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TOTAL FERTILITY RATE AND ECONOMIC DEVELOPMENT: NEW EVIDENCE FROM BRUNEI

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Abstract

The demographic transition from high fertility rate to low fertility rate has a strong impact on the economic development process. It has played the central role to shape the economy and society in any country. The centrality of the demographic role in the economic development has been neglected. Thus, this paper chose Brunei as a case study to examine the relationship between economic development and total fertility rates. The empirical findings of the present study show that there is a long-run relationship between Brunei's growth and its growth and there is also the long run causality from growth to fertility in the country. On the other hand, the results show that in the short run there has been no short-run causality between two variables. As a conclusion, these findings provide empirical evidence to support the hypothesis that economic development act as the "driving force" behind the demographic transition in Brunei.

Keywords: fertility, development, Brunei

Introduction

The demographic transition from high fertility rate to low fertility rate has a strong impact on the economic development process. It has played the central role in shaping the economy and society in any country (Dyson, 2010). In other words, the demographic transition would influence the various aspects of society, such as urbanization, gender equality, education system, labour force participation of female or the elderly and so on.

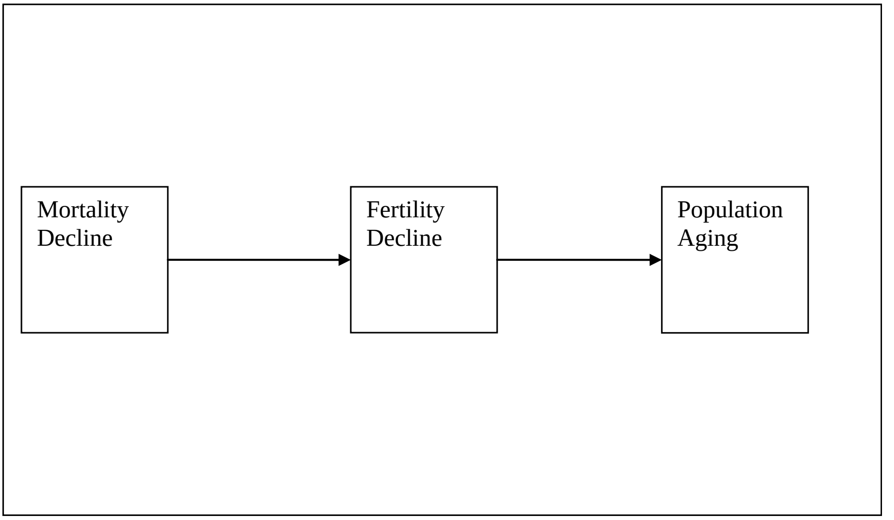
For example, the high labour force participation rate of the elderly is one of the important consequences of the aged society in Japan. In other words, Japan is a country whose population is ageing at a rapid pace. Thus, there is a co-existence of the most aged society and high labour force participation of the elderly. According to Katsumata (2000), it is a well-known fact that Japan's labour force participation rate among the elderly is relatively high.

For example, the labour participation rate among Japanese elderly age 65 and over was 36 percent. The labour force participation of the elderly is much significantly higher than that of other Organization for Economic Co-operation and Development (OECD) countries. More importantly, the employment of the elderly in Japan is always important issues in Japan's labour policy because it is closely related to Japan's pension system (Katsumata, 2000). In other words, the Japanese government tried to promote the employment of the elderly in an ageing society to prevent the bankruptcy of the Japan's public pension system.

For examples, former Japanese Prime Minister Ryutaro Hashimoto attended a conference on the population ageing. The former Prime Minister Hashimoto argued that lessening the burdens faced by an ageing society (i.e. high dependency rate or public pension system crisis) requires the continued employment of older workers, not their early retirement (*Kyodo News*, 2001).

The question remains: what is the prime cause of population ageing? Tim Dyson (2010) argued that the prime cause of the population ageing is the mortality declines. As Figure 1 showed, Dyson argued that the mortality decline is the crucial initiating process. In other words, the fertility decline has never occurred in the absent of mortality decline. The mortality decline can be considered as the underlying cause of the fertility declines (Casterline, 2004; Ni Bhrolchain & Dyson, 2007).

Figure 1: Demographic Transition



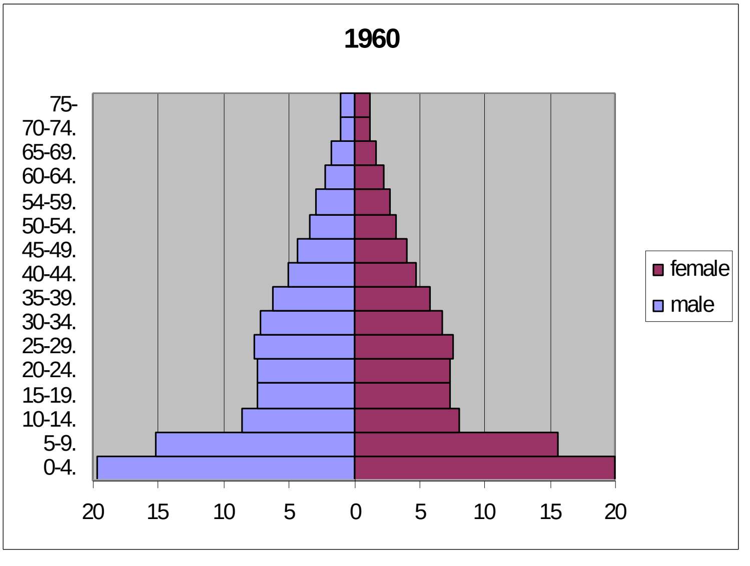
Furthermore, the fertility decline is the main cause of the population ageing. This is because the population decline would cause a reduction in the proportion of children in the population and an increase in the population of the elderly in the total population (Dyson, 2010). However, Dyson pointed (2010) pointed out that the central role of the demographic transition in the economic development has been neglected. Thus, this paper chose Brunei as a case study to examine the relationship between economic development and total fertility rates.

This paper consists of five parts. Following this introductory section, the next section examines briefly main characteristics of the demographic condition in Brunei by using population pyramid. The third section is to explain the methodology. The fourth section is to report the findings, and final section is the conclusion.

Main characteristics of demographic conditions in Brunei

As Figure 2 showed that the Bruneian population pyramid in 1960 is an expansive population pyramid with high mortality rate and high total fertility rate. Total population in Brunei was 81,800. The male's population is more than the female's one. The female's share in the total population is 48.4 percent while the male's share is 51.6 percent. The total fertility rate is 6.92.

Figure 2: Population Pyramid in Brunei (1960)

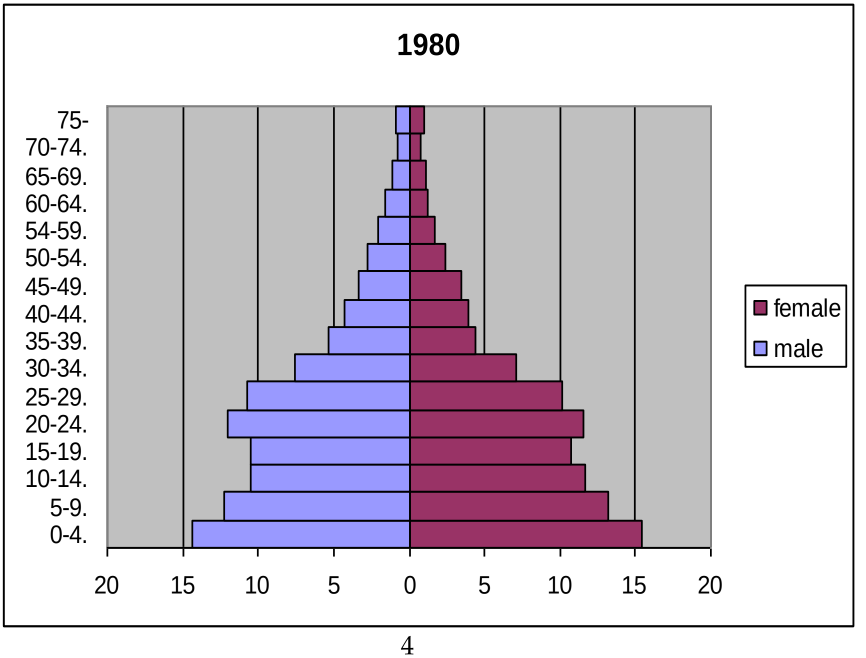


In 1960, the life expectancy in the Brunei was 62.1 years old. The female's life expectancy is longer than the male's life expectancy. The female's life expectancy is 62.8 years old while the male's life expectancy is 61.7 years old. As the population pyramid showed, there is a dominant number of younger people in Brunei in 1960. Thus, the dependency ratio is relatively high, 90.2 percent. The child dependency ratio is 82.8 percent while the aged dependency ratio is 7.4 percent. In 1960, the around half of total population still stayed in the rural area. The share of rural population in the total population is 56.6 percent while the share of urban population is 43.4 percent (World Bank, 2011).

Figure 3 showed that the Bruneian population pyramid in 1980 remained the same shape and it is still an expansive population pyramid with high mortality rate and high total fertility rate. Total population in Brunei increased to 193,028. The male's population remained higher than the female's one. The female's share in the total population is 46.7 percent while the male's share is 53.3 percent. The total fertility rate is 4.05.

In 1980, the life expectancy in the Brunei increased to 70.7 years old. The female's life expectancy still is longer than the male's life expectancy. The female's life expectancy is 72.5 years old while the male's life expectancy is 69.1 years old. As the population pyramid showed, the share of younger people in the total population is still very high in Brunei in 1980. Thus, the dependency ratio is relatively high, 70.7 percent. The child dependency ratio is 65.8 percent while the aged dependency ratio is 4.9 percent. In 1980, some Bruneian still preferred to stay in the rural area. The share of rural population in the total population is 40.1 percent while the share of urban population is 59.9 percent (World Bank, 2011).

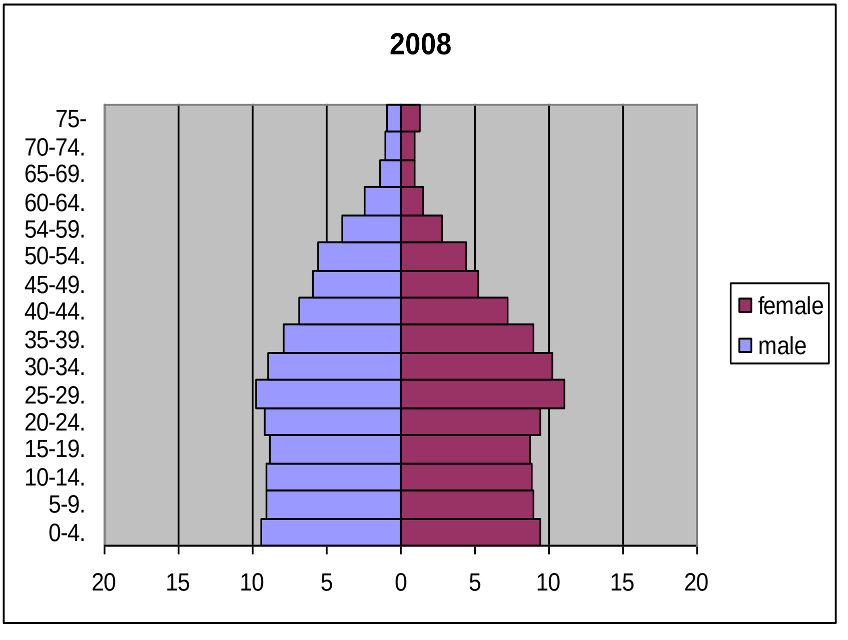
Figure 3: Population Pyramid in Brunei (1980)



Finally, as Figure 4 showed that the Bruneian population pyramid in 2008 became a stationary population pyramid with relatively low mortality rate and relatively low total fertility rate. Total population in Brunei increased to 392,280. The male's population remained higher than the female's one. The female's share in the total population is 48.3 percent while the male's share is 51.7 percent. The total fertility rate is below the replacement rate of 2.10, and it is 2.08.

In 2008, the life expectancy in the Brunei increased further to 77.3 years old. The female's life expectancy still is longer than the male's life expectancy. The female's life expectancy is 79.7 years old while the male's life expectancy is 75.0 years old. The population pyramid in Brunie indicated the share of younger people in total population decreased in 2008. Thus, the dependency ratio became lower, 44.1 percent. The child dependency ratio is 39.4 percent while the aged dependency ratio is 4.7 percent. In 2008, many Bruneian still preferred to stay in the urban area. The share of rural population in total population decreased to 25.2 percent while the share of the urban population increased to 74.8 percent (World Bank, 2011).

Figure 4: Population Pyramid in Brunei (2008)



Research Methodology

The current study uses Vector Error Correction Model (VECM) analysis to test the relationship between total fertility rate (TFR) and per capita Gross Domestic Product (GDP) for the period from 1965 to 2006. The main data source is World Development Indicator (World Bank, 2011).

Three separate econometric methods are used in this research, i.e. 1) unit root test, 2) Johansen cointegration test, and 3) Granger causality based on the VECM. In the first stage of the study, the unit root test is used to examine the stationarity of data sets. The current paper uses the augmented Dickey-Fuller (ADF) unit root test to investigate the stationarity (Dickey & Fuller, 1979, 1981). The ADF test is based on the following regression,

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^{n} \delta_i \Delta y_{t-i} + \varepsilon_t \qquad (1)$$

Where t is a linear time trend, and Δ is the difference operator. β, γ and δ are slope coefficients, and ε is the error term. The ADF tests tend to be sensitive to the choice of lag length n which is determined by minimising the Akaike information criterion (AIC) (Akaike, 1974).

In the second stage, this study would employ the Ordinary Least Squares (OLS) regression model if the variables are integrated of order zero. On the other hand, if the variables are integrated of order one, the Johansen cointegration test would be used to check the long-run movement of the variables (Johansen, 1988, 1991). The Johansen cointegration test is based on maximum likelihood estimation of the K-dimensional Vector Autoregressive (VAR) model of order p,

$$Z_t = \mu + A_1 Z_{t-1} + A_2 Z_{t-2} + ... + A_{t+1} Z_{t-p+1} + \varepsilon_t \qquad (2)$$

Where Z_t is a vector of stochastic variables, μ is a vector of constants, at is matrices of parameters, and εt is a vector of error terms. The model could be transformed into an error correction form:

$$\Delta Z_t = \mu + \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + ... + \Gamma_{t+1} \Delta Z_{t-p+1} + \pi Z_{t-1} + \varepsilon_t \qquad (3)$$

Where π and $\Gamma_1 \ldots \Gamma_{t+1}$ are matrices of parameters. On the other hand, if the coefficient matrix π has reduced rank, $r < k$, then the matrix can be decomposed into $\pi = \alpha\beta'$. The Johansen cointegration test involves testing for the rank of π matrix by examining whether the eigenvalues of π are significantly different from zero. There could be three conditions: 1) $r = k$, which means that the Z_t is stationary at levels, 2) $r = 0$, which means that the Z_t

is the first differenced Vector Autoregressive, and 3) $0 < r < k$, which means there exist r linear combinations of Zt that are stationary or cointegrated.

The current study uses the Trace (Tr) eigenvalue statistics and Maximum (L-max) eigenvalue statistics (Johansen, 1988; Johansen & Juselius, 1990). The likelihood ratio statistic for the trace test is:

$$Tr = -T \sum_{i=r+1}^{p-2} \ln(1-\hat{\lambda}_i) \quad (4)$$

Where $\hat{\lambda}_{r+1},.........,\hat{\lambda}_p$ are the smallest eigenvalues of estimated $p - r$. The null hypothesis for the trace eigenvalue test is that there are at most r cointegrating vectors. On the other hand, the L-max could be calculated as:

$$L - \max = -T \ln(1-\hat{\lambda}_{r+1}) \quad (5)$$

The null hypothesis for the maximum eigenvalue test is that r cointegrating vectors are tested against the alternative hypothesis of $r+1$ cointegrating vectors. If trace eigenvalue test and maximum eignevalue test yield different results, the results of the maximum eigenvalue test should be used because the power of maximum eigenvalue test is considered greater than the power of the trace eigenvalue test (Johansen & Juselius, 1990).

Finally, this study uses Granger causality test to analyse the causality between fertility and economic growth (Granger, 1969). If both variables are integrated order zero, I(0), a standard Granger causality test with the lag length of k could be based on the following equations

$$TFR_t = \alpha_1 + \sum_{i=1}^{k} \beta_{1i} TFR_{t-i} + \sum_{i=1}^{k} \gamma_{1i} GDP_{t-i} + \varepsilon_1 \quad (6)$$

$$GDP_t = \alpha_2 + \sum_{i=1}^{k} \beta_{2i} TFR_{t-i} + \sum_{i=1}^{k} \gamma_{2i} GDP_{t-i} + \varepsilon_2 \quad (7)$$

Where TFR_t is the total fertility rate at year t, GDP_t is the per capita GDP at year t, α_1 and $\alpha_2$are constants; β and γ are slope coefficients. Granger causality could be examined by using the Wald test for the joint hypothesis

$$\gamma_1 = \gamma_2 = \ldots\ldots \gamma_k = 0 \quad (8)$$

The null hypothesis for equation (6) is that GDP does not Granger cause TFR. On the other hand, the null hypothesis for equation (7) is that TFR does not Granger cause GDP. The rejection of null hypothesis could indicate the causal relationship between the two variables.

On the other hand, if both variables are integrated order one, I(1), and there is a cointegrating relationship between them, Granger causality test could be based on the following Vector Error Correction Models (VECMs)

$$\Delta TFR_t = \alpha_1 + \sum_{i=1}^{k} \beta_{1i} \Delta TFR_{t-i} + \sum_{i=1}^{k} \gamma_{1i} \Delta GDP_{t-i} + \delta_2 EC_{t-1} + \varepsilon_1 \quad (9)$$

$$\Delta GDP_t = \alpha_2 + \sum_{i=1}^{k} \beta_{2i} \Delta TFR_{t-i} + \sum_{i=1}^{k} \gamma_{2i} \Delta GDP_{t-i} + \delta_2 EC_{t-1} + \varepsilon_2 \quad (10)$$

Where Δ is difference operator; EC_{t-1} is the one-period lagged value of the error correction term; δ is slope coefficients.

There is a great advantage to using Granger causality test based on the VECM rather than the standard one. The Granger causality test based on the VECM could identify both the short-run and the long-run causalities. The Wald test of the independent variables could be interpreted as the short run causal effect while the significant correction term (ECt-1) could be interpreted as the long-run causal effects.

Four types of causal relationship between fertility and growth are possible:

(1) Independence: no causality between fertility and growth, which could be interpreted as the independent relationship between fertility and growth.

(2) Growth-driven fertility expansion: unidirectional causality from growth to fertility, but not vice versa, which could be interpreted as support for the existence of the "growth-led" fertility expansion.

(3) Fertility-driven growth: unidirectional causality from fertility to economic growth, but not vice versa, which could be interpreted as support for the existence of the "fertility-led" output expansion.

(4) Two-way causality: unidirectional causality from fertility to economic growth, and vice versa, which could be interpreted as a mutually reinforcing bilateral causality between fertility and growth.

Empirical Findings

The ADF root test was conducted to examine the stationarity of the variables. The results from the ADF test are shown in Table 1. Despite minor differences in the findings as reported in the table, the obtained results indicate that the two variables -- TFR and GDP -- are integrated of order one, I(1).

Table 1: ADF Unit Root Test

	Levels		First Difference	
	Constant without trend	Constant with trend	Constant without trend	Constant with trend
TFR	-1.882(1)	-0.802(9)	-0.213(3)	-4.273(8)**
GDP	-0.417(0)	-1.831(1)	-5.038(0)**	-5.009(0)**

Notes: Figures in parentheses indicate number of lag structures
** indicates significance at 1% level

In the second stage, the Johansen cointegration test was used to test the long-run movement of the variables. As Engle and Granger (1987) pointed out, only variables with the same order of integration could be tested for cointegration such as the present study; both variables could be examined for cointegration.

Results of the cointegration tests are reported in Table 5 and Table 6. Both the Trace Eigenvalue test and the Maximum Eigenvalue test indicate one cointegrating equation. The findings indicate that there exists the long-run relationship between the two variables (i.e., TFR and GDP), which means that these variables are co-integrated. In other words, although the variables are not stationary at levels, in the long run, they closely move with each other. These results support the existence of a long-run equilibrium relationship between total fertility rate and per capita GDP in Brunei.

Table 2: The Johansen Cointegration Test (Trace Eigenvalue Statistic)

Eigenvalue	Trace statistic	5 percent critical value	Probability	Number of cointegrating equations
0.370	17.74	12.31	0.005	None**
0.003	0.12	4.12	0.769	At most 1

The result corresponds to VAR's with three lags
** indicates significance at 1% level

Table 3: The Johansen Cointegration Test (Maximum Eigenvalue Statistic)

Eigenvalue	Max statistic	5 percent critical value	Probability	Number of cointegrating equations
0.370	17.61	11.22	0.003	None**
0.003	0.12	4.12	0.768	At most 1

The result corresponds to VAR's with three lags
** indicates significance at 1% level

Finally, the "Growth-driven fertility expansion" hypothesis was tested using Granger causality test which is based on equation (9). The results of the Wald statistics and t-statistics are reported in Table 4. The findings show that the error correction term (ECTt-1) is statistically significant. This means that there exists long run Granger causality between TFR and GDP. This long-run Granger causality confirms the existence of the long run equilibrium relationship between fertility and growth in Brunei, as indicated in Johansen cointegration test. On the other hand, the Wald statistics indicate that there was no unilateral causality from growth to fertility in the country over short periods of time. In other words, Brunei's income expansion does not "Granger cause" increase in fertility n the short run.

Table 4: Growth-Driven Fertility Expansion Hypothesis

Dependent Variable: ΔTFR		
Variable	**Degree of Freedom**	**Wald Test Statistics**
ΔGDP	3	0.123
	Coefficient	**t-statistics**
ECT_{t-1}	-0.002	-4.257**

The result corresponds to VAR's with three lags
* indicates significance at 5% level

On the other hand, the results of Granger causality test, which is based on equation (10), for the "fertility-driven growth" hypothesis are reported in Table 5. The findings show that the error correction term (ECTt-1) is not statistically significant. This means that there is no long-run Granger causality between Brunei's fertility and economic growth. Furthermore, the Wald test does not detect Granger causality between the variables in the short run. This means that it does not seem to exist unilateral causality from fertility to growth in Brunei over short periods of time.

Table 5: Fertility-Driven Growth Hypothesis

Dependent Variable: ΔGDP		
Variable	**Degree of Freedom**	**Wald Test Statistics**
ΔTFR	3	0.636
	Coefficient	**t-statistics**
ECT_{t-1}	79.863	0.116

The result corresponds to VAR’s with three lags
** indicates significance at 1% level

In short, the empirical findings of the present study show that there is a long-run relationship between Brunei's growth and its growth and there is also the long run causality from growth to fertility in the country. On the other hand, the results show that in the short run there has been no short-run causality between two variables. As a conclusion, these findings provide empirical evidence to support the hypothesis that economic development is playing a role of the "driving force" behind the demographic transition in Brunei.

Conclusion

Brunei is a dynamic economy that has been enjoying a rapid growth for several decades. Demographic factor, such as fertility rate, is usually seen as an important element in propelling the developing countries, such as Brunei, towards the status of fully developed economies. The current study carried out an empirical analysis of the relationship between fertility and economic growth in Brunei.

The empirical findings of the present study show that there is a long-run relationship between Brunei's growth and its growth and there is also the long run causality from growth to fertility in the country. On the other hand, the results show that in the short run there has been no short-run causality between two variables. As a conclusion, these findings provide empirical evidence to support the hypothesis that economic development act as the "driving force" behind the demographic transition in Brunei.

Findings of the current research encourage a closer look at other factors that may influence the pace of demographic transition in Brunei (i.e. mortality rate, urbanisation, etc.). Future studies on this topic may want to incorporate other than the present study's variables to better capture the complexities of the process of economic growth and demographic transition.

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