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## Economic Determinants of Japan's Low Fertility Rate: Cointegration Analysis

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**Abstract**

This paper discusses the determinants of Japan's declining fertility rate from 1973 to 2008. We examine various economic factors: GDP per capita, infant mortality rates, female labour participation, cost of education, and urbanization and find that these variables are cointegrated. We discover that GDP per capita has a negative relationship with fertility rates and a 1% increase in GDP per capita leads to a decrease in fertility by 2.1%. In addition, we discover that female labour participation shows an unexpected positive relationship to fertility suggesting that their financial contribution to the family has lowered the cost of child rearing.

**Keywords**

Japan, fertility, cointegration

**Jel Classification Numbers**

J13, C22

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## 1.0 Introduction

Since the mid-1970s, Japan's total fertility rate has plummeted to the point where today, Japan has one of the lowest total fertility rates in the world (World Bank Group 2010b). In 1973, Japanese women between the ages 15 to 49 gave birth to 2.14 children. By 2005, the total fertility rate dropped to a record low of 1.26 and has since risen slightly to a mere 1.37 in 2008 (Ministry of Health, Labor, and Welfare of Japan 2008). Despite the minimal increase in the total fertility rate, the figure remains far below the replacement level of 2.1 needed to keep Japan's population stable (Espenshade Guzman and Westoff 2003). The population is expected to decrease from 127,176 million in 2010 to 95,152 million by 2050 (see Table 1). This is likely to adversely affect Japan's demographic structure, welfare distribution and output growth.

**Table 1. Trends in Japan's Population**

| Year | Population (1,000) | Age Composition (%) | | | Average Annual rate of Increase |
|---|---|---|---|---|---|
| | | 0-14 years | 15-64 years | 65 + years | |
| 2010 | 127,176 | 13.0 | 63.9 | 23.1 | -0.16 |
| 2020 | 122,735 | 10.8 | 60.0 | 29.2 | -0.35 |
| 2030 | 115,224 | 9.7 | 58.5 | 31.8 | -0.63 |
| 2040 | 105,695 | 9.3 | 54.2 | 36.5 | -0.86 |
| 2050 | 95,152 | 8.6 | 51.8 | 39.6 | -1.05 |

**Source:** (Ministry of Internal Affairs and Communications 2008b)

The decline in fertility coupled with an increase in life expectancy makes Japan's demographic structure unsound. Since 1982, the population of 0 to 14 year olds has shrunk due to the declining fertility rate and by 2007, the population of 65 years and older made up a remarkable 21.5% of the total population (Ministry of Internal Affairs and Communications 2008b). By 2025, one elderly Japanese will be dependent on two employed people, and this dwindling population of the working age will be responsible for shouldering the progress and future of Japan's economy (Narayan and Peng 2007). As a result, the sustainability of the public pension system and other welfare spending could be damaged (Bogaarts 2004).

A decreased population could lead to greater capital deepening, however, because of Japan's demographic imbalance productivity is expected to decrease. The IMF's World Macro-economic Model (MULTIMOD) long-term simulation predicts that there will be a decrease in Japan's level of real GDP by an overall 20% over the next 100 years (Mühleisen and Faruqee 2001). Therefore, the high old age dependency ratio, resulting from decades of declining fertility rates, is likely to weigh heavily on Japan's economic future[3].

Increasing the rate of immigration could help alleviate the declining fertility rate, but would be difficult to achieve and likely to be met with domestic opposition. If Japan wanted to maintain the population size it had in 2005, it would require 17 million net immigrants over the next 45 years. By 2050, these immigrants and their offspring would make up 17.7% of the total population. Today, non-native Japanese make up hardly 1% of the total population,

[3] Old age dependency ratio refers to the amount of elderly (65 + years) per one hundred persons to the age of the employed population (15-64 years old) (United Nations 2009).

therefore raising this rate to 17.7% would be quite substantial over the next 40 years (United Nations 2001). At the same time, public opinion against accepting foreign workers in Japan has increased. In 1990, the percentage of people who believed that unskilled foreign workers should not be accepted into Japan was 14.1% and by 2004 had reached 25.9%. Out of the 25.9% of those opposing foreign workers, 74.1% of them expressed concerns regarding public security (Ogawa 2005). Therefore, even if immigration policy appears to be a possible solution for Japan's declining fertility rate, it is likely to meet resistance.

Section 2 of this paper explores existing literature regarding determinants of total fertility rates; infant mortality, cost of education, female education, female employment, gender equality, economic development, and urbanization. Section 3 provides empirical analysis of the major determinants of total fertility, presenting descriptive data as well as regression (cointegration) analysis. Section 4 summarizes the empirical results and Section 5 provides the conclusion and closing remarks.

## 2.0 Literature Review

Fertility rates in Japan have gained much attention due to concerns over an aging society, and the possible economic repercussions of a declining labor force and consumer market (Ogawa 2003). Some of the variables thought to be responsible for the plummeting fertility rate are a decreasing infant mortality rate, higher costs of educating children, increasing female attainment of higher education, increasing female labor participation, gender inequality, economic development and urbanization. Much research has been conducted on the following variables and can help to give us an idea on Japan's specific condition of low fertility rates.

### 2.1 Infant Mortality and Fertility

Much attention has been given to the demographic transition as an explanation for the relationship between mortality and fertility. Demographers who first studied this topic, Thompson (1929) and Notestein (1945), described how modernization and development lead to a decrease in fertility[4]. The importance of mortality and its relationship to fertility from the view of the demographer is explained through three main channels: *physiological, replacement,* and *hoarding effects* (Olsen 1983). With each of these effects, mortality will have a positive impact on fertility.

The *physiological effect* occurs when an infant dies and as a result, the mother stops breastfeeding. The termination of lactation prompts the mother to begin her menstruation cycle, which creates a larger period of exposure for additional births. The mechanism is stronger in locations where breastfeeding is widespread and contraceptive use is rare (Palloni and Rafalimanana 1999). The *replacement effect* refers to the response of the parents after the death of their child. Here, the parents conceive again in order to compensate for the mortality of their prior child, motivated by the need to obtain a desired number of children with the lagged response depending on the age of the child and mother (Ben-Porcth 1976). The difference between the *physiological* and *replacement effects* is that the latter is influenced by infant mortality as well as child mortality (Palloni and Rafalimanana 1999). The *hoarding effect* is different from both *physiological* and *replacement effects* because parents decide to have more children than their desired family size in anticipation of high mortality in the future. Couples implementing the *hoarding* approach do so by having children earlier, and later, or by decreasing the time period between each birth (LeGrand et al. 2003).

[4] The idea of modernization represents a shift from a pre-modern period of high mortality and high fertility to a post-modern period where fertility and morality are low (Kirk 1996).

Another explanation regarding the positive relationship between mortality and fertility can be explained by the unified growth theories. Using the work of Becker (1960), parents decide whether to have many children and invest a minimal amount of human capital per offspring or have fewer children and invest more human capital. This is known as the quantity vs. quality trade-off and can help to explain the transition from the pre-industrial period with close to zero rates of growth to the industrial revolution and beyond with a constant rate of growth (Angeles 2009). For example, when mortality rates are high, parents have less incentive to invest in their children's human capital (preschool, trumpet lessons, books) since there is a greater probability of early death and a loss of investment. As mortality decreases, however, parents would be inclined to choose quality over quantity resulting in fewer children with more human capital as a result of an increased likelihood of realized investment (Becker 1960).

Despite theoretical differences, there appears to be consensus on the positive relationship between infant mortality and total fertility among empirical results. Angeles (2009) finds that a change in the mortality rate plays a strong influence on fertility rates after a lagged period characterizing the demographic transition. Chowdhury (1988) as well finds that the relationship between mortality and fertility slightly supports the demographic transition in some countries but not in others. Sandberg's (2006) research finds that the spread of information regarding the level and variation of infant mortality experiences amongst social networks in a small Nepalese mountain population lead to a faster rate of fertility. Handa (2002) also discovers that infant mortality has a positive impact on fertility rates both in rural and urban Jamaica. However, Narayan and Smyth (2006) find a neutral relationship between fertility rates and infant mortality using a Granger Causality test and reject the demographic transition.

### 2.2 Cost of Raising and Educating Children

Another determinant that has been seen to negatively influence fertility is the cost of raising and educating children. Again we can refer back to the quantity quality trade-off. As Becker and Lewis (1973) suggest, if parents decide to have more children and keep the level of education constant, the cost is greater the higher their level of education. As well, if parents decide to increase the amount of education to a constant number of children, the cost is greater the more children they have. Therefore, if parents feel the need to invest more education in their offspring, they will choose to have fewer children due to the increased cost of education.

In Japan, there is high competition to get into the finest universities in order to obtain the best job after graduation and have a more affluent life. Acceptance into Japanese universities is primarily based on entrance exams. As a result, there is an increased demand for Juku, a cram school that teaches after school and when school is out of session in order to help prepare Japanese students for exams. Recently, Juku is considered more essential, and from 1982 to 1991 attendance increased from 40% to 48% among sixth graders and 43% to 58% for ninth graders (Retherford Ogawa and Sakamoto 1996). Retherford Ogawa, and Sakamoto go on to say that "spending on private education has increased to the point where the costs now exceed normal expenses for pupils in Japanese public high schools."

Numerous studies on the effect of increased cost of education have been conducted and find similar results. Oyama (2006) uses the equivalence scale estimation for the satisfaction of income and finds that the cost of raising and educating children in Japan is higher than expected. Retherford Ogawa, and Sakamoto (1996) state that the cost of educating children is on the rise, adversely affecting fertility rates. Ogawa (2003) provides micro-data on the difficulties of raising children from Japanese mothers. From the Population Problems Research Council 1981 and 1996 (respectively), the cost of education increased from 42% to

66%, and the physiological strain of educating and training children increased from 55% to 59%.

### 2.3 Education and Fertility

Education can have a negative impact on fertility through various channels. First, increased education can facilitate the use of contraceptives and empower couples to control the size of their families. Second, increased female education can raise the opportunity cost of marriage which can lead to marriage postponement, and increase lifetime celibacy rates[5]. As a result, higher rates of education can adversely affect total fertility rates (Retherford Ogawa and Matsukura 2001).

The *taste hypothesis* states that parents with higher education see the size of their family as something they can control and would hold back fertility more thus having fewer offspring (Hashimoto 1974). In addition, the *cost-of-fertility hypothesis* explains that couples with greater levels of education have a better understanding and also better access to birth control allowing them to make use of it more effectively. Higher education would thus lower the cost of birth control, inducing parents with more education to use contraceptives more often than others (Hashimoto 1974).

Various studies have reaffirmed the relationship between education and fertility. Shapiro and Tambashe (1994) find that increased levels of education result in an increased probability of contraceptive use. Martin (1995) shows that women with greater levels of education have higher rates of contraceptive use and employ more effective means of contraceptives than uneducated women. Also, a study on 14 Sub-Saharan African countries discovered that female schooling had a positive influence on the use of contraceptives (Ainsworth Beegle and Nyamete 1996).

In addition, increased female education can negatively influence fertility by increasing the opportunity cost of marriage, resulting in the postponement of matrimony. If couples marry later, the singulate mean age at marriage (SMAM) increases and the time period for conception decreases, limiting the biological sum of possible children a family can have[6]. In Japan for example, women with higher levels of education tend to marry much later. As can be seen in Table 2 (based on Retherford Ogawa, and Matsukura 2001), women with a university education will have a SMAM of 3.5 years higher than those with a junior high school education and almost a year higher than those who went to junior college.

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[5] The lifetime celibacy rate represents the average of the age-specific shares of singles that are 45-49 and 50-54 years old (Retherford Ogawa and Matsukura 2001).

[6] Singulate mean age at marriage refers to the "average age at which men and women first marry." (United Nations 2006)

**Table 2. Singulate mean age at marriage and lifetime celibacy rate (percentage) by education and sex: Japan, 1990**

| | SMAM | | LCR | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| **Education** | | | | |
| 1990 | | | | |
| Junior high school or less | 24.6 | 30.3 | 4 | 8 |
| Senior high school | 25.9 | 29.9 | 4 | 4 |
| Junior college | 27.4 | 30.3 | 6 | 4 |
| University | 28.1 | 30.7 | 9 | 3 |

**Source:** Based on figures from the 1990 population census of Japan. A specified level of education such as senior high means that persons classified at that level graduated at that level (Retherford Ogawa and Matsukura 2001).

What's more, increased female education is also viewed to affect fertility rates by increasing the rate of lifetime celibacy. If the percentage of lifetime celibacy increases, the opportunities for procreation are limited, especially in the case of Japan, where out of wed-lock birth is still quite rare (Boling 2008). Note, as Table 2 reveals, the lifetime celibacy rate is 5 percentage points greater for women with university degrees than women with junior education (Retherford Ogawa and Matsukura 2001).

Both Ogawa (2003) and Date and Shimizutani (2007) discover that later marriages have been the major contributor to the decrease in fertility in Japan since the mid-1970s. Narayan and Peng (2007) demonstrate that a 1% rise in age of marriage decreased fertility by 3.5% in the long-run and 1.2% in the short-term. Raymo and Iwasawa (2005) find that "decreases in the supply of highly educated men and the improvements in women's educational attainment have contributed to lower rates of marriage among highly educated women and somewhat higher rates of marriage among women with a high school education or less." In Italy and Spain however, Billari (2008) finds that postponed fertility is the major factor for the decreased fertility rate rather than later marriage.

### 2.4 Female Employment and Fertility

An increase in female labor participation is also thought to decrease fertility by increasing both the age of marriage and the lifetime celibacy rate. The *cost-of-time* hypothesis states that as female education increases, so does her productivity at home and in the labor market. If women's productivity increases more in the market (increasing the real wage) rather than at home, this would induce them to choose employment over child-rearing or delay marriage which would lower their fertility. It is important to note however, that for the *cost-of-time hypothesis*, increased education of fathers has a positive impact on fertility (Hashimoto 1974).

Additionally, female employment can have a negative effect on fertility through wage increases. The theory of *specialization and exchange* posits that within a country women with higher economic status have a lower probability of marriage, and as a result, indirectly decrease their fertility (Ono 2003). As female wages increase their incentive to enter into marriage decreases due to greater economic independence. It is important to note, however, that in many industrialized nations once female labor participation reaches a certain level fertility rates tend to be brought under control by government and business policies, which help and support working mothers. For most developed countries, fertility tends to recover when female labor participation reaches 60%. In 2001, Japanese female labor participation had reached 64.4%, but by 2008 fertility had yet to experience a substantial rebound (Date and Shimizutani 2007)

Osawa (1988) finds that wives working outside the home had much lower fertility than wives working for no pay in a family business or not working at all. Yamada and Yamada (1984) also find a strong negative correlation between married women's employment and fertility in urban Japan. Butz and Ward (1979) find in the U.S., that the baby bust in the 1960s was the result of increases in female wages and incomes. In Italy however, Del Boca (2002) discovers that fertility rates declined despite meek employment participation as a result of rigid institutions. In Sweden, Sundström and Stafford (1992) show that in the 1980s and beginning of the 1990s, there was a positive relationship between female labor participation and fertility due to maternal policies[7]. Cheng Hsu and Chu (1997) on the other hand were able to establish a casual relationship from fertility to female labor participation.

### 2.5 Gender Equality and Fertility

Another reason as to why employed females tend to have fewer children can be explained by gender equality. Since post-World War II, Japanese female employment participation has increased along with equality in the labor market. Despite these positive gains, household equality has not yet been realized and a majority of the childcare and domestic work remains the major responsibility of the mother. McDonald (2000) states that if there is equality in the labor market and with educational institutions, but not at home or among political policies to support working mothers, the fertility rates will be low. He uses the example of Nordic, English speaking countries and France, where both social and economic institutions are more gender equal and fertility rates are not extremely low. In contrast however, countries that focus on the importance of the male as the main source of income of the family, and where mother's employment opportunities are limited (unequal income tax system, social arrangements discouraging working mothers, and limited family support services) fertility will be very low (McDonald 2000).

Feyrer, Sacerdote, and Stern (2008) emphasize how the father's participation in childcare and domestic production plays an important role in determining the fertility rate and how this evolves through three stages. In the *early phase*, there are large wage differentials between men and women making the male the breadwinner. In this phase, women are responsible for almost all of the childcare and as a result most women focus mainly on domestic care. In the *intermediate phase*, gains are realized in labor market equality, but are not completely equal. At the same time however, women are still expected to handle most of the childcare. Therefore, opportunity cost to have children is high which decreases the fertility rate. In the *final phase*, labor opportunities between the sexes begin to balance out resulting in more equal wages. This in turn increases the mother's "bargaining power", consequently resulting in more assistance from the father with domestic activities. As childcare becomes more equally shared between both parents, the mother's opportunity cost to have children is weaker and the fertility rate rises (Feyrer Sacerdote and Stern 2008).

Torr and Short (2004) find the relationship between gender equality and fertility is represented by an inverted U. Duvander and Andersson (2006) discover that males taking parental-leave have a positive relationship to continued fertility in Sweden. Morgan and Niraula (1995) analyze two Nepalese villages with contrasting gender equality and find that the families in the village with low equality are less likely to have additional children.

### 2.6 Economic Development and Fertility

[7] Maternal policies refer to subsidized childcare, variable employment hours, high average and marginal tax rates for mothers, and parental leave programs (Sundström and Stafford 1992).

The relationship between economic development and fertility can be explained through the *demographic transition* theory. The theory states the level of economic development a country is experiencing determines its stage in the transition. Proponents of the *demographic transition* point out the opposite relationship between fertility rates and the level of industrialization. For example, highly developed nations tend to have lower fertility rates than most developing nations (Heer 1966). Therefore, in the *demographic transition* theory, economic development has a negative relationship to fertility.

The empirical results tend to support the idea that economic development has a negative relationship with fertility. Heer (1966) finds that economic development leads to increases in education and lowers mortality, which reduces fertility. In the sub-regions of China and Taiwan, Poston (2000) discovers that social and economic development had a pervasive negative relationship with fertility. As well, Gertler and Molyneaux (1994) show that education and economic development led to the use of contraceptives, which accounted for 75% fertility reduction in Indonesia from 1982 to 1987.

### 2.7 Urbanization and Fertility

Living in an urban setting can be seen to have both a positive and negative relationship with fertility. People living in agglomeration economies (areas that benefit economical from a concentration of productive output and housing) tend to have higher wages, which can affect fertility in two ways. Increases in wages can increase disposable income making it easier to afford children. At the same time, higher wages can mean higher opportunity costs to stay at home and raise children, especially for mothers (Sato 2007). Therefore, an increase in male wages tends to increase fertility while an increase in female wages tends to decrease it.

On the other hand, congestion dis-economies, which represent the increased cost of living due to the higher population density (land rent), can have a negative impact on fertility. Predominantly, the costs are higher to raise children in the city and children tend to donate less to the family in an urban setting than in the countryside (Osawa 1988). As well, the increased cost of land rent along with a higher cost of living would mean that urban families would tend to live in smaller houses, making it more expensive and too confined to have many children (Sato 2007).

In addition, migration has long been thought to reduce fertility. Hervitz (1985), states that the relationship can be partially explained through four hypotheses: *socialization, adaptation, selection*, and *disruption.* The *socialization hypothesis* believes that fertility behaviors of migrants are the same as their region of origin. On the other hand, the *adaptation hypothesis* states that fertility behaviors adapt and reflect that of the migrants' destination rather than their origin. The *selection hypothesis* says that migrants consist of a certain group of people that possess beliefs regarding fertility similar to their destination. This theory, however, does not insist that migration lowers fertility since migrants have similar fertility behavior of the destination with or without migration. Finally, the *disruption hypothesis* argues that immediately after the migration period, migrants would have a lower fertility rate as a result of the disruptive factors related with migrating. In addition, women would tend not to migrate during pregnancy (Hervitz 1985).

Many empirical results agree that urbanization has a negative effect on fertility. Few, however, attribute such declines to a specific hypothesis. Zhang (2002) shows that increased urbanization on average has lowered fertility rates. Kulu (2004) discovers that post-war Estonian female migrants adjusted their fertility rates similar to their destination, supporting the *adaptation theory*. Sato (2007) discovers that urban regions with higher agglomerations economies draw more migrants, which increases the congestion dis-economies and results in a decreasing fertility rate. However, Retherford Ogawa, and Matsukura (2001) find that urbanization has contributed almost nothing to the change in fertility from 1960 to 1990 in Japan.

### 3.0 Data and Methodology

To carry out an estimation procedure of the determinants of Japan's fertility rate, we employed annual data covering the period from 1973–2008. We included only those variables that are frequently used in the literature. Following earlier studies (Masih and Masih 2000; Narayan and Peng 2007) fertility is modelled as a function of GDP per capita, infant mortality per 1000 live births, share of women of working age in employment, average life expectance at birth, cost of education as a % of current income and urban population as a % out of total population. Also all variables are in natural logarithmic form.

$$\ln F_t = \alpha_0 + \alpha_1 \ln GDP_t + \alpha_2 IMR_t + \alpha_3 WES_t + \alpha_4 \ln LEB_t + \alpha_5 CE_t + \alpha_6 UP_t + \varepsilon_t \quad (1)$$

In this equations lnF denotes the log of the fertility rates, lnGDP is the log of the GDP per capita, lnIMR is the log of the infant mortality rate, lnWES is the log of women share in employment, lnLEB is the log of average life expectance at birth, lnCE is the log of the cost of education as a % of current income, lnUP is the log of urban population as a % out of total population, $\varepsilon_t$ is the error term and $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$ are the coefficients to be estimated.

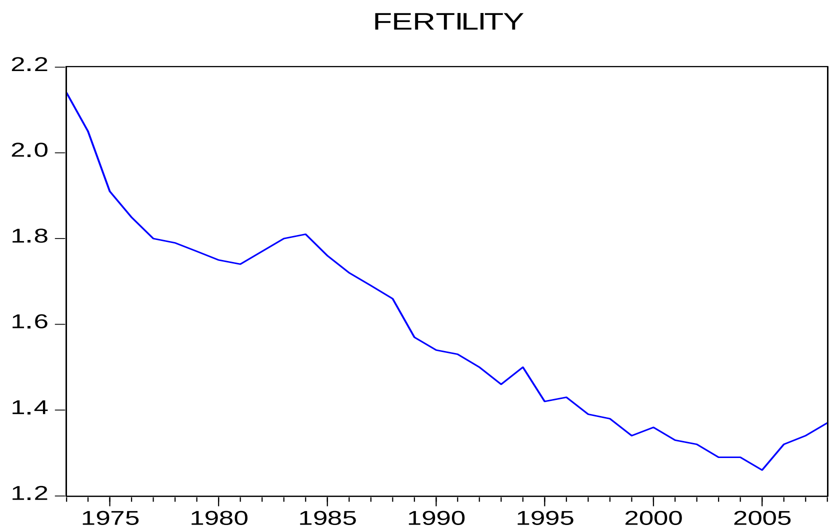
**Table 3. Descriptive Statistics of the Data**

| | Woman Share In Employment | Cost of Education | Fertility | Infant mortality* | Life | Urban Population |
|---|---|---|---|---|---|---|
| Mean | 54.65304 | 2.988889 | 1.581944 | 5.322222 | 78.77778 | 62.34167 |
| Median | 56.11298 | 3.180000 | 1.535000 | 4.550000 | 79.00000 | 63.25000 |
| Maximum | 59.73646 | 3.790000 | 2.140000 | 11.30000 | 83.00000 | 66.48000 |
| Minimum | 48.79127 | 1.820000 | 1.260000 | 2.600000 | 74.00000 | 55.36000 |
| Std. Dev. | 3.107328 | 0.537427 | 0.235358 | 2.485743 | 2.608898 | 3.273573 |
| Skewness | -0.313584 | -0.714195 | 0.432226 | 0.925122 | -0.135100 | -0.526651 |
| Kurtosis | 1.912607 | 2.529203 | 2.211145 | 2.793345 | 1.940984 | 2.062550 |
| Jarque-Bera | 2.363645 | 3.392925 | 2.054351 | 5.199162 | 1.791784 | 2.982383 |
| Probability | 0.306719 | 0.183331 | 0.358017 | 0.074305 | 0.408243 | 0.225104 |
| Sum | 1967.509 | 107.6000 | 56.95000 | 191.6000 | 2836.000 | 2244.300 |
| Sum Sq. Dev. | 337.9420 | 10.10896 | 1.938764 | 216.2622 | 238.2222 | 375.0699 |
| Observations | 36 | 36 | 36 | 36 | 36 | 36 |

*per 1000 live births

Table 3, provides descriptive statistics regarding the variables used in this study. When observing the variables we can see that the average fertility rate in Japan is 1.58 between 1973 and 2008. During this period, Japan's maximum and minimum fertility rate is 2.14 and 1.26; respectively. The average share of women of working age in employment is 54.65%. In this period the maximum and minimum share of women in employment is 59.73% and 49.79%; respectively. The average of infant mortality per 1000 live births is 5.32 and the maximum and minimum value is 11.3 and 2.6; respectively. The Jarque Bera statistics probabilities show that the original variables are not normal distributed. In regression we used the variables in logarithm form.

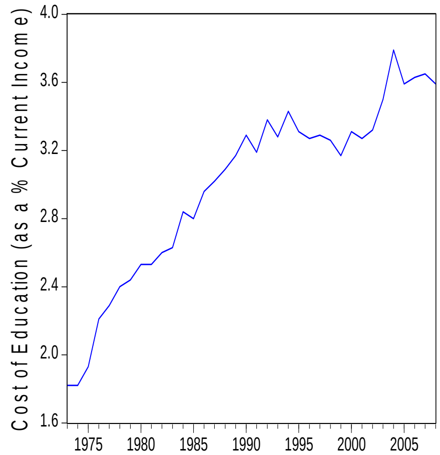
**Graph 1. Total Fertility Rate in Japan**



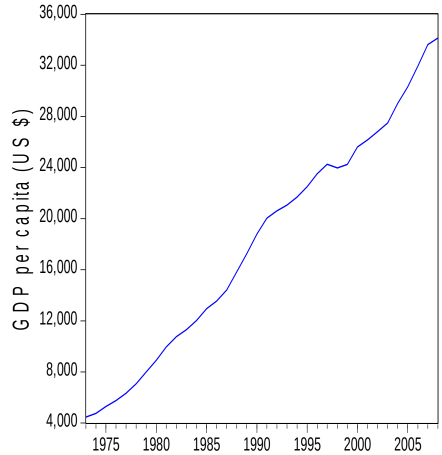

(Ministry of Health, Labour, and Welfare 2008)

Graph 1 shows a negative trend for Japan's total fertility rate. Between the dates 1973-1975, the fertility rate of Japan declined dramatically. After 1980, the fertility rate in Japan increased slightly until 1985 where it again has decreased significantly. In recent years, Japan's fertility rate has risen slightly reaching 1.37 in 2008. However, this rate remains far below the replacement level of 2.1 needed to keep population stable. Next, we can conclude from graphs 2 that the cost of education in Japan has been increasing from 1973-2008. In addition, all of the variables that we use for empirical analysis have a trend. Except for fertility rate and infant mortality rate however, all other variables have been increasing during the analysis period. Moreover, women's share in employment is fluctuating sharply and in 1975, there was a sharp drop before rising again in the following year.

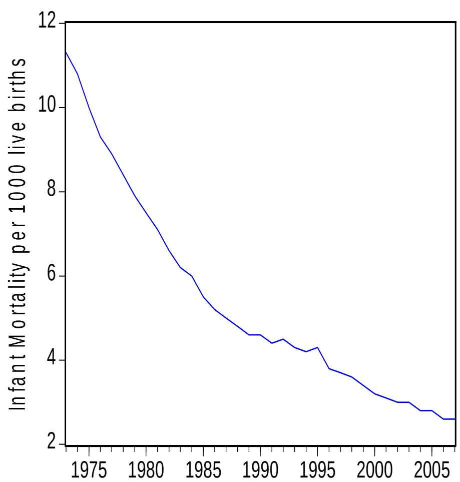
**Graphs 2. Independent Variables**



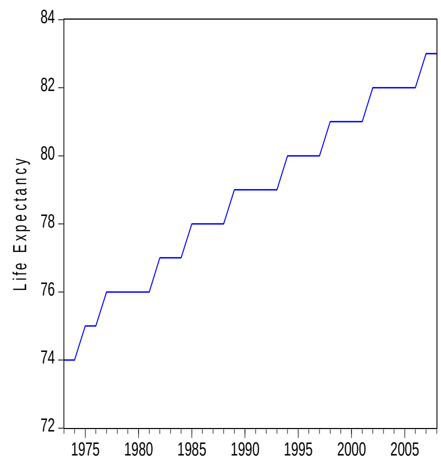

(Ministry of Internal Affairs and Communications 2008a)



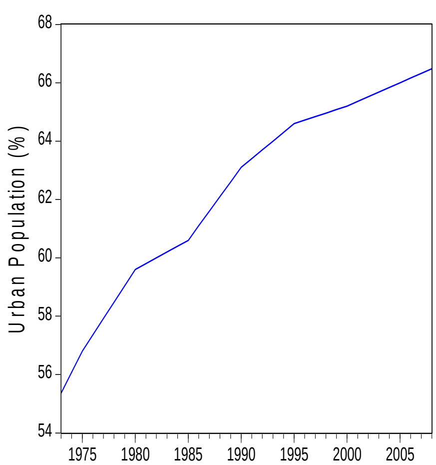

(OECD 2010a)



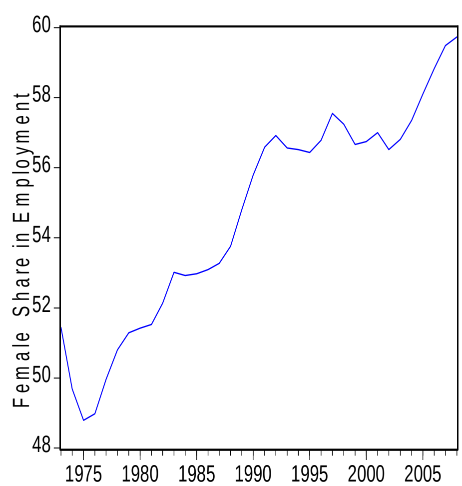

(Ministry of Health, Labour, and Welfare 2010)




(World Bank Group 2010a)




(World Bank Group 2010c)




(OECD 2010b)

In this paper we test the presence of cointegrating relationships among several non-stationary variables. We use several tools for testing the cointegrating relationships.

## 4.0 Empirical Results

### *Unit Root Test*

We test for stationality to ensure that the variables used in the regressions are not subject to spurious correlation. The Augmented Dickey-Fuller (ADF) unit root test and Phillips-Perron (PP) are employed to investigate the stationary status of each variable and are applied to the level variables. The results are presented in Table 4. The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation with the assumption that the y series follows an AR(p) process and adding p lagged difference terms of the dependent variable y to the right-hand side of the test regression (Dickey and Fuller 1979).

$$\Delta y_t = \alpha yt\text{-}_1 + x_t\delta + \beta_1\Delta y_{t-1} + \beta_2\Delta y_{t-2} + .... + \beta_p\Delta y_{t-p} + \nu_t \qquad (2)$$

The estimation results show that the null hypothesis of unit root can not be rejected at the 5 per cent level of significance in the Augmented Dickey-Fuller (ADF) unit root test for I(0). The only exception is the average life expectance at birth. It is stationary at I(0) level. Other variables are stationary at first difference I(1). In the ADF test, fertility rate is only significant at 10 per cent. Although, when the Phillips-Perron (PP) test is applied, the fertility rate becomes significant at 5 per cent levels. Therefore, the results imply that the underlying variables after differentiation show a stationary process.

**Table 4. Results of Unit Root tests Using The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)**

| Variables | Augmented Dickey-Fuller (ADF) | Phillips-Perron (PP) |
|---|---|---|
| ln WES | -3.323345 | -2.878047 |
| ln F | -1.439684 | -1.856753 |
| ln IMR | -1.627016 | -1.499967 |
| ln CE | -2.098232 | -2.082157 |
| ln LEB | -5.061066 | -4.911513 |
| ln UP | -1.557776 | -2.238381 |
| ln GDP | -2.3400 | -1.439643 |
| Variables in first difference form | | |
| Δ ln WES | -4.754453 | -4.950382 |
| Δ ln F | -2.889014 | -4.925290 |
| Δ ln IMR | -6.567321 | -6.579945 |
| Δ ln CE | -6.146166 | -6.169427 |
| Δ ln LEB | -6.005791 | -12.12437 |
| Δ ln UP | -4.106777 | -2.331566 |
| Δ ln GDP | -3.553540 | -3.553540 |

**Note:** MacKinnon (1996) one-sided p-values for rejection of hypothesis of a unit root at the 5% level of significance

***Cointegration Tests***

This paper emphasizes the long term perspective for economic determinants of Japan's low fertility rate from 1973-2008. Engle and Granger (1987) present several representations for co-integrated systems including an autoregressive representation and an error-correction representation for the long run relationship.

In the Engle and Granger approach, the results of the tests are sensitive to the left side variable of the regression and residual-based test tends to lack power, therefore we utilize Johansen cointegration test in order to present evidence for the existence of a long run relationship between Japan's fertility rate and the other independent variables (Verbeek 2008) The beginning point of the Johansen procedure is the VAR representation of $X_t$ given in equation (3) (Johansen and Juselius 1992) :

$$X_t = A_1X_{t-1} + \ldots + A_kX_{t-k} + \mu + \psi D_t + \varepsilon_t, \qquad t=1,\ldots,T, \qquad (3)$$

Where $X_t = [p_1,p_2,e_{12},i_1,i_2]$ as defined above , $X_{-k+1},\ldots,X_0$ are fixed. By differencing we write the model in error correction form (3):

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1}\Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \psi D_t + \varepsilon_t, \quad t=1,\ldots,T \;, \quad (3)$$

Where $X_t$ is a column vector of the m variables $\alpha$ and $\beta$ are px r matrices. $\Gamma$ and $\Pi$ represent coefficient matrices, $\Delta$ is a difference operator, k denotes the lag length. The hypothesis $H_1$ (r) is the hypothesis of reduced rank of $\Pi$ implying that under certain conditions the process $\Delta X_t$ is stationary, $X_t$ is nonstationary, but also that $\beta`X_t$ is stationary. If $\Pi$ has zero rank , no stationary linear combination can be defined. Thus the varibles in $X_t$ are non-cointegrated. If the rank r of $\Pi$ is bigger than zero there will exist r possible staitonary linear combinations (Johansen and Juselius 1992).

$$H_1(r) : \Pi = \alpha \beta` \qquad (4)$$

The cointegration rank test is created to reject the null hypothesis of no cointegration when the residuals $u_t$ are I(0). A long–run equilibrium in the form of cointegration can only exist if the variables have the same order of integration. The presence of a cointegrating vector can be interpreted as the presence of a long-run equilibrium relationship (Verbeek 2008).

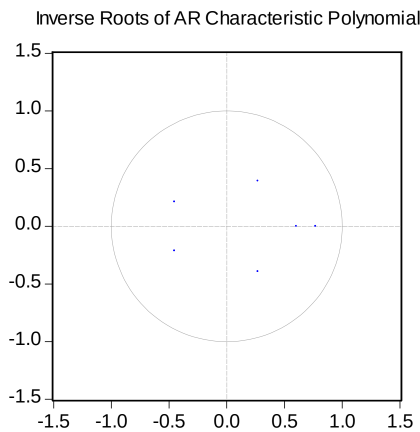
**Table 5. VAR Lag Order Selection Criteria**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 560.9469 | NA | 9.97e-23 | -33.63315 | -33.36105* | -33.54160 |
| 1 | 621.6564 | 95.66337* | 2.32e-23* | -35.13069* | -33.22604 | -34.48983* |
| 2 | 650.1680 | 34.55957 | 4.60e-23 | -34.67685 | -31.13965 | -33.48669 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error,
AIC:Akaike information criterion, SC: Schwarz information criterion,HQ: Hannan-Quinn information criterion

In literature, it is recognized that Johansen's cointegration tests are quite sensitive when making the choice of the lag length. As a result, the VAR (Vector Autoregression) model is applied to the data in order to find a suitable lag structure (Chang and Caudill 2005). The Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQ) suggest 1 lag for the VAR model that we used (seen in Table 5). To check the appropriateness of the estimated VAR we applied many tests. The estimated VAR is stable (stationary), if all roots have modulus less than one and lie inside the unit circle. As we have seen at graph 3 all roots lie inside the unit circle so estimated VAR is stationary.

**Graph 3. Inverse Roots of AR Characteristic Polynomial**




The VAR Residual Serial Correlation LM Tests, the null hypothesis, $H_0$: There is no serial correlation at lag order h, the probabilities are higher at 5% significant level, thus we accept the $H_0$ so there is no autocorrelation between the residuals (Table 6).

**Table 6. VAR Residual Serial Correlation LM Tests**

| Lags | LM-Stat | Prob |
|---|---|---|
| 1 | 29.78053 | 0.7581 |
| 2 | 34.23078 | 0.5529 |
| 3 | 27.96085 | 0.8286 |
| 4 | 26.76439 | 0.8682 |
| 5 | 27.33592 | 0.8500 |
| 6 | 33.80166 | 0.5736 |
| 7 | 37.48929 | 0.4007 |
| 8 | 32.26203 | 0.6471 |
| 9 | 33.90443 | 0.5686 |
| 10 | 31.24833 | 0.6940 |
| 11 | 30.32069 | 0.7351 |
| 12 | 35.57049 | 0.4889 |

VAR Residual Heteroskedasticity Tests, the null hypothesis, $H_0$: There is no heteroskedasticity and the probabilities are higher at the 5% level of significance, thus we accept the $H_0$ so there is no heteroskedasticity between the residuals (Table 7).

**Table 7. VAR Residual Heteroskedasticity Test**

| Joint test: | | |
|---|---|---|
| Chi-sq | Degree of Freedom | Prob. |
| 241.812 | 252 | 0.6665 |

VAR Residual Normality Tests, the null hypothesis of normal distribution, the probabilities are higher at 5% significant level, thus we accept the $H_0$ so the residual of VAR distributed normally (Table 8).

**Table 8. VAR Residual Normality Tests**

| Component | Jarque-Bera | Degree of Freedom | Prob. |
|---|---|---|---|
| | | | |
| 1 | 2.446748 | 2 | 0.2942 |
| 2 | 3.151711 | 2 | 0.2068 |
| 3 | 3.117286 | 2 | 0.2104 |
| 4 | 3.363739 | 2 | 0.186 |
| 5 | 2.34704 | 2 | 0.3093 |
| 6 | 1.894329 | 2 | 0.3878 |
| | | | |
| Joint | 16.32085 | 12 | 0.177 |

The Trace Test, for which the null hypothesis of no cointegration is rejected when the test statistic takes on a value below the critical value at a given significance level. The null hypothesis can be tested using two well-known test statistics, trace and max statistics. As Table 9 shows, we reject the null hypothesis at the 5% level. Table 9 summarizes Johansen's (1988) cointegration rank tests. The trace tests suggest r = 2 as the number of cointegrating vectors with a 5% significance level.

**Table 9. Unrestricted Cointegration Rank Test (Trace)**

| No. of CE(s)Hypothesized | Eigenvalue | Trace Statistic | Max-Eigen Statistic | Trace0.05 Critical Value | Eigenvalue 0.05 Critical Value |
|---|---|---|---|---|---|
| | | | | | |
| None * | 0.761036 | 117.9679 | 47.23753 | 95.75366 | 40.07757 |
| At most 1 * | 0.588696 | 70.73041 | 29.31797 | 69.81889 | 33.87687 |
| At most 2 | 0.464621 | 41.41245 | 20.61772 | 47.85613 | 27.58434 |
| At most 3 | 0.263007 | 20.79472 | 10.07083 | 29.79707 | 21.13162 |
| At most 4 | 0.193356 | 10.72389 | 7.090799 | 15.49471 | 14.26460 |
| At most 5 | 0.104250 | 3.633089 | 3.633089 | 3.841466 | 3.841466 |
| | | | | | |
| Trace test indicates 2 cointegrating eqn(s) at the 0.05 level<br>* denotes rejection of the hypothesis at the 0.05 level<br>**MacKinnon-Haug-Michelis (1999) p-values | | | | | |

The Johansen test clearly rejects the null hypothesis of no linear cointegration for the series Japanese fertility, infant mortality rate, female employment, GDP per capita, average life expectance at birth, cost of education and urban population. As a result the factors of Japan's fertility rate such as infant mortality rate, female employment, GDP per capita, average life expectance at birth, cost of education and urban population are cointegrated. As shown in this table, Trace statistic suggests that there exist two cointegrating vectors among these four variables. This result suggests that these variables would not move too far away from each other through time. That is, a comovement phenomenon for Japan's fertility rate, GDP per capita, infant mortality per 1000 live births, average life expectance at birth, share of women of working age in employment, cost of education as a % of current income and urban population as a % out of total population (Chang and Caudill 2005).

**Table 10. Vector Error Correction Estimates**

| Variables | Coefficient | Standard errors | t-statistics |
|---|---|---|---|
| **VEC Results**<br>**Variables ($\Delta$ ln $F_t$ is the dependent variable)** | | | |
| ΔLNFERTILITY | 1.000000 | | |
| ΔLNEDUCATION | 0.767106 | 0.20221 | 3.79358 |
| ΔLNFEMALE | 5.026709 | 0.73280 | 6.85962 |
| ΔLNGDP | -2.106312 | 0.31967 | -6.58904 |
| ΔLNINFANT | -1.357027 | 0.30166 | -4.49849 |
| ΔLNURBAN | 11.45313 | 2.64921 | 4.32322 |
| ***C*** | -0.022466 | | -0.022466 |

All variables are tested within Vector Error Correction Models with one lagged difference and all the variables are used in logarithmic form so that all parameters are interpreted as elasticities. The transformation to logarithms minimizes evidence of heteroskedasticity in the residuals of the model. According to the results; share of women in employment, urban population, and cost of education appear to have positive effects on the Japanese fertility rate. However GDP per capita and infant mortality rate appear to have negative effects on Japan's fertility rate. Higher share of woman in employment increases fertility rate. Therefore on average, a 1% increase in share of woman in employment leads to an increase in Japan's fertility rate 5.026%. The estimated relationship between women share in employment and fertility rate is not consistent with the theoretical conclusion. One interpretation of this result is that higher woman's employment increases the budget of the family, making child rearing more affordable and leading to a positive effect with fertility. 1% increase in Cost of Education (as a % of current income) increases the fertility rate by 0.767%. Also, on average, a 1% increase in Urban Population (as a % out of total population) leads to an increase in the Japanese fertility rate 11.45%. A 1% increase in GDP per capita decreases the fertility rate by 2.106%. The estimated relationship between GDP per capita and fertility rate is consistent with the theoretical conclusion. The theory of demographic transition, believes that economic development has a negative effect on fertility. A 1% increase in infant mortality rate decreases the fertility rate by 1.35%. The estimated relationship between infant mortality rate and fertility rate is consistent with the theoretical conclusion. Reduction in the infant mortality rate encourages people to having children.

**Table 11.Variance Decomposition of Japan Fertility Rate**

| Period | S.E. | FERTILITY | FEMALE EMPLOYMENT | EDUCATION COST | GDP PER CAPITA | INFANT RATE | URBAN POPULATION |
|---|---|---|---|---|---|---|---|
| 1 | 0.021345 | 100.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 0.026065 | 78.15181 | 0.671640 | 16.48739 | 0.639244 | 3.949614 | 0.100311 |
| 3 | 0.031717 | 80.71033 | 0.514258 | 11.19928 | 1.205543 | 5.493570 | 0.877023 |
| 4 | 0.034852 | 77.13663 | 0.443441 | 15.23784 | 1.090778 | 5.292805 | 0.798505 |
| 5 | 0.038266 | 78.64167 | 0.399827 | 12.79803 | 0.920633 | 6.353007 | 0.886838 |
| 6 | 0.041022 | 78.54014 | 0.378174 | 13.54495 | 0.811501 | 5.951585 | 0.773648 |
| 7 | 0.043694 | 78.77733 | 0.335877 | 12.56163 | 0.721988 | 6.830490 | 0.772691 |
| 8 | 0.046145 | 79.31598 | 0.302916 | 12.39900 | 0.648186 | 6.633123 | 0.700798 |
| 9 | 0.048433 | 79.41892 | 0.275209 | 12.06569 | 0.588546 | 6.987297 | 0.664334 |
| 10 | 0.050678 | 79.89000 | 0.251918 | 11.76469 | 0.538555 | 6.930266 | 0.624572 |

The variance decompositions reveal the percentage of forecast error variance for each variable that is attributed to its own shocks to the other system variables. It helps identify the main channels of influence for the individual variables. The variance decompositions up to 10 years for the model are presented in Table 11. The variance of fertility was totally accounted for by itself in the first year. In the long term (after 10 years) cost of the education and infant mortality rate contributed increasingly to variation in fertility rate.

## 5.0 Conclusion

The following research provides a fresh examination of fertility rates in Japan. According to short-run results of the VAR models the estimated coefficients are insignificant. Their t statistics are smaller than 1.96 at 5% significance level. Also, between the variables we could not find a short-run relationship however the results reveal that variables are cointegrated. Through the use of Johansen (1990) cointegration analysis, we find Japanese fertility, infant mortality rate, women's employment, average life expectancy at birth, cost of education and urban population are cointegrated. Also, we find that the comovement phenomenon exists between these variables. GDP per capita shows the expected negative relationship with fertility rates. We find that a 1% increase in GDP per capita decreases the fertility rate by 2.1%. This is consistent with the theory of demographic transition, which believes that economic development has a negative relationship with fertility. However, the estimated relationship between infant mortality, urban population, cost of education, female labor participation and fertility rate are not consistent with the theoretical conclusions. The unexpected positive relationship between female labor participation and fertility may suggest that as more women enter the workforce, the overall budget of the family increases, lowering the cost of child rearing. Future research is needed however, to provide a deeper understanding regarding the relationship between female employment and fertility in Japan.

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## Appendix 1.

### Table 10.Vector Autoregression Estimates

| | | | | | | |
|---|---|---|---|---|---|---|
| | DLNFERTILITY | DLNFEMALE | DLNEDUCATION | DLNGDP | DLNINFANT | DLNURBAN |
| | | | | | | |
| DLNFERTILITY(-1) | -0.128058 | -0.091860 | -0.625287 | 0.131999 | 0.524876 | -0.006984 |
| | (0.19274) | (0.06377) | (0.31342) | (0.18136) | (0.26596) | (0.01457) |
| | [-0.66439] | [-1.44054] | [-1.99502] | [ 0.72784] | [ 1.97348] | [-0.47939] |
| | | | | | | |
| DLNFEMALE(-1) | 0.602500 | 0.389035 | -0.377668 | -0.077677 | 1.171.617 | 0.010672 |
| | (0.39763) | (0.13155) | (0.64659) | (0.37414) | (0.54868) | (0.03005) |
| | [ 1.51524] | [ 2.95727] | [-0.58410] | [-0.20762] | [ 2.13534] | [ 0.35510] |
| | | | | | | |
| DLNEDUCATION(-1) | -0.203237 | 0.046989 | -0.186102 | -0.010480 | 0.009118 | 3.82E-05 |
| | (0.10377) | (0.03433) | (0.16875) | (0.09764) | (0.14320) | (0.00784) |
| | [-1.95847] | [ 1.36863] | [-1.10284] | [-0.10733] | [ 0.06368] | [ 0.00487] |
| | | | | | | |
| DLNGDP(-1) | 0.226581 | 0.111442 | 0.092375 | 0.386597 | -0.575859 | -0.006829 |
| | (0.18467) | (0.06110) | (0.30029) | (0.17376) | (0.25482) | (0.01396) |
| | [ 1.22696] | [ 1.82405] | [ 0.30762] | [ 2.22490] | [-2.25986] | [-0.48926] |
| | | | | | | |
| DLNINFANT(-1) | 0.106507 | -0.047257 | -0.459528 | -0.034879 | -0.281221 | -0.017999 |
| | (0.13180) | (0.04361) | (0.21432) | (0.12402) | (0.18187) | (0.00996) |
| | [ 0.80809] | [-1.08375] | [-2.14408] | [-0.28125] | [-1.54627] | [-1.80679] |
| | | | | | | |
| DLNURBAN(-1) | -3.529.649 | -0.823720 | 1.573.997 | 5.887.375 | 3.842.626 | 0.827973 |
| | -192.971 | (0.63843) | -313.792 | -181.571 | -266.277 | (0.14585) |
| | [-1.82911] | [-1.29023] | [ 0.50160] | [ 3.24246] | [ 1.44309] | [ 5.67674] |
| | | | | | | |
| C | -0.002134 | -0.002755 | -0.016914 | 0.004651 | -0.038215 | 9.00E-05 |
| | (0.00852) | (0.00282) | (0.01386) | (0.00802) | (0.01176) | (0.00064) |
| | [-0.25046] | [-0.97731] | [-1.22055] | [ 0.58001] | [-3.24978] | [ 0.13971] |
| | | | | | | |
| R-squared | 0.425289 | 0.528132 | 0.406374 | 0.736104 | 0.364618 | 0.804504 |
| Adj. R-squared | 0.297575 | 0.423273 | 0.274457 | 0.67746 | 0.223422 | 0.761061 |
| Sum sq. resids | 0.011351 | 0.001242 | 0.030015 | 0.01005 | 0.021614 | 6.48E-05 |
| S.E. equation | 0.020504 | 0.006784 | 0.033342 | 0.019293 | 0.028293 | 0.00155 |
| F-statistic | 3.330018 | 5.036568 | 3.080533 | 12.55217 | 2.582353 | 18.51843 |
| Log likelihood | 87.83756 | 125.4454 | 71.30701 | 89.90786 | 76.8896 | 175.6433 |
| Akaike AIC | -4.75515 | -6.967377 | -3.782765 | -4.876933 | -4.111153 | -9.920193 |
| Schwarz SC | -4.4409 | -6.653127 | -3.468515 | -4.562682 | -3.796902 | -9.605942 |
| Mean dependent | -0.011854 | 0.005418 | 0.01998 | 0.058034 | -0.041883 | 0.005004 |
| S.D. dependent | 0.024465 | 0.008933 | 0.039143 | 0.033971 | 0.032106 | 0.00317 |
| | | | | | | |
| Determinant resid covariance (dof adj.) | | 6.97E-24 | | | | |
| Determinant resid covariance | | 1.75E-24 | | | | |
| Log likelihood | | 640.4944 | | | | |
| Akaike information criterion | | -35.20555 | | | | |
| Schwarz criterion | | -33.32005 | | | | |

*Standard errors in ( ) & t-statistics in [ ]