Childbearing and Sex Selection with Incomplete Financial Markets: Theory and Evidence from Mainland China

Yu Zhang and Mario J. Miranda*

April 4, 2020

Abstract

This paper examines childbearing decisions in developing countries where financial markets are incomplete due to the lack of old-age entitlements, access to credit, and where social norms place expectations on children to support their parents financially in old age. Of special interest is how financial market imperfections affect childbearing decisions and potentially the use of sex-selective abortion. We build a discrete-time stochastic life-cycle model in which children serve as an asset that is illiquid during the parents' working life, but which provides a financial payoff to parents upon and after retirement. Our results show that, in the era of One-Child Policy: 1) adequate public old-age entitlements would reduce the number of births, the incidence of sex-selective abortion, and delays in childbearing; 2) providing higher return in the capital market and greater to credit to the households would have both income effect and substitution effect on the household demand to children asset, and the effects are joint results of quantity-sex ratio-childbearing time trade-off; 3) relaxation of the One-Child Policy would reduce the incidence of sex-selective abortions; 4) under a restricted Two-Child Policy could reach the level under the One-Child Policy, but have a balanced male-female sex ratio at birth.

*Respectively, School of Insurance and Economics, University of International Business and Economics, Beijing, China, zhangy2119@uibe.edu.cn, and Department of Agricultural, Environmental and Development Economics, The Ohio State University, Columbus, OH, USA, miranda.4@osu.edu.

1 Introduction

Population dynamics, with a wide range of population size, growth, age structure, sex structure, migration, death rates and so on, has been identified as a major contributor to a series of environmental, social and economic issues (United Nations, 2005; De Sherbinin et al., 2007). As a key element of demographic transition, childbearing decisions affect the long-run population size, age structure and sex structure, which influences the social welfare and sustainability in a country. Therefore, understanding the mechanisms of childbearing decisions is very important to better understand the demographic transition. Childbearing decisions in developing countries require peculiar focus due to their essential features of high total fertility rates and the presence of sex selection.[1] This paper aims at examining how households residing in developing countries adjust childbearing and sex selection decisions in response to the increase in public old-age entitlements, the rise in the annual rate of financial asset return, the access to credits, and the relaxation of family planning policy, with the application to China.

In developing countries, where credit systems, financial market and old-age social security insurance programs are typically inadequate or nonexistent, parents often have children with an expectation that they will provide them with financial support in their old age, with greater expectations placed on male children (Das Gupta et al., 2003). In this context, financial market imperfections and family planning policies can have a profound effect on household childbearing decisions, including the unintended promotion of sex-selective abortion practices.

Over the past half-century, Asian countries such as China, India, Vietnam, Singapore, and South Korea, have encountered social problems stemming from overpopulation and high degrees of urbanization, including environmental pollution, accelerated depletion of natural resources, and severe stress on public services and public support programs. These problems have been exacerbated by high population growth rates, leading these Asian countries to implement population control policies, including imposing limits on the number of children a family may have without penalty, providing financial incentives to have fewer children, and to introduce more generous government pension and old-age entitlements to reduce the dependence on

[1]The total fertility rate is the population average number of children a woman would have if she survives her childbearing years (United Nations, 2017).

children for old-age support (Herold et al., 1986; Cho, 1996; Wong and Yeoh, 2003; Li, Zhang, and Zhu, 2005; Pham, 2014).

These policies have had some undesirable consequences, however. Family planning policies, in particular, have increased the incidence of sex-selective abortion, leading to gender imbalances in the general population, particularly among the young. Li, Yi, and Zhang (2011) estimate that the One-Child Policy implemented in various provinces of China led to 7 extra male births per 100 female births between 1991 and 2005, accounting for about 55% of the increase in male-female sex ratio at birth during that period. Anukriti (2018), using data from the National Family Health Survey of India, finds that financial incentives to limit the number of children provided to households in the Haryana state of India increased the male-female sex ratio at first birth by as much as 2.3 percent.[2]

Numerous studies have also examined the effects of old-age social security programs on fertility rates (Caldwell, 1978, 1982; Cain, 1981; Boldrin and Jones, 2002; Boldrin, De Nardi, and Jones, 2005). These studies have generally found that the decline in fertility rates observed over the past two decades in the developing world is largely due to enhanced public old-age security programs that have reduced the need for financial support derived from children after retirement. However, theoretical models employed in these studies typically assume a demand for the number of children and thus cannot adequately explain how childbearing decisions will be affected by changes in access to credits, financial assets, pension programs, and old-age entitlements, and very few of these addresses sex-selective abortion (Schultz, 1997). Econometric studies on these subjects have also tended to employ reduced-form models that are inherently unable to address counterfactual changes in the policy and economic environment.

Access to affordable savings and credit can also have a significant impact on household childbearing decisions in developing countries. Numerous empirical studies find that rural households employ children in their risk-coping strategies, diverting them from schooling to on-farm or off-farm employment in response to adverse income shocks (Cain, 1982; Appelbaum and Katz, 1994; Portner, 2001; Duryea, Lam, and Levison, 2007; Bandara, Dehejia,

[2]The male-female sex ratio at birth is the number of male births per one-hundred female births (United Nations, 2017). Imbalances in the sex ratio in Asian countries have been blamed for increases in the crime rate and for causing a severe imbalance in the marriage market, often referred to as the "marriage squeeze" (Wei and Zhang, 2009; Edlund et al., 2013; Choukhmane, Coeurdacier, and Jin, 2014b).

and Lavie-Rouse, 2015). Access to affordable credit and reliable deposit facilities can provide an alternative means for households to manage transitory income risk, reducing the reliance on children to smooth income. However, few studies have carefully examined the effects of credit market imperfection on childbearing.

In this paper, we examine how government old-age social security benefits, return rate of financial assets, access to affordable credits, and family planning policies in China affect household childbearing decisions, including the use of sex-selective abortion. To this end, we first develop and analyze a dynamic stochastic life-cycle model in which households exposed to uninsurable income shocks and financial punishment on out-of-plan children make choices over time regarding how much to save and whether to conceive a child, and if so, whether to test for the sex of the fetus and abort if it is a female. In our model, children take the form of an asset that is illiquid during the parent's productive life and convertible to benefits at retirement, and whose terminal value is determined by the number, gender composition and age of children at retirement. We calibrate our model by matching the simulated data moments to the real data moments between the year of 1989 and 2011 from the China Health and Nutrition Survey (CHNS). Under the environment of One-Child Policy, we find that financial market imperfections in China have both an income effect and a substitution effect on Chinese household demand to children asset, and the effects are joint results of choices on children quantity, gender composition and timing of births. Moreover, we also find that, even under a less restricted Two-Child Policy, the government would also reduce the average number of births each household has to the level under the One-Child Policy by raising the return in financial assets, providing credits and increasing the public old-age pension, but having a balanced aggregate sex ratio at birth that did not exist under the One-Child Policy.

The rest of this chapter is organized as follows. In section 2, we provide the background information about China's Family Planning Policy, and its relationship with childbearing and sex selection in China. In section 3, we present a theoretical dynamic model of a household facing childbearing and saving decisions in the presence of transitory income shocks and birth gender uncertainty under alternative social security and family planning policies and interest rates. Section 4 provides the details of calibration and model fit. In section 5, we present the structural evidence for heterogeneous households with utility heterogeneity to examine the effects of old-age security

programs, deposit interest rates, access to credit and family planning policies on childbearing choices, including the use of sex-selective abortion. Section 6 summarizes our conclusions and provides suggestions for further research.

2 Background

China has been the most populous country in the world since its establishment in 1949 (United Nations, 2017). From 1949 to 1970, China's total population increased from 554 million to 825 million under Mao's pro-natalist era during which the total fertility rates exceeded 6 for decades. In 1970, the central government started to realize the importance of integrating population control into their economic planning and to propagandize having fewer children, delaying childbearing time and prolonging birth interval. In 1980, an *Open Letter to All Members of the Communist Party and Communist Youth League* initiated the nationwide One-Child Policy that every household could only have one child (Communist Party of the People's Republic of China, 1992). The policy, at first, was a completely administrative regulation without financial incentives or disincentives. The forced abortion and sterilization created domestic unrest, which compelled the government to relax the nationwide One-Child Policy to One-and-one-half-child Policy in the major rural areas, and households residing in the remote areas and minorities could have two or more children (Ebenstein, 2010).[3]

The dot signs in Figure 1 show the spatial distribution of the policy. Six provinces and municipalities implemented a One-Child Policy in both urban and rural areas; nineteen provinces had a One-Child Policy in urban areas and One-and-one-half-child Policy in rural areas; five provinces implemented a 2-Child Policy and Tibet was the only province with an exemption from the policy. Moreover, central government also revised the policy with a mixture of administrative regulations and financial incentives and disincentives. The amount of lump-sum financial punishment for an additional out-of-plan child ranged from 3 to 10 times as much as the household's annual income. Since then, the Family Planning Policy framework had been sustained without major revision until the end of 2015. Starting from January 1st, 2016, the policy was relaxed to a nationwide Two-Child Policy so that every household could have up to two children without financial punishment.

[3]Under a one-and-one-half-child policy, if the first child is a girl, the household is allowed to have a second child; otherwise, the household is not allowed to have more children.

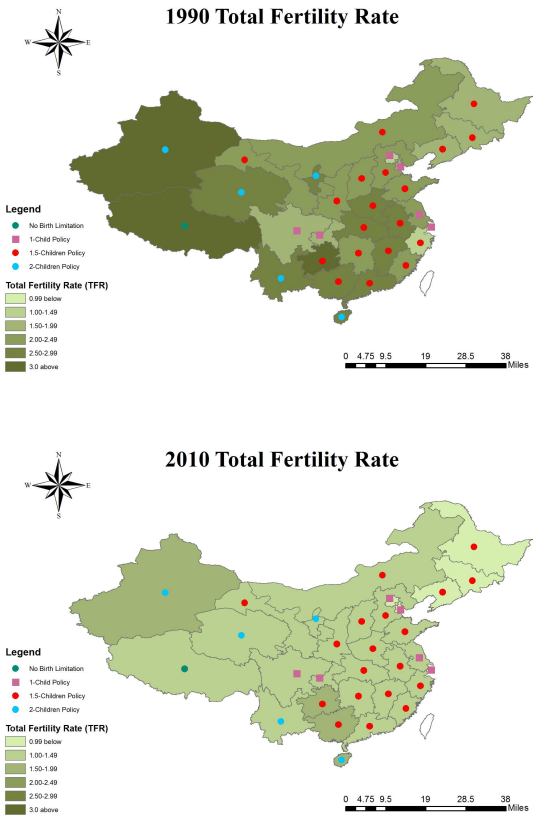


Figure 1: Total Fertility Rates and Spatial Distribution of Family Planning Policy in China

As policy makers expected, this policy greatly and rapidly reduced the total fertility rates in China, which halved from 3.00 in early 1980s to 1.26 in 2010. Figure 1 shows the change in total fertility rates by provinces in the 4th, 5th and 6th population census, being conducted in the years of 1990, 2000 and 2010, respectively. In 1990, the province-level total fertility rates ranged from 1.334 to 4.224, while 6 of 31 provinces had a total fertility rate below 1.0 in 2010.

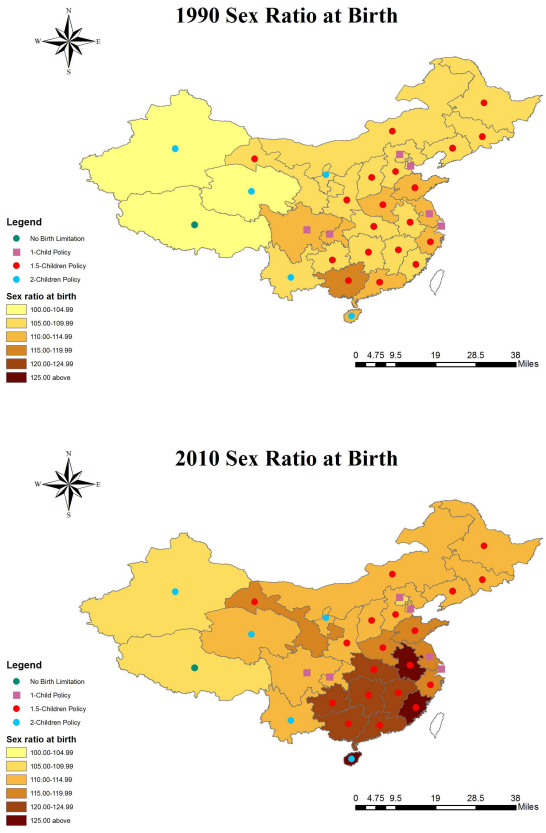


Figure 2: Sex Ratio at Birth and Spatial Distribution of Family Planning Policy in China

However, the implementation of the policy also triggered severe unintended outcomes in China. Even though the *Open Letter* had noted a slight advantage in the number of male babies from some pre-policy surveys, and

the government had been advocating gender equality to the public, the continuously rising male-female sex ratio at birth after the policy was still unexpected and out of control of the policy makers. This made China one of the countries with the most imbalanced male-female sex ratio at birth, increasing from 107 in 1950 to 117 in 2010 (United Nations, 2017).[4] Figure 2 shows the male-female sex ratios at birth of 31 provinces and municipalities. In 1990, 9 provinces had a male-biased sex ratio at birth above 110, while the number of provinces with a sex ratio at birth above 110 had increased to 25 and 28 in 2000 and 2010, respectively, and 9 provinces had a male-female sex ratio at birth exceeding 120 in 2010. Vast literature attributes the highly male-biased sex ratio at birth in China to the Family Planning Policy (Sen, 1990; Hesketh and Zhu, 2006; Ebenstein, 2010; Li, Yi, and Zhang, 2011).

From Figure 2, it's easy to see that the high sex ratio at birth is associated with stricter policy enforcement. Given the family planning policy on the maximum allowable number of children each household can have, parents' demand for more children is limited, they thus shift the demand from quantity of children to gender composition, selecting the gender they prefer, which increases the male-female sex ratio at birth.

3 A Life-Cycle Model of Childbearing with Sex Selection

We formulate a three-stage annual household life-cycle model of parents's childbearing-saving-borrowing decisions when: 1) children provide financial benefits to parents after they retire, with males providing more than females; 2) parents may test for the sex of the fetus and abort if it is female; and 3) parents must pay a financial penalty if they have more children than the maximum allowed by law. The three stages of the life-cycle are:

- *Working-Fertile Stage*: Years $t = 1, 2, \ldots, T_1$, during which parents earn wage income and may elect to have children;
- *Working-Infertile Stage*: Years $t = T_1 + 1, T_1 + 2, \ldots, T_2$, during which parents earn wage income but cannot have additional children; and
- *Retirement Stage*: Years $t = T_2 + 1, T_2 + 2, \ldots$, during which parents do not earn wage income, cannot have additional children, and subsist

[4]The natural "sex ratio at birth" is often considered to be around 105 (WHO)

on cash savings accumulated during their working lifetime, financial support provided by their grown children, and government old-age entitlements (if any).

We formulate the model with four state variables, all observed by the household at the start of each year: w, liquid wealth; a, retirement adult male equivalent children; b, number of boy children in household; and g, number of girl children in household. Here, a is not a simple function of b and g. Increments to a depend on the year t, with increments equaling 1 if a boy is born in early years, but less if a boy is born closer to retirement; also, increments to a are proportionately less if a girl is born.

The model has two decision variables. During both the fertile and infertile working stages, households must decide how much to net save x, which may be negative if the household is a net debtor. During the fertile stage, the household must additionally make a childbearing decision, with three options: do not conceive a child; conceive a child, but do not test for the sex of fetus; or conceive a child, test for the sex of the fetus, and abort it if is female.

Households maximize the present value of current and expected future utility of consumption plus nonpecuniary benefits derived from children. Let $V_t(w, a, b, g)$ denote the maximum attainable present value of current and expected future utility of consumption plus nonpecuniary benefits derived from children, given parents possess liquid wealth w, have retirement adult male equivalent children a, have b boys, and have g girls, at the beginning of year t. Then, by Bellman's Principle of Optimality,

- For $t = T_2 + 1$,

$$V_t(w, a, b, g) = \frac{1}{1-\delta}\left(u(r_s w + f(a) + P) + v(b+g)\right) \tag{1}$$

- For $t = T_1 + 1, T_1 + 2, \ldots, T_2$,

$$\begin{array}{rlll} V_t(w, a, b, g) = & \max_{x,c} & \{u(c) + v(b+g) + \delta E_{\tilde{w}} V_{t+1}\left(\tilde{w}, a, b, g\right)\} \\ & \text{s.t.} & c \geq 0, x \geq \underline{x} \\ & & w = c + x + m(b+g) + \kappa_1 \\ & & \tilde{w} = R(x) + \tilde{y} \end{array} \tag{2}$$

- For $t = 1, 2, \ldots, T_1$,

$$V_t(w, a, b, g) = \max\left\{V_{t1}(w, a, b, g), V_{t2}(w, a, b, g), V_{t3}(w, a, b, g)\right\} \tag{3}$$

where

$$\begin{aligned} V_{t1}(w,a,b,g) = \quad & \max_{x,c} \quad \{u(c) + v(b+g) + \delta E_{\tilde{w}} V_{t+1}\left(\tilde{w}, a, b, g\right)\} \\ & \text{s.t.} \quad\quad c \geq 0, x \geq \underline{x} \\ & \qquad\quad w = c + x + m(b+g) + \kappa_1 \\ & \qquad\quad \tilde{w} = R(x) + \tilde{y} \end{aligned} \tag{4}$$

$$\begin{aligned} V_{t2}(w,a,b,g) = \quad & \max_{x,c} \quad \{u(c) + v(b+g) + \\ & \qquad\quad (\delta/2) E_{\tilde{w}} V_{t+1}\left(\tilde{w} - \phi(b+g), a + \psi_t^b, b+1, g\right) + \\ & \qquad\quad (\delta/2) E_{\tilde{w}} V_{t+1}\left(\tilde{w} - \phi(b+g), a + \psi_t^g, b, g+1\right)\} \\ & \text{s.t.} \quad\quad c \geq 0, x \geq \underline{x} \\ & \qquad\quad w = c + x + m(b+g) + \kappa_2 \\ & \qquad\quad \tilde{w} = R(x) + \tilde{y} \end{aligned} \tag{5}$$

$$\begin{aligned} V_{t3}(w,a,b,g) = \quad & \max_{x,c} \quad \{u(c) + v(b+g) + \\ & \qquad\quad (\delta/2) E_{\tilde{w}} V_{t+1}\left(\tilde{w} - \phi(b+g), a + \psi_t^b, b+1, g\right) + \\ & \qquad\quad (\delta/2)\left(E_{\tilde{w}} V_{t+1}\left(\tilde{w} - \kappa_a, a, b, g\right) - \psi_a\right)\} \\ & \text{s.t.} \quad\quad c \geq 0, x \geq \underline{x} \\ & \qquad\quad w = c + x + m(b+g) + \kappa_3 \\ & \qquad\quad \tilde{w} = R(x) + \tilde{y} \end{aligned} \tag{6}$$

are, respectively, the value conditional on not conceiving a child; the value conditional on conceiving a child but not entertaining sex-selective abortion; the value conditional on conceiving a child, testing for its sex, and aborting if it is female.

The model parameters are summarized in Table 1.

4 Functional Forms and Parameterization

- Utility of household consumption $u(c)$ is continuous, strictly increasing and strictly concave in consumption c. Specifically, we assume it exhibits constant relative risk aversion θ:

$$u(c) = \frac{c^{1-\theta}}{1-\theta} \tag{7}$$

where $\theta \geq 0$.

Table 1: Model Parameter Definitions

Symbol	Definition
T_1	Number of years in the working-fertile stage
T_2	Number of years in the working-infertile)
r_s	Annual rate of return on liquid asset
r_d	Annual rate of interest charged on loans
ρ	Annual subjective rate of time preference
$\underline{x}$	Borrowing limit
$u(c)$	Annual utility of consuming c
$v(b,g)$	Annual nonpecuniary benefit of having b boys and g girls
$m(b,g)$	Annual cost of maintaining b boys and g girls
$f(a)$	Annual retirement support provided by a adult male chidren
N	Maximum number of children allowed without penalty
P	Annual public old-age retirement entitlements
$R(x)$	Gross return next period from net savings x this period
$\phi(n)$	Financial penalty for bearing child, if have n children
ψ_t^b	Adult male equivalency at retirement of boy born year t
ψ_t^g	Adult male equivalency at retirement of girl born year t
ψ_a	One-time nonpecuniary penalty for having an abortion
κ_d	Financial cost of childbearing decisions $d = 1, 2, 3$
κ_a	Financial cost of aborting
$\tilde{y}$	Exogenous annual stochastic income (i.i.d)

- Gross return from net savings takes the form

$$R(x) = \begin{cases} (1+r_s)x & x \geq 0, \\ (1+r_d)x & x < 0. \end{cases} \tag{8}$$

where r_s is the annual rate of return on savings deposits and r_d is the annual rate of interest charged on loans. We assume $0 < r_s < r_d < 1$.

- Annual nonpecuniary benefit from having children $v(b, g)$ is nondecreasing and concave in the number of boys b and girls g, with $v(0, 0) = 0$. Specifically, we assume

$$v(b,g) = \begin{cases} \bar{v}\left(1 - e^{-\gamma_v(b+g)}\right) & \text{if } n \leq N, \\ \bar{v}\left(1 - e^{-\gamma_v(b+g)}\right) - \psi_v & \text{otherwise} \end{cases} \tag{9}$$

where ψ_e is a nonpecuniary penalty suffered from the "shame" associated with having more children than allowed by law. Choices of $\bar{v} \geq 0$ and $\gamma_v > 0$ should be guided by the following. Note that $\bar{v}$ is the maximum annual nonpecuniary benefit from having children; since annual consumption in the model (if mean income is normalized to 1) is roughly 1, marginal utility of consumption is also roughly 1, so that $\bar{v}$ is approximately equal to the maximum annual consumption the household would be willing to forgo to have children. Also, a small γ_v indicates a preference for large families over small ones; a large γ_v indicates that the household derives utility simply from having a family, with little regard for its size.

- Annual cost of maintaining children $m(b, g)$ is nondecreasing and concave in the number of boys b and girls g, with $m(0, 0) = 0$. Specifically, we assume:

$$m(b,g) = \bar{m}\left(1 - e^{-\gamma_m(b+g)}\right). \tag{10}$$

Choices of $\bar{m} \geq 0$ and $\gamma_m \geq 0$ should be guided by the following. Note that $\bar{m}$ is the maximum annual cost of maintaining a family, regardless of its size. A large γ_m indicates significant economies of scale in maintaining a family.

- Children retirement support $f(a)$ is nondecreasing and concave in adult male equivalent children a at retirement, with $f(0) = 0$. Specifically, we assume it takes the following form:

$$f(a) = \bar{f}\left(1 - e^{-\gamma_f a}\right). \tag{11}$$

Choices of $\bar{f} \geq 0$ and $\gamma_f \geq 0$ should be guided by the following. Note that $\bar{f}$ is the maximum retirement financial support children are willing to provide collectively, regardless of their number. A large γ_f indicates that if the family has only one adult male child, he should be willing to provide very nearly this amount of support; a small γ_f indicates the maximum level of support will be provided only if the family is large. In the limit, $\gamma_f = \infty$, children are committed to providing collectively a fixed level of support, regardless of their number; having, say, two adult male children rather than one, does not alter the level of support, and only serves to reduce the support each child provides by one-half.

- Assume increments to adult male equivalent children a at retirement takes the form:

$$\psi_t^b = min(1, (T_2 - t)/2T_a) \tag{12}$$

$$\psi_t^g = \psi\psi_t^b \tag{13}$$

where t is year of conception, T_a is the age of adulthood, and $0 \leq \psi \leq 1$. Assume each male child is expected to contribute the same amount to his parents retirement support each year, but not until they have reached adulthood. A male child conceived on or before year $t = T_2 - T_a$ will have reached adulthood by the date of his parents retirement. However, a male child conceived in year $t = T_2 - T_a + \tau, \tau > 0$, will not reach the legal working age and thus will not begin to contribute to his parents retirement support until τ years after his parents retire; as such, the amortized value of that childs contributions at his parents retirement must be discounted.

- The financial penalty $\phi(n)$ for bearing an additional child when the household already has n children is

$$\phi(n) = \begin{cases} 0 & \text{if } n \leq N, \\ \phi_e & \text{otherwise} \end{cases} \tag{14}$$

Note that the financial penalty is imposed each time a child is born in excess of the maximum allowable, but is imposed only once, in the year that the excess child is born.

- Annual income $\tilde{y}$ is i.i.d. lognormal with mean 1 and lognormal standard deviation σ.

- κ_d represents the financial cost of childbearing decision $d = 1, 2, 3$, and we assume $0 \leq \kappa_1 \leq \kappa_2 \leq \kappa_3$. $\kappa_a \geq 0$ is the financial cost of aborting. $P \geq 0$ is the public old-age entitlements the household receives after retirement at T_2; $\underline{x} \leq 0$; $\overline{x} \geq 0$.

5 Model Calibration

5.1 Financial Market Parameters

Our model has two credit market frictions: 1) the degree of borrowing limit and 2) the interest rate spread between the lending interest rate and the deposit interest rate. In the benchmark model, we follow Choukhmane, Coeurdacier, and Jin (2014a) to calibrate the borrowing limit at 1% of annual income. We calibrate the annual return rate of financial assets to 4.65% and the bank lending interest rate to 7.46% to match China's official average one-year interest rates between 1989 and 2011, published by People's Bank of China. The amount of public old-age entitlements is set to 0.1 based on the estimate of Yang, Wiliamson, and Shen (2009) that more than 90% of rural residents have not yet participated in the rural old-age insurance of China in 2007.

5.2 Childbearing and Childrearing Parameters

The cost of electing to not conceive a child, κ_1, is assumed to be 0. According to Li et al. (2005), the cost of hospital delivery in China between 1998 and 2003 is approximately $5\% \sim 10\%$ of the household annual disposable income, thus we calibrate κ_2, the cost of conceiving a child and not testing the sex of the fetus, at 0.1. The ex ante cost of conceiving a child and making gender test, κ_3, includes the formal payment of the ultrasonic test and an informal payment to know the gender of the fetus. Since 1994, the central government of China has prohibited Chinese citizens from identifying the gender of the

fetus by using the medical technologies to avoid sex-selective abortion (Communist Party of the People's Republic of China, 1995).[5] However, the poor enforcement and the easy ways to avoid prosecution still made it possible to test the gender and make the selective abortion by bribing the gynecologists, or by having a good connection with the gynecologists (Loveland, 2012). Such informal payments for the gender test motivate the calibration of κ_3 to 0.1, and of κ_a, the ex post abortion cost, to 0.2. Thus, the total cost of aborting a female fetus includes both κ_3 and κ_a, exceeding the cost of a natural birth without testing the gender.

The calibration of parameters related to children's return is borrowed from existing literature. Based on the census data of 1982, 1990 and 2000, Ebenstein (2011) estimates that the value of the first son in China is 1.85 years of income and the value of the first daughter in China is 0.43 years of income. Therefore, we calibrate the $\bar{f}$ to 1.85 and β to 0.23 ($\approx 0.43/1.85$). Moreover, we also assume that the rate of increase in annual financial retirement support provided by children γ_f is 2.5. The maximum annual cost of maintaining children $\bar{m}$ is set to 0.2 and the rate of increase in annual cost of maintaining children γ_m is assumed to be 3.0.

5.3 Family Planning Policy and Preference Parameters

The maximum allowable number of births a household can legally have without financial punishment is set to 1 to capture China's One-Child Policy implemented from 1980 to 2015. The financial punishment rate ϕ_e is calibrated to 1.4. Even though the Policy required a financial punishment 3 to 10-fold annual income for each excess child, numerous households evaded the punishment through temporary migration, bribing or having close connections with the enforcement officials. Because our model does not capture the possibility of evading the punishment, we thus calibrate a lower financial punishment rate at 1.4 to match the birth data in China Health and Nutrition Survey (Carolina Population Center at the University of North Carolina at Chapel Hill, 2019).[6] We also assume that the household is risk-averse so

[5]Adopted at the Tenth Meeting of the Standing Committee of the Eighth National People's Congress on October 27, 1994, promulgated by Order No.33 of the President of the People's Republic of China on October 27, 1994, and effective as of June 1, 1995.

[6]CHNS is jointly conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at

that $\alpha = 2$.

The maximum non-pecuniary utility benefits of having children and the rate of increase in annual non-pecuniary utility benefits from having children, $\bar{v}$ and γ_v, are calibrated at 0.3 and 1.6, respectively. We also assume that the parents will not enjoy a utility from not conceiving a child, but suffer a one-time disutility from making the abortion decision, which gives $\psi_a = 0.5$.

The benchmark parameters are summarized in Table 2.

5.4 Fit of Benchmark Parameters

We allow that households are heterogeneous at the annual disutility from having excess children, ψ_e. We assume that the disutility is i.i.d lognormal distributed with mean $\psi_e = 0.03$ and lognormal standard deviation $\sigma_{\psi_e} = 0.2$. Our benchmark parameters represents a good fit to the average number of children each family has, male-female sex ratio at birth and the average age of mother at first and second birth for the 13,418 births in 6,409 sampled households in the China Health and Nutrition Survey (CHNS) between 1989 and 2011. The model fit is displayed in Table 3.

Table 3 shows the moment match between the simulated data and CHNS data, which contains 13,418 births in 6,409 households between the year of 1989 and 2011.

According to the CHNS data, each family had 2.09 children on average and 111 boys were born when every 100 girls were born. In our simulated data, each family has 2.09 children on average and the sex ratio at birth is 112. The average age to have first and second child in the CHNS data is 24.88 years old and 26.97 years old, while the two numbers in the simulated data is 24.82 and 26.85.

6 Policy Analyses

6.1 Public Old-Age Security

The substitution effect between the demand for children as an asset and the public transfer for retirement, government old-age entitlements, has been tested widely for liquidity-constrained households in both developing and

the Chinese Center for Disease Control and Prevention.

Table 2: Summary of Model Parameters

Symbol	Value	Definition
T_1	35	Number of years in working/fertile stage
T_2	40	Number of years in working stage (fertile & infertile)
T_a	25	Child conceived on or before $T_2 - T_a$ will reach the legal working age before parents' retirement
θ	2.0	Coefficient of relative risk aversion
ρ	0.05	Annual subjective rate of time preference
r_s	4.65%	Annual rate of return on deposits
r_b	7.46%	Annual rate of interest charged on loans
$\underline{x}$	0.01	Borrowing limit
N	1	Maximum number of children allowed without penalty
P	0.1	Annual public old-age retirement entitlements
κ_1	0.0	Cost of not conceiving child
κ_2	0.1	Cost of conceiving child and not testing the gender
κ_3	0.1	Cost of conceiving child and testing gender
κ_a	0.2	Cost of aborting
ϕ_e	1.4	Penalty for bearing excess child
ψ_e	0.03	Annual nonpecuniary penalty for excess children
ψ_a	0.5	One-time nonpecuniary penalty for having an abortion
$\bar{v}$	0.3	Maximum annual nonpecuniary benefit from children
$\bar{m}$	0.2	Maximum annual cost of maintaining children
$\bar{f}$	1.85	Maximum annual retirement support from children
γ_v	1.6	Annual rate of increase in nonpecuniary benefit from having children
γ_m	3.0	Annual rate of increase in cost of maintaining children
γ_f	2.5	Annual rate of increase in retirement support from children
β	0.23	Fraction of retirement support provided by girl vs. boy
$\bar{y}$	1.0	Expectation of annual income
σ	0.2	Log standard deviation of annual income

Table 3: Summary of Model Fit

	Simulated	Historical
Average number of births	2.09	2.09
Male-female sex ratio at birth	112	111
Average age of mother at first birth	24.82	24.88
Average age of mother at second birth	26.85	26.97

developed countries. Nevertheless, the research on the impact of government old-age entitlements on gender selection and childbearing time is very scant. In this section, merely modifying the exogenous government pension and keeping other benchmark parameters, we can observe to what extent the multiple childbearing behaviors will change in response to a higher government pension.

The four panels in Figure 3 shows the effect of public old-age entitlements on average number of births, sex ratio at birth, mother's age to have first and second birth, respectively. We find that adequate old-age pension has substitution effect on number of births, sex ratio at birth and childbearing time. Adequate old-age pension disincentivizes the parents to treat children as an asset for their old-age life such that they demand less children, fewer motivations to make sex selection and delay their childbearing time. More specifically, an old-age entitlements equivalent to or above 30% of parents' pre-retired income will reduce the number of children from 2.14 to 2.00 and reduce the sex ratio at birth from 124 to a balanced ratio 100. Moreover, the childbearing time of the first birth will be delayed 0.31 year from 24.86 years old to 25.17 and the time of the second birth will be delayed more than two years from 26.73 to 28.96 years old if the public old-age pension can reach the 100% pension replacement rate.[7]

6.2 Return From Capital Markets

The relationship between the rate of return on liquid financial assets and childbearing is complicated. On the one hand, as two major mechanisms

[7]Pension replacement rate: gross pension entitlement divided by gross pre-retirement earnings.

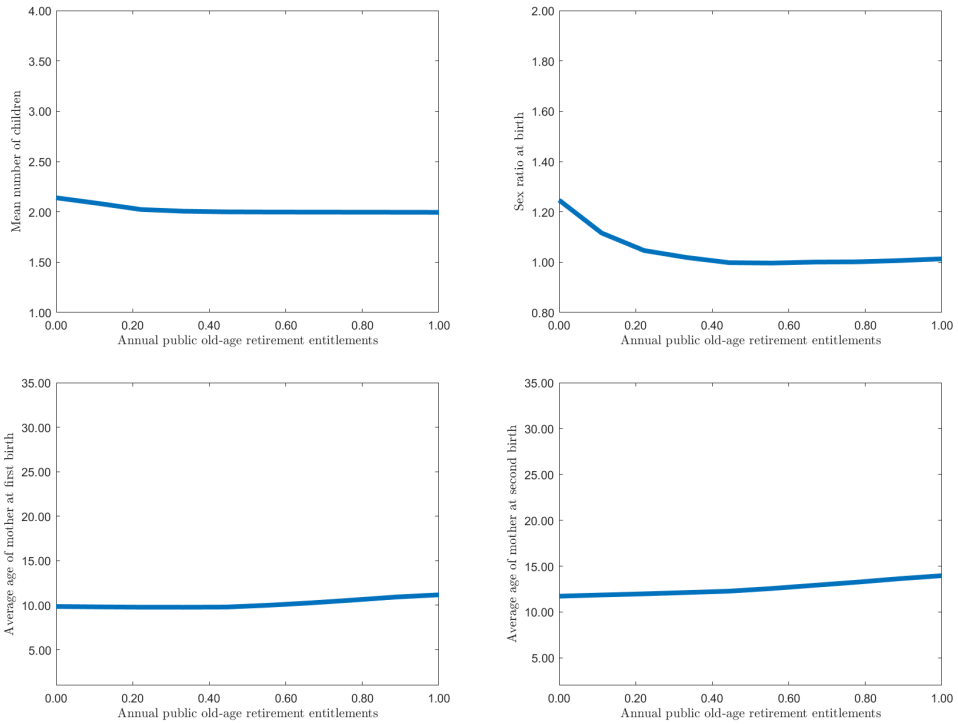


Figure 3: The Effect of Public Old-age Entitlements on Childbearing Behavior

the parents can adopt for the old-age life, savings for retirement and children's support may be substitutes for each other so that a higher return from capital markets will decrease parents' demand on children asset, given that childrearing is costly. Intuitively, the parents will invest additional unit wealth on having a natural birth, instead of on asset markets, if the expected net return afterwards provided by children exceeds the expected net return obtained from the asset market. On the other hand, higher return from the capital market has an income effect for childbearing such that parents can afford more children and sons. For example, Lovenheim and Mumford (2013) identify the positive income effect of house price growth on the probability of having an additional child for homeowners. Therefore, the effect of increasing rates of asset return on childbearing depends on which effect is dominant.

Figure 4 shows the co-existence of the two types of effects. When the annual rate of return on liquid assets increase from 0% to 3%, parents demand less children's support, indicating that the substitution effect of savings dominates. However, the rise in rate of return on liquid assets from 3% to 6% leads to higher demand for children's support, showing the income effect of liquid assets.

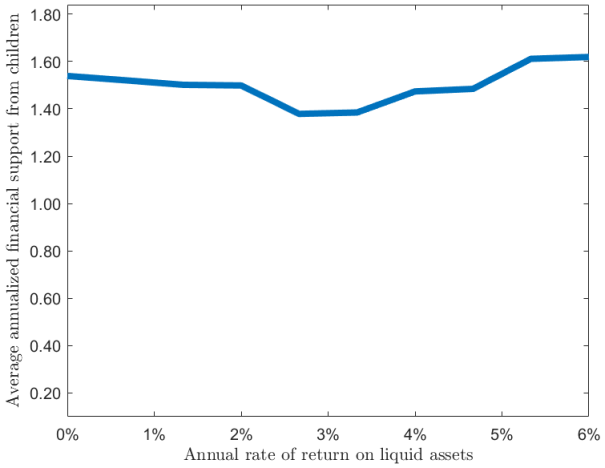


Figure 4: The Effect of Rate of Return on Liquid Assets on Demand for Children Asset

The four panels in Figure 5 shows the effect of liquid asset return on average number of births, sex ratio at birth, mother's age to have first and

second birth, respectively. The figure illustrates that the substitution effect of liquid assets is a trade-off between reducing the incidence of sex selection and the slight advance in the childbearing time of the second birth, while the income effect is a joint result of having more children and adopting selective abortion to have more sons.

The increase in liquid asset return from 0% to 4% leads to a reduction in sex ratio at birth from 135 to 112. To compensate the loss in children's support resulting from the more balanced sex ratio, the parents advance their second birth from 29.05 years old to 26.66 years old. Given that liquid asset return rates have little effect on the timing of first birth as showed in Panel (c), higher liquid asset return shrinks the time space between the two births. However, if the rate of liquid asset return continues to increase, the parents can afford more sons by taking selective abortion and raise more children. The sex ratio at birth will move up back to 120 and each family will have 2.20 children on average if the rate of return on liquid assets reaches 6%.

This result provides an additional explanation to the birth puzzle that Southern China, which is more developed than Northern China, has a higher total fertility rate and a more imbalanced sex ratio at birth, even though country-level data always show that developed areas generally have a lower fertility rate and a more balanced sex ratio at birth than the developing areas. Given that number of birth is limited, higher economic growth and capital return from the financial market in the Southern China provide an income effect to having children and sex selection.

6.3 Credit Access

Access to the credit may also exert two opposite effects on childbearing, the income effect and the substitution effect. On the one hand, access to the credit market can increase households' liquidity to rear more children, sons or have children early, which is the income effect. On the other hand, the existence of credit market is able to help the households smooth the consumption after the adverse income shocks such that the long-run family wealth is more stable, reducing parents' demand for riskless children's financial support. In this section, we test two mechanisms of providing credits: one is to relax the household borrowing limit, the credit size the household can get access; the other one is the loan interest rates.

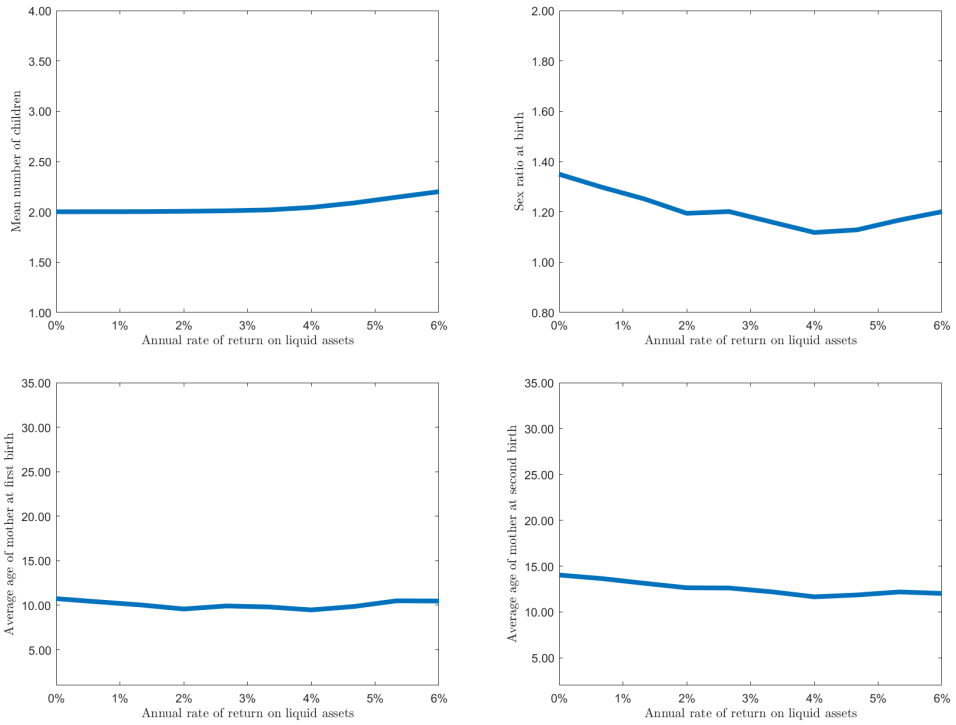


Figure 5: The Effect of Rate of Liquid Asset Return on Childbearing Behavior

6.3.1 Borrowing Limit

Figure 6 shows that households tend to have more children asset when the borrowing limit is more relaxed, even though the effect is very modest. This result mainly stems from the income effect of credits, which provides more liquidity to the households, on sex selection as displayed in Panel (b) of Figure 7. Therefore, China's restricted borrowing limit in the past actually played a role to relieve the pressure of imbalanced sex ratio at birth, given the One-Child Policy.

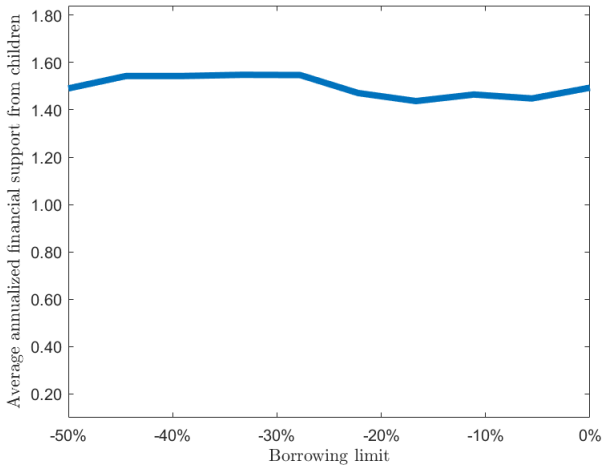


Figure 6: The Effect of Borrowing Limit on Children's Financial Return

6.3.2 Interest Rates

Due to the very strict borrowing limit in China during our research time span, we find little evidence that debt interest rates will exert effect on childbearing. We thus relax the borrowing limit to 50% of the family's annual income and test the households response to the varying debt interest rates. Figure 8 indicates that rising debt interest rates will deteriorate the imbalanced sex ratio, delay the childbearing time of both first and second birth when the debt interest rates are below 8%. Even though the rate of debt has little effect on the average number of births of each family, the delay in childbearing time will significantly decrease the aggregate total fertility rate of the country as

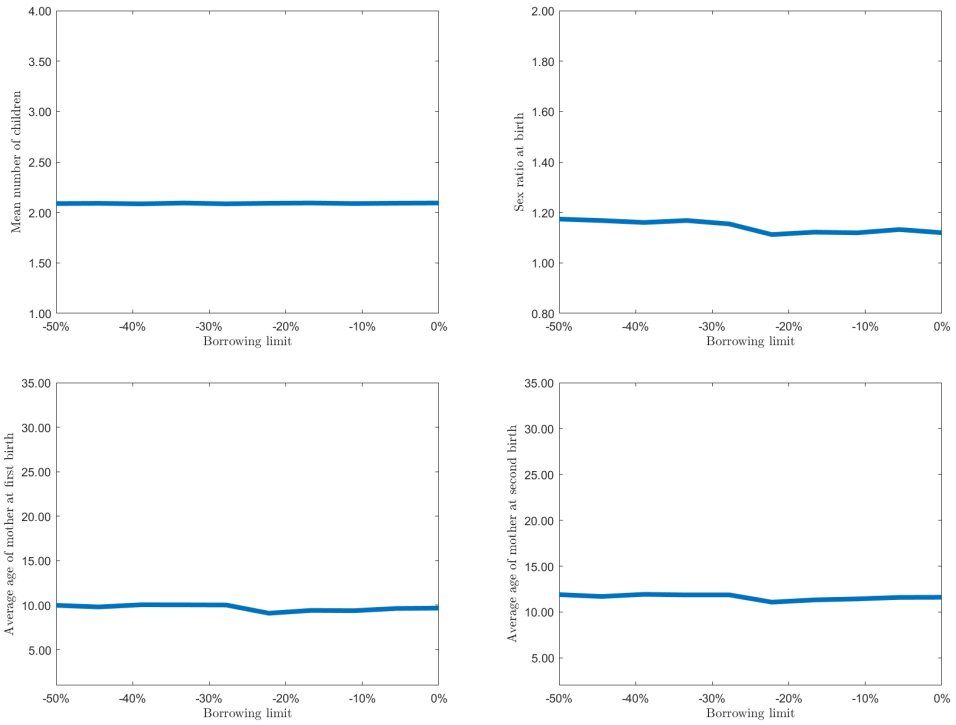


Figure 7: The Effect of Borrowing Limit on Childbearing Behaviors

a whole. However, a rate of debt above 8% will start to reduce the sex ratio, but advance the childbearing time, meaning that the sex ratio at birth will tend to be balanced, but the aggregate total fertility rate will be raised up.

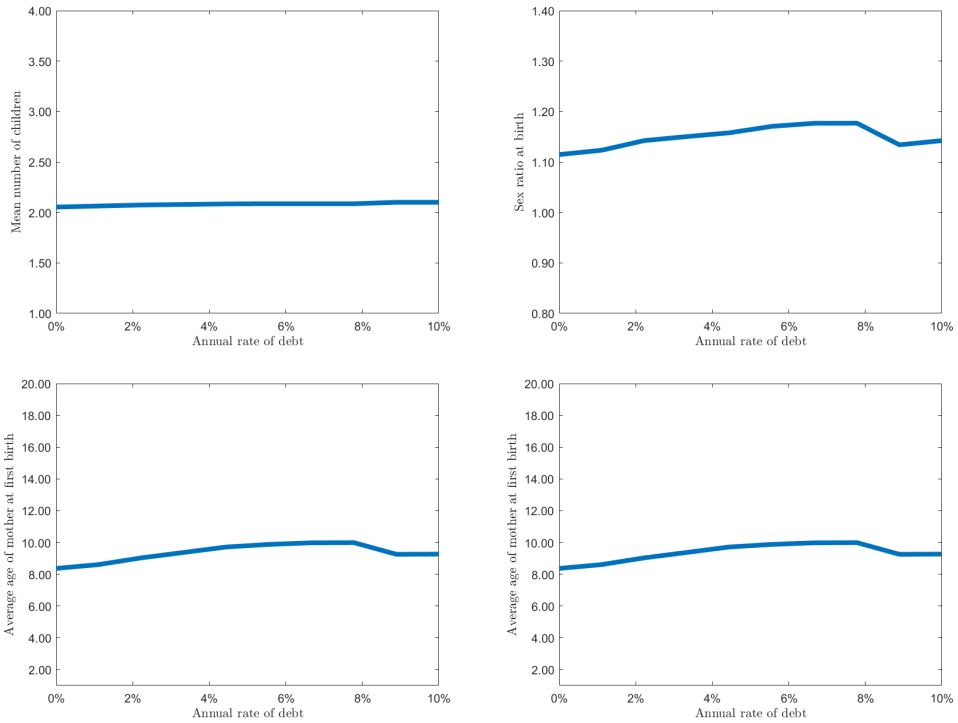


Figure 8: The Effect of Annual Rate of Debt on Childbearing Behavior

6.4 Relaxing the Two-Child Policy

Multiple countries once adopted family planning policies in their history by setting up an upper limit in number of births. Households might lose certain public services if having excess children or obtain financial incentives if having fewer children during the periods of policy implementation. A Two-child limit is widely used in these countries. However, China's One-Child Policy in most urban areas was treated as the most restricted family planning policy in world's history. Households violating the policy not only suffered huge financial punishment but also lost their job position if civil servants. In this

section, we conduct a counterfactual analysis on family planning policy to relax the One-Child Policy to a Two-Child Policy and see how the childbearing outcomes vary. The childbearing outcomes are summarized in Table 4.

Table 4 shows the aggregate childbearing outcomes of simulated households under One-Child Policy and Two-Child Policy.

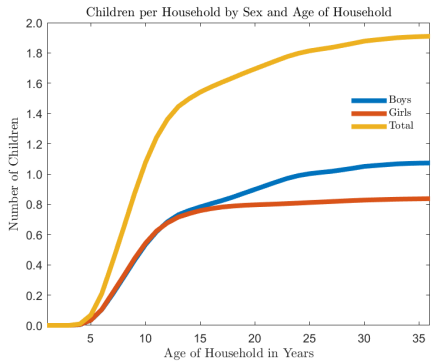
Table 4: The Effect of Family Planning Policies on Childbearing

	One-Child Policy	Two-Child Policy
Average number of births	2.09	2.25
Male-female sex ratio at birth	112	101
Average age of mother at first birth	24.82	22.51
Average age of mother at second birth	26.85	23.51

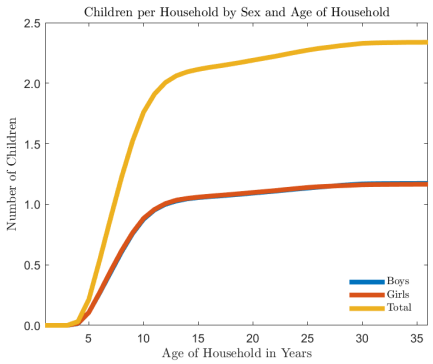
Holding other parameters constant, sex ratio at birth will be reduced to a balanced level at 101 under the Two-Child Policy, showing no significant evidence to selective abortion. Comparing the Panel (c) and Panel (d) representing the age-specific fertility rate by sex in Figure 9, we know that the elimination of the selective abortion is mainly attributed to the disappeared sex selection occurred when mothers' age is between 30 and 49, the age to have second or higher-order birth, while we find little evidence showing the sex selection when mothers are younger than 30 years old. Under the One-Child Policy, the cost to have the second child is large because of the huge financial punishment of having an excess child, and the household will have the second birth only when the marginal benefit is greater than its marginal cost. Therefore, the parents decided to have a second birth tend to select a son, which is expected to provide higher benefit than a daughter, to cover the financial punishment they have to pay for over-birth. Such phenomenon diverges the average number of boys and girls since the second birth, which is showed in Panel (a) of Figure 9. Nevertheless, a Two-Child Policy reduces the cost to have the second birth such that the expected marginal benefit of a natural birth is large enough to cover the cost. Thus, the selective abortion is eliminated as it shows in Panel (b) of Figure 9.

However, to compensate the loss in children's support stemming from having fewer sons, households under the Two-Child Policy tend to have more children, advance their childbearing time and shrink the time space between

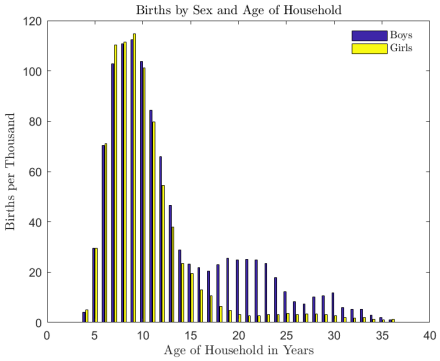
two births. Each family will have 2.25 children on average during 1989 and 2011, 0.16 more than the number under the One-Child Policy. The first birth will come up when the mother is 22.51 years old, 2.31 years forward compared with their counterparts under the One-Child Policy. Similarly, the parents will have the second child earlier to 23.51 years old, 3.34 years forward relative to the situation under the One-Child Policy. The advance in childbearing time will shrink the age gap between two generations, leading to more births in the country.



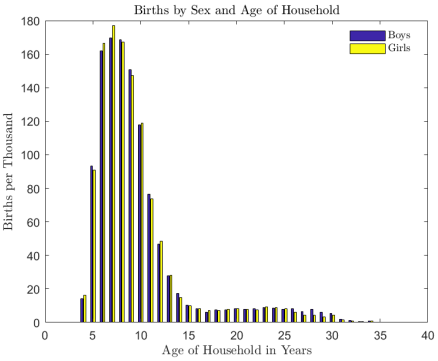
(a) One-Child Policy



(b) Two-Child Policy



(c) One-Child Policy



(d) Two-Child Policy

Figure 9: The Effect of Family Planning Policy on Childbearing Behaviors

6.5 A One-Child-Policy-Equivalent Policy with a Relaxed Two-Child Policy

We have shown that a relaxed Two-Child Policy can greatly relieve the male-biased sex ratio at birth emerged under the One-Child Policy, but may not decrease the number of births as effective as the One-Child Policy. Thus, we want to find out if there is any other way to reduce number of birth as the policy goal of the One-Child Policy, but can keep a balanced sex ratio as under the Two-Child Policy. Therefore, we continue to conduct policy analyses for public old-age pension, asset return rates and debt interest rates under the environment of Two-Child Policy. Our results show that, under the Two-Child Policy, increasing the asset return rate to 10%, old-age entitlements to 0.30 level, relaxing the borrowing limit to 20% of the annual income and raising the annual rate of debt to 12% will reach this goal. The childbearing outcomes are summarized in Table 5. Under this new financial environment, each family has 2.14 children on average, the aggregate sex ratio at birth is a balanced 101, and the average childbearing time of first and second child are 25.02 and 26.02, respectively. This result indicates that, even with a more relaxed Two-Child Policy, China still could reach the same fertility rates and childbearing time under the One-Child Policy, but keep a balanced sex ratio at birth.

Table 5 shows the aggregate childbearing outcomes of simulated households under One-Child Policy with benchmark parameters and under Two-Child Policy with another financial environment. For One-Child Policy, $r_s = 4.65\%$, $r_d = 7.46\%$ $r_s = 10\%$, $r_d = 12\%$; for Two-Child Policy, $P = 0.10$, $\underline{x} = 0.01$ $P = 0.30$, $\underline{x} = 0.20$.

Table 5: A One-Child-Policy-equivalent Policy with a Relaxed Two-Child Policy

	One-Child Policy	Two-Child Policy
Average number of births	2.09	2.14
Male-female sex ratio at birth	112	101
Average age of mother at first birth	24.82	25.02
Average age of mother at second birth	26.85	26.02

7 Conclusions

This paper builds up a dynamic childbearing model with sex selection in a developing country setting where the old-age security system, financial market and credit market are incomplete, and a birth upper limit exists. Our model captures several salient features widely existing in developing countries: children are expected to provide financial return to the parents after they retire, sons are expected to shoulder more responsibilities than daughters to return the parents financially and children's return is expected to vary across ages. We match our model simulations to the stylized facts of number of births, sex ratio and childbearing time of the mothers sampled in China Health and Nutrition Survey data 1989-2011 to calibrate our model parameters. Our counterfactual policy analyses find certain results that have not been noticed in existing literature.

The first is that adequate old-age security exerts a substitution effect on children asset accumulation. We find that a hypothetical higher old-age pension would reduce the number of births, the adoption of selective abortion techniques and delay the childbearing time of a household. A gross pension replacement rate at 30% would be enough to completely eliminate the selective abortion. Because higher children asset is associated with more number of births, sons and having children early, providing more old-age entitlements actually decrease households' demand on children asset.

In addition, we find that higher return obtained in capital market will have both income effect and substitution effect on childbearing. When the rates of return of financial assets are below 3%, increasing the return rate would lower the children asset accumulation, which is a trade-off outcome of reducing the adoption of sex selection and advancing the childbearing time of the second birth. However, if the rates of return on liquid financial assets continue to rise, the households would employ the liquid asset return to afford more children and sons, which increases the financial return the parents can receive from the children.

We also test the effect of credit market perfections on childbearing. We first find that less credit-constrained households tend to have higher children asset than their more credit-constrained counterparts because the access to the credits provide them more liquidity to make the sex selection and raise more sons. We then hypothetically release the borrowing limit to 50% of households' annual income and conduct policy analysis on debt interest rates. We find a mixed effect of rising interest rates of debt. When the rate is

below 8%, increasing the debt interest rate would trigger higher incidence of selective abortion such that the sex ratio at birth would increase from 111 to 120, but postpone the childbearing time by two years. Nevertheless, when the rate is above 8%, the parents will reduce the sex selection, but advance the childbearing time in the response to higher debt interest rates. These results show that a trade-off between the choices on sex composition and childbearing time exists when the parents are facing various debt interest rates.

Finally, we conduct the counterfactual policy analysis to relax the One-Child Policy to a Two-Child Policy, but keep other elements unchanged. Our results indicate that each household would have 0.16 more children and move forward childbearing time by 2.31-3.34 years under the Two-Child Policy, but would have a balanced sex ratio. We then find that, even under a less restricted Two-Child Policy, Chinese government could still reduce the total fertility rates and delay the average childbearing time to the level under the One-Child Policy by raising up the deposit interest rate to 10%, the loan interest rate to 12%, relaxing the borrowing limit to 20% of annual income and moving up the gross pension replacement rate to 30%, and more importantly, have a balanced sex ratio at birth that did not exist under the One-Child Policy.

References

Carolina Population Center at the University of North Carolina at Chapel Hill. 2019. "China Health and Nutrition Survey." Available online at `cpc.unc.edu/projects/china`. Accessed November 18, 2019.

Anukriti, S. 2018. "Financial Incentives and the Fertility-Sex Ratio Trade-Off." *American Economic Journal: Applied Economics* 10(2):27–57.

Appelbaum, E. and E. Katz. 1994. "The Demand for Children in the Absence of Capital and Risk Markets: A Portfolio Approach." *Oxford Economic Papers* 43(2):292–304.

Bandara, A., R. Dehejia, and S. Lavie-Rouse. 2015. "The Impact of Income and Non-income Shocks on Child Labor: Evidence from a Panel Survey of Tanzania." *World Development* 67(March):218–237.

Boldrin, M., M. De Nardi, and L.E. Jones. 2005. "Fertility and Social Security." NBER Working Paper No. 11146, National Bureau of Economic Research, Cambridge, MA.

Boldrin, M. and L.E. Jones. 2002. "Mortality, Fertility, and Saving in a Malthusian Economy." *Review of Economic Dynamics* 5(4):775–814.

Cain, M.T. 1981. "Risk and Insurance: Perspective on Fertility and Agrarian Change in India and Bangladesh." *Population and Development Review* 7(3):435–474.

———. 1982. "Perspectives on Family and Fertility in Developing Countries." *Population Studies* 36(2):159–175.

Caldwell, J.C. 1978. "A Theory of Fertility: From High Plateau to Destabilization." *Population and Development Review* 4(4):553–577.

———. 1982. *Theory of Fertility Decline*. New York: Academic Press.

Cho, N. 1996. "Achievements and Challenges of the Population Policy Development in Korea." Technical report, Korea Institute for Health and Social Affairs, Seoul.

Choukhmane, T., N. Coeurdacier, and K. Jin. 2014a. "Fertility Policies and Social Security Reform in China." *IMF Economic Review* 62(3):371–408.

———. 2014b. "The One Child Policy and Household Savings." CEPR Discussion paper No.9688, Centre for Economic Policy Research, London.

Communist Party of the People's Republic of China. 1992. "Open Letter to All Members of the Communist Party and Communist Youth League - on the Issue of Controlling the Population Growth." Available online at `tandfonline.com/doi/pdf/10.2753/CSA0009-4625240311`. Accessed November 18, 2019.

———. 1995. "Law of the People's Republic of China on Maternal and Infant Health Care." Available online at `china.org.cn/china/2010-03/04/content_19522945.htm`. Accessed November 18, 2019.

Das Gupta, M., J. Jiang, B. Li, Z. Xie, W. Chung, and B. Hwa-Ok. 2003. "Why is Son preference so persistent in East and South Asia? A Cross-Country Study of China, India and the Republic of Korea." *Journal of Development Studies* 40(2):153–187.

De Sherbinin, A., D. Carr, S. Cassels, and L. Jiang. 2007. "Population and Environment." *Annual Review of Environment and Resources* 32:345–373.

Duryea, S., D. Lam, and D. Levison. 2007. "Effects of Economic Shocks on Children's Employment and Schooling in Brazil." *Journal of Development Economics* 84(1):188–214.

Ebenstein, A. 2010. "The 'Missing Girls' of China and the Unintended Consequences of the One-Child Policy." *Journal of Human Resources* 45(1):87–115.

———. 2011. "Estimating a Dynamic Model of Sex Selection in China." *Demography* 48:783–811.

Edlund, L., H. Li, J. Yi, and J. Zhang. 2013. "Sex Ratio and Crime: Evidence from China." *Review of Economics and Statistics* 95(5):1520–1534.

Herold, J.M., C.W. Warren, J.C. Smith, R.W. Rochat, R. Martinez, and M. Vera. 1986. "Contraceptive Use and the Need for Family Planning in Puerto Rico." *Family Planning Perspectives* 18(4):185–188?192.

Hesketh, T. and W.X. Zhu. 2006. "Abnormal Sex Ratios in Human Populations: Causes and Consequences." *Proceedings of the National Academy of Sciences* 103(36):13271–13275.

Li, H., J. Yi, and J. Zhang. 2011. "Estimating the Effect of the One-Child Policy on the Sex Ratio Imbalance in China: Identification Based on the Difference-in-Differences." *Demography* 48(4):1535–1557.

Li, H., J. Zhang, and Y. Zhu. 2005. "The Effect of the One-Child Policy on Fertility in China: Identification Based on the Differences-in-Differences." Discussion paper, Chinese University of Hong Kong, Department of Economics, Hong Kong.

Li, X., Z. Wu, L. Xu, D. Jiang, and J. Gao. 2005. "Cost Analysis of Hospital Delivery in China, 1998-2005 (in Chinese)." *Chinese Primary Health Care* 19(11):13–15.

Loveland, T.R. 2012. "Sex-Selective Abortion Law in China and Corresponding Conception in the United States." *Annals of Health Law* 21:173–192.

Lovenheim, M. and K.J. Mumford. 2013. "Do Family Wealth Shocks Affect Fertility Choices? Evidence From the Housing Market." *Review of Economics and Statistics* 95(2):464–475.

Pham, B.N. 2014. "The Demographic Transition and Implications for the New Law on Population in Vietnam." *Asian Population Studies* 10(3):237–240.

Portner, C.C. 2001. "Children as Insurance." *Journal of Population Economics* 14(1):119–136.

Schultz, T.P. 1997. "Demand for Children in Low-Income Countries." In *Handbook of Population and Family Economics, Volume 1, Part A*, edited by M.R. Rosenzweig and O. Stark. Amsterdam: North-Holland, 349–430.

Sen, A. 1990. "More Than 100 Million Women Are Missing." *New York Review of Books* 37(20):61–66.

United Nations. 2005. "Population Challenges and Development Goals." Technical report, United Nations, Department of Economic and Social Affairs, New York.

———. 2017. "United Nations World Population Prospects." Available online at `population.un.org/wpp/Download/Standard/Fertility/`. Accessed November 18, 2019.

Wei, S. and X. Zhang. 2009. "The Competitive Saving Motive: Evidence From Rising Sex Ratios and Savings Rates in China." *Journal of Political Economy* 119(3):511–564.

Wong, T. and B. Yeoh. 2003. "Fertility and the Family: An Overview of Pro-natalist Population Policies in Singapore." Research Paper 12, Asian MetaCenter, Singapore.

Yang, Y., J.B. Wiliamson, and C. Shen. 2009. "Social Security for China's Rural Aged: A Proposal Based on a Universal Non-contributory Pension." *International Journal of Social Welfare* 19(2):236–245.