The One-child Policy: A Macroeconomic Analysis

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Abstract

This paper studies the effects of a one-child policy. A benchmark without the fertility constraint is compared to a counterfactual experiment with the fertility constraint in place. The results suggest that imposition of a one-child policy promotes the accumulation of human capital and increases per capita output. In partial equilibrium, an unskilled adult’s welfare is lowered by the policy. However, in general equilibrium, the policy triggers a decrease in the supply of unskilled labor, which increases the unskilled wage rate. Thus, an unskilled adult is in fact better off with the policy due to higher wages. This paper demonstrates the importance of accounting for general-equilibrium effects and heterogeneity when analyzing population policies.

JEL Classification: O11, J13, O53.

Keywords: A One-child Policy, Fertility, Population Policies.

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1 Introduction

China has introduced the one-child family policy since 1979 with the goal of controlling rapid population growth. The debate on the merits of the one-child policy continues after three decades. On the positive side, the policy results in lower fertility, which contributes to economic growth and improves families’ standards of living.\(^1\) On the negative side, Bongaarts and Greenhalgh (1985) discuss the possible social and economic problems with the one-child policy, such as the detrimental effects on the age composition of the population, sex imbalance, effects on the support of elderly people, psychological effects on only children, and preclusion of the development of family firms, which have spurred growth in other East Asian countries.\(^2\)

Most existing studies explore the effects of the one-child policy from an empirical perspective. In contrast to the existing literature, this paper takes the lead in studying the effects of the one-child policy using a theoretical approach: an overlapping generations model with a fertility constraint is employed to discuss the impacts of the policy on fertility, age structure, human-capital accumulation, and output per capita. Changes in welfare resulting from a one-child policy is also quantified. In addition, this paper considers heterogeneous individuals. The literature discusses the policy from an aggregate perspective. However, different groups in one economy may react differently to the policy. Therefore, this paper examines the effects of a one-child policy on skilled and unskilled adults.

This paper builds on the theoretical model of Liao (2009). The benchmark model is a three-period overlapping generations model with endogenous fertility. Children do not work, but depend on their parents for support. If they survive, children become adults. Adults make decisions and supply labor to the production sector. Then, subject to a

\(^1\)McElroy and Yang (2000) suggest that China’s population policies have played a important role in lowering China’s fertility. Li, Zhang, and Zhu (2005) also find similar results. In addition, Li and Zhang (2007) shows that the birth rate has a negative impact on economic growth, suggesting that China’s birth control policy is growth enhancing.

\(^2\)Hesketh and Zhu (1997) also discuss the good and the bad of the one-child policy. Hesketh, Lu, and Zhu (2005) report the sex ratio at birth and the ratio of old-age dependency in China. The sex ratio is defined as the proportion of male live births to female live births. In industrial countries, it is about 1.03-1.07. In China, the sex ratio was 1.17 in 2001. The ratio of old-age dependency in China was 7.5 percent in 2005 but is expected to rise to more than 15 percent by 2025.
survival probability, adults become the elderly and consume their own savings. An adult chooses consumption, asset holdings, the number of children he wants, and an education level for his children. Education is discrete, either skilled or unskilled. The production sector is perfectly competitive. There exists a representative firm using skilled labor, unskilled labor, and physical capital as inputs.

Outcomes in the benchmark model are compared to an alternative in which a fertility constraint representing the one-child policy is introduced. China’s one-child policy restricts families to have one child per family. Parents who follow the policy will receive government subsidies, and will also get priority in schooling, housing, health care, and work. Punishments are also built into the policy. For example, government workers will be punished for having a second child with a 20 percent cut in their basic salary for seven years. For simplicity, subsidies and punishments are not considered in this paper. A couple is allowed to have at most one child when the policy is imposed. Although China’s one-child policy is only strictly applied to urban areas, the policy in the model is applied to all adults without exception.

In the calibration, the strategy is to calibrate the benchmark to a country so that it is as close to China as possible. Due to this purpose, the benchmark is calibrated to represent the demographic change in Taiwan in 1970-2004. Taiwan is selected because Taiwanese and Chinese cultures have many similarities, such as the preference for boys rather than girls and the expectation of getting support from one’s family in old age. Besides, the decline in fertility in Taiwan was nearly the same as in China in 1965-1990, as reported in Johnson (1994). Because of these similarities, Taiwan can serve as a useful benchmark for exploring China’s one-child policy.

Two experiments are discussed in this paper. The benchmark in the first experiment represents Taiwan’s demographic change. Then, a counterfactual experiment with a one-child policy is carried out in comparison to the benchmark. The purpose of this experiment is to study what Taiwan would be if Taiwan had imposed a one-child policy in the 1970s.

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3Table 1 in Johnson (1994) provides fertility rates for China and other eight countries in 1950-1990. The fertility rate for China in 1965-70 and 1985-90 was 5.99 and 2.38, respectively. Thus, the percentage decline was about 60 percent. The fertility rate for Taiwan was 4.2 and 1.74, respectively. The percentage decline was about 59 percent.
First of all, the results suggest that introducing a one-child policy promotes the accumulation of human capital. The literature discusses the quantity-quality tradeoff of children. For example, Becker and Lewis (1973) suggest that a decrease in the quantity of children releases resources to children so that the average quality of children increases. The finding is consistent with their suggestion. The human capital under the policy could be about 42 percent higher than what Taiwan actually had in 2004. Thus, human capital is rapidly accumulated in the environment with the policy. Second, lower fertility leads to a lower dependency ratio and a higher fraction of working-age population, thereby increasing output per capita. The experiment supports the idea that imposing the policy leads to higher output per capita. In other words, Taiwan would have a higher output per capita in 2004 if the policy had been introduced in the 1970s.

However, the policy also has detrimental effects: per capita output increases in the period when the policy is imposed, but declines later on. At that time, the fraction of old people as a percentage of total population increases, thereby reducing output per capita. At steady state, the fraction of old people as a percentage of total population is higher than that in the benchmark. Thus, Taiwan would have an older population if the policy had been imposed. Actually, China will experience rapid aging population in the next few decades. As Table 1 shows, the fraction of the population aged 65 and above in China will double over the next twenty years. China will have more people above age 65 than below 15 by 2035.

One advantage of the analysis in this paper is that the changes in welfare due to the implementation of a one-child policy can be measured. Different people may react to the policy in different way. For example, people living in rural areas like to have more children because children give contribution to home production. Thus, they may be unhappy if the policy is imposed. In contrast, people living in cities may automatically have at most one child because of the higher cost of childrearing. In the model, individuals are classified.

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4 However, Rosenzweig and Zhang (2006) suggest that the contribution of the one-child policy in China to the development of its human capital is modest. The policy results in an increase in schooling attainment by 4 percent at most, the probability of attending college by less than 9 percent, and school grades by 1 percent.

5 Using China’s provincial-level data, Li and Zhang (2007) suggest that a decline of the birth rate by 1/1000 will increase the economic growth rate by 0.9 percentage point in a year.

6 Source: The UN population projection (the 2008 revision)
as skilled or unskilled adults. In generally, people who have less education tend to live in rural areas and have more children. Once the policy is introduced, they are likely to be unhappy because they cannot have the number of children that they want. In contrast, because highly educated people tend to live in cities and have fewer children, they may automatically obey the policy and are not be influenced by the policy. The results in partial equilibrium are consistent with the intuition that the welfare of an unskilled adult becomes lower because his fertility is restricted.\footnote{Zhang and Spencer (1992) find that woman’s education and husband’s occupation significantly influence compliance of the one-child policy in China.} However, in general equilibrium the results are surprising and counterintuitive. When the policy is introduced, the supply of unskilled labor declines due to the lower fertility of unskilled adults, and the unskilled wage rate then increases. Consequently, an unskilled adult is in fact better off with the policy as a result of the higher wage rate.

The second experiment studies what Taiwan would be if Taiwan introduced a one-child policy now. Starting with 2004, an experiment with the policy is provided. The results are similar to the first experiment, but the effects of the one-child policy is relatively small. For example, output per capita will increase by only 6 percent from 2004 to a new steady state. In conclusion, the positive effects of a one-child policy is relatively small when the fertility is low. In 2000-2005, China’s fertility was about 1.77. Comparing the benefits to the social and economic costs, China may reconsider its population policies to achieve its long-term demographic goals.

This paper provides a framework for discussing the effects of a one-child policy. The results confirm the positive aspects of introducing the policy, which are higher per capita GDP and the accumulation of human capital. These experiments also show the negative effects on the age structure. Although China’s one-child policy is more complicated than the fertility constraint imposed in the model, this paper shows the importance of accounting for general-equilibrium effects and heterogeneity when discussing population policies. Studying population policies from an aggregate perspective or partial equilibrium may be misleading.

The rest of this paper is organized as follows. Section 2 describes the benchmark and the model with a fertility constraint. Section 3 discusses the calibration. The experiments
and the results are provided in Section 4. Finally, Section 5 concludes this paper.

2 The Model

The benchmark employs the general equilibrium overlapping generations model of Liao (2009). In the model, an individual can live for at most three periods: childhood, young adulthood, and old adulthood. Children are assumed not to work but to depend on their parents for support. If they survive, they become young adults. The survival probability for children is $\pi^c$. Then, subject to the survival probability for young adults $\pi^y$, young adults become old adults who consume their savings. Only young adults supply labor and make decisions. A young adult chooses consumption, asset holdings, the number of children he wants (fertility), and the education level of his children. Education level is discrete, either skilled or unskilled. The benchmark with endogenous fertility is provided in the first part of this section. Then a fertility constraint is introduced in the second part, representing the implementation of a one-child policy.

2.1 The Benchmark

Assume an individual can have children at the beginning of his young adulthood. Define $N^z$ as the population of $z$, where $z \in \{c, y, o\}$ representing children, young adults, and old adults, respectively. Besides, a young adult can be either skilled ($s$) or unskilled ($u$), which was determined by his parent. Thus, $N^y_s$ denotes the population of skilled young adults and $N^y_u$ is the population of unskilled young adults. The evolution of population is given by:

$$N^c = (n_{ss} + n_{su})N^y_s + (n_{us} + n_{uu})N^y_u,$$

$$N^y' = \pi^c N^c,$$

$$N^o' = \pi^y N^y,$$

where $n_{ij}$ is the number of $j$-type children that each $i$-type young adult has, $i \in (s, u)$. The population of children is determined by the fertility. Then, children will become
young adults if they can survive to the next period. Young adults will become old adults with the survival probability of young adults.

Given his type is \( i \), a young adult derives utility from consumption for his young adulthood \((c_i)\), consumption for his old adulthood \((c'_i)\), and his surviving children. The number of his skilled children is \( n_{is} \), and the number of his unskilled children is \( n_{iu} \). The lifetime utility of an \( i \)-type young adult is given by:

\[
\frac{c_i^{1-\sigma}}{1-\sigma} + \beta \pi^y \left( \frac{c'_i^{1-\sigma}}{1-\sigma} \right) + \psi [\pi^e(n_{is} + n_{iu})]^{-\varepsilon}[\pi^e n_{is} V'_s + \pi^e n_{iu} V'_u],
\]

where \( \beta \) is the subjective discount factor with respect to the utility of consumption; \( \varepsilon \) determines the elasticity of altruism with respect to the number of children; and \( \frac{1}{\sigma} \) denotes the elasticity of intertemporal substitution. \( \beta, \varepsilon, \) and \( \sigma \) are all range between zero and one. \( \psi \) represents how much a young adult loves his children. \( V'_s \) is the utility that a child will receive when he becomes a skilled young adult, and \( V'_u \) is the child’s utility when he becomes an unskilled young adult. Both utilities are foreseeable and are known when a current young adult is making decisions.

Each young adult has one unit of time. By assumption, only skilled young adults can be teachers. Thus, a skilled young adult can allocate his time between working in the production sector, teaching, and raising children. In contrast, an unskilled young adult only has two options: working in the production sector and raising children. The skilled wage rate for one unit of time is \( w_s \). The compensation for being a teacher is also equal to \( w_s \). The unskilled wage rate is \( w_u \).

Children cannot work but depend on their parents for support. Thus, a young adult need to pay the good cost \( p \) and the time cost \( \phi \) of raising a child. In addition, the education time cost is \( \phi_s \). Thus, the cost of raising a child is given by:

\[
p_{ij} = \begin{cases} 
\phi w_i + p + \phi_s w_s & \text{if } j = s; \\
\phi w_i + p & \text{if } j = u;
\end{cases}
\]

where \( i \) denotes the type of young adult and \( j \) represents the type of child. The budget constraint for an \( i \)-type young adult in his young adulthood and old adulthood is given
by:

\[ c_i + \pi y a_i' + p(n_{is} + n_{iu}) + \phi_s w_s n_{is} = [1 - \phi(n_{is} + n_{iu})]w_i; \quad \text{(3)} \]

\[ c_i' = (1 + r')a_i'; \quad \text{(4)} \]

where \( r' \) is the interest rate in the next period. There exists a perfectly competitive insurance company. An \( i \)-type young adult saves \( \pi y a_i' \) in his young-adult period. If he survives, he will receive \( a_i' \) for his consumption in old age. Otherwise, he will receive nothing.

The production side is perfectly competitive. There exists one representative firm using skilled labor, unskilled labor, and physical capital as inputs. Because capital-skill complementarity is observed in many developing countries, the main purpose of setting the production function is to generate capital-skill complementarity. Therefore, this paper employs a CES function instead of a Cobb-Douglas function. The production function in this economy is given by:

\[ Y = A[\mu L_u^\alpha + (1 - \mu)(\theta K^\rho + (1 - \theta)L_s^\rho)]^{\alpha/\rho}, \quad \text{(5)} \]

where \( A \) denotes total factor productivity, \( \mu \) and \( \theta \) are factor weights that govern income shares, and \( \alpha \) and \( \rho \) govern the elasticities of substitution between unskilled labor, physical capital, and skilled labor. \( L_u \) refers to the number of unskilled workers and \( L_s \) is the number of skilled workers. \( K \) is physical capital. Capital-skill complementarity requires that \( \alpha > \rho \). The production function can be rewritten as:

\[ y_{pc} = \frac{L}{N} [\mu l_u^\alpha + (1 - \mu)\theta k^\rho + (1 - \theta)l_s^\rho]^{\alpha/\rho}, \quad \text{(6)} \]

where \( y_{pc} \) denotes output per capita, \( k \) is the capital-labor ratio, \( l_u \) is the fraction of unskilled labor as a percentage of total labor, \( l_s \) is the fraction of skilled labor, and \( N \) is the total population.

Liao (2009) shows that the young adult’s maximization problem only has corner solutions in equilibrium. A young adult will send either all or none of his children to school. Skilled children and unskilled children will not live in the same family. However, it is possible that a specific type of young adult is indifferent between always having skilled
children and always having unskilled children in his family. In this case, some young adults of a given type decide to always have skilled children, while others decide to always have unskilled children. Because the total cost of raising a child is different between two types, a young adult who decides to always have skilled children will have fewer children than a young adult who always has unskilled children. A typical case for a balanced growth path is that skilled young adults always have skilled children and unskilled adults are indifferent between always having skilled children and always having unskilled children. The fertility of unskilled adults is higher than the fertility of skilled adults, so other cases will lead to an unskilled wage rate of zero. In the typical case, upward mobility and an accumulation of human capital occur in this economy. In equilibrium, the fraction of unskilled adults having skilled children is determined by the relative utility of having skilled children and unskilled children.

Following the corner solutions and the indifference condition, a young adult only has one type of child. The model can be simplified as follows:

\[
\max_{c_{ij}, a'_ij, n_{ij}} \left\{ c_{ij}^{1-\sigma} \left( \frac{V_j}{1-\sigma} \right) + \beta \pi^y \left( \frac{c_{ij}^{1-\sigma}}{1-\sigma} \right) + \psi \pi c n_{ij}^{1-\epsilon} V_j' \right\},
\]

subject to

\[
c_{ij} + \pi^y a'_ij + p_{ij} n_{ij} = w_i,
\]

\[
c_{ij}' = (1 + r') a'_ij,
\]

where \( p_{ij} \) is defined in (2) and \((i, j) \in \{(s, s), (u, s), (u, u)\}\). \( i \) denotes the type of young adult and \( j \) refers to the type of his children.

### 2.2 A One-child Policy

China’s one-child policy refers to the restriction of having one child per family. It is strictly applied to urban areas with few exceptions, such as if the first child has a disability. On the other hand, the policy is not strictly enforced in rural areas or in areas with low populations. For example, a second child is generally allowed if the first child is a girl in rural areas.

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8Because the wage rates are different, only one type can satisfy the indifference condition. Liao (2009) shows the detail.
The model in this paper makes no distinction based on gender or areas. Every young adult is considered to be identical in every respect except for education. Thus, a one-child policy is imposed on every young adult without exception. In addition, this model ignores marriage, so there is only one young adult per family and each young adult is restricted to have at most 0.5 or fewer children when the policy is imposed.9

To introduce a one-child policy in the model, a fertility constraint is included: \( n_{ij} \leq 0.5 \). Thus, the maximization problem of (7) becomes:

\[
\max_{c_{ij}, a'_{ij}, n_{ij}} \left\{ \frac{c_{ij}^{1-\sigma}}{1 - \sigma} + \beta \pi y \left( \frac{c'_{ij}^{1-\sigma}}{1 - \sigma} \right) + \psi \pi c n_{ij}^{1-\epsilon} V'_{j} \right\},
\]

subject to

\[
c_{ij} + \pi y a'_{ij} + p_{ij} n_{ij} = w_{i},
\]
\[
c'_{ij} = (1 + r')a'_{ij},
\]
\[
n_{ij} \leq 0.5,
\]

where \( p_{ij} \) is defined in (2) and \((i,j) \in \{(s,s),(u,s),(u,u)\}\). \( i \) denotes the type of young adult and \( j \) refers to the type of his children. If a young adult prefers to have more than 0.5 children, he is forced to satisfy the fertility constraint. If his preference is smaller than 0.5, he is not influenced by the constraint.

3 Calibration

As discussed in the introduction, Taiwan is selected due to its cultural similarity to China and to the same percentage decrease in fertility over the past decades in the two countries. Two steady states are solved to calibrate to the data of Taiwan in 1970 and in 2004, respectively. The first part discusses the parameters. The calibrated results are provided in the second part.

9The limit is 0.5 because the model is formulated at the level of individuals rather than couples.
Table 2 summarizes the parameters used to calibrate the data from Taiwan in 1970 and 2004. Time period in the model is twenty-five years. There is no technological progress, thus the total factor productivity is one. Sun (2004) employs an annual depreciation rate of 9.25 percent for Taiwan. However, this estimation is only for the manufacturing sector, not for the whole economy. Thus, the annual depreciation rate ($\delta_a$) in the experiments is equal to 9.05 percent, as suggested by Thangavelu and Heng (2004). The corresponding depreciation rate of one period in the model is computed by $\delta = 1 - (1 - \delta_a)^{25}$. The elasticities of substitution are computed following the suggestions in Krusell, Ohanian, Rios-Rull, and Violante (2000). They estimate that the elasticity of substitution between unskilled labor and physical capital is about 0.67. Furthermore, they also estimate the elasticity of substitution between skilled labor and physical capital to be 0.67. Following their estimate, $\alpha$ is equal to 0.401 and $\rho$ is $-0.493$, so capital-skill complementarity is guaranteed.

Young (1995) and Young (2000) estimate that the income share of total labor in Taiwan is 0.67. Thus, the income share of physical capital is 0.33. The income share of total labor can be decomposed into two parts: the income share of skilled labor and the income share of unskilled labor. The unskilled labor income share is computed by the following formula:

$$\frac{w_u L_u}{w_u L_u + w_s L_s} = \frac{1}{w_u l_u + 1},$$

where $l_s$ is the ratio of skilled workers to total workers and $l_u$ is the ratio of unskilled workers to total workers. In this paper, “skilled” workers are defined as those with at least a college-level education. In 1978, the fraction of skilled workers as a percentage of total workers was about 8.51 percent, and the skill premium was 1.76.\(^{10}\) Therefore, the income share of unskilled labor to total labor income was 0.8594 at the first steady state. The corresponding income share of unskilled labor to output was 0.5758, and the corresponding skilled labor income share to output was 0.0942. In 2004, the fraction of

\(^{10}\)The initial steady state calibrates the data of 1970. Due to data availability, the data of 1978 for the fraction of skilled workers and skill premium are used to calculate the unskilled labor income share. Source: Council of Labor Affairs, Executive Yuan, Taiwan and Report on the Survey of Personal Income Distribution in Taiwan Area, Republic of China 1978, DGBAS, Taiwan.
skilled workers was 32.9 percent and skill premium was 2.19.\textsuperscript{11} Thus, the income share of unskilled labor to total labor income was 0.4914. Finally, $\mu$ and $\theta$ are the factor weights of the production function, and are determined by the physical capital income share and the income share of unskilled labor to total labor income. Thus, $\mu$ is equal to 0.1736 and 0.1951 and $\theta$ is 0.3172 and 0.1492 at the first and second steady state respectively.

Preference parameters are determined so that the initial period is equal to the 1970s of Taiwan. Consumption in old adulthood (age 50 or above) relative to consumption in young adulthood (age 25 to 49) was about 1.2 in 1979.\textsuperscript{12} In the calibration, $\sigma = 0.5$ is used to match the relative consumption. The elasticity of altruism with respect to the number of children ($\varepsilon$) is 0.5, so about 5 percent of children had parents educated at the college level or above in 1975. The fertility rate in 1972 was 3.364.\textsuperscript{13} Since the model is formulated at the level of individuals rather than couples, the altruism coefficient ($\psi$) is chosen to be 0.145 to match a half of the fertility, which equals 1.682. The final preference parameter is the annual discount factor ($\beta_a$). In 1982-2007, the annual stock market return was about 10 percent in Taiwan.\textsuperscript{14} Thus, the annual discount factor is equal to 0.9125 to match the annual stock market return. I also assume that the preference does not change over time. Therefore, the preference parameters in the second steady state are the same as those in the first steady state.

Liao (2009) constructs a series of survival rates for Taiwan in 1956-2004. The survival rate for children in 1970 is $\pi^c = 0.9305$ and the survival probability for young adults is $\pi^y = 0.9090$. In 2004, the survival probability is equal to 0.9666 for children and 0.9351 for young adults.

There are three costs associated with children: the good cost $p$, the education time cost $\phi_s$, and the time cost $\phi$. The good cost becomes less important in a balanced growth

\textsuperscript{11}The fraction of skilled workers is from Council of Labor Affairs, Executive Yuan, Taiwan. Wages by education are from The Survey of Family Income and Expenditure 2004, DGBAS, Taiwan.
\textsuperscript{12}Source: Report on the Survey of Personal Income Distribution in Taiwan Area 1979. The age groups are classified by the age of the household head. In each age group, final consumption expenditure per person is equal to final consumption expenditure per household dividend by average number of person in one household in the age group.
\textsuperscript{13}Source: Statistics, Department of Household Registration, Ministry of the Interior, Executive Yuan, Taiwan.
\textsuperscript{14}Annual TAIEX is used to calculate the stock market return. The 25-year accumulated return is computed. Then the annual stock market return is around 10 percent. Annual TAIEX is obtained from Taiwan Stock Exchange Corporation.
path, thus, $p$ is equal to 0. The education time cost can be measured by the number of teachers per student. A student on average had 0.0325 teachers in 1972 and 0.07 teachers in 2004.\footnote{The number of students per teacher is obtained from Department of Statistics, Ministry of Education, Taiwan.} Regarding the time cost of childrearing, Liu and Hsu (2004) estimate that a family needs an extra 28.2 percent of its original income after the first child is born in order to maintain its quality of life. The marginal costs of the second, third, and fourth children are an extra 24.8 percent, 22.4 percent, and 20.8 percent, respectively. The more children a family has, the lower the marginal cost. Since the fertility rate in 1972 was 3.364, the average of the marginal costs of the first four children is used as the marginal cost of having a child. This yields the result that a family needs to have an extra 24 percent of its income to rear a child. Suppose that in a family only the father and mother have incomes and that they equally share the cost of childrearing. As a result, a young adult needs to make an extra 12 percent of his income to rear a child. Thus, the time cost of childrearing is about 0.09.\footnote{The estimation in Liu and Hsu (2004) is the marginal cost of a child in one family. However, there is only one young adult in my model, not a couple. Thus I assume a young adult needs to pay half of the marginal cost, 12 percent. Suppose a young adult’s income is 50000 dollars. Then he needs extra 6000 dollars to maintain the same quality of life. 6000 dollars is equal to 10.7 percent of 56000 dollars. Then, the time cost is determined by: $\phi w_i = 0.107(1 - \phi n) w_i$. Applying $n = 1.6825$ to the above equation, the time cost is about 0.09.} The fertility rate of 2004 was 1.18. Considering the economic scale of childrearing, a young adult needs an extra 14.1 percent of his income. Thus, the time cost of childrearing is about 0.12. To match the proportion of skilled labor in 1978, the education time cost is set as 0.0328 and the time cost is set as 0.0897 in the first steady state. In the second steady state, the education time cost is set as 0.0714 and the time cost is set as 0.1499 to match the proportion of skilled labor in 2004.

3.2 Calibrated Results

Table 3 provides the calibrated results. Young adults would like to have more children if the survival rate for children increases, regardless of the type of young adults. However, the time cost of childrearing in the second steady state goes up. Thus, the fertility of each type declines. From the first steady state to the second steady state, the fertility
on average decreases by about 65 percent. Because the unskilled wage rate is lower than the skilled wage rate, the cost of childrearing for unskilled adults ($\phi w_u$) is smaller than the cost for skilled adults ($\phi w_s$). Thus, the fertility of unskilled adults having unskilled children declines by 60 percent, which is lower than the decrease in the fertility of skilled adults (68 percent).

All young adults in 1970 prefer to have more than 0.5 children. Others being equal, if a one-child policy had been imposed in 1970, all young adults would be influenced by the policy and could not have the number of children that they wanted. In contrast, in 2004 only unskilled adults having unskilled children prefer more than 0.5 children. Other types automatically have fewer than 0.5 children. Therefore, the impacts of imposing a one-child policy may be smaller in 2004. More discussion are provided in Section 4.

The ratio of skilled labor to total labor increases to 32.9 percent in the second steady state, almost four times as large as the ratio in the first steady state. First of all, the skill-biased technology and skill premium provide an incentive for parents to send their children to school. Second, skilled adults spend more time on working rather than raising children. At the second steady state a skilled young adult only spends 6.2 percent of his time on his children while he spends 11.7 percent on childrearing in 1970.\textsuperscript{17} Thus skilled adults offer more labor to the production sector. Third, the demand of teachers declines because of lower fertility. The fraction of teachers as a percentage of available skilled labor decreases from 8 percent to 5 percent.\textsuperscript{18} More skilled labor is released to the production sector. Therefore, the fraction of skilled labor in the second steady state increases.

\section{The Results of Experiments}

This section discusses the experiments of imposing a one-child policy. The first experiment is counterfactual: what Taiwan would be if Taiwan had imposed a one-child policy in the 1970s. Both partial equilibrium and general equilibrium are discussed. Outcomes in the

\textsuperscript{17}By assumption, each young adult has one unit of time. A skilled adult spends $\phi n_{ss}$ of his time on childrearing. It is equal to 0.117 and 0.062 in the first steady state and in the second steady state, respectively.

\textsuperscript{18}The fraction of teachers as a percentage of available skilled labor is measured by $\frac{\phi_s(n_{ss}N_s^y+n_{us}\lambda_{us}N_u^y)}{(1-\phi n_{ss})N_s}$.
benchmark model are compared to an alternative in which the policy is introduced. The second experiment studies what would happen if Taiwan imposed the policy now. Finally, the sensitivity tests are discussed.

In the first experiment, every transition path starts at the steady state of 1970. In the benchmark, four parameters permanently increase at period 0 to represent the demographic change in Taiwan: the survival probability for children, the survival probability for young adults, the time cost for childrearing, and the education time cost. In the environment with the policy, the transition paths also start with the steady state of 1970. In addition to the demographic change, the fertility constraint is imposed at period 0. Thus, the difference between the two environments is the fertility constraint. The algorithm for solving transition paths is discussed in the Appendix.

The demographic change refers to the permanent increases in four parameters: the survival probability for children, the survival probability for young adults, the time cost for childrearing, and the education time cost. These values increase from the first steady state to the second steady state. The increases in survival rates may be due to improvements in sanitation, safer water, and the development of antibiotics and medical science. The increase in the time cost may be due to the less contribution of children to home production or because of the introduction of child labor laws. The increase in the education time cost may be because of education reforms (so that a teacher has fewer students) or simply because parents decided to spend more time on education in response to technological change.

4.1 Partial Equilibrium

To solve a partial equilibrium, I assume prices ($w_s$, $w_u$, and $r$) in all transitional periods are equal to the prices in the initial period. Thus, the prices keep unchanged at the level of the steady state of 1970.

The result shows that the fertility rates of all types in the benchmark significantly

\footnote{In the calibration, the production shifts to skill-biased technology. In other words, the factor weights $\mu$ and $\theta$ change in the second steady state. However, in this section I focus on the demographic change and the effects of imposing a one-child policy. Thus, the production does not shift to skill-biased technology. $\mu$ and $\theta$ remain unchanged in the experiments.}
decline at period 0 due to the demographic change. The fertility of skilled parents decreases from 1.30 to about 0.41 and the fertility of unskilled parents who prefer skilled children decreases from 1.46 to about 0.45. Therefore, neither group is constrained by the one-child policy. However, the fertility of unskilled parents who prefer unskilled children decreases from 2.27 to 0.86, which is still higher than the fertility constraint. Thus, this type is constrained by the policy. Additionally, young adults adjust their fertility decisions within one period. The transition path immediately converges to a new steady state.

The common intuition about the imposition of a one-child policy is that people will be hurt by the policy because their choices are limited. Figure 1 shows the transition paths of life-time utility in partial equilibrium. A skilled young adult and an unskilled young adult having skilled children are roughly indifferent between the benchmark and the environment with the policy. Intuitively, this is because the fertility constraint is not binding. They freely make decisions in both environments. In contrast, an unskilled young adult who wants unskilled children is worse off when a one-child policy is introduced, as his fertility constraint is binding. Therefore, unskilled young adults who choose to have unskilled children suffer under the policy.

There are two sources of derived utility: having children and consumption. Figure 2 shows the utility derived from consumption. An unskilled young adult with unskilled children loses utility because of lower fertility. On the other hand, he transfers his resources to consumption. Thus, this type derives higher utility from consumption. Since the loss is larger than the gain, this type is worse off under the one-child policy. The findings in partial equilibrium are consistent with intuition.

4.2 General Equilibrium

Table 4 provides the fertility rates at general equilibrium for the two environments. Demographic change occurs at period 0. Unlike the results at partial equilibrium, all fertility rates at period 0 are still larger than 0.5. Therefore, all types are constrained at period 0 when the policy is imposed. After period 0, skilled parents and unskilled parents having skilled children lower their fertility level to 0.42 and 0.46, respectively. In contrast,
the fertility of unskilled parents with unskilled children is always above 0.9. Thus, only unskilled parents are constrained by the policy after period 0. This is the same as the results at partial equilibrium.

However, the changes in welfare at general equilibrium are surprising. A skilled young adult is roughly indifferent between the two environments, but the other two types are in fact better off in the environment with the one-child policy. Figure 3 shows the lifetime utility at general equilibrium. Unskilled adults are better off because the policy triggers a decrease in the supply of unskilled labor at general equilibrium. In the model, only unskilled parents will have unskilled children, since skilled parents always prefer skilled children. The decline in the supply of unskilled labor is therefore due to two effects. First, the fertility of unskilled parents who prefer unskilled children is constrained by the policy. Thus, the supply of unskilled labor will decrease when the children become young adults. Second, many unskilled parents choose to have skilled children when the policy is introduced. Thus, the supply of unskilled labor declines further. These two effects result in a decline in unskilled labor supply and a higher unskilled wage rate, as shown in Figure 4. Although unskilled parents who prefer unskilled children are constrained by the policy, they enjoy a higher unskilled wage rate, have higher consumption, and derive higher utility from consumption (Figure 5 and 6). Therefore, unskilled adults are in fact better off when the one-child policy is imposed. The results are counterintuitive, but they demonstrate the importance of accounting for general-equilibrium effects and heterogeneity when analyzing population policies.

Figure 7 provides the fraction of skilled labor as a percentage of total labor and output per capita. Human capital is rapidly accumulated in the environment with the one-child policy. In the second steady state, the human capital is about 42 percent higher than that in the benchmark. Besides, output per capita is 12 percent higher than that in the benchmark. Based on the results, I conclude that Taiwan would have a higher per capita output and have faster accumulation of human capital if a one-child policy had

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20The fraction of skilled labor in the benchmark converges to about 11.5 percent. But, the fraction of skilled labor in the steady state of 2004 is 32.9 percent. They are different because the factor weights (µ and θ) are changed (so that the production is more skill-intensive) when I solved the steady state of 2004. In the benchmark here, only survival probabilities and costs of children are changed. The factor weights keep constant. Thus, the fraction of skilled labor is lower than 32.9 percent.
been introduced in 1970. In fact, rapid human capital accumulation and fast increases in per capita GDP are also observed in China after the institution of one-child policy.

However, output per capita fluctuates, jumping up during the period when the policy is introduced, and declining later on. At that time, the proportion of old people increases, thereby reducing output per capita. After a one-period adjustment (one generation), the transition path gradually converges to a new steady state.

Figure 8 shows the age structure of the population. The proportion of children is about 27 percent in the benchmark, but it is only 14 percent under the one-child policy. On the other hand, the proportion of old people under the policy is about 57 percent, much higher than that in the benchmark. In conclusion, the one-child policy results in an older population. If Taiwan had have a one-child policy in 1970, Taiwan would have an older population now. Actually, this is what China will experience in the near future. In 1980, the year in which China introduced its one-child policy, the proportion of people aged 65 or above was 4.7 percent. After 25 years, the ratio almost doubled (7.6 percent). According to the UN population projection (the 2008 revision), elderly will comprise over 20 percent of the country’s total population in 2040.

4.3 What if Taiwan Introduced the Policy Now?

The purpose of the second experiment is to study the effects of imposing a one-child policy when the fertility is relatively low, such as the current fertility in Taiwan. The experiment starts with the steady state of 2004. It can be interpreted as the future of Taiwan if the policy was introduced now.

As Table 3 reports, the average fertility in 2004 is 0.59, which is equal to 1.18 per couple. Only the fertility of unskilled parents who prefer unskilled children is greater than 0.5. Thus, only this type will be constrained when the one-child policy is enforced.

21In Taiwan of 2004, the ratio of people aged 0-14 to total population was 19.3 %, aged 15-64 was 71.2%, aged 65 and above was 9.5%. After age adjustment to the model, it is equal to 33.5% for the childhood, 35.6% for the young adulthood, and 30.9% for the old adulthood. In the experiment, the population distribution of the benchmark at the steady state that the path converges to is 26.9%, 33.3%, and 39.8% for the childhood, the young adulthood, and the old adulthood, respectively.

The results are similar to the first experiment. The policy results in a decrease in the supply of unskilled labor and an increase in the unskilled wage rate. As Figure 9 shows, unskilled young adults are better off under the policy. Besides, Figure 10 shows that the human capital will be accumulated and output per capita will increases. They are similar to previous results, but the positive effects of the policy will not be large: the fraction of skilled labor will increase from 33 to 41 percent and output per capita will increase by about 6 percent. The results suggest that the effects of a one-child policy may become small when the fertility is relatively low because only the fertility of people with less education is influenced. China’s fertility was about 1.77 in 2000-2005. Comparing the benefits and the cost of imposing its one-child policy, China may change its population policies to achieve its long-term demographic goal.

4.4 Sensitivity Tests

In the above discussion, the experiments begin at 1970 due to data availability. This analysis assumes that 1970 is a steady state and that all transition paths start with the steady state of 1970. However, demographic change in Taiwan actually started earlier than 1970. The fertility rate in 1951 was about 7 children per woman, which decreased to 5.6 in 1961 and to 3.7 in 1971. Therefore, the 1970s were actually in the midst of demographic change and were not a relatively stable period of time.

To test the influence of this assumption, the state variables of the initial period in a transition path are artificially modified as a percentage of the state variables in 1970, such as 70 percent or 50 percent of 1970. With the modified state variables, a new transition path is calculated. The demographic change and/or the one-child policy occur in the second period of the new transition path. Then, the results are compared to the case with 100 percent of the state variables in 1970 (called the primary case below).

The result shows that the gaps between the benchmark and the one-child policy in the third period could be larger or smaller, but that the patterns are quite similar to the primary case. For example, when both state variables are 50 percent lower than those in the primary case, the gap in the skill premium between the benchmark and the one-child policy in the third period is 0.30, but the gap is 0.25 in the primary case. The gaps in
per capita output are similar. Considering the population distribution, the gap in the proportion of old people between the policy and the benchmark is 0.21 in the 50 percent case but 0.19 in the primary case. These experiments were also conducted with changes of only one state variable. For example, the proportion of skilled young adults is 50 percent lower than that found in the primary case but the physical capital stock does not change. In this case, the gap in the skill premium is about 0.33, and the gap in the proportion of old people is 0.20, both of which are larger than values found in the primary case, but present similar patterns. Therefore, the results suggest a conclusion similar to that reached during the primary experiment. The assumption of steady state in 1970 does not have a significant influence on the main conclusions.

5 Conclusions

The debate over China’s one-child policy continues after three decades. To explore this issue, this paper introduces a fertility constraint into an overlapping generations model. Compared with the benchmark, an environment with a fertility constraint is built to represent the implementation of a one-child policy.

This paper calibrates the benchmark model to the data from Taiwan in 1970-2004. The results suggest that imposing a one-child policy promotes the accumulation of human capital. In addition, the economy enjoys higher per capita output. However, output per capita fluctuates after the policy is enforced. This paper also shows the importance of considering general-equilibrium effects and the different reactions of skilled and unskilled adults to the policy. Thus, heterogeneity is important when analyzing population policies. Finally, the results show that the effect of the policy is small if fertility is relatively low, suggesting that China may revise its population policies in the near future.

This paper does not make judgments regarding China’s one-child policy. Based on the experiments, this paper suggests that people with less education are better off under the policy. However, it is important to note that the model in this paper is simplified and that some issues are not included in the model. For example, skill-biased technological progress may increase the demand for skilled labor and decrease the demand for unskilled
labor. In this case, the effects on unskilled adults are unclear. Besides, the one-child policy in China is more complicated than a fertility constraint. For example, China’s policy provides economic incentives (penalties and subsidies) for parents to change their fertility decisions. Therefore, this paper provides a framework for analyzing a one-child policy; but does not make strong judgments about this issue.
Appendix: Algorithm for Solving a Transition Path

Transition Path for General Equilibrium

The initial period is a steady state representing Taiwan in 1970. The state variables are physical capital \((K)\), the population of skilled young adults \((N^y_s)\), and the population of unskilled young adults \((N^y_u)\). All state variables are normalized by the population of young adults. In steady state, the initial population distribution is the data in 1971, but adjusted to match the age group in the model: aged 0-24 for childhood, aged 25-49 for young adulthood, and aged 50 or above for old adulthood. The initial physical capital per young adult is equal to 0.0011 to match the capital-output ratio (annually) 0.77 in the 1970s.

To solve a transition path, I initially guess a sequence for each of these variables: \(\{w_s, w_u, r, V_{ss}, V_{uu}, \lambda_{us}\}\) and then update all sequence at the same time. Given the initial guess, the fertility of each type \((n_{ss}, n_{us}, n_{uu})\) can be solved. Then, I compute the number of skilled workers, the number of unskilled workers, the fraction of skilled labor as a percentage of total labor \((l_s)\), the fraction of unskilled labor \((l_u)\), and physical capital per labor \((k)\). Now the new price \((w_s, w_u, r)\) can be computed by marginal product. Since the fertility of each type has been calculated, the following variables for each type can be solved: asset holdings, consumption for young adulthood, consumption for old age, new life-time utility, and output per capita. At this point, based on the initial guess, the second period is solved. Then, state variables of the next period are computed so that the third period can be solved. I repeat this procedure to compute every period.

After all periods are calculated, I have new sequences of \(w_s, w_u, r, V_{ss}, V_{uu}\). They are updated by a linear combination of the initial guess and the new values. \(\lambda_{us}\) is updated by the following equation:

\[
\lambda_{us} = \lambda_{us} \left( \frac{V_{us}}{V_{uu}} \right)^\nu,
\]

where \(\nu\) is the updated speed. The iteration stops if two criteria are satisfied at the same time: (i) The guess and the new values are very close to each other; (ii) \(V_{us}\) and \(V_{uu}\) are close to each other. In equilibrium, \(V_{us}\) is equal to \(V_{uu}\) so that an unskilled young adult is indifferent between having skilled children and unskilled children.
In the case of the benchmark, four parameters go up at period 0: the survival rate for children \((\pi^c)\), the survival rate for young adults \((\pi^y)\), the time cost of childrearing \((\phi)\), and the time cost of education \((\phi_s)\). Table 2 reports the values in the first steady state and in the second steady state. For example, the survival rate for children is equal to 0.9305 before period 0, and it is equal to 0.9666 at and after period 0. The determination of these values are discussed in Section 3.1. Other parameters remain unchanged.

In addition to the permanent increases in four parameters, the fertility constraint \(n_{ij} \leq 0.5\) is permanently imposed after period 0 when I solve the transition path for the case of a one-child policy. Before period 0, I apply the same algorithm to compute the transition path for the case of imposing the policy. After period 0, the fertility constraint should be taken into account. At the beginning, I assume all types are not constrained and solve their fertility decisions. Then, I check five possible cases to determine the correct fertility: (1) If the fertility decisions without constraint are all smaller than or equal to 0.5, the constraint is not binding. Thus, the correct fertility is equal to the fertility decisions without constraint. (2) If the fertility decisions without constraint are all larger than 0.5, the constraint is binding for all types. Thus, the correct fertility of each type is equal to 0.5. (3) If the type \(ss\) and \(uu\) are both binding but the type \(us\) is not binding, \(n_{ss}\) and \(n_{uu}\) should be equal to 0.5. Then, given \(n_{ss}\) and \(n_{uu}\) are both equal to 0.5, I solve \(n_{us}\) again. If the new \(n_{us}\) is smaller than or equal to 0.5. The new \(n_{us}\) is the correct fertility for type \(us\). Otherwise, the correct fertility for type \(us\) should be equal to 0.5. (4) If \(n_{us}\) and \(n_{uu}\) are binding but \(n_{ss}\) is not binding, the correct fertility of type \(us\) and type \(uu\) are both equal to 0.5. Then I solve \(n_{ss}\) again. If the new \(n_{ss}\) is smaller than or equal to 0.5, it is the correct fertility of type \(ss\); otherwise, the correct fertility of type \(ss\) is equal to 0.5. (5) If \(n_{uu}\) is binding but \(n_{ss}\) and \(n_{us}\) are not binding, then \(n_{uu}\) is equal to 0.5. Then I solve \(n_{ss}\) and \(n_{us}\) again. There are four possibilities for the new \(n_{ss}\) and \(n_{us}\). First, if both of them are smaller than or equal to 0.5, the new \(n_{ss}\) and \(n_{us}\) are the correct fertility for the corresponding types. Second, if both of them are larger than 0.5, the correct fertility for both types should be equal to 0.5. Third, if \(n_{ss}\) is larger than 0.5 but \(n_{us}\) is not binding, the correct fertility of type \(ss\) is 0.5. Given \(n_{ss}\) and \(n_{uu}\) are both equal to 0.5, I solve \(n_{us}\) again. If the new \(n_{us}\) is smaller than or equal to 0.5, it is the correct fertility for type \(us\);
otherwise, \( n_{us} \) is equal to 0.5. Fourth, if \( n_{ss} \) is not binding but \( n_{us} \) is binding, \( n_{us} \) should be equal to 0.5. Given \( n_{us} \) and \( n_{uu} \) are both equal to 0.5, I solve \( n_{ss} \) again. If the new \( n_{ss} \) is not binding, it is the correct fertility for type \( ss \); otherwise, \( n_{ss} \) should be equal to 0.5.

**Transition Path for Partial Equilibrium**

First, I solve the initial period as 1970 in Taiwan. Suppose the prices \((w_s, w_u, \text{ and } r)\) at all periods are equal to the price of the initial period. Then transition paths for partial equilibrium are solved for two cases: the benchmark and a one-child policy.

The algorithm are similar to that of solving general equilibrium. The difference is that I only guess sequences of \( V_{ss} \) and \( V_{uu} \) here. Given the initial guess, the partial equilibrium and new values of life-time utilities are solved. Then, life-time utilities are updated until the new values and the guess are close to each other. The four parameters also permanently increase at period 0 when demographic change occurs. In the case of a one-child policy, the fertility constraint is imposed. Then, I check possible cases using the algorithm that I discussed above.

**References**


Table 1: Age Structure in China

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Age 0-14</td>
<td>39.7</td>
<td>28.4</td>
<td>22.0</td>
<td>19.9</td>
<td>16.9</td>
<td>15.3</td>
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<tr>
<td>Age 15-64</td>
<td>56.0</td>
<td>66.1</td>
<td>70.4</td>
<td>71.9</td>
<td>67.2</td>
<td>61.4</td>
</tr>
<tr>
<td>Age 65 and above</td>
<td>4.3</td>
<td>5.5</td>
<td>7.6</td>
<td>8.2</td>
<td>15.9</td>
<td>23.3</td>
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</tbody>
</table>

Note: Percentage of total population. Source: *World Population Prospects*, the 2008 revision, Population Division of the Department of Economic and Social Affairs, UN. http://esa.un.org/unpp
### Table 2: Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>SS1</th>
<th>SS2</th>
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<tr>
<td>Survival rate for children</td>
<td>$\pi^c$</td>
<td>0.9305</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9666</td>
</tr>
<tr>
<td>Survival rate for young adults</td>
<td>$\pi^y$</td>
<td>0.9090</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9351</td>
</tr>
<tr>
<td>Time period</td>
<td></td>
<td>25 years</td>
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<td>Annual discount factor</td>
<td>$\beta_a$</td>
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<td>Risk aversion</td>
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<td>Elasticity of altruism</td>
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<tr>
<td>Altruism coefficient</td>
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<td>Annual depreciation rate</td>
<td>$\delta_a$</td>
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<tr>
<td>Elasticity of substitution ($L_u$ and $K$)</td>
<td>$\frac{1}{1-\alpha}$</td>
<td>1.67</td>
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<tr>
<td>Elasticity of substitution ($L_u$ and $K$)</td>
<td>$\frac{1}{1-\rho}$</td>
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<tr>
<td>Total factor productivity</td>
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<tr>
<td>Physical capital income share</td>
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<tr>
<td>Unskilled labor income share</td>
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<td>Factor weight (unskilled labor)</td>
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<td>Factor weight (physical capital)</td>
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### Table 3: Calibrated Results

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<th>1970</th>
<th>2004</th>
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<tr>
<td></td>
<td>Data SS1</td>
<td>Data SS2</td>
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<tr>
<td>$n_{ss}$</td>
<td>1.303</td>
<td>0.415</td>
</tr>
<tr>
<td>$n_{us}$</td>
<td>1.468</td>
<td>0.452</td>
</tr>
<tr>
<td>$n_{uu}$</td>
<td>2.275</td>
<td>0.904</td>
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<tr>
<td>Average fertility</td>
<td>1.682</td>
<td>1.682</td>
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<tr>
<td>$l_s$</td>
<td>0.085</td>
<td>0.085</td>
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<tr>
<td>$w_s$</td>
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<tr>
<td>$w_{ss}$</td>
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<td>2.112</td>
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Note: The fertility of Taiwan was 3.364 and 1.18 in 1970 and 2004, respectively. Because the model is formulated at the level of individuals rather than couples, a half of 3.364 and 1.18 are matched in the calibration.
Table 4: General Equilibrium-Fertility

<table>
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<th>Period</th>
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<tr>
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<td>$n_{ss}$</td>
<td>$n_{us}$</td>
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<td>-3</td>
<td>1.2994</td>
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<td>-2</td>
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<td>-1</td>
<td>1.2036</td>
<td>1.3603</td>
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<tr>
<td>0</td>
<td>0.5052</td>
<td>0.5468</td>
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<tr>
<td>1</td>
<td>0.4495</td>
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<td>2</td>
<td>0.4299</td>
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<td>3</td>
<td>0.4219</td>
<td>0.4599</td>
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Figure 1: Partial Equilibrium-Lifetime Utility
Figure 2: Partial Equilibrium-Utility from Consumption

Figure 3: General Equilibrium-Lifetime Utility
Figure 4: General Equilibrium-Wage rates

Figure 5: General Equilibrium-Consumption at Young Adulthood
Figure 6: General Equilibrium-Utility from Consumption

Figure 7: General Equilibrium-Human Capital and Output per capita
Figure 8: General Equilibrium-Age Structure

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Figure 9: The Second Experiment-Lifetime Utility

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Figure 10: The Second Experiment-Human Capital and Output per capita

![Graph showing human capital and output per capita over a transition period. The graph compares the benchmark scenario with a one-child policy scenario.]