Demographic Transition, Childless Families and Economic Growth

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Abstract

In recent decades, several East Asian economies have been going through the demographic transition at rapid paces. With total fertility rates well below replacement ratio, it is no surprise that childless families have begun to emerge on a large scale. For example, in Hong Kong, where total fertility rate is below one, 30 percent of the women in their mid-forties have never borne any children, and this ratio is increasing quickly. This poses new challenges not only to public policymaking but also to the theoretical literature on quality-quantity tradeoff of children. When there are no children, the vehicle for human capital investment may disappear. In this paper, we present a model that that can naturally generate the demographic transition with corner solution occurring at zero fertility. Using a variety of censored and count regression models to analyze the data collected from a survey conducted before the spring of 2008, we have verified that parental human capital is a very significant factor affecting fertility rate. Moreover, several important factors that may have an impact on the demographic transition and zero fertility have been identified.

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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, saving behavior and even international balance of payments. 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 much lower than those in the

[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.

US or Europe. Comparisons with the 1965 figures 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 prevailing 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 ---- an economy having one of the lowest TFR's in the world---- will never have any children, and this percentage is rising rapidly! Similar situations also occur in many other economies. Thus, the issue of childless families is not a trivial issue that can be ignored by model-builders.

The purpose of this paper, which is part of a larger study on the demographic transition, 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) The Prevalence of Childless Families

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 surprising 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's TFR has fallen below one only in recent years. Back in 1965, it was 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.

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[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).

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 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 have never borne any children for the years 1996, 2001 and 2006.

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

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

In 2006, the proportion of childless 45-year-old women is 29.22 percent. While this is already a very large proportion, we should note from Figure 1 that the childless rates of 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 20.9 percent in 1996 to 31.81 percent in 2006, representing roughly 11 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, 31.81 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 of 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.[6]

The prevalence of childless families is a common phenomenon that goes far beyond Hong Kong's borders. Based on data from China's 2005 one-percent population census, my preliminary estimate indicates that 25.7% of women in Chinese cities will remain childless when they reach the age of 50. This ratio is likely to be much higher in major cities such as Beijing and Shanghai.[7] From Table 1, the TFR's for Japan and the four Asian dragons are close to one. Since many women in these economies have more than one child, but the average number of children per woman is around one, the proportion of those who are childless cannot be negligible.

Childlessness is prevalent not only in Asia, but also in the West. Even the United States, which has an exceptionally high TFR compared with other advanced economies, has a moderate, but nevertheless significant, voluntarily childless rate of 7% in 2002 (Abma and Martinez, 2006). In Germany, 21% of the women of birth cohort 1960 do not

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[6] Another robustness test is to look at the proportion of childless men in the population. By using a methodology similar to that we have applied to women, we estimate that 36.85 to 38.5 percent of the men in the 41-45 age group in 2006 do not have children. This confirms the notion that many families in Hong Kong will remain childless. The reason why there is a range for the estimate is that the census database only reports the number of children living in the household. It is well known that some Hong Kong men have married women in the Chinese mainland, and whose children have not migrated to Hong Kong yet. Thus, in our estimation, we have to take into account the number of men who are married, but whose wives and children are not in the household in Hong Kong. Since husbands tend to be older than wives, it is no surprise that the proportion of childless men is larger than that of childless women in the same age group. The corresponding estimate for the proportion of childless men in 2001 is between 27.83 to 29.02 percent.

[7] See Table 8.2a and 8.3a of China National Bureau of Statistics (2007). According to the 2005 one-percent population census in China, the TFR's of Beijing and Shanghai are 0.617 and 0.643, respectively. Although some under-reporting might have occurred because of the one-child policy in China, these extremely low TFR's imply that childless rates in these two cities could be higher than 35%.

have children. Childless rate for the birth cohort 1966 is estimated to be 29%. For university-educated women born in 1965, the rate is much higher at 38.5% (Dorbritz, 2008). In Italy, it has been estimated that about one-fifth of the women born in 1965 will remain childless (Mencarini and Tanturri, 2006). Among British women who have received university education, 25% of those born in 1970 will likely remain childless (Kneale and Joshi, 2008). In fact, the European baby bust has attracted so much attention that the *New York Times Magazine* finds it news-worthy to publish an investigative cover story with the sensational title of "Childless Europe" (Shorto, 2008).

Thus, the emergence of childless families is not an isolated event, nor can this be regarded as quantitatively trivial. The analysis of Hong Kong's experience is valuable because this can be regarded as a leading indicator for other economies whose TFR's have not yet reached the low levels of Hong Kong. In this paper, I shall confine myself only to the causes of low or zero fertility rates, but not to their implications.

(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[8]

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

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

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

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

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 treated as exogenous here.[9] 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 $\pi_2 w H_t$ is that a young adult does not have to pay for the old-age

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

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

support of his parent if the latter has not survived. Hence, $\pi_2 w H_t$ 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.[10] 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, h_t, and n_t. The first-order conditions are given by the following.

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

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

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

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

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

The left-hand sides of (3.5) to (3.7) can be interpreted as the marginal rate of substitution between period 1 and period 2 consumptions. 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.[11] 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 $N^{-1} > (1 - \alpha)\,[(h_t/v) - \alpha/(1-\alpha)]$. 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.[12]

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

[11] 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.

[12] 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.

the children because they do not exist. 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. During retirement, her consumption comes from savings only. There is no financial support from the children and 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.

The model discussed above provides a coherent framework that generates a number of testable hypotheses. The most important of these is the **Demographic Transition Hypothesis**: *In an economy that has entered a perpetual growth equilibrium, total fertility rate of the potential parent is negatively related to her human capital*.

To test the demographic transition hypothesis, we have to introduce a number of control variables, some of which are interesting on their own. The model can guide us in identifying the proper controls. From (3.7), an increase in v will lower the return to the quantity of children. This leads us to the **Opportunity Cost Hypothesis**: *When a parent finds it more costly to raise children, she will have fewer of them.*

From (3.6) and (3.7), an increase in the educational technology parameter A will raise not only the return to investment in human capital, but also the return to the quantity of children. Hence, we have the **Educational Technology Hypothesis**: *The more effective is a parent in educating her children, the greater is the quantity of children she wants to raise.* .

Equation (3.7) includes an old-age support parameter w. It follows from the equation that when w goes up, the return to quantity of children will also rise. We can

state the **Old-Age Security Hypothesis** as follows: If a person's old-age security motive is stronger, she will raise more children.

Both (3.6) and (3.7) contain a parameter, μ, which is a measure of people's preference for children. This is another control variable that has to be included in our empirical analysis in the next section. It is beyond the scope of this paper to explicitly model the factors affecting taste, since there is already an extensive literature on this issue in different branches of social science. For example, Koropeckyj-Cox and Pendell (2007) find that religiosity and attitudes about marriage and gender equality an affect women's acceptance of childlessness. Barber and Axinn (2004) reports that exposure to mass media influences can change people's childbearing behaviors and preferences for smaller families. Schmidt (2008) provides evidence showing that attitude towards risks can also affect a woman's fertility decision. Thus, the literature and the theoretical model of this paper both indicate that we should incorporate preference variables as controls in our regressions. Another advantage of including preference variables is that we can quantitatively assess their relative importance in determining a woman's fertility.

(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 and a generalized Poisson model are presented and the economic interpretations discussed. I shall then use a Probit model to focus more sharply on the choice of whether or not to have children at all. For reasons to be explained below, despite the fact that the Probit estimator is less efficient than the Tobit, the results generated by the former can still provide us with additional insights. 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 raise 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.[13]

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 total fertility rate, which is the main dependent variable to be explained in this paper. Given this information, we can also easily construct a dichotomous variable (FERTDUMMY) on whether the respondent wants to have zero, or a positive number of children.

------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.[14] Other than these, the respondents were chosen randomly. Because of the constraints, the respondents were

[13] 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.

[14] 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.

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

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

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

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

where y_i is the dependent variable, $\boldsymbol{x}_i$ is a vector of the explanatory variables, $\boldsymbol{\beta}$ is the vector of coefficients of the variables, and ε_i is an error term with standard normal distribution.

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

Table 5 presents the summary of several regressions aimed at identifying the determinants of fertility in Hong Kong.[15] The benchmark regression is the Tobit model in regression 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 have to be identically distributed.[16]

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 SCHOOLING and EXPERIENCE, desired TFR is always negatively related to these measures of human capital. **This result supports the Demographic Transition Hypothesis** discussed in Section 3. As the human capital of the potential parent increases, they tend to have fewer or even no children. We should note that the negative effect of SCHOOLING on desired TFR is quantitatively much larger than that of EXPERIENCE. Other things equal, an adult who has 14 years of schooling would have 1.24 fewer children compared to one who has no education at all.[17]

The positive effect of marriage on desired TFR is consistent with the **Opportunity Cost Hypothesis**. 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

[15] To mitigate possible endogeneity problems, I have also tried various instrumental variable estimators in the regressions. However, the Wald exogeneity tests applied to these regressions indicate that endogeneity is not a problem. In fact, the results reported in Table 5 and 6 generally remain robust when instrumental variables are used.

[16] If we do not use the robust estimator for the standard errors, as expected, the results are more significant.

[17] 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.

the Section 3. We expect that the desired TFR's of married people are higher. The negative effect of age on desired TFR may be due to the nature of the dependent variable. Young adults may not fully realize the high cost of bearing, nurturing and educating children and therefore may plan to have too many children. However, as they get older, they become more realistic about the cost.[18] 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 the **Opportunity Cost Hypothesis**.

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 the **Opportunity Cost Hypothesis.**[19] 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.

Assuming that children are normal goods, we should expect some positive effect of income on fertility rate. However, the results of the Tobit regression in Table 5

[18] Heaton, Jacobson and Holland (1999) studies how intended childlessness changes over time. Our finding that intended fertility declines as age goes up is consistent with this early study. If we use the actual number of children as the dependent variable, then the evidence indicates that this is positively related to age.

[19] Parr (2005) also finds that the number of siblings of a parent is positively related to her own fertility rate.

indicate the income effect is quantitatively rather small and statistically insignificant.[20] One may suspect that the apparent absence of significant income effect is due to problems inherent in the Tobit estimation, which presupposes that the error term is normally distributed. However, the dependent variable--desired total fertility rate--consists of discrete integers. An alternative approach is to rely on a count model. By doing so, we can also check the robustness of the other results obtained by the Tobit model.

A convenient count model that can be used is the Poisson model. However, this has the restrictive property that the expected number of children would be equal to the variance of the number of children. To mitigate this problem, we employ a generalized Poisson model, which is more flexible. The probability mass function of this model is[21]

$$f(y_i ; \lambda_i , \delta) = [\lambda_i (\lambda_i + \delta y_i)^{y_i - 1} e^{- \lambda_i - \delta y_i}] / y_i ! \qquad (4.2)$$

for $y_i = 0, 1, 2, \ldots,$ and $\ln \lambda_i = \boldsymbol{x}_i' \boldsymbol{\beta}$. If the parameter $\delta = 0$, then (4.2) reduces exactly to the probability mass function of the usual Poisson model. It can be shown that

$$E[y_i \mid \boldsymbol{x}_i] = \lambda_i / (1 - \delta), \qquad (4.3)$$

$$Var [y_i \mid \boldsymbol{x}_i] = E[y_i \mid \boldsymbol{x}_i] / (1 - \delta)^2. \qquad (4.4)$$

Results of the generalized Poisson estimation are presented in regression II of Table 5.[22] It can readily be seen that the coefficient for the income variable, though very small, is statistically significant and positive, thus supporting the hypothesis that children

[20] Income data from the survey has been modified to reduce possible biases in the estimation of income effect. For married respondents whose reported personal income is zero (most of them being housewives), we use the income of spouse instead of the person's own income.

[21] See Hardin and Hilbe (2007).

[22] Since the estimated δ in regression II is negative, there is "under-dispersion" in the data.

are normal goods.[23] All other results are similar to those in the Tobit estimation, with the exception that the coefficient for the size of living quarters is not significant. The core story for demographic transition remains clear and valid. Thus, the results in the benchmark regression I appear to be robust. In IV of Table 5, we also report results from an OLS estimation. Again, we find results similar to the Tobit estimation.

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 desired 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 contribute to the low or zero fertility in Hong Kong? In all the regressions in Table 5, I have added 9 dummy variables, each representing the respondent's subjective assessment of different factors that may affect fertility. These variables, acting as controls, considerably sharpen the estimations for the objective variables included in Table 5. The results for these dummies also provide additional opportunities for us to test the hypotheses discussed above. 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. The Tobit and generalized Poisson models discussed above are appropriate tools for predicting fertility rates of different values, including zero. However, one can argue that the factors determining the choice between zero and positive fertility could be different from the decision on whether one should have even more children. The Tobit or generalized

[23] The marginal effect of an increase in income on fertility rate in the generalized Poisson model can be estimated by making use of the incidence-rate ratio. To induce a person having one child to have another one, her monthly income has to be increased by more than HK$85000. 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 consistent with the very small income effect estimated here.

Poisson model does not recognize that the margin between zero and one could be different from, say, the margin between three and four children. Hence, there is some value in using a binary model to explicitly deal with the choice between zero and positive 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 Probit model, which can be represented by the following:

$$Prob\ (Y = 1 \mid \boldsymbol{x}) = \Phi(\boldsymbol{x'\beta}), \qquad (4.5)$$

where Y is a dichotomous dependent variable that assumes the value of either 0 or 1, $\Phi(.)$ is the standard normal distribution function, $\boldsymbol{x}$ is a vector of explanatory variables and $\boldsymbol{\beta}$ is the vector of the corresponding coefficients. Estimation results of the Probit model are presented in regression III in Table 5.

Before interpreting the results from the Probit estimation, we should note three things. First, the variables included in the two regressions are the same, which make comparisons between the two easier. Second, the error terms of both regressions are normally distributed. Third, by using a single value of one to represent different quantities of children, the Probit method loses some information that is available to the Tobit estimator. This makes Probit a less efficient estimator. Despite this, comparison of regressions I and III readily indicates that most of the results obtained in the Tobit model remain intact in Probit.[24] The exceptions are SCHOOLING, SCHOOLING^2, and HOUSE SIZE, which do not have significant results.

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

[24] We have also tried a Logit model. The results are very similar to those in Probit and therefore not reported here.

whether to have children at all.[25] 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 the Tobit model, but much less so in Probit, which deals only with positive or zero fertility decisions.

(D) Subjective Assessment Variables

In the regressions reported above, I have included 9 dummy variables as controls, but their results have been suppressed. This sub-section discusses them. 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 11 factors were important, the statistical evidence does not support the claim and so they are excluded.

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

Table 6 reports the results on the 9 included dummies. 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 to III, the results are similar in the OLS regression IV.

Quantitatively the factor that seems to have the most powerful effect on fertility is whether the respondent liked children or not. This indicates that the preference parameter,

[25] The theoretical explanation behind this phenomenon is being explored in another paper of this author.

μ, that we discussed in Section 3 is indeed a useful control. However, we should note that only 4.5% of the respondents claimed that they did not like children. This percentage is not big enough to explain the very low fertility rate in Hong Kong.

Estimations for other variables in Table 6 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. About one-third of the respondents regard this as an important factor. The negative sign of the parameter estimated again supports the **Opportunity Cost Hypothesis.**

Variables *b, c* and *e* are related to 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 did not feel that they were prepared. These results support both the **Opportunity Cost Hypothesis** and **Educational Technology Hypotheses**. Variables *g* indicates that some respondents' decisions were dependent on the views of others. 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.[26] In a city where information dissemination by the media is rapid, many people would have remembered this well-known remark, and some (16% in our sample) would believe that giving birth to children was part of their social responsibility. Finally, Tobit and Poisson estimations for variables *h* and *i* indicate that for those people who have strong old-age security motives, it is more likely for them to increase the quantity of children. This supports the **Old-Age Security Hypothesis**.

Although the primary purpose of including these dummies as control variables is to sharpen the estimations for other variables, we have also obtained more evidence to support the hypotheses discussed in Section 3.

(5) Concluding Remarks

[26] 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.

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.

I have shown that an extension of the Ehrlich-Lui (1991) model can naturally generate not only the demographic transition, but also zero fertility rates for some families. Based on this model, I have proposed several testable hypotheses related to the determinants of demographic transition. These hypotheses are tested by a Tobit model, a generalized Poisson model and a Probit model using data from a survey that I conducted. The empirical results make a lot of sense. The quantity-quality of children tradeoff, which drives the demographic transition, clearly exists. Other variables, such as different measures of the cost of educating and raising children, number of siblings of the parents, preferences for children, sizes of residential quarters, and social responsibilities also play significant roles in determining total fertility rate.

A number of puzzles remain unexplained in this paper. For example, the speed of the emergence of childless families in Hong Kong, and possibly in some Chinese cities and several other East Asian economies as well, seems to defy any form of culture-based explanations. Confucian values, which heavily influence East Asian countries, attach the highest importance to making dynastic families sustainable. Why is it that we find some of the world's lowest fertility rates in these economies? The findings in this paper also suggest that heterogeneous preferences for children may be an important variable that should be explicitly modeled in future research.

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	1970	1981	1991	1996	2001	2006
4.5	3.3	1.95	1.30	1.20	0.93	0.98

Sources: 1965 and 1970 figures are from World Bank (1992, 1993). 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	**58.22%**	20.90%
2001	**63.83%**	25.31%
2006	69.75%	31.81%

Sources: Figures for 2001 and 2006 are derived from the 5%-samples of the 2001 and 2006 Hong Kong Census micro data. Figures for 1996 are derived from the 1%-sample of the 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 never married 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

	(I) Tobit Dep. Var. = Desired TFR	(II) Generalized Poisson Dep. Var. = Desired TFR	(III) Probit Dep. Var. = FERTDUMMY	(IV) OLS Dep. Var. = Desired TFR
Constant	2.95582**** *(0.73271)*	1.60520**** (0.38530)	2.07478* *(1.29690)*	2.78667**** *(0.64604)*
INCOME	0.0000043 *(0.0000047)*	0.000008**** *(0.000002)*	0.0000072 *(0.0000089)*	0.000003 *(0.000004)*
MARRIED DUMMY	0.46078**** *(0.09089)*	0.24701**** *(0.04714)*	1.07197**** *(0.20328)*	0.35063**** *(0.07555)*
AGE	-0.02126**** *(0.00757)*	-0.01470**** *(0.00397)*	-0.05604**** *(0.01573)*	-0.01432*** *(0.00652)*
SCHOOLING	-0.20422*** *(0.10287)*	-0.14388**** *(0.05214)*	0.00997 *(0.17742)*	-0.18473*** *(0.09141))*
SCHOOLING^2	0.00709** *(0.00370)*	0.00462**** *(0.00190)*	-0.00014 *(0.00623)*	0.00642** *(0.00329)*
EXPERIENCE	-0.02758**** *(0.00752)*	-0.01235**** *(0.00400)*	-0.03329** *(0.01866)*	-0.0239**** *(0.00647)*
EXPERIENCE^2	0.000108**** *(0.000038)*	0.000046*** *(0.000021)*	0.00033 *(0.00038)*	0.00009**** *(0.00003)*
SIBLINGS	0.06384**** *(0.01993)*	0.00730 *(0.01039)*	0.13163**** *(0.04434)*	0.05039**** *(0.01724)*
TRAFFIC TIME	-0.05215* *(0.03723)*	-0.03168** *(0.01849)*	-0.14216*** *(0.06857)*	-0.04056* *(0.03197)*
HOUSE SIZE	0.000216*** *(0.000103)*	0.00017**** *(0.000048)*	-0.0000028 *(0.00021)*	0.000199*** *(0.00009)*
9 DUMMIES (Results presented in Table 6)				
No. of observations	929	929	929	929
Wald χ^2	235.11	288.77	153.02	
Prob > χ^2	0.0000	0.0000	0.0000	
ln σ	-0.12738**** *(0.03920)*			
δ		-0.42616**** (0.03149)		
Pseudo R^2		0.0852	0.2963	
R^2				0.2324

Notes: (1) Terms inside brackets are standard errors estimated by the method of White (1980) and Huber (1967). (2) **** means significant at 1% level for one-tail test; *** means significant at 2.5% level; ** means significant at 5% level; * means significant at 10% level.

Table 6: Results for the Dummy Variables on Subjective Assessment

Factors that negatively affect my fertility decision: Yes = 1; No = 0	From (I) Tobit	From (II) Generalized Poisson	From (III) Probit	Percentage of answers with dummy = 1
(a) Negative impact on my job and career	-0.18370**** *(0.06793)*	-0.06121** *(0.03527)*	-0.28677*** (0.12576)	32.6%
(b) No confidence in educational system	-0.14572*** *(0.06863)*	-0.06128** *(0.03545)*	-0.22817** (0.12287)	27.0%
(c) Don't know how to raise children	-0.26491**** *(0.08241)*	-0.17184**** *(0.04219)*	-0.41467**** (0.13671)	21.1%
(d) Don't like children	-1.07425**** *(0.23034)*	-0.46225**** *(0.08297)*	-0.97074**** (0.24338)	4.5%
(e) No confidence in marriage	-0.24085** *(0.1256)*	-0.12819*** *(0.06291)*	-0.41780*** (0.18717)	9.5%
Factors that positively affect my fertility decision: Yes = 1; No = 0				
(f) Like children	0.46071**** *(0.07692)*	0.12010**** *(0.04214)*	0.77030**** (0.12632)	69.9%
(g) Having children is part of my social responsibility	0.23870**** *(0.08258)*	0.11025**** *(0.04018)*	0.34071** (0.18914)	16.0%
(h) Raise children to secure old-age support	0.14859* *(0.09992)*	0.19844**** *(0.04588)*	0.15119 (0.18264)	14.6%
If you don't have children, what will you do to protect your retirement?				
(i) Don't know what to do = 1; otherwise = 0.	0.32013*** *(0.15618)*	0.13867** (0.07107)	0.15278 (0.30129)	6.0%

Figure 1: Percentage of Women who Have No Children