

Risky Child Investment, Fertility, and Social Insurance in China

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Abstract

This paper tries to explain the decline in total fertility rate (TFR) in China by investigating the quantitative effect of social insurance on peoples' fertility choice in an environment where investment in children is risky. The price and income effects of social insurance are heterogeneous depending on peoples' position in the income distribution: low-income people tend to raise more children due to the reinforcing income and price effects, whereas for rich families the income effect dominates the price effect so that their fertility declines in the presence of the social insurance program. Our results based on Chinese economy do not support the hypothesis that increasing social insurance tax rate has a negative impact on fertility rate, as argued in Boldrin, Nardi, and Jones (2005). Through decomposing calibration results under hypothetical policy scenarios and simulating TFRs for various parameter values, we show that liquidity constraints created by a public pension program plays a significant role in *reducing* fertility rate. Factors related to the rate of return on child investment, such as a slowing economic growth, a rise in the cost of childbearing, and potential social attitude changes such as expectations of lower transfers, also contribute to the long-term declining trend in fertility observed in the data.

Keywords: child investment, total fertility rate, social insurance, China

JEL Classification Codes: E10, H55, J13, O10

1 Introduction

1.1 Motivation

As the most populous country, China has had a continuous decline in its total fertility rate (TFR) since the 1960s. A nation-wide family control policy that restricts urban families to have only one child and rural families to have at most two kids was implemented in the 1970s to control the population growth, and it appears to be the driving force behind the TFR decline. However, the time-series data show that TFR in China peaked at 5.9 kids in 1967, dropped dramatically to 3.1 in 1977 *before* the start of the one-child policy, then fell between 1978 and 1980 from 2.9 to 2.6. The TFR remained around 2.6 until 1986, and then entered another period of decline from 2.6 to 1.8 between 1987 to 1998. After that, the TFR stabilized around 1.8 until 2009.

When the one-child policy was initially implemented, it prevented people who already have one or two kids from bearing another one and restricted people without children to have only one child. The sharp decline in TFR between 1978 and 1986 comes from the reduction of childbearing from those who already have children. However, the decline after 1986 is different: more and more people decided not to have children instead of cutting the number of children they wanted to have because of the policy constraint. Thus, it is clear that the one-child policy can not explain the big drop from 1967 to 1977 prior to its imposition, and it is not strong enough to explain the further drop between 1986 and 2009 when it is already widely publicized and enforced. In fact, especially since 2000, the one-child constraint has been relaxed in some places in China. Therefore, it seems like a puzzle why the TFR kept declining after 1985. The purpose of this paper is to investigate whether the advent of social insurance can explain the decline in TFR between 1986 and 2009.

Existing literature demonstrates a significantly negative correlation between TFR and social insurance generosity. China launched its social insurance program in the early 1990s, which motivates us to examine whether the introduction of this program was the primary cause of the decline in TFR. Although the development of social insurance coincides with the drop in TFR, this observation does not reveal by what means this program was able to affect peoples' fertility choices, since

many other factors also changed during the same period. We focus on several channels through which social insurance affects childbearing decisions and show that this program helps reduce TFR particularly through the liquidity constraints social insurance taxes induce on the poor, while increases TFR if people can borrow against their pension benefits through informal channels. Thus, factors outside the one-child policy and social insurance may play a dominating role in reducing TFR and keeping it at a very low level after 1986; we acknowledge that other effects that affect return on investment in children could be contributing factors.

1.2 International Background

According to US Census Bureau, world population is expected to reach more than 9 billion in 2050, accompanied with a falling growth rate, which was more than 2% in the 1960s and is projected to be only 0.5% in 2050. However, the pattern is quite uneven across the globe: the population growth will be contributed exclusively by the developing countries; while the population in the developed nations will most likely decline because of the total fertility rate falling below the replacement levels. For example, nowadays countries in Middle East and Sub-Sahara Africa still experience a growth as high as 3%; while the growth rate is less than 1% in developed countries and even becomes negative in Central and Eastern Europe.

Given that one major motive for childbearing is the old-age support, one might ask whether the development in social insurance program, which provides an alternative for retirement funding, can explain the sharp differences in population growth between developed and developing countries. Indeed, under any current classification standard¹, there is much difference in social insurance coverage between developed and developing nations. Within the former group, social insurance was established several decades ago, has developed into a rather comprehensive system, and is run extremely proficiently. In the US, several government-sponsored programs are well designed to take care of the post-retirement lives, like Social Security, Medicare, the Pension Benefit Guaranty Cor-

¹To define developed and developing countries, IMF and World Bank usually look at two criteria: (1) income per capita, (2) industrialization. United Nations Development Programme devised a human development index (HDI) that considers three dimensions: (1) life expectancy, (2) years of schooling, and (3) GNI per capita (PPP US\$).

poration (PBG) program, the railroad retirement program, etc. And in the case of Social Security, all administrative duties are performed at a cost of 0.9 percent of total expenditures, or less than a penny per dollar². Similar retirement funding programs are offered in all OECD countries, and pension benefits are very generous in welfare states like Sweden. Within the latter group, many developing countries are in the process of setting up a formal social insurance program or undergoing dramatic reforms. For example, Chile introduced a system of privately managed individual accounts in 1981, and this Chilean model was adopted by 10 other countries in Latin America since 1990. Despite a series of improvements made to the system, however, it still faced several challenges, including high administrative fees. In 2008, the system was overhauled. According to the international research program at the U.S. Social Security Administration, most developing countries only place the old-age security program in their priority list, but not the unemployment or health insurance; in some Asian nations, only certain type of people can apply for unemployment or health insurance benefits; and in most African countries, programs of similar type are of limited scope.

In the context of comparison between developing and developed countries, it seems that there exists a strong correlation between peoples' fertility choices and the social insurance progress. When the social insurance program is comprehensive and generous, people tend to raise fewer kids, while they may rear more with a less-developed program.

Several papers provide empirical tests of the old-age security motivation for childbearing by looking at the influence of social insurance on fertility in developed countries. Boldrin, Nardi, and Jones (2005) argue that an increase in government provided old-age pensions is strongly correlated with a reduction in fertility. They show that the impact of social security on fertility is sizeable in their model, which accounts for 55% to 65% of the observed Europe-US fertility differences both across countries and over time, while the altruism motivation of childbearing is shown to have a small effect.

Billari and Galasso (2008) propose an empirical test using the Italian pension reforms in the 1990s as a natural experiment, which suddenly and substantially decreased pension prospects for

²Data source: <http://www.ssa.gov/oact/STATS/admin.html>.

a large group of individuals and thus introduced a clear discontinuity in the size of future pension benefits across workers. The empirical results identify a clear and robust effect: less generous future pensions have induced more post-reform fertility, which is again consistent with the old-age security motive.

In addition, Ehrlich and Kim (2007) show that social security taxes and benefits generate incentives to reduce both family formation and fertility. Through a dynamic over-lapping generation model and using panel data from 57 countries over 32 years, they illustrate that the social security tax measures account for a non-trivial part of the downward trends in fertility; and the result is significant and sizeable for OECD countries, but insignificant for non-OECD countries. Similarly, Zhang and Zhang (2004) find that the estimated coefficient on social security is significantly negative in the fertility equation, using data on a group of market economies in the 1960-2000 period.

To sum up, for the seemingly negative correlation between social insurance progress and peoples' fertility choices, the above literature shows that this is true at least in developed countries. They further proceed to interpret it as a causality relationship.

Finally, it is worthwhile to mention the often neglected feedback channel: while social insurance is *associated* with a lower fertility, the prospect of fewer kids poses a solvency challenge for a pay-as-you-go system. In this sense, the generosity of a pension program itself is inadvertently contributing to its own funding problem in the long run.

1.3 Contribution

We develop a tractable life-cycle model to capture peoples' decisions on whether or not to have children and how many they would like to have. In light of the old-age support motive, in our model parents view children as risky investment goods, where the risks come from mortality that children can not grow up to adults and the expected transfer parents obtain in the next period. The major feature of our framework is a macro aggregation based on micro optimization. Instead of focusing on a representative agent in the general equilibrium framework, we solve the individual

dynamic fertility choice model in a partial equilibrium framework for agents with heterogeneous budget constraints, then aggregate individual fertility choices to obtain the society-wide TFR.

Our calibration results match the declining trend in TFR quite well. A decomposition of the calibrated TFRs reveals that the combined price and income effects of social insurance tend to increase the TFR by a limited amount, while imposing the liquidity constraint helps reduce the fertility rate significantly. Moreover, the price and income effects are heterogeneous depending on peoples' positions in the income distribution: relatively poor people tend to have more kids since the two effects work in the same direction, while income effect dominates the price effect for relatively rich people so that their fertility rate falls. Our results are not consistent with the negative relationship between social insurance tax rate and fertility rate in Boldrin, Nardi, and Jones (2005). An increase in tax rate has trivial impact on peoples' fertility choices in our framework. Beyond this, we bring out other factors that could have important influence on fertility choices such as the expected GDP growth rate, childbearing cost, and expected children's transfer rate. All these factors jointly determine the rate of return on child investment, which we think is the key element people consider when making fertility decisions.

The remaining of the paper is organized as follows: Section 2 describes the dynamic fertility choice model and discusses several channels through which social insurance can affect fertility. Section 3 presents the main calibration results. In order to examine the relationship between social insurance and fertility, we calibrate our theoretical model to match the 1985 and 2005 TFRs in China, which represents the scenarios with and without social insurance. We further simulate our model under hypothetical scenarios to isolate the role of social insurance from other factors. In Section 4, we show how the price and income effects as well as the liquidity constraint affect the fertility choices of families with heterogeneous income. Section 5 provides sensitivity analysis on childbearing cost, potential change in social attitudes and the social insurance tax rate. We make some concluding remarks in Section 6.

2 The Model

The theoretical framework in this paper is a dynamic fertility choice model, which examines peoples' decisions on whether or not to have children and how many children they would like to have. Instead of assuming the number of children is a continuous variable, we suppose peoples' fertility choice is discrete in that they can choose to have one, two or three children³. Considering that the one-child policy may not be the driving force for the consistent TFR decline after 1985, we do not impose the one-child limit in our framework. To determine the optimal number of children to bear, parents will compare the expected life-time utility under each situation, assuming other decisions like consumption, saving and transferring to elderly parents are made optimally.

2.1 A Generic Model

We assume individuals can live three periods: young, middle-age, and old⁴. Young individuals simply consume parents' resources to grow up. When they are middle-aged, they supply one unit of labor, obtain income⁵ (W_t) and make optimal decisions on fertility (0, 1, 2, or 3), consumption (C_t^m), saving (s_t), and transfer to their elderly parents (d_t). Under the old-age support motivation, parents view children as investment goods and expect to receive transfers from them when parents become old next period. The level of attention adult children give to their elderly parents is denoted by η , which can also be regarded as the degree of altruism of adult children to their elderly parents. In addition, the cost of rearing children consists of two parts: a fixed cost (a) and an income-varying cost (bW_t). When individuals become old, they retire and their consumption is financed from three

³Although we observe some families having more than three kids, the maximum number of children considered in our framework is three. Based on the United Nations data, worldwide average TFR was around 4.9 in the 1950s, decreased to 3.5 in the 1980s, 2.6 in the 2000s, and is projected to fall to 2.2 in 2050. In the US, TFR fell from 3.7 in 1960 to 2.1 in 2008; in China this number decreased from 5.5 in 1960 to 1.8 in 2008; and for European Union countries, the TFR was only 1.6 in 2008. Considering all these historical data and the predicted trend, we believe a fertility quota of three children per family is reasonable and should not distort our main conclusion.

⁴To avoid confusion, we call them children, parents (or adult children), and grandparents (or elderly parents).

⁵Here is a rule for notation: lower-case letters usually represent the percentage or ratio, while upper-cases represent the absolute level. For example \bar{W}_t is the society-wide average income, $W_{t,i}$ is the income for individual i , and the corresponding relative income is $w_{t,i} = W_{t,i}/\bar{W}_t$. Similarly, $s_{t,i}$ represents the private saving rate for individual i , while $S_{t,i} = s_{t,i}W_{t,i}$ is his/her private saving amount. For ease of notation, we omit the subscript i .

sources: the transfers from their adult children (D_{t+1}), private saving from the previous period ($R_{t+1}s_tW_t$) and social insurance benefits (SI_{t+1}) if they are covered by the program.

In this framework, children are viewed as risky investments in the eyes of their parents. On the one hand, with probability p , young individuals can not grown up (i.e. mortality risk); on the other hand, children's transfers in the next period (D_{t+1}) are uncertain. In detail, we decompose the transfer amount as: $D_{t+1} = d_{t+1}w_{t+1}\bar{W}_{t+1}$, where both transfer rate (d_{t+1}) and children's relative income (w_{t+1}) are random variables⁶. We further assume that d_{t+1} follows a Beta distribution which guarantees the transfer rate is within the range of $[0, 1]$; and w_{t+1} is log-normally distributed, which ensures that the relative income is positive, and the median income is smaller than the mean, as consistent with empirical income distributions.

A generic version of the individual optimization problem when social insurance program is in place is as follows⁷:

$$\text{Max}_{\{s_t, d_t, f_t\}} \mathbb{U}(C_t^m, C_{t+1}^o, C_t^o) = \{u(C_t^m) + \delta \mathbb{E}_t u(C_{t+1}^o) + \eta u(C_t^o)\} \quad (1)$$

s.t.

$$C_t^m = (1 - s_t - d_t)(1 - \alpha_t)W_t - (a + b(1 - \alpha_t)W_t)f_t \quad (2)$$

$$C_{t+1}^o = \sum_{i=1}^{f_t} d_{t+1,i}w_{t+1,i}(1 - \alpha_{t+1})\bar{W}_{t+1} + R_{t+1}s_t(1 - \alpha_t)W_t + SI_t \quad (3)$$

$$C_t^o = f_{t-1}d_t(1 - \alpha_t)W_t + R_t s_{t-1}(1 - \alpha_{t-1})W_{t-1} + SI_{t-1} \quad (4)$$

$$SI_t = (\gamma_t \bar{W}_t + \beta_t \alpha_t (1 - b f_t) W_t) R_{t+1} \quad (5)$$

$$SI_{t-1} = (\gamma_{t-1} \bar{W}_{t-1} + \beta_{t-1} \alpha_{t-1} (1 - b f_{t-1}) W_{t-1}) R_t \quad (6)$$

$$f_t \in \{0, 1, 2, 3\} \quad (7)$$

⁶We do not assume aggregate growth uncertainties, so \bar{W}_{t+1} will grow in a deterministic way.

⁷In our framework, we don't consider the economies of scale in raising children so that the cost of bearing two kids is twice as much as that of having one child. In addition, we assume transfers from children are independent from each other and follow the same product distribution.

For fixed f_t the F.O.C.s are:

$$u'(C_t^m) = \delta R_{t+1} \mathbb{E}_t \left(u'(C_{t+1}^o) \right) \quad (8)$$

$$u'(C_t^m) = \eta f_{t-1} u'(C_t^o) \quad (9)$$

Using logarithmic utility function and after some algebraic manipulation of eq. (8) and (9), we can substitute out d_t as:

$$d_t = \frac{\eta}{1 + \eta} \left(1 - s_t - b f_t - \frac{a f_t}{(1 - \alpha_t) W_t} \right) - \frac{R_t s_{t-1} (1 - \alpha_{t-1}) W_{t-1} + \text{SI}_{t-1}}{(1 + \eta) f_{t-1} (1 - \alpha_t) W_t} \quad (10)$$

The solution is characterized by an equation on s_t : $\text{LHS}(s_t) = \text{RHS}(s_t)$, where

$$\text{LHS}(s_t) = \frac{(1 + \eta) f_{t-1}}{\left(1 - s_t - b f_t - \frac{a f_t}{(1 - \alpha_t) W_t} \right) (1 - \alpha_t) W_t f_{t-1} + R_t s_{t-1} (1 - \alpha_{t-1}) W_{t-1} + \text{SI}_{t-1}} \quad (11)$$

However, $\text{RHS}(s_t)$ depends on the number of children parents decide to have. We first show that for $f_t = 1$:

$$\begin{aligned} \text{RHS}(s_t) &= \delta R_{t+1} \mathbb{E}_t \left(\frac{1}{d_{t+1} w_{t+1} (1 - \alpha_{t+1}) \bar{W}_{t+1} + R_{t+1} s_t (1 - \alpha_t) W_t + \text{SI}_t} \right) \\ &= \frac{\delta R_{t+1} p}{R_{t+1} s_t (1 - \alpha_t) W_t + \text{SI}_t} \\ &+ \int_{\mathbb{R}} \int_0^1 \frac{\delta R_{t+1} (1 - p)}{d_{t+1} w_{t+1} (1 - \alpha_{t+1}) \bar{W}_{t+1} + R_{t+1} s_t (1 - \alpha_t) W_t + \text{SI}_t} \\ &\quad f(d_{t+1}) f(w_{t+1}) d(d_{t+1}) d(w_{t+1}) \end{aligned} \quad (12)$$

where,

$$\begin{aligned} d_{t+1} &\sim \text{Beta}(\alpha_d, \beta_d) \\ \log(w_{t+1}) &\sim \mathcal{N}(\mu, \sigma^2) \\ \mathbb{R} &\equiv (-\infty, +\infty) \end{aligned}$$

Double integrations are necessary in eq. (12), because we assume both transfer rate d_{t+1} and relative

wage w_{t+1} are random variables. Given our parametric assumptions, there is no analytical solution for the equation $\text{LHS}(s_t) = \text{RHS}(s_t)$.

In order to find numerical solutions, we could construct discrete approximations to the two continuous distributions, i.e. find the appropriate grid points to represent the corresponding distributions and approximate the integral by summations. However, approximating the Beta and the log-normal distribution separately will end up with nested summations and be time-consuming⁸. A more efficient alternative is to approximate the product distribution. Although there is no analytical density function of the product distribution, we could generate a representative sample from it, by first simulating two large samples from the Beta and log-normal distributions separately, and second multiplying the simulated grid points from the above two samples. Denoting $z = d_{t+1}w_{t+1}$, we have reduced the double integral into a single integral so that RHS for the one-child case can be rewritten as:

$$\begin{aligned} \text{RHS}(s_t) &= \frac{\delta R_{t+1}p}{R_{t+1}s_t(1 - \alpha_t)W_t + SI_t} \\ &+ \int_{\mathbb{R}^+} \frac{\delta R_{t+1}(1 - p)}{z(1 - \alpha_{t+1})\bar{W}_{t+1} + R_{t+1}s_t(1 - \alpha_t)W_t + SI_t} f_Z(z) dz \end{aligned} \quad (13)$$

After this, we could select a certain number of grid points from the simulated product distribution $f_Z(z)$, and then approximate the integral by summation. Similarly, RHS(s_t) for the two- and three-child cases are as follows⁹:

$$\begin{aligned} \text{RHS}(s_t) &= \frac{\delta R_{t+1}p^2}{R_{t+1}s_t(1 - \alpha_t)W_t + SI_t} \quad (14) \\ &+ \binom{1}{2} \int_{\mathbb{R}^+} \frac{\delta R_{t+1}(1 - p)p}{z_1(1 - \alpha_{t+1})\bar{W}_{t+1} + R_{t+1}s_t(1 - \alpha_t)W_t + SI_t} f_Z(z_1) dz_1 \\ &+ \binom{2}{2} \iint_{\mathbb{R}^{+2}} \frac{\delta R_{t+1}(1 - p)^2}{(z_1 + z_2)(1 - \alpha_{t+1})\bar{W}_{t+1} + R_{t+1}s_t(1 - \alpha_t)W_t + SI_t} \prod_{i=1}^2 (f_Z(z_i) d(z_i)) \end{aligned}$$

⁸Applying the discretization to the Beta and the log-normal distribution separately will cause more efficiency problems when people choose to have two or three children. In the two-child case, if both children successfully survive to adulthood, one need to calculate two double-integrals, or do four nested summations. By the same token, the three-child case requires six nested summations to approximate the integrals. Not surprisingly, computing burden will then increase exponentially.

⁹ $\binom{n}{r}$ represents the number of possible combinations of r objects from a set of n objects, which is calculated as: $\binom{n}{r} = \frac{n!}{r!(n-r)!}$.

$$\begin{aligned}
\text{RHS}(s_t) &= \frac{\delta R_{t+1} p^3}{R_{t+1} s_t (1 - \alpha_t) W_t + \mathbf{SI}_t} & (15) \\
+ \binom{1}{3} & \int_{\mathbb{R}^+} \frac{\delta R_{t+1} (1-p) p^2}{z_1 (1 - \alpha_{t+1}) \bar{W}_{t+1} + R_{t+1} s_t (1 - \alpha_t) W_t + \mathbf{SI}_t} f_Z(z_1) dz_1 \\
+ \binom{2}{3} & \iint_{\mathbb{R}^{+2}} \frac{\delta R_{t+1} (1-p)^2 p}{(z_1 + z_2) (1 - \alpha_{t+1}) \bar{W}_{t+1} + R_{t+1} s_t (1 - \alpha_t) W_t + \mathbf{SI}_t} \prod_{i=1}^2 (f_Z(z_i) d(z_i)) \\
+ \binom{3}{3} & \iiint_{\mathbb{R}^{+3}} \frac{\delta R_{t+1} (1-p)^3}{(z_1 + z_2 + z_3) (1 - \alpha_{t+1}) \bar{W}_{t+1} + R_{t+1} s_t (1 - \alpha_t) W_t + \mathbf{SI}_t} \prod_{i=1}^3 (f_Z(z_i) d(z_i))
\end{aligned}$$

2.2 Does Social Insurance Really Reduce Fertility Rate?

A close look at the model, however, shows that things are more complicated than the intuitive idea that fertility drops in the presence of social insurance. In fact, social insurance has a heterogeneous effect on fertility and its impact is reflected through several channels: the price effect, the income effect, the liquidity constraint effect, and the change in expectation on future transfers.

The first channel through which social insurance directly affects fertility is the income effect. As an income redistribution program, social insurance favors poor people at the expense of the rich. After the introduction of social insurance, poor peoples' present discounted value of lifetime income should increase while that of the rich decreases. Since children, saving, transfer, and consumption are all normal goods, poor people would like to raise more kids and the rich tend to rear fewer.

The second channel is the direct price effect. We assume the income-varying part of the child-bearing cost is tax-deductible: parents could either send children to daycare and deduct the child-care expense when filing their tax returns, or reduce their labor supply, like working at home, to take care of their kids. After social insurance tax is introduced, the actual income-varying cost is $(1 - \alpha_t) b W_t$ instead of $b W_t$. This is equivalent to a per-child subsidy of the size $\alpha_t b W_t$. Since childbearing becomes cheaper, the fertility rate should increase, for both the poor and the rich.

Combining these two effects, however, we find that the effects work in the same direction for poor people so that they will have more kids; the effects are offsetting for the rich so whether

they have more or fewer kids depends on which effect dominates. Since a country's TFR is an average fertility choice of different types of people and given that the income distribution is usually more skewed to the left (far more people below the mean than those above), it could happen that the overall fertility rate could increase after a pension system is introduced, instead of declining as Boldrin, Nardi, and Jones (2005) have argued. However, it is too early to conclude that social insurance should increase TFR since there are two indirect channels that this program could affect peoples' fertility decisions.

The third channel is whether people can borrow against their future pension benefits. Our previous argument that social insurance increases the life-time income for the poor but decreases that for the rich holds under the condition that financial markets are complete so that people can borrow against their future pension benefits. This will lead to a negative private saving rate, especially for those poor people whose future pension benefits occupy a large proportion of their life-time income. The assumption of a complete market makes some sense in that several informal channels like borrowing from relatives are available in China. On the other hand, we also need to acknowledge that a mature consumer credit market does not exist in China¹⁰. Hence any informal borrowing may be able to lessen the liquidity constraint, but not eliminate it completely. So the degree of liquidity constraint should be a continuous variable between 0 and 1. This effect will be explicitly considered in our calibration exercises.

The fourth channel is a potential change in peoples' expectations. Once social insurance is introduced, a social attitude on who cares for the elderly may shift. The grown-up children in the next period, after realizing that their elderly parents' retirement lives are taken care of by the pension plans, will feel that their role of supporting elderly parents' old-age life has been substituted, and thus exhibit less altruistic behavior (i.e. a smaller degree of altruism), and in turn transfer less. The current parents, in anticipation of this change, will rationally expect a lower return on child investment, since the distribution of the transfer rate from children moves leftwards, and respond by having fewer kids. This channel will take effect gradually and it is hard to verify whether parents are forward-looking and whether such expectation shifts have happened. We will deal with

¹⁰This is in great contrast to the advanced economies, where the credit market is well developed. In the US, several state pension benefit agencies have the pension loan programs, and various commercial products are available, like the loan provisions under 401(k) plans.

this issue in the sensitivity analysis part.

In sum, considering all the four possible channels, we see that social insurance may have an ambiguous effect, with the price and income effects pushing up the fertility rate while liquidity constraint and social attitude changes pulling down the TFR.

However we do see in reality that there is an obvious downward trend in fertility over the past few decades. If social insurance's effect is ambiguous, what are other factors that contribute to the decline in TFR? We propose that factors closely related to the rate of return on child investment (i.e. the cost and rewards of childbearing) are responsible. One factor is that as economy develops and living standard rises, the cost of raising children increases. The other factor is that people may predict that the aggregate economic growth will slow down¹¹. Both factors imply that children's value in terms of investment return will decline¹². Thus, people tend to have fewer kids and allocate extra resources to saving, transfer or consumption.

3 Calibration

In this part we calibrate our model under two scenarios (with and without social insurance), to match the TFR in China in 1985 (when social insurance system was absent) and in 2005 (when the government has undertaken a series of structural reforms to the pension system). This 20-year gap¹³ also facilitates our overlapping generation framework.

China's national social insurance program was launched around 1993. Before that, the period 1950-1978 was characterized by two anomalous events—the Great Famine and the 10-year Cultural

¹¹To have a snapshot on this hypothesis, we find that US real GDP grew at 6.34% in 1935-1939, 5.98% in 1940-1949, 4% during 1950-60s, dropped to 3% in the last three decades of the 20th century, and was only 2.33% between 2000 and 2008. During the same period, the TFR falls from around 3.0 in the 1930s to the current level of 2.06, a decline of 30%.

¹²Based on our assumption that $D_{t+1} = d_{t+1}w_{t+1}\bar{W}_{t+1}$ and the growth in average wage is equal to GDP growth, even if the distribution of d_{t+1} does not shift leftwards, an expected decrease in GDP growth will lead to a smaller \bar{W}_{t+1} , which then lowers D_{t+1} .

¹³Throughout the calibration, we assume that a period is 20 years which may be a bit away from the realistic setting, i.e 40 years of working and 20 years of retirement.

Revolution. Both have had major impacts on the economy as well as on fertility, especially the Great Famine. Beginning in 1979, the government adopted the “reform and opening-up” policy and the economy experienced dramatic changes in the early 1980s. For all these reasons, we choose the TFR in year 1985 as the empirical target for the scenario without insurance. After the 1993’s launching, various policy reforms took place to the social insurance programs, and by 2005 the system has stabilized. Therefore, our calibration target for the scenario with social insurance is the TFR in 2005.

3.1 Parameter Choices

For all the parameters, we summarize their values in Table 1. Since we calibrate our model to two different years (1985 and 2005), there are four generations in our calibrations, i.e. 1965, 1985, 2005, and 2025.

First, we provide formal justifications for those parameters related to child investment. Child-bearing cost consists of two parts: a fixed cost (a) and an income-varying cost (bW_t). For the fixed cost a , we assume it is around 5% of the average income, i.e. one-year’s average income. With regard to the income-varying part, Echevarria and Merlo (1999) find that cost to a woman of having a child is about 5% of her working lifetime, while according to Juster and Stafford (1991), hours per week allocated on childcare account for between 6.43% and 18% of parents total available time. In China, children are heavily dependent on parents’ support at least before marriage. In order to capture this characteristic, we set b as 10%. In terms of child investment rewards, we assume that children’s transfer rate follows a Beta distribution ($d_{t+1} \sim \text{Beta}(\alpha_d, \beta_d)$) and the mean ($\mathbb{E}_t[d_{t+1}]$) is 12.5%.

Second, since we solve our model in a partial equilibrium framework, we need to set appropriate values for interest rates, income levels, etc. across periods. (1) R_{1985} and R_{2005} are computed as the products of annual real gross interest rate for 1966-1985 and 1986-2005¹⁴. And one might

¹⁴The real interest rates are calculated from nominal rates and inflation rates as $R = 1 + r = (1 + i)/(1 + \pi)$, where r is net real interest rate, π inflation and i nominal rate. The inflation rates are available from 1980 to 2008, and are assumed to be 0 from 1950 to 1979, a time when Chinese economy almost stagnated. The calculated net real interest

conjecture that the real interest rate will stay at a relatively low level between 2006 and 2025, so we assume $R_{2025} = (1 + 1\%)^{20}$. (2) Using historical data, we calculate the real GDP growth rate, and use it to approximate the real income growth between 1966 and 1985 as well as between 1986 and 2005. In addition, we pick 6% as annual GDP growth during 2006-2025, accounting for the recent financial crisis. (3) $\bar{W}_{t+s}, \forall s \in \{-1, 0, 1\}$ are the average labor income: we normalize $\bar{W}_t = 1$ and set $\bar{W}_{t-1} = \bar{W}_t/g_t$ and $\bar{W}_{t+1} = g_{t+1}\bar{W}_t$, where g_t and g_{t+1} are real GDP growth rate for the current and next period. (4) Within each period, we define relative income ($w_{t+s,i}, \forall s \in \{-1, 0, 1\}$) as the ratio of individual income to average level. There is a cross-sectional distribution of this relative income: $w_{1985,i}$ follows the empirical income distribution for year 1985, $w_{2005,i}$ for year 2005. Due to data limitation, $w_{1965,i}$ is assumed to follow the same distribution as $w_{1985,i}$ ¹⁵. Since income distribution is moving slowly and it is difficult for parents to make an accurate conjecture, we assume a static expectation: parents believe that the distribution of the next generation's income will be identical to the income distribution in their own generation. Based on this, $w_{2025,i}$ has the same distribution as $w_{2005,i}$. The details are shown in Table 2.

Third, the utility is set as the natural logarithm function; the intertemporal discount factor is set as $\delta = 0.99^{20}$. In addition we also need a value for η (parents' attention on grandparents' utility). As expected, there is no direct data measuring this; and it should vary across countries and even households. Boldrin, Nardi, and Jones (2005) calibrate their model using $\eta = 0.185$ for England. Here we set it as 0.5, since under the Confucian doctrine, Chinese people tend to care more about their elderly parents' old-age life.

Fourth, we don't have data on child mortality rate between age 0 and 19. However, according to the World Development Indicators database by the World Bank, the mortality under age 5 per 1,000 live births is around 45 in 1995 and 25 in 2005. We conjecture that the mortality rate between age 0 and 19 should be fairly close to the mortality rate under age 5. Therefore, we pick a moderate value 5% for our calibration exercises.

rate between 1966 and 1985 is around 90%, while it is slightly negative for the period 1986-2005.

¹⁵The earliest income distribution data we could obtain is for year 1995, which is used to approximate the cross sectional distribution of labor income in 1985. Because of a series of disruptions, the income distribution did not change much from 1965 to 1985.

Fifth, social insurance benefit reflects a combination of minimum living expenses and personal contribution history. The minimum pension is a small percentage of average income level and the contribution-based benefit is positively related to individual contribution history. From year 2000 onwards, Chinese workers contributed on average 8% of their incomes to the social insurance trust fund. We further assume the minimum pension ratio is 10%. Due to this setting, a balanced government budget constraint requires that the marginal pension increase should always be less than 1 for one more dollar's tax payment, and thus we set the value of this coefficient to be 0.8. We also suppose middle-age people between 1966 and 1985 were not covered by any pension system, and that the expected social insurance tax rate for 2005-2025 remains at 8%¹⁶.

Finally, in terms of the two state variables—TFR and saving rate in the previous period, we use historical data in the 1960s and 1980s when matching the 1985 and 2005 fertility rates, respectively. In particular, we approximate the saving rate of the middle-age people by household saving rate in Modigliani and Cao (2004).

3.2 Calibration Results

Before showing our results, we briefly discuss the calibration procedures. There are three dimensions of heterogeneity here: income of parents $W_{t,i}$, grandparents $W_{t-1,j}$, and the expected income distribution of kids $W_{t+1,k}$. First, we solve individual maximization models with different fertility choices for each combination of (i, j, k) . Second, by comparing the expected life-time utility when $f_t = 0, 1, 2, 3$, we obtain the optimal fertility decision for each income combination pair. Third, we aggregate the individual fertility choices over dimension k , then over j and finally over i , which leads to a society-wide TFR, corresponding to a particular setting on social insurance.

The stylized fact we aim at matching is TFR, which equals 2.60 in 1985's China and 1.80 in 2005, as computed from the World Development Indicators database by the World Bank. Calibrated from the model without social insurance, the weighted average of TFR is 2.55 which is quite close

¹⁶With the rise in the aged dependency ratio, it is expected that the social insurance tax rate might increase in the future. And we will deal with its effect in the sensitivity analysis part.

to its empirical counterpart. And the society-wide average private saving rate is 0.56%¹⁷ and people on average transfer 19.76% of their income to elderly parents.

The calibration results for 2005 China is also encouraging. Without applying the liquidity constraint, the calibrated TFR is 1.96 kids with -8.9% private saving¹⁸ and 23.72% transfer rates from adults to their elderly parents when social insurance is in place. When the liquidity constraint is turned on, the calibrated TFR drops to 1.27 kids with a significant increase in private saving rate to 6.99% and a relatively stable transfer rate of 22.75%. Although banks normally do not accept pension benefits as collateral, various borrowing channels exist such as from relatives and friends. The liquidity constraint may be binding for some people, but not for others. We find that the average TFR from the models with and without liquidity constraint is around 1.60 kids, which is not far away from the values we observed in the data.

In addition, we find that our calibrations match the declining tendency in TFR and the increasing trend in private saving as Chinese economy develops. However, the decline in TFR seems to contradict our discussion of the price and income effect of social insurance. Hence, we are interested in examining whether our calibration results are consistent with the predictions from our theoretical framework; if so, what are the factors (outside the social insurance program) that contribute to the decline in TFR from 1985 to 2005. We provide a detailed analysis of our calibration results by decomposing and comparing outcomes under various hypothetical environments in the next part.

3.3 Analysis of Calibration Results

Comparing the calibrated TFR between 1985 and 2005 can not give us a clear answer on the effect of social insurance on fertility since many other factors also change during this period. To distinguish the impact of social insurance from that of other factors, we calibrate the model under

¹⁷The calibrated 0.56% saving rate in 1985 is too small as compared to that from Modigliani and Cao (2004) where the saving rate is around 15%. This is because parents in our model invest a lot in children, whose transfers will substitute, to a great extent, the role of saving for retirement. Another reason is our utility setting: the natural logarithm implies a relative risk aversion parameter of 1, while it is commonly estimated to be 3-5 from micro level data. As expected, the more risk averse, the more the households will save.

¹⁸Combining the private saving and the mandatory social insurance saving, the total saving rate is around 11.62%.

hypothetical environments such as the presence of social insurance in 1985 and the absence of it in 2005. The calibrated results are summarized in Table 3. The dark gray cells represent the actual scenarios, while the light gray ones reflect the hypothetical environments.

First, we suppose parents in 1985 were covered by the social insurance program and calibrate the model using parameter values corresponding to the 1985 economy. It is clear that, other things equal, the combination of the price and income effect of social insurance increases TFR from 2.55 to 2.82, a net change of 0.27, which is consistent with our discussion that increased life-time income and reduced childbearing cost induce people to have more children by running a negative private saving at the current period. However, if people can not borrow against their future pension benefits, calibrated TFR drops from 2.82 to 2.10, indicating a substantial effect of liquidity constraints on reducing fertility.

Second, we assume parents in 2005 were not covered by the social insurance program. The calibrated TFR is 1.80, which can be compared with 1.96 under the scenario with social insurance in 2005. Once again, this shows that the combined price and income effect of social insurance is positive. When we add the liquidity constraint, the TFR falls to 1.27, confirming the substantial effect of this constraint under the 2005 parameter combination.

In sum, Table 3 gives us a good example to understand the effect of social insurance on TFR. Although the price and income effects and the impact of liquidity constraint are consistent with our predictions, they, themselves, can not explain the big drop in the calibrated TFR from 1985 to 2005. Looking at Table 3 vertically, we see that the 2005 parameter combination generates lower TFRs than the 1985 one, whatever we impose social insurance or not. Factors other than social insurance may play a dominating role in reducing the TFR over time.

As documented in Table 1 and 2, a set of parameters change their values from 1985 to 2005, including the real interest rate (R_{t+1} and R_t), GDP growth rate (g_t and g_{t+1}), TFR and saving rate in the previous period (f_{t-1} and s_{t-1}), and income distribution of parents (w_t). In order to examine the effect of each factor, we calibrate the model under several hypothetical environments: each time only one parameter changes its value to reflect the 2005 economy, while all the other parameters

take their values in 1985. A summary of this comparative statics exercise is reported in Table 4.

The first parameter is R_{t+1} , i.e. the real interest rate on private savings between period t and $t + 1$. The change in this parameter value affects the interest income parents will receive when they become old. From Table 1, R_{2025} is higher than R_{2005} , indicating a rise in the rate of return on private savings, which will induce a higher private saving rate and a lower fertility. Our result confirms this argument: the TFR drops from 2.55 to 2.49, with an increase in the average saving rate from 0.56% to 1.42%.

The second parameter is g_{t+1} , i.e. the expected GDP growth rate in period $t + 1$. This parameter matters because it is used to calculate the society-wide average income \bar{W}_{t+1} , which in turn affects the expected child transfer for everyone ($D_{t+1} = d_{t+1}w_{t+1}\bar{W}_{t+1}$). Historical data shows that the annual real GDP growth rate is more than 9% during the period 1986-2005. However, due to the recent financial crisis, we think it is very hard for China to keep growing at such a high speed for the next 20 years. A less impressive long-run economic growth translates into a lower growth of the average income, and thereby a reduced rate of return on child investment and an expected drop in fertility. Our calibration shows a relatively large drop in TFR from 2.55 to 2.21 kids.

The third parameter we examine is g_t , which is used to compute the average income in the previous period ($\bar{W}_{t-1} = \bar{W}_t/(1 + g_t)$). Since Chinese economy grew at a higher speed during the period 1986-2005 than 1966-1985, the average grandparents' income calculated using g_{2005} is lower than the one using g_{1985} . This means grandparents would become poorer, which would induce a higher transfer. When parents transfer more resources to their elderly parents, fewer resources are left at current period and we expect to see a drop in both saving and fertility. However, since the difference between g_{2005} and g_{1985} is small and it does not affect the rate of return on child investment, the calibrated fertility rate remains roughly the same and the changes in transfer and saving are trivial.

The fourth parameter we are interested in is f_{t-1} , i.e. the state variable indicating the number of siblings of parents. China's TFR in 1965 was 6.08 kids, but this number decreased dramatically to 2.60 in 1985. According to eq. (10), where we assume cooperative transfer game among sib-

lings, there is a positive relationship between optimal transfer rate and the number of siblings. Our calibration shows that when f_{t-1} becomes smaller, d_t drops from 19.76% to 19.24%, with TFR unchanged.

The fifth parameter we look at is $R_t s_{t-1}$, which measures grandparents' saving balances. Everything else equal, a higher $R_t s_{t-1}$ represents richer grandparents. Rationally, parents should transfer less to their elderly parents and use the extra resources to save or to raise children. From 1966-1985 to 1986-2005, R_t decreased by a small amount, but the average saving rate increased from 5% to 15%, thus grandparents became richer. Our calibration results reveal that the effect of grandparents' financial position is quite limited in that parents only decrease their transfer by a tiny percentage. Naturally, since $R_t s_{t-1}$ does not directly affect the rate of return on child investment, there is no change in the calibrated TFR.

The final one is income distribution among the current generation of parents, where the gap between poor and rich people enlarges significantly from 1985 to 2005. Our calibration results indicate that TFR decreases while both saving and transfer rates rise. We will have a detailed discussion of the relationship between parents' income position and their fertility decisions in the heterogeneity analysis part below.

4 Heterogeneity Analysis

The effect of social insurance is not uniform across the population. In this part we show that the heterogeneous effects of social insurance depend largely on one's position in the income distribution. We focus on the dimension of parents' income (W_t): normalize the average income (i.e. $\bar{W}_t = 1$), and assume relative income ranges from 10% to 6 times of the average. All the other parameter values remain the same as in the above calibrated models.

Different from the benchmark calibration, we only aggregate the individual fertility choices over the dimensions of expected kids' and grandparents' income to obtain a series of weighted average TFRs corresponding to each grid point in parents' income distribution. In addition, we also

calibrate our model under a hypothetical scenario, where both parents and grandparents were not covered by the social insurance program in 2005. Thus, a comparison between the outcome from the hypothetical scenario and that from the actual one helps us to single out the impact of social insurance.

4.1 Total Fertility Rate

Figure 1 describes the optimal fertility choices across parents' income. The blue line is the calibrated TFR for 1985, which can be regarded as a baseline scenario. The green line represents the optimal fertility choices under the hypothetical scenario that both parents and grandparents were not covered by the program in 2005. The orange and the purple lines are results when social insurance is in place. The orange line indicates the price and income effect, while the purple one shows how TFR changes if parents face liquidity constraints.

One common feature across all these scenarios is: starting from the lowest income percentile, fertility rate increases as income rises; however this trend reverses when income is above a threshold level¹⁹. The negative relationship between TFR and income when $W_t > \bar{W}_t$, is consistent with previous literature that when parents become rich, the income-varying cost of childbearing becomes higher, which prohibits some of them from raising children. The smaller fertility rate among the poor is because they don't have enough resources to bear the fixed cost of raising children.

Besides the above common feature, there are dramatic differences among these scenarios. First, comparing the blue line with the green one, we find that for every income level, TFR under the hypothetical scenario is lower than that under the baseline scenario, indicating a consistent effect of other factors (such as expected long-run economic growth and interest rate) on reducing TFR from 1985 to 2005. Moreover, the magnitude of the differences between these two scenarios enlarges when parents' income rises, which suggests that rich people may be more sensitive to changes in other contributing factors. For example, the difference is only 0.05 for people earning $0.2\bar{W}_t$ and

¹⁹The threshold level is roughly equal to the society average income, although it shifts slightly across different scenarios.

less than 1.0 if parents' income is within $[0.1, 1.3]\bar{W}_t$; but the gap increases to 1.8 kids when people earn $[3.0, 4.1]\bar{W}_t$. Second, comparing the green with the orange line, we see vividly the combined price and income effect of social insurance on fertility. On the one hand, for relatively poor people, the price and income effects reinforce each other and push up the TFR. In Figure 1, for people whose income is within $[0.1, 1.1]\bar{W}_t$, TFR in the presence of social insurance is higher than that in the absence of social insurance. On the other hand, changes in fertility rate among relatively rich people depend on which of the two effects dominates. According to Figure 1, we observe a weak dominance of the income effect in that for parents earning $[1.2, 6.0]\bar{W}_t$, TFR with social insurance is lower than or equal to the one without social insurance. Third, the impact of the liquidity constraint is quite clear by comparing the orange with the purple line. If people can not borrow against their future pension benefits, their current period resources shrink after tax payments, which induces a lower fertility rate. This effect is particularly significant for the poor. For example, people earning $0.1\bar{W}_t$ choose not to have children if they can't borrow against their future pension benefits; but instead raise 1.3 kids if this liquidity constraint is absent. The magnitude of this effect diminishes when peoples' income rises. That is, if their income is sufficiently high, this constraint will not bind and thus have no impact on their fertility.

4.2 Average Saving Rate

According to our model, parents face two basic decisions: consumption and investment. The former one is divided into consumption of themselves and transfer to their elderly parents; while the latter one is divided into investment in children which is risky and in risk-free private savings, plus some mandatory social insurance contributions. Based on our previous discussion, the price effect of social insurance lowers the cost of childbearing, which induces an increase in the rate of return on child investment. Similarly, other factors such as expected long-run GDP growth and interest rate also affect the rewards on child investment. Since saving and fertility are close substitutes for parents in our model, we are interested to see whether saving behavior changes in an opposite way as compared to the fertility.

Figure 2 shows the average private saving rate as a function of parents' income. As expected, people tend to save more when their income rises. A comparison between the baseline scenario (the blue line) and the hypothetical scenario without social insurance in 2005 (the green line) indicates that the saving rate of the poor stagnates around 0.1%, while private saving among the rich increases significantly in response to the big drop in TFR as seen in Figure 1. What's more, there are two other notable observations when social insurance is in place. First, according to the orange line, relatively poor people whose income is less than $1.1\bar{W}_t$ have great incentives to borrow against their future pension benefits to raise children, reflected as the negative private saving rate at the current period. However, this borrowing incentive diminishes quickly when parents' income rises above the society average, indicating the loss of interest in borrowing as a result of a decline in the rate of return on child investment for the rich. Second, when the liquidity constraint is applied, everyone's saving rate is positive, but the value is lower than the one without social insurance because people have fewer resources left after tax payments.

4.3 Transfer Rate

The third variable of potential interest is the transfer from the middle-age people to their elderly parents, which measures the cross-generational linkages between adult children and elderly parents.

Given our model specification, decisions on investment and consumption can be separated. Within consumption, because of logarithm utility, parents are maximizing a Cobb-Douglas aggregation of their own and their elderly parents' consumption²⁰. Therefore, if there is no uncertainty in child investment, transfer and consumption each occupies a fixed proportion of the total expenditure. It is then quite natural to see a convergence in the transfer rate for people earning above average income, and some dynamics for people whose consumption decisions are affected by precautionary motive in the absence of social insurance and by pension benefit generosity in the presence of such an income redistribution program. From Figure 3, when parents' income is above the average, the

²⁰This is because

$$\log[C_t^m] + \beta \log[C_{t+1}^o] + \eta \log[C_t^o] = (1 + \beta + \eta) \log[(C_t^m)^{\frac{1}{1+\beta+\eta}} (C_{t+1}^o)^{\frac{\beta}{1+\beta+\eta}} (C_t^o)^{\frac{\eta}{1+\beta+\eta}}]$$

transfer rate stabilizes around 20% without social insurance coverage; and around 23% with the coverage²¹.

From Figure 2, private saving rate in the presence of social insurance is always smaller than that without the program. With the mandatory social insurance saving, parents' burden to save enough resources for their own elderly life due to the precautionary saving motive lessens so that they can transfer more resources to their elderly parents, which helps explain the higher convergence level in transfer when social insurance is in place. In addition, although some factors consistently affect the rate of return on child investment and thus on fertility, they have almost no impact on transfer behavior when comparing the 1985 baseline with the hypothetical scenarios. This is another confirmation that fertility and private saving are close substitutes.

5 Sensitivity Analysis

Broadly speaking, the main factor that affects fertility rates is the rate of return on child investment, which could be decomposed into the childbearing cost ($a + bW_t$) and the expected transfer from children (D_{t+1}). First, since we do not have data to measure the fixed and income-varying costs of raising children, we make somewhat arbitrary assumptions on related parameters and suppose that their values did not change between 1985 and 2005. However, we conjecture that there might exist an increasing trend of childbearing cost in reality and the cost itself may be heterogeneous across income groups. Therefore, we provide sensitivity analysis on both the fixed and income-varying costs to show their impacts on fertility choices.

Second, based on our discussion of the channels through which social insurance can affect fertility, we consider the price and income effects as well as the liquidity constraint channel explicitly in our calibration exercises and heterogeneous analysis. However, in terms of potential changes in social attitudes that the degree of altruism may decrease and parents may expect a lower children's transfer rate in the presence of social insurance, it is hard to tell whether social attitude changes

²¹The transfer rate is defined as a percentage of disposable income. So a 23% transfer rate with social insurance is roughly equal to 21% ($= 23\% \times (1 - 8\%)$) of pre-tax income.

have already taken place, and if so, to measure the magnitude of the changes. In order to shed light on the potential impact of this channel on fertility, we simulate our models under hypothetical scenarios that either η or \bar{d}_{t+1} ($\mathbb{E}_t[d_{t+1}]$) changes its value in 2005.

Third, social insurance program is not stationary over time and due to the progress of an aging society, it is expected that the social insurance tax rates will rise to raise more funds from the working generation in order to support the retired generation. The changes in social insurance tax rates will alter both the opportunity cost of childbearing and the expected life-time income. Boldrin, Nardi, and Jones (2005) show that more than 50% of the differences in TFR between US and European countries can be explained by the differences in social insurance programs. They also find a significantly negative relationship between TFR and the social insurance tax rates. Thus, we are interested to see whether this relationship holds in China and whether Chinese parents are sensitive to the tax rate changes.

5.1 Childbearing Cost

In our benchmark calibration, we assume the fixed cost of raising a child equals one year's average income (i.e. $a = 0.05$). Here, we consider two candidate values of a to examine its effect on fertility. The simulated TFRs across parents' income distribution are displayed in Figure 4.

The blue line represents the 1985 benchmark scenario and the green line shows the results in the presence of social insurance in 2005. The orange and the purple lines are simulated TFRs under two hypothetical scenarios when the fixed cost of childbearing increases to two year's or four year's average income (i.e. $a = 0.1$, or 0.2). It is clear that TFR is negatively correlated with the fixed cost and poor peoples' fertility rates are more sensitive to changes in the fixed cost. For example, for people earning $0.1\bar{W}_t$, they choose to have 1.3 kids when the fixed cost equals one year's average income; however, this number decreases to 0.6 if the fixed cost doubles; and it further drops to 0 if the fixed cost rises to four years' average income. By contrast, rich peoples' fertility rates are not affected much by this kind of change; the magnitude in TFR decline is less than 0.5 when people earn more than 3 times the average.

Regarding the income-varying cost, we treat it as 10% of parents' income W_t in the baseline scenario, and then increase it to 15% and 20%. We also find a negative relationship between simulated TFRs and the income-varying cost in Figure 5, but this negative relationship is different from the one between TFR and the fixed cost in several aspects. First, relatively poor people are not so sensitive to the changes in b . For people earning $[0.1, 0.5]\bar{W}_t$, the difference in TFRs is less than 1.0 when b increases from 10% to 20%. The poorest people still choose to have 0.9 kids, while we notice that they will choose not to have children when a rises from one year's to four year's average income. Second, changes in TFR for relatively rich people are more pronounced. For those whose incomes are within the range of $[0.6, 2.7]\bar{W}_t$, the decline in TFR is larger than 1.0. Third, we find that when couples' income is higher than $3.2\bar{W}_t$, they choose not to have children if the income-varying cost rises to 20%. This result provides a supporting evidence for the low fertility rate among the rich: the high income-varying cost prohibits some of them from having children.

5.2 Potential Changes in Social Attitudes

The potential changes in social attitudes are twofold: one is parents' degree of altruism towards their elderly parents (η) may decrease; the other is parents expect that the distribution of their children's transfer rate may move leftwards. First, we consider two candidate values for η ($\eta = 0.35$, or 0.20) to examine how peoples' fertility rates change if they do not pay as much attention to their parents as before. Second, based on our assumption that transfer rate d_{t+1} follows a Beta distribution (i.e. $d_{t+1} \sim \text{Beta}(\alpha_d, \beta_d)$), we modify the parameter values so that the average transfer rate declines from the original 12.5% to 10% or 8%.

The simulated TFRs under various η values are shown in Figure 6. For people earning $[0.1, 0.7]\bar{W}_t$, when η declines, TFR increases by a small amount. However, when parents' income is higher than $0.7\bar{W}_t$, there is almost no change in TFR when η drops from 0.5 to 0.2, which is a little bit surprising.

In order to explain this observation, we need to look at the changes in optimal transfer rate d_t when η decreases. Since η represents how grandparents' utility is viewed by parents, a smaller

η means the same amount of transfer brings less rewards (i.e. utility) to parents²². Figure 7(a) illustrates the interactions between η and d_t that when η declines from 0.5 to 0.2, everyone's transfer declines and thus the transfer rate converges to a much lower level at around 10% compared to the previous 23%. At the same time, from Figure 7(b), when η falls, the private saving rate does not change for those whose incomes are within $[0.1, 0.7]\bar{W}_t$, but rises significantly for people earning $[0.8, 6.0]\bar{W}_t$. Combining Figure 7(a) and 7(b), a decline in η directly reduces the transfers from the middle-age people to their elderly parents, while how they allocate the extra resources depends on the comparison in the rate of return between risky child investment and risk-free private saving. For relatively poor people, rate of return on fertility is higher than that on saving so that we observe an increase in TFR; by contrast, relatively rich people see higher return on saving than on fertility, which induces an increase in s_t instead.

In contrast to the minor change in TFR when η declines, TFR decreases significantly when the mean expected old-age transfer from children declines. In Figure 8, when \bar{d}_{t+1} falls from 12.5% to 8%, the simulated TFRs decline for everyone, although the magnitudes are different depending on parents' income position. For people earning $[0.1, 0.5]\bar{W}_t$ or $[2.8, 6.0]\bar{W}_t$, the simulated TFR only changes a small amount (less than 0.5) even if \bar{d}_{t+1} drops by nearly 40%. However, people earning $[0.6, 2.7]\bar{W}_t$ are quite sensitive to changes in \bar{d}_{t+1} . For example, for people earning average income, their TFR drops from 2.4 to 1.15, when \bar{d}_{t+1} decreases from 12.5% to 8%.

5.3 Social Insurance Tax Rate

Due to the rapid development of an aging society, the aged dependency ratio rises dramatically in China. In a "pay-as-you-go" system, a challenging question is how to ensure that this program is sustainable in the long run²³. There are two options: one is to increase the social insurance tax rates; the other is to cut benefits. In light of this, we simulate our model under hypothetical assumptions

²²This can be proven in eq. (10), from which we can derive that $\frac{\partial d_t}{\partial \eta} > 0$. This shows a positive relationship between parents' altruism degree η and their optimal transfer rate d_t .

²³In our partial equilibrium framework, we do not explicitly specify a dynamic budget constraint for the government. In practice, with overlapping generations, there are arguments for a "pay-as-you-go" pension such as efficiency gains and intergenerational redistribution. However, there are tensions when the ratio of the number of contributors to the number of retirees decreases, which justify a need to raise taxes.

of higher social insurance tax rates and examine peoples' reactions in fertility.

As expected, an increase in social insurance tax rates can affect fertility through two channels. First, an increased tax rate α_t indicates a smaller childbearing cost ($b(1 - \alpha_t)W_t$) for everyone; according to the price effect, this may induce a higher fertility rate.

Second, the income effect of a rise in α_t is slightly complicated. Our specification on social insurance benefits consists of two parts: one is called "minimum pension" which is a small percentage (γ_t) of the average income level \bar{W}_t ; the other varies with workers' contribution. One important parameter is β_t , which can be viewed as "marginal actuarial fairness index"—the marginal pension increase for one more dollar's tax payment. To fund the minimum pension, it is necessary for the administration to impose a β_t less than 1. Such design of social insurance implies that poor people will get a better deal than the rich: the government-provided social insurance is an income redistribution from the rich to the poor. The net benefit from social insurance could be written as:

$$\text{Net Benefit at } t = \frac{\text{Benefit at } t + 1}{R_{t+1}} - \text{Contribution at } t \quad (16)$$

$$= \gamma_t \bar{W}_t + \beta_t \alpha_t (1 - bf_t) W_t - \alpha_t (1 - bf_t) W_t \quad (17)$$

$$= \gamma_t \bar{W}_t - (1 - \beta_t) \alpha_t (1 - bf_t) W_t \quad (18)$$

A threshold level of income (W_t^*), where the contribution to and the benefit from the program are equal, can be derived as follows:

$$W_t^* = \frac{\gamma_t \bar{W}_t}{(1 - \beta_t) \alpha_t (1 - bf_t)} \quad (19)$$

For families with income higher than the threshold level, the program reduces their present discounted life-time income; and vice versa for people with income below the threshold level. *Given f_t fixed*, eq. (18) implies a negative relationship between the net benefit and α_t . Hence a rise in α_t will reduce the net benefit for everyone (both the rich and the poor), and lead to a smaller W_t^* . Therefore we expect to see a lower f_t since children are normal goods. However this is not the end of the story: *given α_t fixed*, eq. (18) implies a positive relationship between the net benefit and f_t . An initial decline in f_t due to an increase in α_t will further reduce the net benefit, and thus leads to

another decline in f_t .

Figure 9 shows the decomposition of the interactions between α_t and f_t . The purple line in 9(a) refers to the contribution as a function of income, and the blue one the benefit function. Hence, the gap between them constitutes the net benefit function as in 9(b), which is positive for $W_t < W_t^*$ and negative for $W_t > W_t^*$. When the social insurance tax rate increases from 8% to 12%, with f_t fixed, we see that the slopes of both the purple and the blue lines increase, but due to $\beta_t < 1$, the slope increase in the benefit function is smaller. This translates into a downward movement of the net benefit function, as displayed by the black dashed line in Figure 9(b). This represents a decline in the lifetime income for everyone (except for those with $W_t = 0$), and the direct income effect says people should demand fewer kids.

There is a further reaction in the model: with α_t now fixed at its new value, a smaller f_t induces higher slopes for both the contribution and the benefit functions, which in turn leads to an even lower net benefit function, as reflected in the black thin line in Figure 9(b). The second round of income effect will further reduce fertility. In the end, families respond to a higher social insurance tax rate by having fewer kids. The economy is characterized by high taxation and generous pension benefit (see the purple and blue thin lines in 9(a)), which resembles what we observe in those European welfare states.

It is interesting to note the difference in the income effect between introducing social insurance into the economy and raising tax rates within an existing system. In the former case, income effect is positive for the poor and negative for the rich. However, in the latter case, the income effect from a rise in α_t is negative for everyone earning a positive income. Combining this with the positive price effect, we must turn to calibration exercise to see how f_t responds.

We simulate our model under hypothetical scenarios that the current social insurance tax rate increases from 8% to 12% or 16%. Figure 10 shows that the magnitude of TFR reduction with respect to an increase in α_t is trivial, indicating an offsetting between the price and income effect.

Finally, we briefly discuss the effect of an increase in expected future tax rate α_{t+1} . This expectation change may happen if couples, for example baby boomers, anticipate a decline in the ratio

of workers to beneficiaries next period. An increased future tax rate means a lower rate of return in child investment from the view of parents. Thus, parents will choose to have fewer kids, which reinforces their initial expectation of a smaller population size and a higher tax rate α_{t+1} .

6 Conclusion

This paper quantified the effect of social insurance on total fertility rate (TFR) through macro aggregation based on solving individual dynamic fertility choice model. From parents' point of view investment in children is risky and the risks are twofold: (1) whether a kid can grow up, represented by the infant mortality rate; (2) uncertainty about the transfer parents expect to get when they become old.

We examined the effect of social insurance on fertility rate from four perspectives. First, we considered the price effect due to payment of social insurance taxes, which decreases the opportunity cost of childbearing and thereby induces higher fertility. Second, we considered the income effect that this income-redistribution program has, which raises the expected life-time income for relatively poor people, while decreasing life-time income of the rich. Since children are viewed as normal goods, there is a positive relationship between life-time income and fertility. Combining these two effects, we find that low-earning people tend to have more kids since the two effects work in the same direction, while changes among high-income people depend on which of these effects dominates. Our heterogeneous analysis indicates that the income effect dominates for relatively rich people so that their fertility rate declines in the presence of the program.

The third factor we considered is the liquidity constraint caused by the need to pay the social insurance taxes, which reduces current cash-on-hand for everyone. Although it is possible to borrow through informal channels, this liquidity constraint plays an important role in reducing fertility rate. Specifically, the fertility rate among the lowest earners where the taxes are most likely to cause binding liquidity constraint experiences the biggest decline.

The final aspect we took into account is the potential change in social attitudes, which is re-

flected in a decrease in either parents' altruism degree towards their elderly parents or expected transfers from their children. On the one hand, these changes in social attitudes were not addressed in previous literature. On the other hand, it is quite hard to examine whether this kind of change already happened after the social insurance program was introduced, and even harder to measure the magnitude of this change. In light of this, we used sensitivity analysis and simulated our model based on various candidate parameter values. Our results show that fertility rates are quite sensitive to changes in expectation of children's transfer rate; a 20% decrease will induce 10-70% drop in fertility rate depending on parents' position in the income distribution. In addition, a smaller degree of altruism induces less transfer from adult children to elderly parents in a direct and significant way. However, comparing the rate of return on private saving and child investment, people have heterogeneous choices in allocating the extra resources on either fertility or saving.

In contrast to Boldrin, Nardi, and Jones (2005), who showed that at least 50% of the differences in TFR between US and European countries can be explained by the differences in the generosity of social insurance, we have shown that a more generous social insurance program has a trivial effect on the fertility rate in China. Beyond this, our calibration results match quite well with the declining tendency in TFR from 1985 to 2005. Decomposing the calibrated TFRs reveals that the combination of price and income effect of social insurance has a slightly positive impact on TFR, while imposing liquidity constraints could decrease fertility rate by around 35%. Moreover, the decomposition brings out an important feature that factors related with the rate of return on child investment and private saving always matter when people are making fertility choices. Any changes in these factors have a direct effect on fertility rate, although the magnitude may vary across scenarios. Our calibrations show that, without consideration of liquidity constraint, the big drop in TFR from 1985 to 2005 is, to a large extent, due to changes in expected GDP growth rate and interest rates, which affect the average income in the children's generation and thus the future retirement income for their parents. In a similar spirit, we show that increases in childbearing costs also have significant effect on reducing fertility rate, although low-income people are more sensitive to changes in the fixed cost while high-income people are more sensitive to changes in the income-varying part.

There are many extensions to this work that could provide further insights on the effect of

social insurance on fertility. First, our model is calibrated to match TFR in China between 1985 and 2005. Besides China, we observe a world-wide decreasing trend in TFR from the 1960s. It is interesting and important we calibrate the models to match other countries' TFRs during the same period. By doing this, we could have a better understanding of whether the same framework can be used among other countries, whether the effect of increasing tax rate on fertility is still limited, and whether those factors related to the rate of return on child investment also play an important role in other countries. Cross-country comparisons could help answer all these questions and provide a more comprehensive explanations on how the social insurance program affects peoples' fertility choices. Second, although our calibrations match actual TFR reasonably well, we make arbitrary assumptions about some key parameter values such as the cost for raising children, the expected transfer rate, and parents' degree of altruism. It would be better if we could utilize micro-level data and empirically estimate these parameters by matching moments from simulations to the data. I leave these extensions for future work.

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Table 1: Benchmark Parameters

Parameter	Symbol	Value
<i>Macro Economy</i>		
Number of years per period	T	20
Risk-free real interest rate 1966-1985	R_{1985}	1.889
Risk-free real interest rate 1986-2005	R_{2005}	0.940
Risk-free real interest rate 2006-2025	R_{2025}	1.220
GDP growth rate 1966-1985	g_{1985}	2.067
GDP growth rate 1986-2005	g_{2005}	5.213
GDP growth rate 2006-2025	g_{2025}	2.207
Average labor income at period t	\bar{W}_t	1.000
<i>Preferences</i>		
Discount factor	δ	0.818
Parents altruism towards grandparents	η	0.500
<i>Child Investment</i>		
Mortality rate between age 0 and 19	p	0.050
Childbearing cost: fixed part	a	0.050
Childbearing cost: income-varying part	b	0.100
Beta Distribution for transfer rate	α	2.000
	β	14.000
<i>Social Insurance</i>		
Marginal tax rate	α_t	0.080
Actuarial fairness index	β_t	0.800
Minimal pension ratio	γ_t	0.100
<i>State Variables</i>		
Grandparents' total fertility rate in 1965	f_{1965}	6.080
Grandparents' total fertility rate in 1985	f_{1985}	2.600
Grandparents' private saving rate in 1965	s_{1965}	0.050
Grandparents' private saving rate in 1985	s_{1985}	0.150

Table 2: Relative Income Distribution for Calibration

Percentile	0-5%	6-10%	11-20%	21-40%	41-60%	61-80%	81-90%	91-100%
Proposed w_{1965}	0.4629	0.5528	0.6480	0.7844	0.9500	1.1563	1.4077	1.9196
w_{1985}	0.4629	0.5528	0.6480	0.7844	0.9500	1.1563	1.4077	1.9196
w_{2005}	0.2414	0.3553	0.4595	0.6340	0.8733	1.2010	1.6507	2.7593
Means of w_{2025}	0.2414	0.3553	0.4595	0.6340	0.8733	1.2010	1.6507	2.7593

Table 3: Calibrated TFR and Private Saving Rate under Hypothetical Environments

		SINo	SIYes	SIYes+LC	Price & Income Effect	Liquidity Constraint Effect
1985	TFR	2.55	2.82	2.10	0.27	-0.72
	s_t	0.56%	-16.06%	0.65%	-16.62%	16.71%
2005	TFR	1.80	1.96	1.27	0.17	-0.69
	s_t	8.43%	-8.90%	6.99%	-17.33%	15.89%

Table 4: Effects of Other Factors on TFR

	TFR	s_t	d_t
Benchmark	2.55	0.56%	19.76%
R_{t+1}	2.49	1.42%	19.76%
g_{t+1}	2.21	4.85%	19.96%
g_t	2.55	0.56%	19.96%
f_{t-1}	2.55	0.57%	19.24%
$R_t s_{t-1}$	2.55	0.56%	19.57%
w_t distribution	2.37	0.85%	19.87%

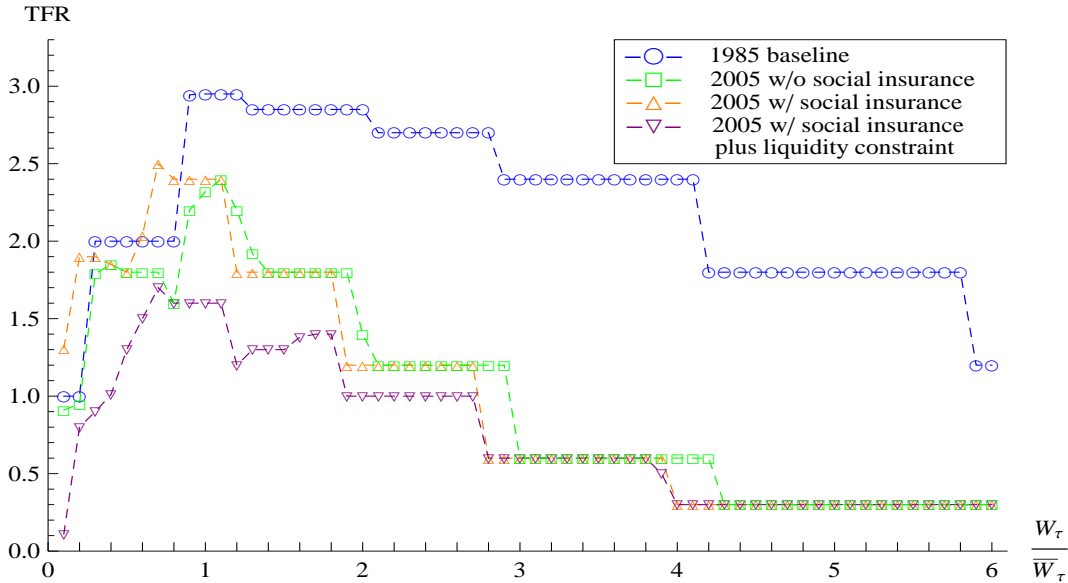


Figure 1: Optimal Fertility Choice across Parents' Income

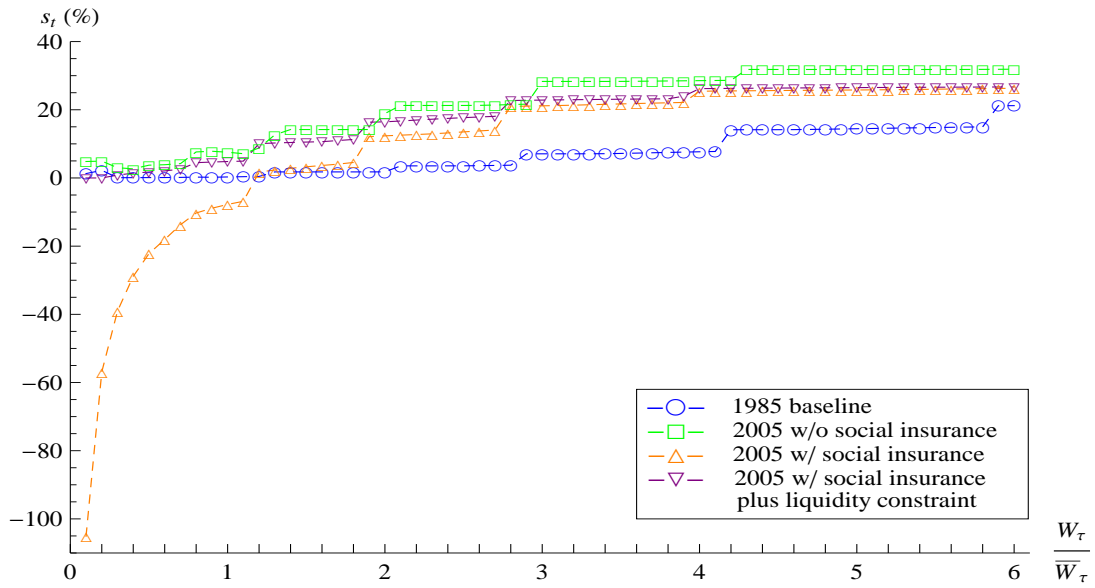


Figure 2: Optimal Private Saving Rate across Parents' Income

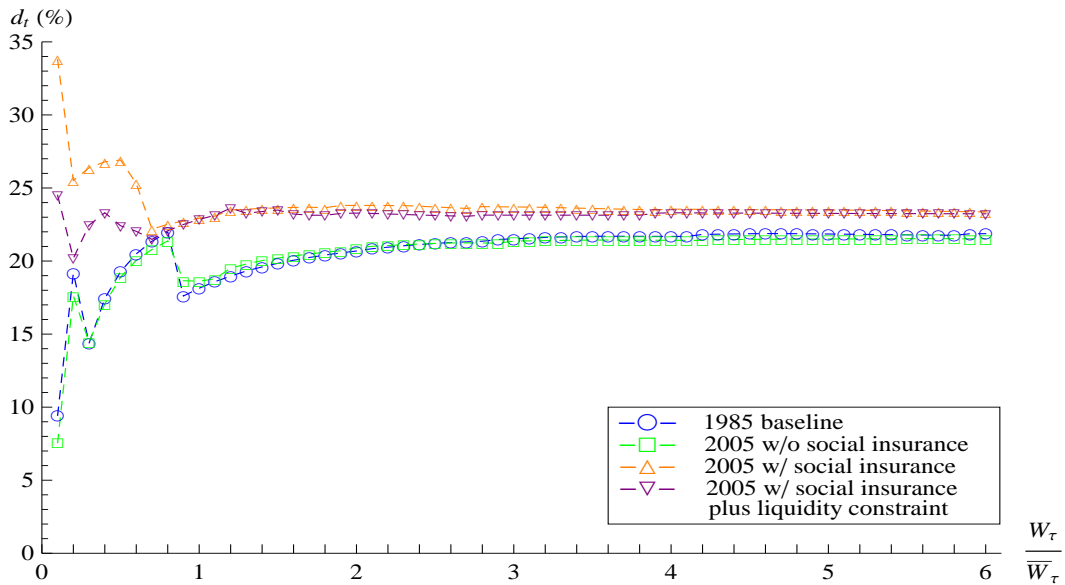


Figure 3: Optimal Transfer Rate across Parents' Income

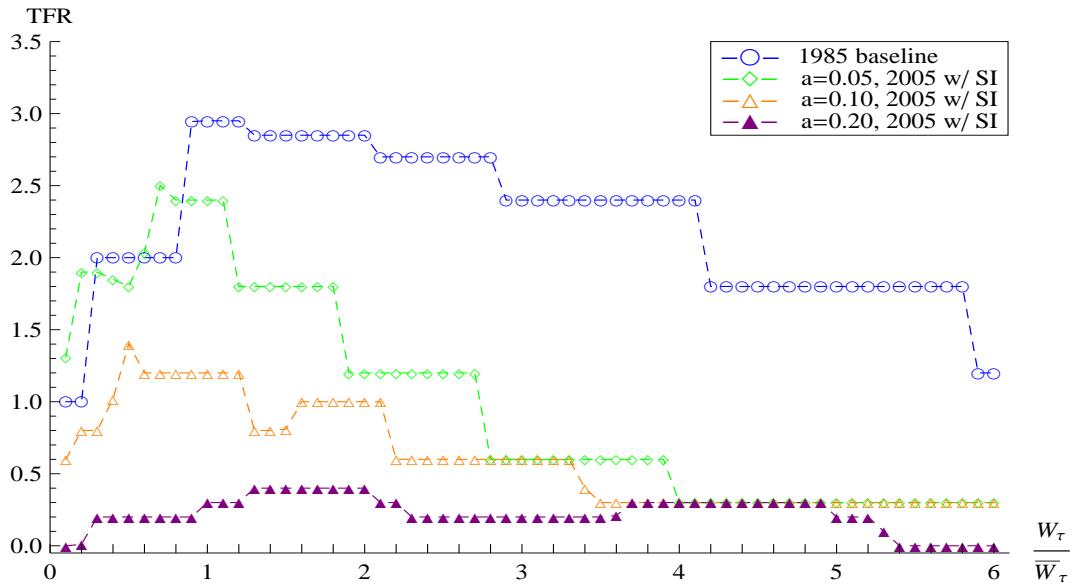


Figure 4: Optimal Fertility Choice and Fixed Cost of Childbearing a

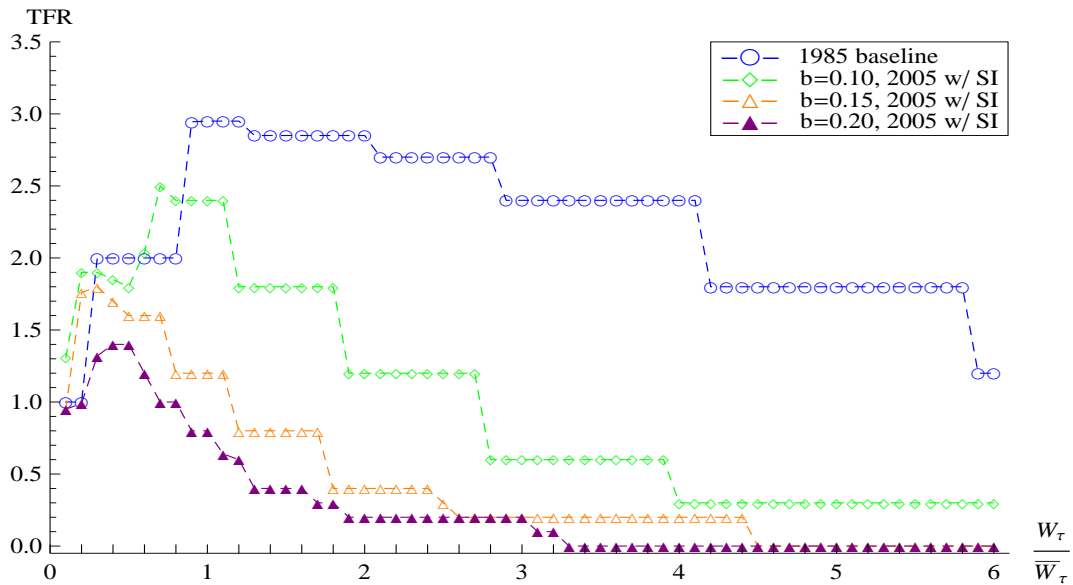


Figure 5: Optimal Fertility Choice and Income-varying Cost of Childbearing b

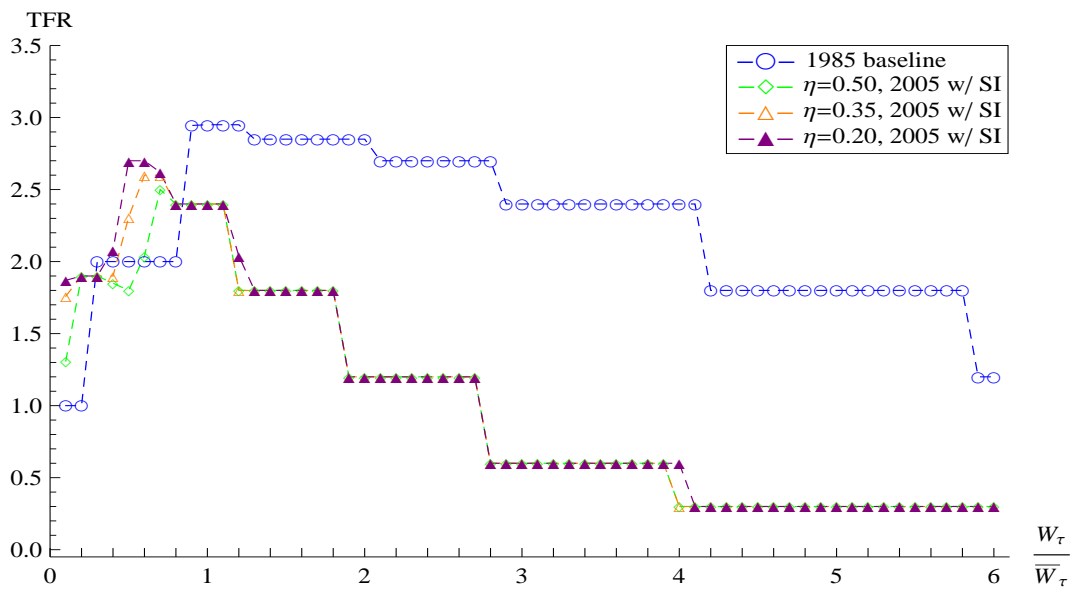


Figure 6: Optimal Fertility Choice and Parents' Altruism Degree towards Grandparents η

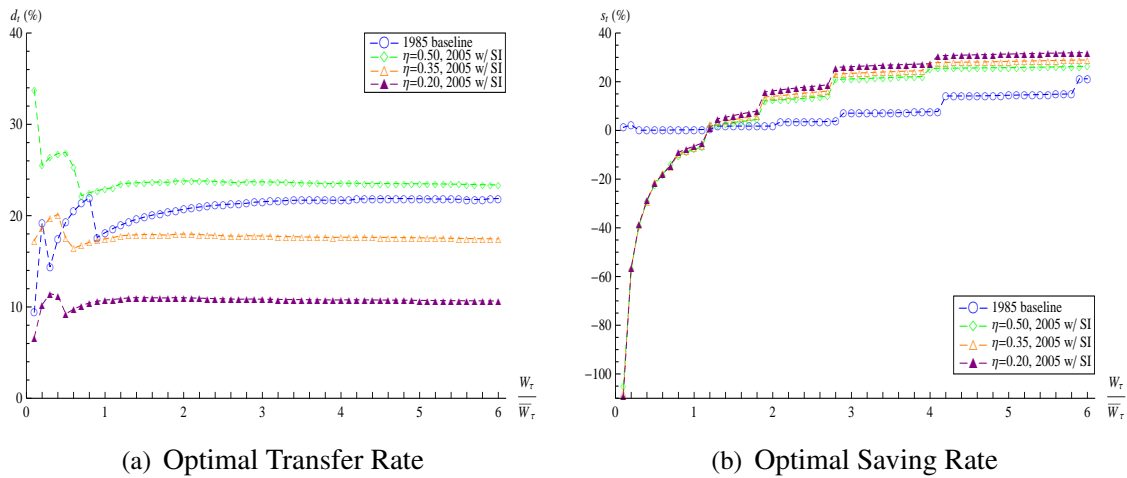


Figure 7: Optimal Transfer/Saving Rate and Parents' Altruism Degree towards Grandparents η

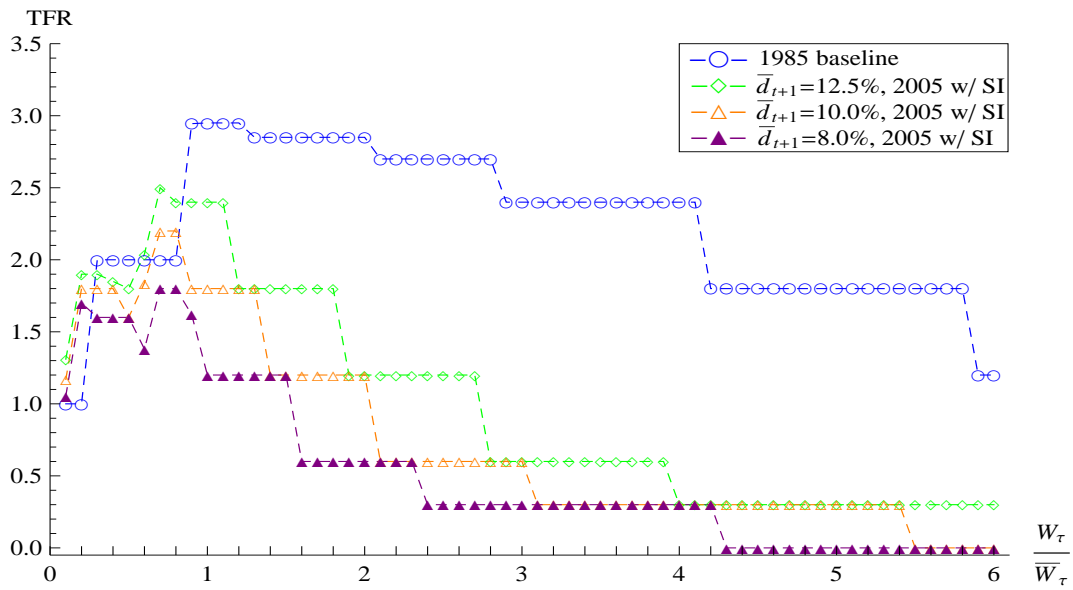
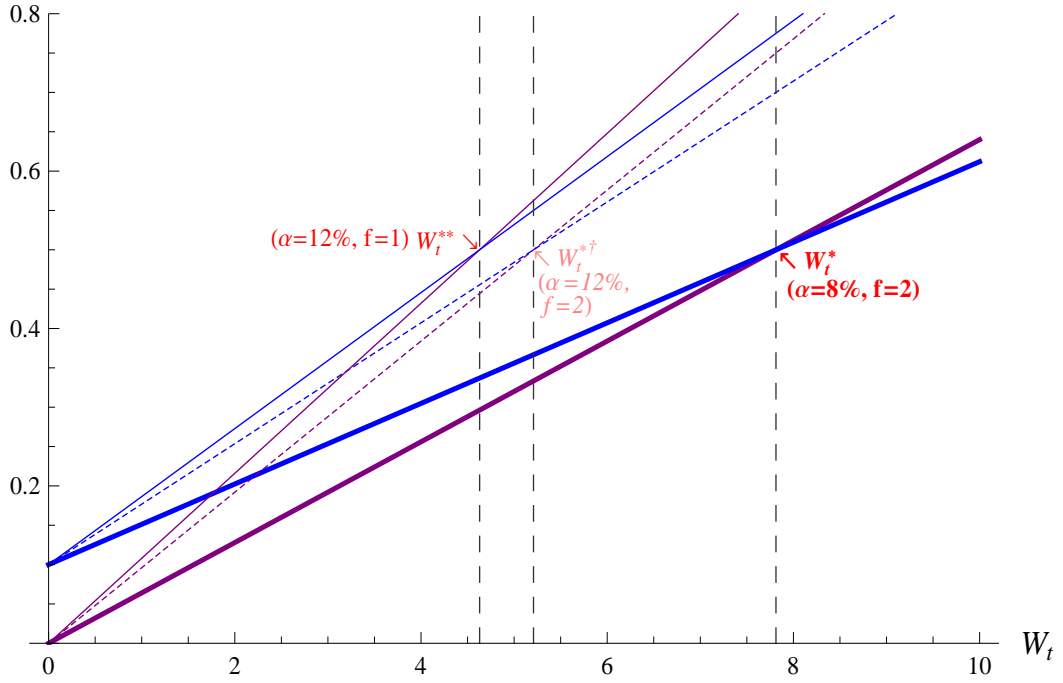


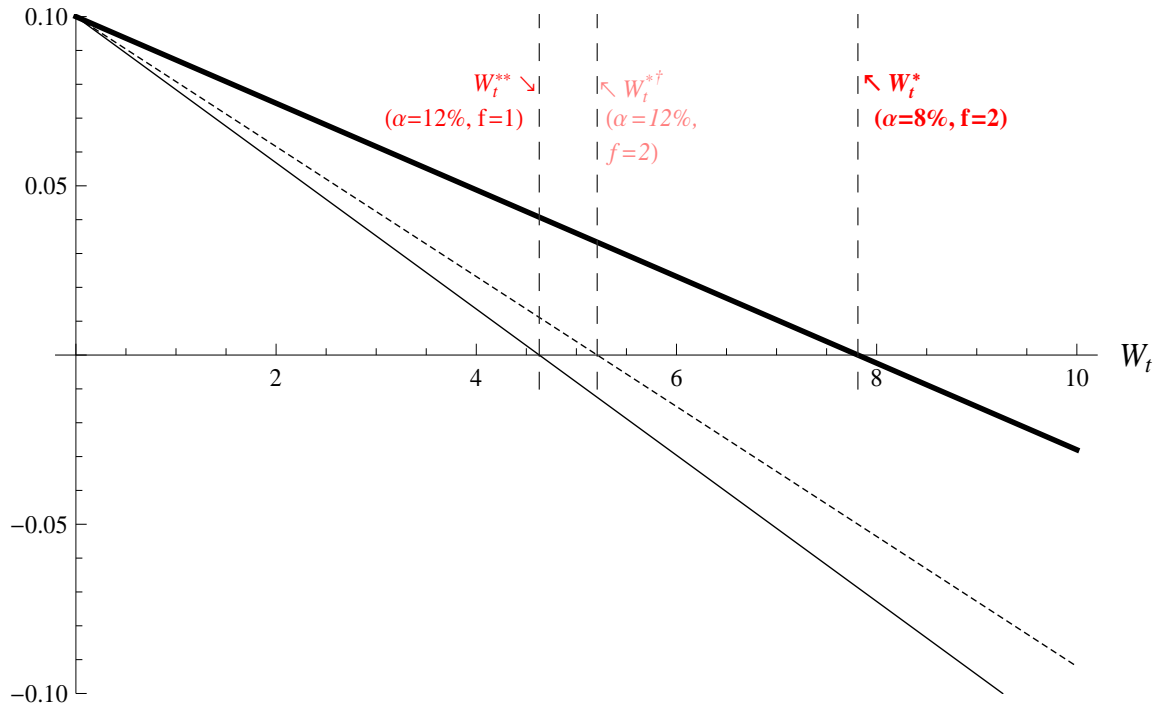
Figure 8: Optimal Fertility Choice and Expected Child Transfer Rate $\mathbb{E}_t[d_{t+1}]$

Contribution & Benefit



(a) Contribution and Benefit

Net Benefit



(b) Net Benefit

Figure 9: Income Effect of an Increase in α_t

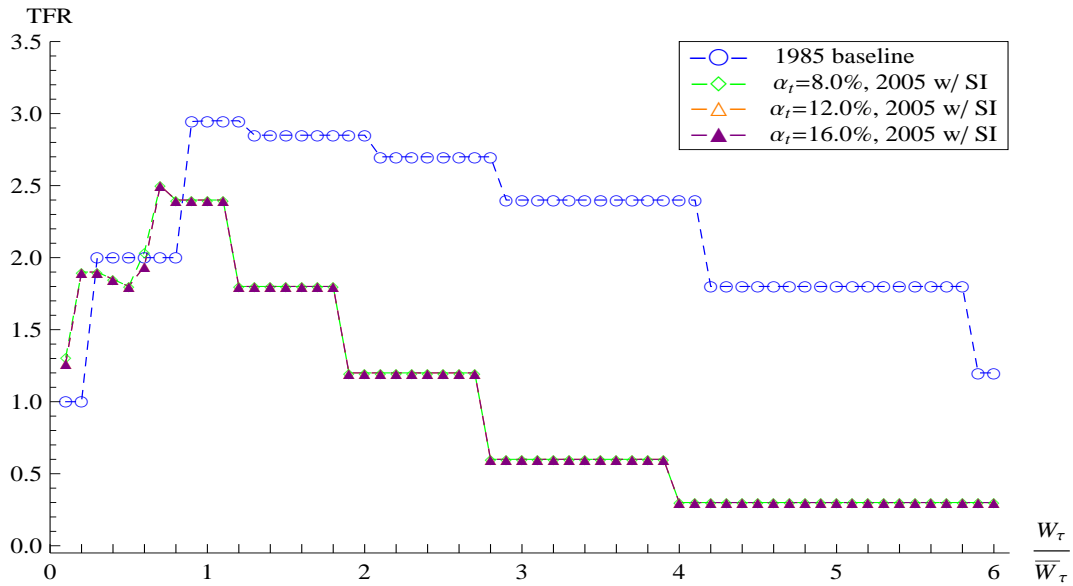


Figure 10: Optimal Fertility Choice and Social Insurance Tax Rate α_t

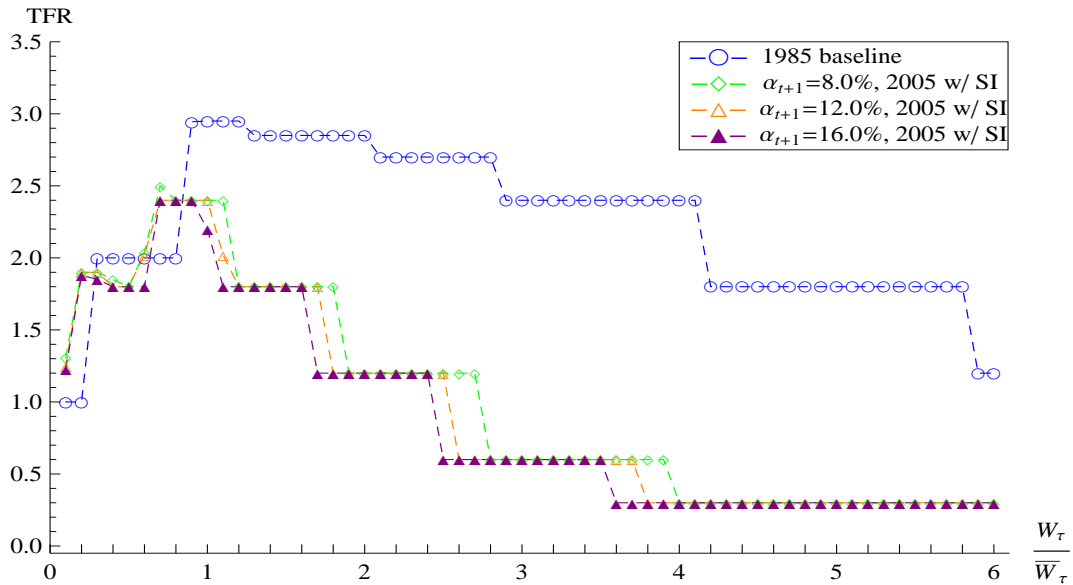


Figure 11: Optimal Fertility Choice and Expected Social Insurance Tax Rate α_{t+1}