Demographic Transition, Childless Families and Economic Growth

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(1) Introduction

Demographic transition is a well known phenomenon that has repeatedly taken place in many countries during the last few centuries. Although characterization of this phenomenon may vary among different authors, its main features can conveniently be summarized as follows.[1] Before a society moves from stagnancy to sustained economic growth, there is often a significant improvement in the life expectancy of its population. In the early phase of the development process, population growth rate rises, not only because people live longer, but also because total fertility rate (TFR) may go up. In the more advanced stage of development, there is marked and continuous decline in fertility until it has hit a "minimum" level.[2]

Understanding the mechanics of demographic transition is important both from the theoretical and policy perspectives. At the theoretical level, demographic transition is closely linked to the interaction between investments in quantity and quality of children, which is at the core of endogenous growth models. On policy grounds, changes in fertility rates can easily exert profound effects on many socio-economic issues, such as education, health care, housing, immigration, retirement protection, business opportunities and saving behaviors. These effects are more prominent in economies where fertility rates deviate significantly from the population replacement ratio, which is roughly equal to 2.1. Table 1 shows that in 2008, average TFR in the world is 2.58, which is well above the replacement ratio.[3] The European Union, consisting of well developed economies, expectedly, has a low TFR of 1.5. The United States, with a TFR as high as 2.1, is more an exception rather than a rule. On the other hand, the low TFR's in many economies in the Asia-Pacific Rim seem to indicate that they have already reached some advanced stages of demographic transition, even though the per capita income levels in some are still well below those in the US or Europe. Comparisons with the 1965 figures

[1] See, for example, Coale (1987), Easterlin (1987), and Dyson and Murphy (1985).

[2] See World Bank (1984), Chapter 2.

[3] The source for Table 1 is CIA (2008). There are minor discrepancies between the data there and those from official government statistics. Since the errors are minor, we ignore them.

readily show that these Asia-Pacific economies have undergone major declines in TFR in recent decades. In view of the possibility that low and declining TFR's can upset social and economic equilibria, it is useful for us to investigate the causes behind the demographic transitions in this region.

----- Insert Table 1 -----

The low TFR's in East Asian countries indicate that the women there on the average bear very few children. However, they do not explicitly tell us how many women choose *not* to bear any children at all. The importance of this matter is often overlooked. Parents can invest in their children's human capital only if they have children. If an adult chooses not to have any children, i.e., the optimal quantity of children has a corner solution, the investment vehicle disappears. Endogenous growth models built upon such investment would lose much of its relevance. This problem would not be too important if only a small percentage of families choose to remain childless. However, as the evidence in the next section shows, up to 30 percent of the women in Hong Kong ---- the economy having the lowest TFR---- will never have any children, and this percentage is rising rapidly! Thus, the issue of childless families is not a trivial issue that can be discarded easily.

The purpose of this paper, which is part of a larger study on the demographic transition of Hong Kong, is to identify the factors that have significant effects on fertility choices. The theoretical framework is a variant of the Ehrlich-Lui (1991) model. The empirical evidence is mainly based on the data collected in a survey that I conducted.

In the next section, I shall present the evidence to support the argument that zero fertility is a matter that we must reckon with. Section 3 briefly discusses a theoretical framework that can generate both the demographic transition and corner solution for fertility. Some testable hypotheses are stated. Section 4 outlines the approach for testing the hypotheses, presents and discusses the empirical results. Concluding remarks are in Section 5. Finally, some details of the survey are discussed in the Appendix.

(2) Some Demographics of Hong Kong

In this section, I shall argue that the experiences of Hong Kong can serve as a "leading indicator" for the demographic transitions in East Asia and possibly other developed economies as well. I shall also provide estimates for the proportion of Hong Kong women who will remain childless throughout their lives.

There is now an extensive literature on the relationship between longevity and fertility,[4] some of them showing that an increase in longevity can initiate the onset of the demographic transition. Life expectancy at birth in Hong Kong in 2006 was 85.6 years for women and 79.5 for men.[5] Not only are these among the highest in the world, they also indicate substantial increases since 1981, when the corresponding figures were 78.5 and 72.3, respectively. As such, it is not much of a surprise to see that the median age of the Hong Kong population has risen from 34 in 1996 to 39 in 2006. More importantly, the total fertility rate in Hong Kong, as evidenced in Table 2, has also experienced a long and rapid decline episode. Table 2 also shows that Hong Kong has reached the world's lowest TFR of below one only in recent years. Back in 1965, it was still as high as 4.5.

------Insert Table 2 Here------

The slight increase in TFR in the last few years should not be interpreted as a reversal in trend. From 1998 to 2003, Hong Kong suffered from a prolonged deflationary recession. Fertility rate in that period, as recorded in the 2001 census, was likely depressed to below trend level because of the unfavorable economic environment. Using arguments similar to Becker and Barro (1988), we expect that parents would try to make up for the "losses" of children when the economy improved again after 2003.

Given the low TFR in Hong Kong, we want to estimate the proportion of women who will have zero fertility in their entire lifetimes. The estimates are based on official

[4] Some examples, in chronological order, are Ehrlich and Lui (1991, 1997), Blackburn and Cipriani (2002), Boldrin and Jones (2002), Kalemli-Ozcan (2003), Doepke (2004, 2005), Zhang and Zhang (2005), and Soares (2006).

[5] See Table 1.4 of Census and Statistics Department (2007).

census data of various years. These data also allow us to make some simple projections of what will happen in the near future.

Census data can provide information on the number of children that have already been born, but there is no direct information on what would happen to women's fertility decisions in the future. However, if a woman aged at 45 does not have any children, we can reasonably expect that the chance for her to bear children in the future is negligibly small. Figure 1 plots the percentages of women at each age group from 20 to 45 who do not have any children for the years 1996, 2001 and 2006.

------Insert Figure 1 Here------

------Insert Table 3 Here-----

In 2006, the proportion of 45-year old women who do not have any children is 29 percent. While this is already a very large proportion, we should note from Figure 1 that these percentages for women in *every* age group have been increasing from 1996 to 2006. Table 3 provides further information on how these proportions change over time. For the 41-45 age group, the percentage of women having no children rises from 20.55 percent in 1996 to 31.58 percent in 2006, representing roughly 10 percentage point increase for the 10-year period. Judging from the high proportion of younger women who do not have any children, a proportion that has also been increasing over time, we can safely project that in the next decade, the percentage of Hong Kong women who will remain childless throughout their lives can easily exceed one-third or even 40 percent of the women population.

As a robustness test for the estimate that in 2006, 31.58 percent of the women in the 41-45 years old age-group do not have any children, we perform another estimate using a completely different data set, namely, data from a survey that we have conducted. Details of that survey are discussed in the Appendix. The survey provides information, among others, on the number of children that the respondents currently have, and the number of children they plan to have *in the future*. The estimate based on these details indicate that 27.5 percent of the women within the 40-44 age group do not have *and* do

not plan to have any children in the future. Since this additional estimate generates a result which is on the same order of magnitude as the earlier one, we can reasonably believe that indeed a very high percentage of the women in Hong Kong will never have any children.

There are good reasons why it is advantageous to use the experiences of Hong Kong as a "leading indicator" for demographic changes in other East Asian economies, and possibly even OECD countries, in the future. Similar to Hong Kong, these economies have all been experiencing the demographic transition, with significant declines in the total fertility rates. The difference is that Hong Kong has attained a very low TFR sooner than others. If the demographic trends continue, there is no compelling reason why the TFR's in some of these economies will not drop to the current level in Hong Kong. When the TFR is low enough, there is likely to be a corresponding increase in the prevalence of childless families. The large proportion of Hong Kong women who have chosen to remain childless could well be an indication of what will happen in other East Asian countries. Thus, it makes sense to study the causes and implications of low fertility and childless families in Hong Kong. In this paper, I shall focus only on the causes.

(3) Theoretical Framework

In this section, I shall briefly outline a theoretical model that is able to generate the demographic transition. The model is adapted from Ehrlich and Lui (1991), modified in such a way that it can accommodate zero fertility. It is presented here to provide a theoretical foundation for the main hypotheses to be tested in the next section.

Consider an overlapping-generations economy where all the agents live for three periods, 0, 1 and 2. In period 0, the person is a child and does not make any decisions. In period 1, the person is a young working adult who has to decide how many children she should bear, how much time she should invest in the human capital of each of her children, and how much she should save for retirement. She is obligated to support her parent if the latter is still alive. She also acts as a "companion" for her parent in, the sense that her being around would give psychological pleasure to the latter. Even though each person lives for at most three periods, the economy can last forever because some agents

are born in each period. In period 2, the agent does not work anymore. She gets material support from her children and her own savings. In addition, she can derive utility both from the quantity and quality of her children.

Let the production function of human capital be[6]

$$H_{t+1} = A(H_t + H^*)h_t, \qquad (3.1)$$

where H_t = human capital of a representative working adult at time t,

H_{t+1} = human capital of a representative working adult in the next generation at time t+1,

H^* = raw labor (which implies that even if $H_t = 0$, H_{t+1} can still be bigger than zero),

h_t = the proportion of time that a representative parent at time t invest in the human capital of each child,

A = technology parameter in the production of human capital.

Consumption of a young adult at time t and the consumption when she is old at time t+1 are given by

$$c_1(t) = (H_t + H^*)(1 - vn_t - h_t n_t - s_t) - \pi_2 w H_t \qquad (3.2)$$

$$c_2(t+1) = [\pi_1 n_t w H_{t+1} + B(H_t + H^*)\, s_t^{m}] + \mu(\pi_1 n_t)\, H_{t+1}^{\alpha} \qquad (3.3)$$

Each young adult has 1 unit of time. If he uses the entire unit to produce the consumption good, output is $H_t + H^*$. Even when $H_t = 0$, raw labor H^* can make output bigger than 0. The number of children borne by a young parent at time t is n_t. The proportion of time spent on raising a child is v. Thus, vn_t is the proportion of time spent on the n_t children. In addition, educating n_t of them requires $h_t n_t$ units of time. Saving rate as a proportion of her maximum possible income is represented by s_t. The amount of consumption good provided by a representative young adult to support his parent at time t is given by wH_t. The rate committed by the young adult to support his parent, w, is

[6] This setup is similar to that in Becker, Murphy and Tamura (1990).

treated as exogenous here.[7] The probability that a young adult can survive to old age is π_2. The larger is π_2, the longer is the life expectancy of people. The reason why π_2 is included in the term $\pi_2 wH_t$ is that a young adult does not have to pay for the old-age support of his parent if the latter has not survived. Hence, $\pi_2 wH_t$ can be interpreted as the expected support for the parent.

The expression for $c_2(t+1)$ in (3.3) can be interpreted as a composite consumption good consisting of the material part (the terms within the square brackets), and the psychological "companionship" function. When an adult has turned old, each of his children will provide support equal to wH_{t+1}. Even though an adult has given birth to n_t children, some of them cannot survive to adulthood. The probability that a child can survive to adulthood and has the chance to work is given by π_1. The second term inside the square brackets is total returns from the agent's savings, where $B > 0$ and $0 < m < 1$. The last term in (3.3) is meant to capture the assumption that the quantity and human capital of her children can be treated as a utility-generating consumption good. The parameter μ can vary across different people. A large μ means that the person likes children very much.[8] We also impose the restrictions that $0 < \alpha < 1$.

The utility function of a young adult at time t is given by

$$u_t = [(c_1(t)^{1-\sigma} - 1) / (1 - \sigma)] + \delta \pi_2 [(c_2(t+1)^{1-\sigma} - 1) / (1 - \sigma)] \qquad (3.4)$$

where δ represents the discount rate for future consumption. Since the chance for an adult to survive to old age is π_2, we have to multiply old age utility by $\delta\pi_2$. We impose the restriction that $0 < \sigma < 1$.

A representative young adult maximizes (3.4) subject to (3.1), (3.2), (3.3) and non-negativity constraints for the choice variables s_t, n_t, and h_t. The first-order conditions are given by the following.

$$(c_2 / c_1)^{\sigma} \geq \delta\pi_2 mB / s_t^{1-m} \equiv \delta R_s \qquad (3.5)$$

[7] This assumption is made for convenience and tractability only. It is possible to model it as the endogenous outcome of an implicit contract.

[8] We assume that μ is positive in the analysis. If a person dislikes children, we can actually treat μ as negative.

$$(c_2 / c_1)^{\sigma} \geq \delta A \pi_1 \pi_2 w [1 + \alpha N] \equiv \delta R_h \quad (3.6)$$

$$(c_2 / c_1)^{\sigma} \geq \delta A \pi_1 \pi_2 w [1 + N] [h_t /(v + h_t)] \equiv \delta R_n \quad (3.7)$$

where $N \equiv \mu w^{-1} H_{t+1}^{\alpha - 1}$. (3.8)

The notations, R_s, R_h and R_n, represent the rates of return to savings, investment in human capital and investment in quantity of children, respectively. There are some useful properties of this model that can help us to understand the process of economic development and demographic transition. Suppose that in the beginning, life expectancy is low, i.e., π_1 *and* π_2 are relatively small. From (3.6) and (3.7), the rates of return to investment in quantity and quality of children are low. The economy could be trapped in a zero-growth stagnant equilibrium with no change in human capital over time. Now assume that π_1 *and* π_2 go up sufficiently. Since both R_h and R_n increase as a result, parents tend to invest more in both quantity and quality of children. Consequently, both n_t and H_{t+1} rise. However, as the human capital stock for the next generation has gone up, its opportunity cost of having children increases as well.[9] In that generation, the parent would reduce the quantity of children, but continue to invest in human capital. As the level of human capital of the parents in each subsequent generation rises, the economy continues to grow, but fertility rate declines. This is the demographic transition.

It should be noted that as H_{t+1} increases during the process of economic development, the term N defined in (3.8) will converge to zero because $0 < \alpha < 1$. From (3.6) and (3.7), it can be shown that $R_h > R_n$ if and only if $N^{-1} > (1 - \alpha)[(h/v) - \alpha/(1-\alpha)]$. Since the left-hand side of this inequality goes up without bound, at some stage of economic development, R_h must exceed R_n. This means that equality for (3.6) and (3.7) cannot hold simultaneously. There is interior solution for h_t, but n_t has a corner solution, in the sense that it should attain the smallest admissible value.[10]

[9] Actually the opportunity time cost of investing in human capital also rises, but from (3.1), the higher human capital stock of the parent will make her more effective in producing human capital. This mitigates the rise in time cost.

[10] From (3.5), since a sufficiently small saving rate can cause the rate of return to savings to go up to some large value, the saving rate always has an interior solution.

This immediately poses a problem. What is the lowest admissible value for n_t? The first candidate is that it is equal to one, and the second is zero. We should note that if the number of children is zero, it will be futile for the adult to invest in human capital of the children because there are none. Consumptions defined in (3.2) and (3.3) collapse to simpler terms. The person does not have to spend any resources in raising and educating children. However, during retirement, her consumption comes from savings only. There is no financial support from the children and there is no utility from companionship. On the other hand, if the person chooses to have one child, she can continue to invest in the human capital of that child. Equations (3.5) and (3.6) are still the laws of motion determining the dynamics of the variables in the model. The decision of whether to choose zero or one can be made by directly computing the utility after substituting the relevant values of n_t and other variables into (3.4). Assume that an agent has chosen to have one child. We can demonstrate by simulation exercises that as the human capital of her descendants grows over time, the latter may find it more advantageous to shift over to zero children. The timing of the shift depends on the parameters of the model. In particular, if companionship is viewed as important, i.e., μ is relatively big, it will be less likely for the family to arrive at either the corner solution of one or zero. After the shift to the new corner solution, this dynastic family will terminate.

A number of testable hypotheses can be drawn from the model discussed above. **Hypothesis 1**: Total fertility rate of the potential parent is negatively related to her human capital. **Hypothesis 2**: If an adult likes children, it is less likely that she will have very few or no children. From (3.6) and (3.7), an increase in the technology parameter *A* will raise the returns to quantity and quality of children. **Hypothesis 3**: The parent's fertility rate is positively related to how efficient she is in educating her children. From (3.7), an increase in *v* will lower the return to quantity of children. **Hypothesis 4***:* When a parent finds it costly to raise children, she will have fewer of them. These hypotheses will be tested in the next section.

(4) Empirical Results

This section presents and discusses the main empirical findings. I shall first explain the choice of the dataset used and provide summary statistics of the data. Then empirical tests based on a tobit model under various specifications are presented and the economic interpretations discussed. I shall then use a logit model to focus more sharply on the choice of whether to have children. Finally, a number of dummy variables have been used in all the regressions. The meanings of the estimated results on these dummies are discussed.

(A) Choice of Dataset and Summary Statistics

To test the basic hypotheses outlined in the previous section and to generate additional results, the official census (or by-census) data conducted in Hong Kong once every 5 years would be a good data source. The 5-percent sample contains micro data for more than 110,000 households and 340,000 individuals. Although the large number of observations can give us greater flexibility in the estimations, there are also important shortcomings. Since it only tells us how many children a parent has already had, but not the number of children she wants to have in the future, we have to rely on more indirect methods of estimation such as survival analysis. Moreover, there are many possible determinants of fertility that are simply not included in the census database.[11]

In this paper, I have chosen to estimate the results using a dataset generated from a randomized survey I conducted. Details of the survey are provided in the Appendix. In addition to having more specific information on fertility behaviors, the survey contains an important new variable, the number of additional children the respondent plans to have. We can add up the value of this variable with the number of children that the respondent has already had. This would generate the total number of desired children of the respondent, which is the main dependent variable to be explained in this paper. Given this information, we can easily construct a dichotomous variable, namely, whether the respondent wants to have zero, or a positive number of children.

[11] It does not mean that empirical estimations using census data are of no value. A separate project with similar objectives using census data has been conducted by the author.

------Insert Table 4 Here------

Table 4 contains summary statistics of some key variables from the survey dataset. It should be noted that we had set constraints on two variables, namely, approximately three-quarters of the respondents should be women and the targeted age group was 20 to 45 years old, who belonged to the child-bearing age.[12] Other than these, the respondents were chosen randomly. Because of the constraints, the respondents were on the average considerably younger than the median age of 39 of the Hong Kong population. Other summary statistics in Table 4 appear to be consistent with the general profiles of this type of people in Hong Kong. For example, the number of years of schooling for these people is higher than the average person in the population, which consists of many less educated older people. Similarly, the low number of years of working experience also reflects the young age of the targeted group. It can also be seen that the majority of the respondents do not have children and many of them do not want to have children in the future.

(B) Verification of the Demographic Transition

According to the model of demographic transition discussed in the previous section, total fertility rate, which is represented here by the variable TFR, defined as the actual number of children plus expected number of children in the future, should go down over time when parents become more and more educated. This longitudinal phenomenon can be captured here by cross-sectional data, if we assume that adults having different levels of human capital at a given point of time are similar to those who belong to different stages of economic development over time. Moreover, the possibility of having corner solutions for fertility, i.e., TFR equals to zero, means that the fertility data are censored at zero. A convenient approach to deal with this phenomenon is to use a tobit

[12] A small portion of the respondents fell outside of the targeted group because their actual ages were not always recognizable to members of the research team.

model where the dependent variable, TFR, is censored at zero. The general formulation for tobit is given by

$$y_i^* = \mathbf{x}_i'\boldsymbol{\beta} + \varepsilon_i \qquad (4.1)$$

$$y_i = 0 \qquad \text{if } y_i^* \leq 0,$$

$$y_i = y_i^* \qquad \text{if } y_i^* > 0,$$

where y_i is the dependent variable, $\mathbf{x}_i$ is a vector of the explanatory variables and $\boldsymbol{\beta}$ is the vector of coefficients of the varibles.

------Insert Table 5 Here------

Table 5 presents the summary of several regressions aimed at identifying the determinants of TFR in Hong Kong. The benchmark regression is the Tobit model in I, where the standard errors are obtained by using the robust estimators of Huber (1967) and White (1980). The error term in this regression does not necessarily have to be identically distributed. (If we do not use the robust estimator for the standard errors, as expected, the levels of significance are higher.)

Two measures of human capital, years of schooling (SCHOOLING) and years of working experience (EXPERIENCE) are used. I have also added the square of these two variables into the regression to capture possible non-linearity in these variables. The estimated coefficients for these four variables are all statistically significant. Moreover, despite the positive signs of the coefficients for the squared variables, within the value ranges of the SCHOOLING and EXPERIENCE, TFR is always negatively related to these measures of human capital. **This result supports Hypothesis 1**, namely, the hypothesis of demographic transition discussed in Section 3. As the human capital level of the potential parent increases, they tend to have fewer or even no children. We should note that the negative effect of SCHOOLING on TFR is quantitatively much larger (about 8 times) than that of EXPERIENCE. Other things equal, an adult who has 14 years

of schooling would have 1.29 fewer children compared to one who has no education at all.[13]

The positive effect of marriage on TFR is consistent with **Hypothesis 4**. Because of economy of scale, married people would be more efficient in raising children. This is similar to the effect of lowering *v* modeled in the Section 3. We expect that the TFRs of married people are higher. The negative effect of age on TFR may be due to the nature of the dependent variable, which should more properly be interpreted as the planned or desired total fertility rate. Young adults may not fully realize the high cost of bearing, nurturing and educating children and therefore they may plan to have too many children. However, as they get older, they become more realistic about the cost.[14] The time it takes to travel to work competes for resources that can be provided to the children. The negative effect on TRAFFIC TIME again provides support to **Hypothesis 4**.

The positive impact of the number of siblings of the parent may be due to economy of scale. Siblings themselves sometimes can help out in baby-sitting and their children can be convenient playmates of one's own children. The result again supports **Hypothesis 4.** This phenomenon may cause long-term effect for future generations. As the average size of the core family is decreasing due to the low TFR, future parents will have fewer siblings of their own. That will in turn weaken their intent to bear children.

It is well known that population density in Hong Kong is among the highest in the world, with the result that its residents have to live in relatively small quarters. According to the results in Table 5, the small size of Hong Kong's residential quarters is likely one of the factors causing the low TFR there. This is consistent with the findings in a recent paper by Murphy, Simon and Tamura (2008), which provides evidence indicating that population density, or price of space, is negatively correlated with fertility rate in the United States. Given the likely scenario that housing in Hong Kong will continue to be expensive, the marginal cost of raising children will remain high.

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[13] To compute marginal effects in the censored regression model, we need the ratio of the uncensored observations to the total number of observations. In this case, it is equal to 0.841. See Greene (2003), p. 765.

[14] If the dependent variable is the number of children that a person actually has, then the evidence indicates that this is positively related to age.

Assuming that children are normal goods, we should expect some positive effect of income on fertility rate. If we take the estimated coefficient of the INCOME variable seriously, an increase of approximately HK$60,000 in the monthly salary would induce the parent to bear one additional child, *ceteris paribus.*[15] However, two problems exist here. First, INCOME may be an endogenous variable that is not independent of other variables in this equation, such as SCHOOLING and EXPERIENCE. Second, the result for INCOME is not statistically significant, even though the sign is correct.

To deal with the first problem, I apply an instrumental variable tobit estimator to the regression. The instruments chosen for INCOME, in addition to other explanatory variables in the equation, include the gender dummy, cost of rent or mortgage for the house, and whether a domestic helper has been hired at home. The results are presented in Regression II in Table 5. In general, there are no major differences with those in Regression I. However, the Wald test of exogeneity shows that we cannot reject the null hypothesis that INCOME is not endogenous. This indicates that it may not be necessary to adopt the instrumental variable approach which treats INCOME as endogenous.

Since the coefficient for INCOME is not statistically significant, a simple approach is to remove this variable from the regression. The advantage of doing this is that any potential endogeneity problem due to INCOME can be eliminated. However, since richer people tend to live in bigger houses, one may suspect that the HOUSE SIZE variable that remains in the equation may reflect the effect of income instead of the price of space. In Regression III, INCOME is omitted. Standard errors are also obtained by the Huber-White robust estimator. Changes in the estimated results are minor. In particular, the coefficient for HOUSE SIZE has increased only by less than 3 percent. This indicates that INCOME is not an important variable in these regressions.

To see how robust the main results in I and III are, I have also used OLS with standard errors estimated by the Huber-White method to obtain IV. The story for

[15] For the calculation, see Footnote 9. In the survey conducted, there is a question asking the respondents to reveal how much government subsidy they would have to be paid in order that they were willing to bear one child more than what they wanted. The answer for most respondents was several million Hong Kong dollars. This seems to be remarkably consistent with the estimated coefficient for the INCOME variable.

demographic transition remains clear and valid. Thus, the results in Regression I appear to be robust.

If we substitute the median values of all the relevant variables into Regression I, we can readily show that quantitatively, the most powerful factor causing the decline in TFR is SCHOOLING. But the median years of schooling of the Hong Kong population is considerably below those in highly developed economies. What are the other factors that induce low or zero fertility in Hong Kong? In all the regressions in Table 5, I have added 8 dummy variables, each representing the attitude of the respondent to different factors that may affect fertility. The estimated results for these dummies can shed more light on the specific question of why Hong Kong has such a low fertility rate. Full discussion of these dummies will be postponed to sub-section D below.

(C) Childless Families

The last sub-section provides explanations for the occurrence of the demographic transition in Hong Kong. We now focus on the choice for zero fertility. A convenient approach is to construct a binary variable, FERTDUMMY, whose value is defined to be equal to one for a person who plans to have at least one child, and zero if she chooses not to have any children. The probability of the occurrence of childless families can be estimated by a discrete choice model. In this paper, we adopt a logit model where robust standard errors are estimated by a method along the lines of White (1980) and Hubert (1967).

A logit model is represented by the following:

$$Prob\,(Y = 1 \mid \boldsymbol{x}) = (e^{\boldsymbol{x'\beta}}) / (1 + e^{\boldsymbol{x'\beta}}), \qquad (2)$$

where Y is a dichotomous dependent variable that assumes the value of either 0 or 1, $\boldsymbol{x}$ is a vector of explanatory variables and $\boldsymbol{\beta}$ is the vector of the corresponding coefficients. Estimation results of the benchmark model are presented in Equation V in Table 6.

------Insert Table 6 Here------

The variables included in Equation V differ from those in Table 5 in several respects. The dependent variable is now the binary FERTDUMMY. By using a single value of one to represent different quantities of children, this method loses some information that is available to the tobit estimator. Several explanatory variables used in Equation I have also been dropped in Equation V because their estimated coefficients are not significant. They are SCHOOLING, SCHOOLING^2, and HOUSE SIZE. At this stage of economic development in Hong Kong, years of schooling seem to have stronger effects on the number of children beyond one than on the decision of whether to have children at all. The average size of living quarters in Hong Kong seems to be able to accommodate a small family with one child. The cost of space for the first child may be low enough for it not to be an important concern. However, marginal cost of space for additional children may be much higher. That is why HOUSE SIZE is an important variable in Table 5, but much less so in Table 6, which deals only with positive or zero fertility decisions.[16]

For those variables that are included in Equation V, the results are very similar to those reported in Table 5. Again, INCOME is not a statistically significant variable. In Equation VI, this variable is removed from the estimation. As we can readily see, the results essentially remain the same. It should be noted that reports on the estimations for the 8 dummy variables have been suppressed. In fact, as in the other models, all the estimations are statistically significant.

The estimates using the logit model introduce new questions for us to answer. For example, if we substitute in some benchmark values of the variables into either Equation V or VI, what is the estimated proportion of people in Hong Kong who will remain childless? This can be readily answered by performing some simulation exercises. In Scenario 1, we plug into Equation V the average values of the dummy variables, including the MARRIED DUMMY, and the median values of income, age, working experience, number of siblings, and traffic time to work. The resulting estimate for the

[16] An alternative explanation for the insignificance of the omitted variables in the logit model is simply that due to the small size of the sample, the data do not contain enough information to generate sharp results for these variables.

probability of zero fertility is 31 percent, which is remarkably close to the 31.58 percent reported for the 41-45 age group in Table 3.

If we examine the list of variables included in the logit model, we can see that there are no good reasons for some of them to change systematically over time. For example, average traffic time, average years of experience and the dummy variables may possibly show little changes. On the other hand, given the declining fertility in Hong Kong, we can expect that the number of siblings of child-bearing-age adults will go down. Since life expectancy in Hong Kong is very high, it is likely that the median age of the population will continue to increase. From census data of 1996, 2001 and 2006, we see that the married rate of the people at every age group has been consistently declining over time. In particular, the MARRIED DUMMY for the 41-45 age group has gone down from 84.36 percent in 1996 to 75.23 percent in 2006. It is likely that this percentage ten years from now will be lower than that of today.

We can perform another simulation exercise to project the proportion of families that will choose to remain childless. In Scenario 2, we retain most of the assumed values of the variables used in Scenario 1, but we focus our attention on the 45-years-old age group. Number of siblings is assumed to go down to 1, Married rate goes down to 0.7, and income goes to $20000. Given these assumptions, the new simulation shows that a 45-year-old woman will have a 41-percent chance of being childless within the next 10 years.

(D) Subjective Determinants of Fertility

In the regressions reported above, I have included 8 dummy variables, but their results have been suppressed. This sub-section will discuss these results. In the original survey, 20 questions related to the respondents' subjective views of the determinants of fertility were asked, and the answers were recorded as dummy variables. These answers provide non-trivial information on what the respondents regarded as important in affecting their own personal fertility decisions. The 20 dummies were all tried out, but finally I have included into the regressions only those that are statistically significant.

Although some respondents had claimed that the other 12 factors were important, the statistical evidence does not support the claim and so they are excluded.

------Insert Table 7 Here------

Table 7 reports the results on the 8 included dummy variables. Some respondents believed that these were important factors and some did not. Among those who did, the statistical evidence shows that these factors would indeed make a difference in their decisions. Although I have only reported the estimations for Regressions I and V, the results are robust across all the regressions.

The subjective factor that has the most powerful effect on fertility is whether the respondent liked children or not. **This supports Hypothesis 2.** Not only are the coefficients of variables d and f the largest in absolute values, the proportion of respondents who had chosen f is also the highest.[17] Using the estimated coefficients in the tobit regression of Table 7, we can easily show that a respondent who liked children would on the average have 1.29 more children than one who did not like children, *ceteris paribus.*[18] If we apply the estimated coefficients from the logit regression of V and those of the dummies in Table 7, and substitute in the values of the variables used in Scenario I in sub-section C above, the simulation indicates that the probability of a respondent who liked children would be 61 percentage points higher than one who did not like children. It appears that preference parameters have to be taken seriously in future research on fertility behaviors.

Estimations for other variables in Table 7 can shed more light on fertility decisions. Variable a, negative impact on job and career, can be interpreted as part of the opportunity cost of having children. **This again supports Hypothesis 4.** About one-third of the respondents regard this as an important factor. Variables b, c and e are related to

[17] It is an interesting coincident that 69.9 percent of the respondents claimed that they liked children and 68.4 percent of Hong Kong's women in the 41-45 age group either have children or want to have children.

[18] See the remark in footnote 8.

the respondents' subjective evaluations of how efficient or confident they would be in meeting the obligations of raising and educating children. Apparently, a sizable proportion of people were not prepared. **The estimation results support both Hypotheses 2 and 3**. Variables g and h indicate that some respondents' decisions were dependent on the views of others. Older people often like to have grandchildren. For those who pay attention to traditional family values, this would have a significant effect. It is interesting to note that in the spring of 2005, the Chief Secretary of the Hong Kong government at that time, Donald Tsang, made a casual, but widely reported, public remark that women in Hong Kong should bear three children because too low a fertility rate could have negative social consequences.[19] In a city where information dissemination by the media is rapid, most people would have remembered this well known remark, and some (16% in our sample) would believe that giving birth to children was part of public service.

Another advantage of including these dummy variables is that all the regression results are considerably sharpened and standard errors reduced. Individual differences in attitude towards fertility appear to be relevant factors we should reckon with, especially when we are dealing with a relatively small sample of data.

(5) Concluding Remarks

In this paper, I have used Hong Kong's experience to demonstrate that economies undergoing rapid demographic transition may end up having large percentages of women who choose not to bear any children. The serious implications of this possible outcome should be studied carefully.

By adapting the Ehrlich-Lui model to accommodate zero fertility, I have proposed several testable hypotheses related to the determinants of demographic transition. These hypotheses are tested by a tobit model and a logit model using data from a survey that I conducted. The empirical results make a lot of sense. The quantity-quality of children

[19] Mr. Tsang told the author of this paper in an informal occasion subsequent to his remark that the latter was indeed casual and that the government of Hong Kong would not adopt any policy to encourage higher fertility.

tradeoff, which drives the demographic transition, clearly exists. Other variables, like different measures of the cost of educating and raising children, preferences for children, sizes of residential quarters, family and social responsibility also play significant roles in determining total fertility rate.

Some of the factors that cause the low fertility will likely remain or even strengthen. If current trends continue, within the next few years, more than one-third of the women in Hong Kong will decide to remain childless throughout their lifetimes.

Appendix

In this appendix, I shall present details of the survey, upon which the empirical results of this paper are based.

The survey was conducted over a 3-month period spanning from November 2007 to February 2008. Each respondent was requested to answer 40 questions, but some of these could be broken down into several sub-questions. Some questions were similar to those asked in the census conducted once every 5 years by the Hong Kong government, but there were also new questions introduced. Most of the questions were related to the socio-economic and educational backgrounds of the respondents and their spouses. There were also specific categorical questions on the factors that the respondents deemed important in affecting their fertility decisions. A key question, not available in the census, was the additional number of children the respondent would like to have. Before formally conducting the survey, the questions were tested on a small sample of respondents to identify potential problems and to make improvements. This paper has not fully made use of the answers to all the questions.

The respondents were chosen randomly according to the following procedure. The research teams were sent to each of the 18 official districts in Hong Kong. The number of respondents chosen in each district was proportional to the population distribution in that district. The research teams were instructed to focus on people who appeared to fall within the age range of 20 to 45. The research teams regularly reviewed the age distribution of the respondents to make sure that they were compatible with that of the general population in Hong Kong. We also decided that about three quarters of the respondents should be women. The survey was conducted at different hours of the day and different dates of the week in public areas of these 18 districts. To enhance randomness, the research teams chose the nth person on sight in the area after finishing with a respondent. A cash coupon equivalent to HK$50 was given to every correspondent who completed the questionnaires. The sample size of the survey is 1017 observations.

After all the answers had been coded, the distributions of many socio-economic variables were compared to those from the census data. We have not spotted major discrepancies.

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Table 1: Total Fertility Rates in a Sample of Economies

	1965	2008
Asia-Pacific Rim		
Australia	3.0	1.76
China	6.4	1.77
Hong Kong	4.5	0.98
Japan	2.0	1.22
South Korea	4.9	1.29
Taiwan		1.13
Thailand	6.3	1.64
Singapore	4.7	1.08
Developed Economies		
European Union	2.7*	1.5
United States	2.9	2.1
World	5.1	2.58

*The 1965 TFR figure of 2.7 is for OECD countries.
Sources: Data for 2008 are from Central Intelligence Agency (2008). Data for 1965 are from World Bank (1992).

Table 2: Total Fertility Rate in Hong Kong

1965	1971	1981	1991	1996	2001	2006
4.5	3.5	1.95	1.30	1.20	0.93	0.98

Sources: 1965 and 1971 figures are from World Bank (1992). 1981 to 2006 figures are derived from the age-specific fertility rates reported in Table 2.6 of Census and Statistics Department (2007).

Table 3: Proportion of women at different age groups who do not have any children

Age Group / Year	**20-40**	**41-45**
1996	57.80%	20.55%
2001	63.80%	24.64%
2006	71.43%	31.58%

Source: Figures for 2006 are derived from the 5%-sample of the 2006 Hong Kong Census micro data. Figures for 2001 and 1996 are derived from the 1%-sample of the 2001 and 1996 Hong Kong Census micro data.

Table 4: Summary statistics of the survey data

Number of respondents	1017
Ratio of female to male respondents	794: 223
Number of unmarried respondents	622
Median Age of respondents	28
Number of respondents who do not want any more children	409
Number of respondents who have no children	705
Median number of total desired children	2
Median number of years of schooling	14
Median years of working experience	5
Median years of experience for those currently employed	7
Median monthly income of all respondents in HK$	8750
Median monthly income of employed respondents in HK$	13750
Number of home owners	590
Median size of home in square feet	600
Number of respondents having domestic helpers	152
Number of siblings of respondents	Minimum 0, median 2, maximum 8)

Table 5: Factors Affecting the Demographic Transition

Dependent Variable = TFR	(I) Tobit (Robust S.E.)	(II) Instrumental Variable Tobit	(III) Tobit (Robust S.E.)	(IV) OLS (Robust S.E.)
Constant	2.99360**** *(0.73233)*	3.32838**** *(0.80730)*	3.00462**** *(0.72937)*	2.86428**** *(0.64467)*
INCOME	0.00000205 *(0.00000439)*	0.0000169 *(0.0000185)*		0.000000947 *(0.00000373)*
MARRIED DUMMY	0.47208**** *(0.09003)*	0.44572**** *(0.09163)*	0.47524**** *(0.08931)*	0.35962**** *(0.07462)*
AGE	-0.01910**** *(0.00725)*	-0.02335**** *(0.00800)*	-0.01886**** *(0.00724)*	-0.01272*** *(0.00631)*
SCHOOLING	-0.21511*** *(0.10342)*	-0.22726*** *(0.11483)*	-0.22003*** *(0.1023)*	-0.19999*** *(0.09136)*
SCHOOLING^2	0.00755*** *(0.00373)*	0.00723* *(0.00453)*	0.00783*** *(0.00366)*	0.00704*** *(0.00329)*
EXPERIENCE	-0.02706**** *(0.00784)*	-0.03664**** *(0.01339)*	-0.02589**** *(0.00736)*	-0.0232**** *(0.00673)*
EXPERIENCE^2	0.000105**** *(0.000037)*	0.00020*** *(0.00010)*	0.00010**** *(0.000036)*	0.00009**** *(0.000029)*
SIBLINGS	0.06089**** *(0.02029)*	0.06866**** *(0.02197)*	0.05972**** *(0.02007)*	0.04744**** *(0.01759)*
TRAFFIC TIME	-0.05832* *(0.0399)*	-0.13498* *(0.08377)*	-0.04959* *(0.03616)*	-0.04347* *(0.03335)*
HOUSE SIZE	0.00022*** *(0.000108)*	0.00021** *(0.000129)*	0.000226*** *(0.000107)*	0.000201*** *(0.000096)*
8 DUMMIES (Results suppressed)				
No. of observations	933	857	933	933
Wald χ^2	244.18	266.47	244.28	
Prob > χ^2	0.0000	0.0000	0.0000	
ln σ	-0.12821 *(0.04033)*	-0.12818**** *(0.02744)*	-0.12815 *(0.04026)*	
Wald exogeneity test Prob > χ^2		0.3504		
R^2				0.2310

Notes: (1) Terms inside brackets are standard errors. (2) **** means 99% significant for one-tail test; *** means 97.5% significant; ** means 95% significant; * means 90% significant. (3) Standard errors for Equations I, III and IV are Huber-White robust estimates. (4) Instrumental variables for estimating INCOME in Equation II include all the exogenous variables in II plus dummies on gender, hiring of a domestic helper and cost of rent or mortgage.

Table 6: Logit Estimations of Factors Determining Zero Fertility Choice

Dependent Variable = FERTDUMMY	(V) Logit (Robust S.E.)	(VI) Logit (Robust S.E.)
Constant	3.16929**** *(0.76066)*	3.06756**** *(0.75384)*
INCOME	0.0000165 *(0.0000126)*	
MARRIED DUMMY	2.02106**** *(0.35260)*	1.96468**** *(0.33708)*
AGE	-0.08364**** *(0.03048)*	-0.07563**** *(0.02973)*
EXPERIENCE	-0.05940*** *(0.02884)*	-0.05353** *(0.02965)*
EXPERIENCE^2	0.000424**** *(0.00015)*	0.000365**** *(0.000136)*
SIBLINGS	0.24257**** *(0.08340)*	0.22691**** *(0.08230)*
TRAFFIC TIME	-0.29522**** *(0.12523)*	-0.23542*** *(0.11693)*
8 DUMMIES (Results suppressed)		
Number of observations	1011	1011
Wald χ^2	157.54	157.54
Prob > χ^2	0.0000	0.0000
Pseudo R^2	0.2909	0.2888

Notes: (1) Terms inside brackets are robust standard errors estimated by the method of White and Huber. (2) **** means 99% significant for one-tail test; *** means 97.5% significant; ** means 95% significant; * means 90% significant.

Table 7: Results for the Dummy Variables on Subjective Assessment

Factors that negatively affect my fertility decision: Yes = 1; No = 0	From (I) Tobit (Robust S.E.)	From (V) Logit (Robust S.E.)	Percentage answering "Yes"
(a) Negative impact on my job and career	-0.18629**** *(0.068797)*	-0.46846*** *(0.21703)*	32.6%
(b) No confidence in educational system	-0.15183*** *(0.06755)*	-0.51642**** *(0.21413)*	27.0%
(c) Don't know how to raise children	-0.27758**** *(0.08171)*	-0.81402**** *(0.23396)*	21.1%
(d) Don't like children	-1.08424**** *(0.22628)*	-1.66543**** *(0.43920)*	4.5%
(e) No confidence in marriage	-0.20616** *(0.1256)*	-0.77078**** *(0.31946)*	9.5%
Factors that positively affect my fertility decision: Yes = 1; No = 0			
(f) Like children	0.44822**** *(0.07856)*	1.47108**** *(0.21944)*	69.9%
(g) Seniors in my family want children	0.20109**** *(0.06914)*	0.80968**** *(0.27591)*	19.6%
(h) Having children is part of my social responsibility	0.23310**** *(0.08148)*	0.85633**** *(0.35310)*	16.0%

Figure 1: Percentage of Women who Have No Children