3] In the third stage, we examined whether there had been a causal relationship between the two variables.[4]

First of all, an important prerequisite for the existence of the long-run equilibrium relationship between two variables, such as *GDP* and *POP,* is that these variables have the same order of integration. This means that if *GDP* is an integrated of order one, the other variable -- *POP* -- should also be an integrated of order one.[5] In order to analyse the common integrational property, unit root tests need to be run. A standard stationarity test -- the augmented Dickey-Fuller (ADF) unit root test -- can be employed for this purpose (Dickey and Fuller 1979). This study also used the Phillips-Perron (PP) test to analyse stationarity (Phillips and Perron 1988). The PP test is more robust for detecting unit roots in the presence of autocorrelation and heteroscedasticity in the data sets.

Secondly, the residual-based Engle-Granger cointegration test was used to examine the long-run equilibrium relationship between *GDP* and *POP*. The cointegration test aimed to determine whether single-equation estimates of the equilibrium error appeared to be stationary (Engle and Granger 1987). In order to analyse a cointegration relationship between *GDP* and *POP*, the following two cointegrating equations were estimated:

$$GDP_t = \alpha_1 + \beta_1 POP_t + \varepsilon_1 \qquad (1)$$

$$POP_t = \alpha_2 + \beta_2 GDP_t + \varepsilon_2 \qquad (2)$$

There are several methods to estimate cointegrating equations. This paper used the following four methods: 1) ordinary least squares (OLS) estimation (Engle and Granger 1987); 2) fully modified ordinary least squares (FMOLS) estimation (Phillips and Hansen 1990); 3) canonical cointegration regression (CCR) estimation (Park 1992); 4) dynamic ordinary least squares (DOLS) estimation (Saikkonen 1992, Stock and Watson 1993). If two variables (e.g., *GDP* and *POP*) are cointegrated, the residuals of cointegrating equations (1) and (2) are stationary. In other words, the stationary residuals imply that the two variables (*GDP* and *POP)* have a long-run relationship (Thomas 1997).

Finally, the present study used the Granger causality test (Granger 1969) to analyse causality between population growth and economic development in Singapore. The Granger causality test can be based on the following Vector Error Correction Models (VECMs):

[2] The time series data is *stationary* if its mean, variance, and covariance remain constant over time (Thomas 1997: 374).
[3] Pairs of variables could be described as co-integrated if they have a long-run equilibrium relationship, which means that these variables move jointly (Gujarati 2003: 822).
[4] According to Granger (1969), a time series *X* is said to Granger-cause another time series *Y* if this *X* would provide statistically significant information about future value of the *Y*.
[5] In general, if time series data has to be differenced *d* times to make it stationary, this time series data is said to be integrated of order *d* (Gujarati 2003: 805).

$$\Delta GDP_t = c_1 + \alpha_1 \Delta GDP_{t-1} + .. + \alpha_k \Delta GDP_{t-k} + \beta_1 \Delta POP_{t-1} + .. + \beta_k \Delta POP_{t-k} + \gamma_1 EC_{t-1} + \varepsilon_1 \quad (3)$$

$$\Delta POP_t = c_2 + \alpha_1 \Delta POP_{t-1} + .. + \alpha_k \Delta POP_{t-k} + \beta_1 \Delta GDP_{t-1} + .. + \beta_k \Delta GDP_{t-k} + \gamma_2 EC_{t-1} + \varepsilon_2 \quad (4)$$

where Δ is the difference operator; EC_{t-1} is a one-period lagged value of the error correction term, γ_1 and γ_2 are coefficients for the error correction terms; c_1 and c_2 are constants; $\alpha_1.......\alpha_k$ and $\beta_1 ...... \beta_k$ are slope coefficients. The Granger causality could be examined by using the Wald test for the joint hypothesis:

$$\beta_1 = \beta_2 = ...\beta_k = 0 \quad (5)$$

There is a considerable advantage to using a Granger causality test based on the VECM rather than a standard test because the former can identify both the short-run and the long-run causalities. In a Granger causality based on the VECM, the Wald test of independent variables could be interpreted as the short-run causal effect, while the significant correction term (EC_{t-1}) could be interpreted as the long-run causal effects.

Four types of causal relationship between population growth and economic development are possible: (1) *Independent*: There is no causality between population growth and economic development, which could be interpreted as an independent relationship between the variables; (2) *Population-driven economic growth*: There is a unidirectional causality from population expansion to economic growth *but not vice versa*, which could be interpreted as evidence in support for the existence of the “population-led” output expansion; (3) *Growth-driven population expansion*: There is a unidirectional causality from economic growth to population expansion *but not vice versa*, which could be interpreted as evidence in support for the existence of the “growth-led” population expansion; and (4) *Two-way causality*: There is a unidirectional causality from population growth to economic growth *and vice versa*, which could be interpreted as the mutually reinforcing bilateral causality between population growth and economic development.

3. Empirical Findings

First of all, the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were employed to test stationarity of the time series data. The results obtained from these tests are shown in Table 1. As the results indicate, the ADF test and the PP test reported similar findings. Both tests indicated that one variable – *POP*—was integrated of order one, *I(1)*, while the other variable -- *GDP* – was also integrated of order one, *I(1)*. Thus, these two variables had the same order of integration.

Table 2(a) shows the results of the four cointegration tests, which analysed the residual series derived from cointegrating equation (1). The findings indicate that the residual series were stationary. This means that there could be a long-run equilibrium relationship between the two variables (i.e., *GDP* and *POP*). In other words, there is a possibility that the variables were cointegrated.

Table 2(b) reports the results obtained from the four cointegration tests, which examined the residual series derived from cointegrating equation (2). Despite some minor differences, the findings confirmed the results reported in Table 2(a). In other words, these test confirmed the existence of a cointegration relationship between *GDP* and *POP*.

Finally, the Granger causality test based on the VECM was employed to examine the causality relationship between population expansion and economic growth in Singapore. This was done because a cointegration relationship between *POP* and *GDP* had been detected by the previous tests. The results obtained from the chi-square statistics, the p-values, the coefficient of the error correction term (ECT_{t-1}), and the t-statistics are reported in Table 3.

According to the results, the null hypothesis that *POP* did not Granger-cause *GDP* could be rejected at the 1 percent level of significance. Therefore, the results indicated that population growth in Singapore Granger-caused the country's real per capita GDP growth. Further, the null hypothesis that *GDP* did not Granger-cause *POP* could be rejected at the 5 percent level of significance. This is because the coefficients of error terms were statistically significantly different from zero. Thus, the obtained results provided evidence that *GDP* growth in Singapore Granger-caused the population expansion.

In short, the present study detected a long-run cointegration relationship between population (*POP)* and real per capita income (*GDP)* in Singapore. As the results show, there was a unidirectional causality from the population expansion to the economic growth in Singapore. And *vice ver*sa, the country's economic growth Granger-caused the population expansion. This lends evidence to the existence of a mutually reinforcing bilateral causality between population expansion and economic growth in Singapore. In other words, Singapore's population growth did contribute to the nation's economic development, which in return stimulated population expansion in the country.

4. Conclusion

This study attempted to examine a complex relationship between population growth and economic development. It chose Singapore as a case study and carried out four different single-equation tests for cointegration to determine whether there existed a meaningful relationship between population and economic development. The unit root tests showed that Singapore's real per capita GDP and the country's population were integrated of order one or *I(1),* which suggested that the two variables (*POP* and *GDP*) had the same order of integration.

Furthermore, the cointegration tests confirmed the existence of a long-run equilibrium relationship between population growth and economic development in Singapore. The findings from the causality test also indicated the presence of a unidirectional causality from Singapore's population expansion to its economic growth, and *vice versa.* Overall, the findings of the econometric analyses imply that there existed a statistically meaningful relationship between Singapore's economic development and the population growth. In other words, there existed a mutually reinforcing bilateral causality between

POP and *GDP* in Singapore: Singapore's population growth did contribute to the nation's economic development, which in return stimulated population expansion in the country.

It should be noted that despite a low fertility rate, Singapore has not suffered from a population decline. The country's remarkable economic achievements may have acted as an attraction factor for migrants to come and work there, which compensated for the low fertility rates. This means that the country's economic success had in effect stimulated population growth, even if it was partially achieved due to the presence of foreigners who work and live in Singapore. At the same time, the migrants may have contributed to a further economic advancement of Singapore, which means that the population expansion promoted the economic development.

The empirical findings of this study indicate the existence of a mutually reinforcing bilateral causality between the population growth and economic development in Singapore, which highlights a dynamic nature of the population-development relationship. Future studies on this topic may want to focus on establishing factors that influence demographic situation in a country and determine the economic development. Recognizing the fact that the relationship between demographic trends and economic development is complex, different from the present study's econometric methods could be employed. The present study concentrated on quantity rather than quality of population. It is possible that if the quality of population is incorporated into the equations, the empirical results could be different from those reported here. Including the quality of population aspect into empirical analyses is a promising direction for future research. On the whole, it is a ripe moment for development economists to have a closer look from different angles at one of the fundamental socio-economic factors – demographic trends.

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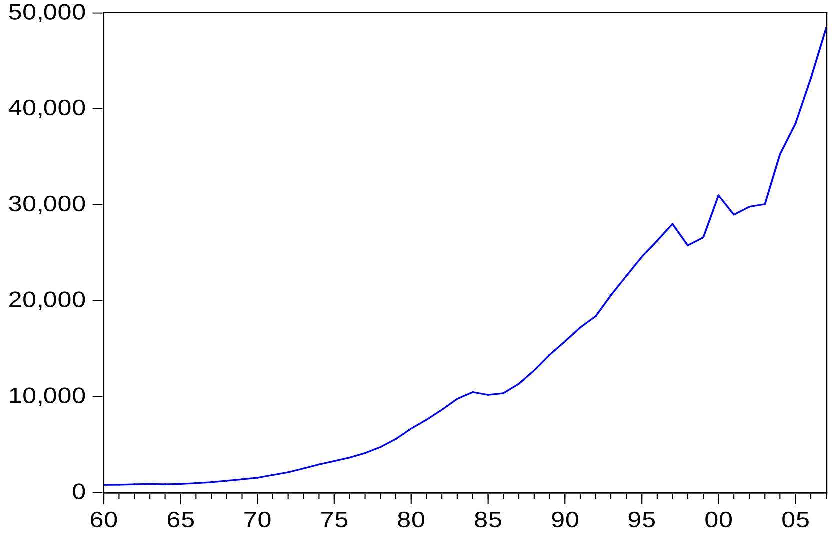
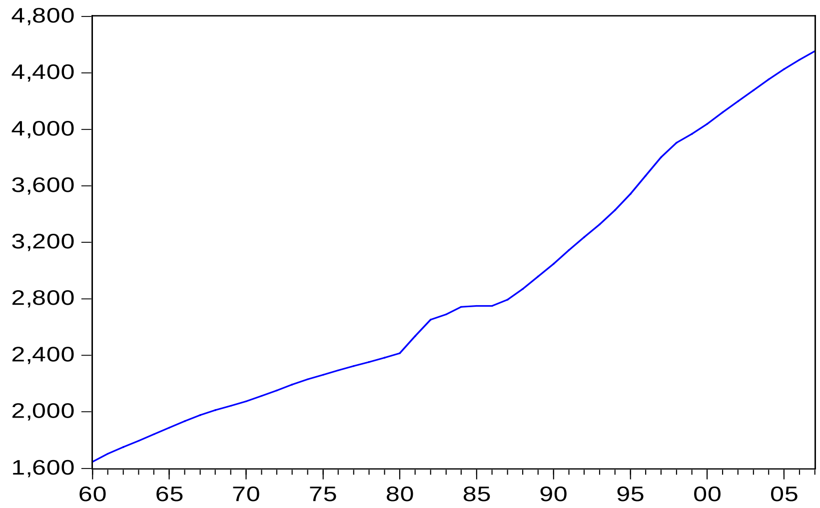
Appendices

Figure 1: Singapore's Real Per Capita GDP from 1960 to 2007 (US dollars)



Source: CIC (2010)

Figure 2: Singapore's Population from 1960 to 2007 (thousand)



Source: CIC (2010)

Table 1: Unit Root Tests

Table 1(a): ADF Unit Root Test				
	Level		First Difference	
	Constant without trend	Constant with trend	Constant without trend	Constant with trend
GDP	-1.079(0)	-1.174(1)	-4.160(0)**	-4.243(0)**
POP	0.396(5)	-2.460(1)	-3.842(1)**	-3.805(1)*
Table 1(b): PP Unit Root Test				
	Level		First Difference	
	Constant without trend	Constant with trend	Constant without trend	Constant with trend
GDP	-0.856(4)	-1.038(4)	-4.112(1)**	-4.243(1)**
POP	-0.184(3)	-1.699(3)	-3.592(1)**	-3.560(1)*

Notes: Figures in parentheses in the ADF test results indicate number of lag structures
Figures in parentheses in the PP test results indicate number of bandwidth
** indicates significance at 1 percent level
* indicates significance at 5 percent level

Table 2: Cointegration tests

Table 2(a): Dependent variable (*GDP*)		
	Constant without trend	*Constant with trend*
1) Ordinary Least Squares (OLS) (Engle and Granger 1987)	-2.986(4)**	-1.246(1)
2) Fully Modified Ordinary Least Squares (FMOLS) (Phillips and Hansen 1990)	-2.977(7)**	-0.722(0)
3) Canonical Cointegration Regression (CCR) (Park 1992)	-2.975(4)**	-1.247(1)
4) Dynamic Ordinary Least Squares (DOLS) (Saikkonen 1992, Stock and Watson 1993).	-2.911(4)**	-1.265(1)
Table 2(b): Dependent variable *(POP)*		
	Constant without trend	Constant with trend
1) Ordinary Least Squares (OLS) (Engle and Granger 1987)	-2.974(7)**	-1.262(1)
2) Fully Modified Ordinary Least Squares (FMOLS) (Phillips and Hansen 1990)	-1.918(9)	-0.565(2)
3) Canonical Cointegration Regression (CCR) (Park 1992)	-2.944(7)**	-1.264(1)
4) Dynamic Ordinary Least Squares (DOLS) (Saikkonen 1992; Stock and Watson 1993).	-2.885(6)*	-1.281(1)

Notes: Figures in parentheses indicate number of lag structures
** indicates significance at 5 percent level
* indicates significance at 10 percent level

Table 3: Granger Causality Test Based on VECM

Singapore		
(a) POP→GDP		
Variable	Chi-square test statistics	Probability
ΔPOP	3.244	0.197
	Coefficient	t-statistics
ECT_{t-1}	-0.001	-3.139**
(b) GDP→POP		
Variable	Chi-square test statistics	Probability
ΔGDP	1.575	0.455
	Coefficient	t-statistics
ECT_{t-1}	-0.001	-2.408*

Notes: ** indicates significance at 1 percent level
* indicates significance at 5 percent level