The Chinese Saving Rate: Long-Term Care Risks, Family Insurance, and Demographics*

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Abstract

In this paper, we show that a general equilibrium model that properly captures the role of family insurance, changes in demographics and the productivity growth rate is capable of generating changes in the national saving rate in China that mimic the data well. Our results suggest that most of the increase in the saving rate between 1980 and 2010 is due to the interaction between the decline in the fertility rate due to the one-child policy and the shortcomings of the old-age insurance programs, especially against the long-term care risks, provided by the government in China. Changes in the productivity growth rate account for the fluctuations in the saving rate during this period.

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1 Introduction

The national saving rate in China has more than doubled since 1980. Accounting for this increase, however, has been challenging. In this paper, we construct an overlapping generations model; calibrate it to some of the key features of the Chinese economy between 1980 and 2011; and investigate the role of old-age insurance systems, demographics, productivity growth, and income uncertainty in shaping the time path of the national saving rate. Given the prevalence of family support in China, we use a model economy that is populated with altruistic agents, as in Fuster, İmrohoroğlu, and İmrohoroğlu (2003 and 2007) who derive utility from their own lifetime consumption and from the felicity of their predecessors and descendants. Retired agents in our economy face health-related risks that necessitate long-term care (LTC) while working-age individuals face idiosyncratic productivity shocks. The decision-making unit is the household consisting of a parent and children. Since parents care about the utility of their descendants, they save to insure them against the labor income risk, and since children are altruistic toward their parents, they support them during retirement and insure them against the LTC risk. Institutional details and changes in demographics influence the size of these intervivos transfers and saving rates.

We model the old age support system carefully, including the social security system and provision of long-term care for the elderly since the 1980s. While the Chinese government initiated a transition to a public pension system in the early 1990s, institutional care for long-term care needs is almost nonexistent.[1] According to Gu and Vlosky (2008), 80% of long-term care services and more than 50% of the costs in China in 2005 were paid by family members. While the Chinese adult children are expected to take care of their parents, the decline in the fertility rate due to the one-child policy and the aging of the population are placing strains on these traditional family responsibilities. The projected structure of families containing four grandparents and one grandchild for two adult children is expected to make it even harder for children to play a major role in taking care of the elderly in the future.

We calibrate the initial steady state of the model to mimic the economic and demographic conditions in China in 1980 and the final steady state to an economy with the one-child policy. We shock the initial steady state by imposing the one-child policy and conduct deterministic simulations as in Chen, İmrohoroğlu, and İmrohoroğlu (2006, 2007) where we incorporate the key features of the social security system, LTC risk, productivity growth, and the labor income risk in China along the transition. We find that our model is capable of generating changes in the national saving rate in China that mimic the data remarkably

[1] Long-term care need is defined as a status in which a person is disabled in any of the six activities of daily living (eating, dressing, bathing, getting in and out of the bed, inside transferring, and toileting) for more than 90 days.

well. Our results identify two factors as the main contributors to the changes in the national saving rate. Changes in demographics that result in less family insurance, especially against the LTC risks, are responsible for most of the increase in the saving rate between 1980 and 2010. While other aspects of the old age insurance system such as social security are calibrated to the current levels in China, the decrease in family insurance itself leads to higher savings due to the existence of LTC risks. In fact, the impact of the LTC risk on savings is stronger after the year 2000 as more and more one-child cohorts start to become economically active. We find that the saving rate would have increased from 20% in the 1980s to around 25% in 2010 in the absence of the LTC risk or the one-child policy. The presence of these facts, on the other hand, results in the saving rate to rise to around 35% in 2010. We also find that the total factor productivity (TFP) growth rate accounts for most of the fluctuations in the saving rate. In this framework, periods of high TFP growth rates are as associated with periods of high marginal product of capital, resulting in high saving and investment rates.[2]

A key feature of the model is the risk-sharing within the family where children play an important role in insuring their parents against the LTC risks while parents insure their children against labor income shocks. Since the one-child policy reduces the extent to which children can provide insurance, households increase their precautionary savings to insure against the LTC risks.[3] This implies that saving behavior of families in 2000s are likely to be different from those of earlier cohorts. The model indeed generates changes in age-savings profiles over time that are qualitatively consistent with the changes observed in the data, especially with the U-shaped age-saving profiles documented by Chamon and Prasad (2010). We also present evidence on the importance of intervivos transfers in China and argue that the dynastic model provides a good approximation for the Chinese economy.

Our paper is closely related to a recently growing literature that finds large effects of uncertain medical expenditures on savings in life-cycle models with incomplete markets.[4] In particular, Kopecky and Koreshkova (2014) find that among all types of medical expenses, LTC expenses are most important in accounting for aggregate savings in the United States. We find that the saving effects of LTC expenses are especially important in China due to

[2] As Bai, Hsieh, and Qian (2006) document, the rate of return to capital has indeed been very high in China. While there is evidence that average households may not have access to assets with high returns, (see, for example, Song, Storesletten, Wang, and Zilibotti (2014)), in a general equilibrium setting, these returns will eventually accrue to individuals in the economy.

[3] It is worth noting that this finding distinguishes our model from several existing studies on China's saving rate that also incorporate changing demographics and intergenerational transfers, such as Curtis, Lugauer, and Mark (2015). These models emphasize the impact on life-cycle saving from expected changes in intergenerational financial transfers caused by demographic changes, while our model highlights the impact on precautionary saving from the loss of family insurance triggered by the one-child policy.

[4] Hubbard, Skinner, and Zeldes (1995); De Nardi, French, and Jones (2010); Kopecky and Koreshkova (2014), Zhao (2014, 2015), etc.

the lack of public programs such as Medicaid insuring against these risks. In addition, as Chinese households gradually lost family insurance due to the one-child policy, the saving effects of LTC expenses have become more important over time. We also examine the role of informal versus formal care in providing for LTC expenses, a feature that is not present in the current literature.

Of course it is challenging to measure precisely the risks faced by the elderly in China. In our calibration, we use measures that reflect the weighted averages of rural and urban areas, thus abstracting from the substantial heterogeneity between these areas. Nevertheless, our calibration is unlikely to exaggerate the average risks faced by the elderly. There are several issues we abstract from in our benchmark calibration, such as medical costs other than LTC costs, increases in LTC costs due to longevity, and the sustainability of the social security system. All of these would increase concerns about old-age support in China, leading to a further increase in savings. We provide sensitivity analysis for some of these possibilities in Section 6.

Our findings contribute to the literature that has focused on the role of life-cycle and precautionary saving motives in explaining the rise in the household saving rates. For example, using a panel of Chinese households for the period 1989-2006, Chamon, Liu, and Prasad (2013) report that rising income uncertainty and pension reforms can account for about half of the increase in the urban household savings. In a partial equilibrium setting, Curtis, Lagauer, and Mark (2015) also find demographic changes to account for half of the increase in the household saving rate. He, Ning, and Zhu (2015), on the other hand, report that aging and pension reform account for 14% of the increase in household saving between 1995 and 2009. Using an identification strategy through families with twins, Choukhmane, Coeurdacier, and Jin (2013) argue that the one-child policy is responsible for 40% of the increase in the household saving rate in China. This literature, however, has not captured the interaction between demographic changes and family insurance, in particular against the LTC risks, in shaping the saving rate fully. In addition, our general equilibrium framework is able to account for the fairly large fluctuations in the national saving rate, a feature that has been understudied in the literature.[5]

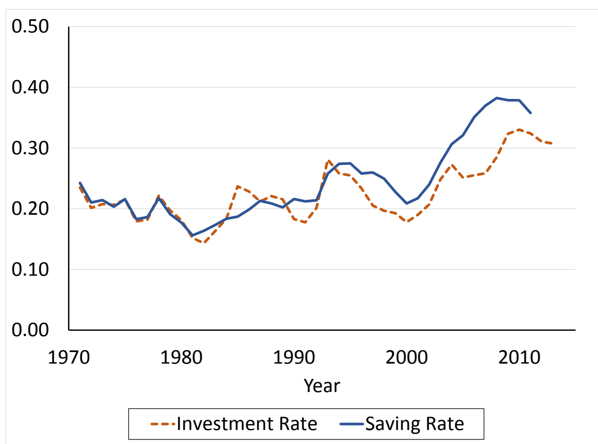
We conjecture that the mechanism we identify is also consistent with the empirical evidence presented in Wei and Zhang (2011), who document that households with a son save more in regions with a more skewed sex ratio. They argue that this observation is inconsistent with many popular explanations of the rise in the saving rate in China but is consistent with their hypothesis where families with sons increase their saving rate in order to help their sons compete in the marriage market. While we do not model the

[5]A large strand of this literature has been focusing on partial equilibrium models of household saving rates with exogenously given interest rates. See the discussion in Banerjee, Meng, Porzio and Qian (2014) which is an exception in that respect.

marriage market directly, our findings about the interaction between the LTC risks and family insurance provide another possibility for this empirical evidence. Since the amount of family insurance is likely to be lower in provinces with a more skewed sex ratio, families in such regions would be expected to rely more on precautionary savings.

Even though our paper's contribution is mostly quantitative, its implications for future saving rates in China are quite striking. If the current high saving rates are indeed due to lack of insurance in old age as opposed to other mechanisms discussed in the literature such as the unbalanced sex ratio, the expected increase in government provided social insurance is likely to have a significant impact on the future saving rates in China. Establishing the right reasons behind the high saving rates in China is important, not only for understanding the Chinese economy, but also for understanding the future path of the China's saving glut which has impacted the world economy.

Figure 1: Saving and Investment



It is important to note that we treat China as a closed economy. While this assumption may not seem very desirable, as can be gleaned from Figure 1, saving and investment rates in China have both been increasing during this time period. Clearly, the current account surplus of China since the 1990s has been an important issue for the world economy. We leave this topic for future research and concentrate on advancing our understanding about the overall increase in the saving and investment rates. By focusing on the national saving rates, we abstract from cross sectional heterogeneity, such as heterogeneity among firms or among the rural versus urban households, as well as the differences between corporate and household saving rates. A more detailed look at these issues is also left for future research.

The remainder of the paper is organized as follows. Section 2 presents the model used in the paper and Section 3 its calibration. The quantitative findings are presented in Section 4. Section 5 examines the micro level implications of the model against the data and Section 6 summarizes sensitivity analysis. Section 7 provides the concluding remarks.

2 The Model

2.1 Technology

There is a representative firm that produces a single good using a Cobb-Douglas production function $Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$ where α is the output share of capital, K_t and L_t are the capital and labor input at time t, and A_t is the total factor productivity at time t. The growth rate of the TFP factor is $\gamma_t - 1$, where $\gamma_t = (\frac{A_{t+1}}{A_t})^{1/(1-\alpha)}$. Capital depreciates at a constant rate $\delta \in (0,1)$. The representative firm maximizes profits such that the rental rate of capital, r_t, and the wage rate w_t, are given by:

$$r_t = \alpha A_t (K_t/N_t)^{\alpha-1} - \delta \quad and \quad w_t = (1-\alpha) A_t (K_t/N_t)^{\alpha}. \tag{1}$$

2.2 Government

In our benchmark economy the government taxes both capital and labor income at rates τ_k and τ_e, respectively, and uses the revenues to finance an exogenously given stream of government consumption expenditures G_t. A transfer that is distributed back to the individuals helps balance the government budget. In addition, the government runs a pay-as-you-go social security program that is financed by a payroll tax τ_{ss}.[6] This way of modeling the government misses the saving done by the Chinese government who has been investing in financial and physical assets at home or abroad.[7] In Section 6, we examine the results of a case where the government is allowed to accumulate assets and build government capital.

2.3 Households

The economy is populated by overlapping generations of agents. Each period t, a generation of individuals is born. All children become parents at age T+1 and face mandatory retirement at age R. After retirement, individuals face random lives and can live up to 2T periods. Depending on survival, an individual's life overlaps with his parent's life in the first T periods and with the life of his children in the last T periods. There are two types of household composition, one where both the parent and the children are alive and another

[6] Both budget constraints are provided in Section 2.4.
[7] See, for example, Ma and Yi (2010).

where the parent may have died (which might happen after the parent reaches the retirement age). A household lasts T periods. A dynasty is a sequence of households that belong to the same family line. At age T +1, each child becomes a parent in the next-generation household of the dynasty. The size of the population evolves over time exogenously at the rate $g_t - 1$. At the steady state, the population growth rate satisfies $g = n^{1/T}$, where n is the fertility rate.

Individuals in this economy derive utility from the consumption of their predecessors and descendants as in Laitner (1992). For simplicity, denote the consumption of the parent (father) with c_{fj} and the children (sons) with c_{sj} where $j = 1, 2, ...T$ is the age of the youngest member. The father and the sons pool their resources and maximize a joint objective function.

Working age individuals are endowed with one unit of labor that they supply exogenously. At birth, each individual receives a shock z that determines if his permanent lifetime labor ability is high (H) or low (L). Labor ability of the children, z', is linked to the parent's labor ability, z by a two-state Markov process with the transition probability matrix $\Pi(z', z)$. Labor income of both ability types have two additional components; a deterministic component ε_j representing the age-efficiency profile and a stochastic component, μ_j, faced by individuals up to age T. The logarithm of the labor income shock is assumed to follow an AR(1) process given by $log(\mu_j) = \Theta log(\mu_{j-1}) + \nu_j$. The disturbance term ν_j is distributed normally with mean zero and variance σ_ν^2 where $\mathit{\Theta} < 1$ captures the persistence of the shock. We discretize this process into a 3-state Markov chain using the method introduced in Tauchen (1986), and denote the corresponding transition matrix by $\Omega(\mu', \mu)$. In addition, the value of μ at birth is assumed to be determined by a random draw from an initial distribution $\overline{\Omega}(\mu)$.

Parents face a health risk, h, that necessitates long-term care (LTC), which also follows a two-state Markov process where $h = 0$ represents a healthy parent without LTC needs. When $h = 1$, the family needs to provide LTC services to the parent. We assume that the cost of LTC services consists of two parts: a goods cost m and a time cost ξ. Here, ξ represents the informal care that requires children's time. For working individuals, the LTC cost also includes their own forgone earnings. The transition matrix for the health state is given by $\Gamma(h', h)$.

Labor income of a family is composed of the income of the children and the income of the father. Income of the children, net of the costs of informal care, is given by $w\varepsilon_j\mu_j z_s(n-\xi h)$ where w is the economy-wide wage rate, ε_j is labor productivity at age j, and μ_j is the stochastic component of labor income. If $h = 0$, the parent does not need long-term care and therefore the n children generate a total income of $w\varepsilon_j\mu_j z_s n$. If $h = 1$, ξ fraction of a child's income is devoted to taking care of the parent who needs long-term care. Before retirement, the father, whose children are j years old, receives $w\varepsilon_{j+T} z_f$ as labor income. Once retired, the father faces an uncertain lifespan where $d = 1$ indicates a father who is alive and $d = 0$ indicates a deceased father. The transition matrix for d is given by $\Lambda_{j+T}(d', d)$ with $\Lambda_{j+T}(0, 0) = 1$, and $\Lambda_{j+T}(1, 1)$ represents the survival probabilities of the father of age $j + T$. If alive, a retired father receives social security income, SS_j. All children in the household split the remaining assets (bequests) equally when they form new households at time $T + 1$.

Earnings, e_j, of the household with age-j children is given by:

$$e_j = \begin{cases} w\varepsilon_j \mu_j z_s(n - \xi h) + w\varepsilon_{j+T} z_f (1 - h) & \text{if} \quad j + T < R \\ \\ w\varepsilon_j \mu_j z_s(n - \xi h) + dSS & \text{if} \quad j + T > R. \end{cases} \tag{2}$$

The budget constraint facing the household with n children is given by:

$$a_{j+1} + nc_{sj} + dc_{fj} + mh = e_j(1 - \tau_{ss} - \tau_e) + a_j[1 + r_t(1 - \tau_k)] + \kappa \tag{3}$$

where r is the before-tax interest rate, τ_e is the labor income tax rate, τ_{ss} is the payroll tax rate to finance the social security program, and τ_k is the capital income tax rate. Here, κ is the government transfer, which consists of two components, i.e., $\kappa = \kappa_1 e_j + \kappa_2$. The first component ($\kappa_1 e_j$) is proportional to household earnings and is used to balance the government budget constraint.[8] The second component (κ_2) guarantees a consumption floor for the most destitute.[9] Following De Nardi, French, and Jones (2010) and Hubbard, Skinner, and Zeldes (1995), the value of κ_2 is determined as follows:

$$\kappa_2 = max\left\{0, (n + d)\underline{c} + mh - [e_j(1 - \tau_{ss} - \tau_e) + a_j[1 + r_t(1 - \tau_k)] + \kappa_1 e_j]\right\} \tag{4}$$

We assume that when the household is on the consumption floor ($\kappa_2 > 0$), $a_{j+1} = 0$ and $c_{sj} = c_{fj} = \underline{c}$.

The maximization problem of the household is to choose a sequence of consumption and asset holdings given the set of prices and policy parameters. The state of the household consists of age j; assets a; permanent abilities of the parent and the children z_f and z_s, respectively; the realizations of the labor productivity shock μ; and the health h and mor-

[8] Redistributing the government surplus in a proportional way, instead of a lump-sum way, is less distorting in a life-cycle setting with an inverse u-shaped age-earnings profile. In the sensitivity analysis, we provide results for the lump-sum redistribution case as well.

[9] Consumption, asset holdings, and earnings are transformed to eliminate the effects of labor augmenting, exogenous productivity growth, A_t, at any period t. For the sake of clarity, we do not introduce time subscripts although we compute both steady states and transitional paths across steady states.

tality d states faced by the elderly.[10] Let $V_j(x)$ denote the maximized value of expected, discounted utility of age-j household with the state vector $x = (a, z_f, z_s, \mu, h, d)$ where β is the subjective time discount factor. The household's maximization problem is given by:

$$V_j(x) = \max_{c_s, c_f, a'} [nu(c_s) + du(c_f)] + \beta E[\tilde{V}_{j+1}(x')] \tag{5}$$

subject to equations 2-4, $a_j \geq 0, c_s \geq 0$ and $c_f \geq 0$, where

$$\tilde{V}_{j+1}(x') = \begin{cases} V_{j+1}(x') \text{ for } & j = 1, 2, ..., T-1 \\ nV_1(x') \text{ for } & j = T \end{cases} . \tag{6}$$

2.4 Equilibrium

Stationary recursive competitive equilibrium (steady state): Given a fiscal policy $(G, \tau_e, \tau_k, \tau_{ss}, SS)$ and a fertility rate n, a stationary recursive competitive equilibrium is a set of value functions $\{V_j(x)\}_{j=1}^{T}$, households' decision rules $\{c_{j,s}(x), c_{j,f}(x), a_{j+1}(x)\}_{j=1}^{T}$, time-invariant measures of households $\{X_j(x)\}_{j=1}^{T}$ with the state vector $x = (a, z_f, z_s, \mu, h, d)$, relative prices of labor and capital $\{w, r\}$, such that:

1. Given the fiscal policy and prices, households' decision rules solve households' decision problem in equation 5.

2. Factor prices solve the firm's profit maximization policy by satisfying equation 1.

3. Individual and aggregate behavior are consistent :

$$K = \sum_{j,x} a_j(x) X_j(x)$$

$$N = \sum_{j,x} [\varepsilon_j z_s(n - \xi h) + \varepsilon_{j+T} z_f(1-h)] X_j(x)$$

4. The measures of households satisfy:

$$X_{j+1}(a', z_f, z_s, \mu', h', d') = \frac{1}{n^{1/T}} \sum_{\{a,\mu,h,d:a'\}} \Omega(\mu', \mu)\Gamma(h', h)\Lambda(d', d) X_j(a, z_f, z_s, \mu, h, d), \text{for } j < T,$$

$$X_1(a', z_s, z_s', \mu', 1, 1) = n \sum_{\{a,\mu,h,d,z_f:a'\}} \overline{\Omega}(\mu')\Pi(z_s', z_s) X_T(a, z_f, z_s, \mu, h, d)$$

where $a' = a_{j+1}(x)$ is the optimal assets in the next period.

[10] All children are born at the same time with the same labor ability and face identical labor income shocks.

5. The government's budget holds, that is, $\sum_{j,x} \kappa_1 e_j X_j(x) = \tau_k r K + \tau_e w N - G$.

6. The social security system is self-financing, and the expenditures for the consumption floor are financed from the same budget:

$$\sum_{j=R-T}^{T} \sum_{x} d(SS_j + \kappa_2) X_j(x) = \tau_{ss} \sum_{j,x} e_j X_j(x)$$

Our computational strategy is to start from an initial steady state that represents the Chinese economy before 1980 and then to numerically compute the equilibrium transition path of the macroeconomic aggregates generated by the model as it converges to a final steady state. Net national saving rate along the transition path for this economy is measured as $\left(\frac{Y_t - C_t - G_t - \delta K_t}{Y_t - \delta K_t}\right)$.[11] The detrended steady-state saving rate is given by $\frac{(\gamma g - 1)\widetilde{k}}{\tilde{y} - \tilde{\delta}\widetilde{k}}$ where γ and g are the gross growth rates of TFP and population, respectively.

3 Calibration

We obtain measurements for the TFP growth rate, the individual income risk, the fertility rate, government expenditures, tax rates, and the long-term care risk in China (both for the steady-state calculations and for the 1980-2011 period) using data from various sources. It is well known that there has been doubt about the accuracy of Chinese national accounts, especially about the growth rate of GDP for some time. These concerns might be especially important in the construction of the TFP series. We use the recommendations in Bai, Hsieh, and Qian (2006) in choosing the right series on the data needed to construct TFP and double check them against the data provided by Chang, Chen, Waggoner, and Zha (2015). In addition, we check the sensitivity of our results by using the TFP series provided by the Penn World Tables, which adjusts the GDP series based on the findings in Wu (2011).[12] In Section 8 we provide detailed information about the data sources as well as a comparison of our TFP series with the one provided by the Penn World Tables.

3.1 Demographics

The model period is a year. Individuals enter the economy when they are 20 years old and live, at most, to 90 years old.[13] They become a parent at age 55 and face mandatory

[11] As individuals "own" the corporations in this framework, corporate savings and household savings are not separately identified. In the data, both of these saving rates have been increasing.

[12] See Feenstra, Inklaar and Timmer (2013).

[13] We abstract from educational costs and their potential impact on saving rates. Choukhmane, Coeurdacier, and Jin (2013) who analyze the saving behavior of households with twins versus single children find that the reduction in expenditures associated with a fall in the number of children tends to raise household

retirement at age 60. At age 55, the parent and his n children (who are 20 years old) form a household. After retirement, the parent faces mortality risk. Table 1 summarizes the mortality risk at five-year age intervals, which are used to calibrate the transition matrix for d.[14]

Table 1: Survival Probabilities:

Age	<60	60	65	70	75	80	85
Surv.	1	.9815	.9696	.9479	.9153	.8642	.7611

At the initial steady state, the fertility rate (average number of children per parent) is set to $n = 2.0$; that is, four children per couple, the average total fertility rate in the 1970s. The corresponding annual population growth rate is 2.0% (i.e., $n^{1/35} - 1 = 2.0\%$). The one-child policy implemented around the year 1980 restricts the urban population to having one child per couple and the rural population to having two children only if the first child is a girl. As the urban population was approximately 40% of the Chinese population, on average, from 1980 to 2011, we set the fertility rate to $n = 0.65$ in the economy with the one-child policy; that is, 1.3 children per couple $(0.4 \times 1 + 0.6 \times 1.5 = 1.3)$.[15] The implied population growth rate at the final steady state is -1.2% (i.e., $n^{1/35} - 1 = -1.2\%$). Since adulthood starts at age 20, the impact of the one-child policy becomes visible 20 years into the transition. With this calibration, the elderly population share generated by the model along the transition path mimics the data reasonably well (see Figure 8 in section 4.3).

3.2 Preferences and Technology

The utility function is assumed to take the following form: $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$. The value of σ is set to 3, which is in the range of the values commonly used in the macroeconomics literature. The subjective time discount factor β is calibrated to match the saving rate in the initial steady state. The resulting value of β is 0.999.[16]

savings even though single child households invest more in the quality of their children.

[14]Data are taken from the 1999 World Health Organization data (Lopez et al., 2001). The survival probability is assumed to be the same within each five-year period and along the transition.

[15]Population control policies in China started before 1980. However, the one-child policy that was implemented in 1979 directly targeted the number of children per family. There was heterogeneity in the implementation of the policy, but, in general, strong incentives and penalties were imposed. According to Liao (2013), single child families were given rewards such as child allowance, priority for schooling and housing while penalties included 10–20% of both parents' wages in cities and large one-time fines in rural areas. Also, the "above-quota" children were not allowed to attend public schools. Ethnic minorities and families facing special conditions, such as a disabled first child, were given permission to exceed the quota. Consequently, some estimates of the fertility rate after the one-child policy (for example Lu, He, Piggott (2014)) are equal to 1.6 per couple. We provide the results for this case in Section 6.7.

[16]Note that the implied time discount factor in the model is lower than the value of β as individuals also face mortality risk. Results with a lower β affect the overall saving rate but not its time path, the main

Based on Bai, Hsieh, and Qian (2006) and Song, Storesletten, and Zilibotti (2011), the capital depreciation rate δ is set to 10% and the capital share α is set to 0.5. The total factor productivity A is chosen so that output per household is normalized to one. The growth rate of the TFP factor $\gamma - 1$ in the initial steady state is set to 6.2%, which is the average growth rate of the TFP factor in China between 1976 and 1985. We assume that the growth rate of the TFP factor in the final steady state is 2%, which is commonly considered to be the growth rate at which a developed economy eventually stabilizes. Between 1980 and 2011, we use the observed growth rates of TFP.[17] For the period after 2011, we use the forecasts provided by Goldman Sachs (2003).[18]

3.3 Labor Income

Labor income of the agents in our framework is composed of a deterministic age-efficiency profile ε_j and a stochastic component (faced up to age 55) given by $log(\mu_j) = \theta log(\mu_{j-1}) + \nu_j$. In our benchmark calibration, we assume that agents face the same income risk at the steady-state and along the transition.[19] Based on the findings in Yu and Zhu (2013) and He, Ning, and Zhu (2015), we take $\theta = 0.86$ and the variance σ_ν^2 as 0.06.[20] We discretize this process into a 3-state Markov chain by using the Tauchen (1986) method. The resulting values for μ are {0.36;1.0;2.7} and the transition matrix is given in Table 2.

Table 2: Income shock

$\Gamma_{\mu\mu'}$	$\mu' = 1$	$\mu' = 2$	$\mu' = 3$
$\mu = 1$	0.9259	0.0741	0
$\mu = 2$	0.235	0.953	0.0235
$\mu = 3$	0	0.0741	0.9259

We take the age-specific labor efficiencies, ε_j from He, Ning, and Zhu (2015) who use the data in CHNS to estimate them. Permanent lifetime labor ability $z \in \{H, L\}$, where the high and low states represent high school graduates and non-high school graduates,

focus of the paper.

[17] We construct the TFP series between 1980 and 2011 using $A_t = \frac{Y_t}{K_t^\alpha N_t^{1-\alpha}}$. In Section 8, we provide detailed information about the data sources.

[18] As the forecasts are available only until 2050, we simply fix the growth rate of the TFP factor at 2% after 2050.

[19] In Section 5, we provide sensitivity analysis to different assumptions about the start of the labor income risk. As discussed in He, Huang, Liu, and Zhu (2014), the labor market reforms that took place in the late 1990s, leading to mass layoffs in state-owned enterprises, might have increased the labor income uncertainty in China.

[20] Yu and Zhu (2013) replicate the exercises in Guvenen (2009) to estimate the stochastic process for household income using the China Health and Nutrition Survey (CHNS). We use their estimates for the persistent shock from the Restricted Income Processes (RIP) model (Table C) for the 1989-2009 period. He, Ning, and Zhu (2015) also provide very similar estimates.

respectively, is also calibrated using the CHNS according to which the average wage rate of high school graduates is approximately 1.79 times higher than that of high school dropouts. Therefore, the value of L is normalized to one and the value of H is set to 1.79. The values for the transition probabilities for z are calibrated to match the following two observations. First, the proportion of Chinese working-age population that are high school graduates is 46%. Second, the correlation between the income of parents and children is 0.63, according to the estimates by Gong, Leigh, and Meng (2012). These observations imply the transition probabilities for labor ability shock z shown in Table 3.

Table 3: Labor Ability Shock

$\pi_{zz'}$	$z' = L$	$z' = H$
$z = L$	0.83	0.17
$z = H$	0.2	0.8

3.4 Long-Term Care Risk

Calibrating the health shock that necessitates LTC and the expenditures associated with LTC is a key component of our study. Using data from the 2005 wave of the Chinese Longitudinal Healthy Longevity Survey, Gu and Vlosky (2008) report that about 5.8% of the Chinese elderly needed LTC in 2005. Based on this information, we set the transition probabilities for LTC shock such that 5.8% of parents will need LTC in a given year. Table 4 presents the resulting transition matrix for LTC shock. This transition matrix also implies that, on average, a parent has a 50% chance of ever needing LTC services in his life, which is consistent with some empirical estimates in the literature. For instance, using Health and Retirement Study (HRS) data, Hurd, Michaud, and Rohwedder (2014) find that men and women aged 50 have a 50 and 65 percent chance, respectively, of ever needing long-term care.

Table 4: LTC Shock

$\Gamma_{hh'}$	$h' = 0$	$h' = 1$
$h = 0$	0.98	0.02
$h = 1$	0.25	0.75

According to the 2005 CLHLS data, the average observed yearly cost of long-term care among those who needed it was RMB 3,606, which corresponds to 34% of disposable income per capita. However, Gu and Vlosky (2008) report that, currently, institutional care accounts for less than 10% of all the care provided for LTC, and the reported expenditures for LTC do not include the time spent by family members who provide informal care.

Therefore, we assume that the goods cost of LTC services m is 34% of disposable income per person in a given year in the model.[21]

We use data from The China Health and Retirement Longitudinal Study (CHARLS) to estimate the time cost of LTC services. CHARLS provides data on both the LTC status of the respondents and the work status of their children. To estimate the impact of the LTC shock on the work time of children, we regress the fraction of children that are working in a household on the LTC status of the respondent. We obtain a point estimate of -0.135 with a standard deviation of 0.042. That is, if the respondent is in need of LTC services, the fraction of his/her children that are working would drop by 0.09 to 0.18. Given the average number of children in the CHARLS households is approximately 3, our estimates imply that the time cost of LTC services is in a range of $\{0.28, 0.54\}$. In the benchmark calibration, we set the value of ξ to 0.5; that is, half-time of one child is required to care for one parent. In Section 6.3, we also try 0.28, the lower bound, for the time cost of LTC services ξ, and find that our key results remain correct. In addition, we check the sensitivity of our results to the possibility of purchasing formal care from the market in Section 6.4. For comparison, according to The Georgetown University Long-Term Care Financing Project, 17% of the elderly in the United States needed LTC in year 2000. The Congressional Budget Office (CBO) estimates the total expenditures for LTC services for the elderly in 2004 as $135 billion, or roughly $15,000 per impaired senior. Out-of-pocket spending constitutes about one-third of total LTC expenditures in the U.S., corresponding to 12% of GDP per capita in 2004. For China, Hu (2012) predicts a sharp increase in the ratio of disabled elders to potential caregivers due to the rapid aging of the population and rising prevalence of major chronic diseases. Therefore, we suspect our calibration of the LTC risk and expenditures are not likely to be exaggerated.

Of course, LTC is only one component of the general issue about old-age support. Gu and Vlosky (2008) report that the health care reform in the 1980s has resulted in fewer elderly being covered by the government provided health care system. For example, the fraction of urban residents that are covered by the health care system went down from 100% in the 1950s to 57% in 2003. They report that in 2002 and 2005, 64% of the urban seniors and 94% of the rural elders' medical expenses were paid by their children or themselves. The pension system, which used to provide about 75-100% of the last wage earned, also went through a series of reforms since the 1980s. Currently, they estimate that only 50-60% of elders in cities and 10% of elders in rural areas have a pension. They conclude that while China has been working on improving its old-age insurance system, the majority of elders consider children their main source of support. Consequently, we also examine the interaction of the LTC risk with different levels of government support during the retirement years.

[21] Disposable income in the model is defined as the output net of government expenditures.

3.5 Government Policies

Government expenditures were, on average, 14% of GDP in China from 1980 to 2011. Based on this information, we set the value of G so that it is 14% of output in both the initial and the final steady states. As discussed previously, we assume that the labor and capital income tax rates, in both steady states are determined so that tax revenues exactly cover government expenditures. At the initial steady state, both the labor and capital income tax rates are set at 17.4%. At the final steady state, the capital income tax rate is set at 15.3% according to Liu and Cao (2007); the labor income tax rate is then set at 28% to balance the government budget. Along the transition path, we use the actual data on government expenditures for values of G_t. There is not detailed enough data to compute the tax rates using methods by Mendoza, Razin, and Tesar (1994) or McDaniel (2007). We summarize our method of constructing labor and capital income tax rates for the 1980-2011 period and provide the data in the Appendix. For the period after 2011, we assume that both government expenditures and the tax rate gradually converge to their final steady state values in 10 years.

The Chinese government used to provide widespread pension coverage and medical care before the 1980s. The reforms introduced since then have been incomplete and insufficient. Gu and Vlosky (2008) report that in 2002 and 2005, 40-50% of the elderly in cities and more than 90% of the elderly in rural areas did not have a pension.[22] According to Song, Storesletten, Wang, and Zilibotti (2014), the Chinese pension system provided a replacement rate of 60% to those retiring between 1997 and 2011 who were covered by the system.[23] As the urban population was approximately 40% of the Chinese population from 1980-2011, we assume that the pension coverage rate was 25% of the population. Therefore, we set the average social security replacement rate at 15% (i.e., 60% $\times$ 25% = 15%) for the whole population. Note that the pension benefits are partially indexed to the wage growth in China. Here, we follow the same indexation as in Song, Storesletten, Wang, and Zilibotti (2014) when calculating the replacement rate. That is, 40% of pension benefits are indexed to wage growth.[24] We assume that the social security program is self-financing and that the social security payroll tax rate τ_{ss} is endogenously determined to balance the budget in each period.

[22] See also He, Ning, and Zhu (2015) for a detailed account of the changes in the social security system in China.

[23] Sin (2005) also reports a 60% replacement rate.

[24] In other words, we approximate the pension benefit by a linear combination of the average past earnings of the retirees and the average earnings of current workers, with weights of 60% and 40%. That is, $SS_j = 0.6 \times e_j^{past} + 0.4 \times e^{current}$. Here, e_j^{past} represents the average past earnings of the retirees with age $T+j$, and $e^{current}$ is the average earnings of current workers. For simplicity, we obtain e_j^{past} by discounting the average earnings of current workers l years back using the growth rate of TFP factor, γ, that is, $e_j^{past} = e^{current} \times \frac{1}{\gamma^l}$. Here, l represents the number of years from the time of their retirement, i.e., $l = j - 5$.

An important calibration issue is the determination of the consumption floor, $\underline{c}$. De Nardi, French, and Jones (2010) report that old age expenditures on medical care and the existence of the right consumption floor are very important in explaining the elderly's savings in the U.S. They estimate the consumption floor, which proxies for Medicaid and Supplemental Security Income (SSI) in the U.S, to be 73% of mean medical expenditures.[25] Currently in China, there are no government provided programs similar to Medicaid. There is one program aimed at helping the elderly who do not have children, a job, and income called the "Five guarantees" program where eligible elders receive the five basics of life: food, clothing, housing, medical care, and burial after death. This program is not really designed for those facing LTC risks, however. For example, according to Wu and Caro (2009), elderly with infectious diseases, mental illness, and functional dependency (semi-bedridden or bedridden) are often excluded from these institutions.[26] Given the lack of government provided assistance for LTC costs of the dire poor, we expect the consumption floor, which affects the most unlucky agents, to be significantly lower in China relative to the U.S. In our benchmark calibration, we set the consumption floor to 10% of mean medical expenses. In Section 6, we provide sensitivity of our results to this parameter, including a consumption floor equal to 73% of medical expenditures used for the US in De Nardi, French, and Jones (2010).

Table 5: Calibration

Parameter	Description	Value
α	capital income share	0.5
δ	capital depreciation rate	0.1
σ	risk aversion parameter	3
A	TFP factor	0.32
β	time discount factor	0.999
m	goods cost of LTC services	34%
ξ	time cost of LTC services	0.5
$z \in \{H, L\}$	permanent life-time labor ability	$\{1.79, 1.0\}$
G	government expenditures	14% of GDP
SS	social security replacement rate	15%
$\gamma_{initial}^{1-\alpha} - 1$	initial steady state TFP growth rate	3.1%
$\gamma_{final}^{1-\alpha} - 1$	final steady state TFP growth rate	1%
$n_{initial}$	initial steady state total fertility rate	2.0
n_{final}	final steady state total fertility rate	0.65

Table 5 summarizes the main results of our calibration exercise and Table 8 provides the data on the TFP growth rate, government expenditures, and the constructed tax rates that

[25]Consumption floor of about $2,700 and mean medical expenses of $3,712 in 1998 dollars.

[26]China introduced a Minimum Living Standard Assistance (MLSA) program nationwide in 1999. This is aimed at helping the poor in general (Gao, Garfinkel, and Zhai (2009)).

are used along the transition.

4 Results

We start this section by examining the key aggregate statistics of the calibrated economy at both the initial and the final steady states. The initial steady state is calibrated to mimic the economic and demographic conditions in China in 1980, while the final steady state, which is assumed to be reached in 150 years, represents the economy with the one-child policy. Next, we examine the time series path of the savings rate along the transition path to the new steady state. In Section 5, we examine the performance of the model economy against the micro data on household saving rates and intervivos transfers followed by a large number of sensitivity analysis in Section 6.

4.1 Steady State

The results presented in Table 6 show that the initial steady state of the calibrated model matches several key aspects of the Chinese economy in 1980, including the saving rate, the return to capital, and the demographic structure. The saving rate is 20.5% at the initial steady state, while the Chinese net national saving rate was, on average, 20.9% in the late 1970s. The return to capital generated by the model at the initial steady state is 15%, which is mostly due to the relatively high TFP growth rate to which the initial steady state is calibrated. Bai, Hsieh, and Qian (2006) argue that the return to capital was, indeed, quite high in China in the 1980s, about 12% between 1978 and 1985.[27] The demographic structure at the initial steady state is also consistent with the Chinese data. For instance, the share of population aged 65+ at the initial steady state is 13%, while the share of the Chinese population aged 65+ was about 11% in 1980.[28]

The final steady state of the economy is generated by simply changing the fertility rate from 2.0 to 0.65 and the growth rate of TFP factor from 6.2% to 2.0% while keeping the rest of the parameters the same as at the initial steady state.[29] The net saving rate at the

[27] Please see panel (a) in Figure 9 (in Section 4.3) where we compare the return to capital implied in this model along the transition with the estimates provided by Bai, Hsieh, and Qian (2006) between 1978 and 2005. It has been argued that Chinese households may not get full access to the high returns to capital due to a variety of reasons including imperfect financial markets, government regulations, etc. In Section 6.9 we examine the sensitivity of our results by considering a partial equilibrium economy with fixed (world) interest rates.

[28] Please see Figure 8 (in Section 4.3) for the detailed population distribution by age in the model versus the data.

[29] The payroll tax rate is also different between the two steady states. In the initial steady state, the social security replacement rate is set at 15%, which results in a payroll tax rate of 2.6%. At the final steady state, a higher payroll tax rate (8.2%) is needed to balance the budget due to a much larger share of the elderly population.

final steady state is much lower (7.4%) than that at the initial steady state. This is due to the dramatic change in the population structure triggered by the one-child policy and the lower TFP growth rate. Elderly individuals save much less than working-age individuals, and the one-child policy substantially increases the elderly population share, i.e., from 13% at the initial steady state to 29% at the final steady state.[30] The lower TFP growth rate also contributes to the lower return to capital at the final steady state.

Table 6: Properties of the Steady States

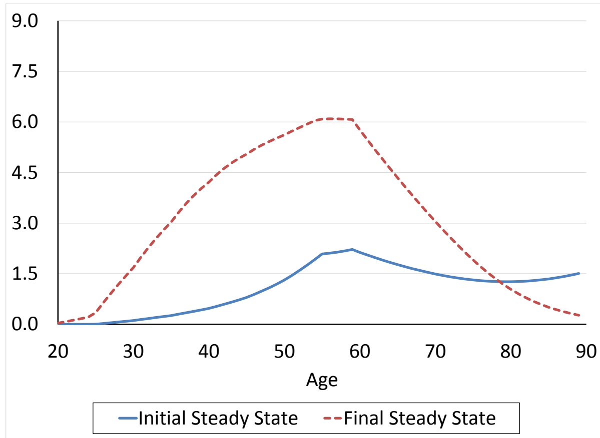
Statistic	Data	Initial steady state	Final steady state
The saving rate in 1970s	20.9%	20.5%	7.4%
Elderly population share (65+)	11%	13%	29%
Share of the elderly in LTC	5.8%	6.0%	6.3%
Return to capital (r)	12%	15.2%	0.1%
Social security payroll tax (τ_{ss})	..	2.6%	8.2%
Capital-output ratio	2.1	2.0	5.1

In Figure 2, we display individual assets held at each age at the initial and final steady states.[31] At the initial steady state, the maximum amount of assets is about 2.5 times household income (given an average household income of one) and individuals leave more than household income's worth of assets as bequests at age 90. At the final steady state, individuals accumulate more assets, until the age of 80, compared to the initial steady state, and deplete them by age 90.

[30]Note that the one-child policy affects the national saving rate via two channels. First, it hampers the original family insurance for long-term care risk and thus encourages precautionary saving. Second, a lower fertility rate increases the elderly population share, which reduces the national saving rate through the compositional effect. Our calibrated model implies that the second channel dominates the first channel at the steady state.

[31]We calculate individual asset holdings and intervivos transfers between parents and children using the same method described in Fuster, İmrohoroğlu, and İmrohoroğlu (2003).

Figure 2: Individual Assets by Age



4.2 Transitions

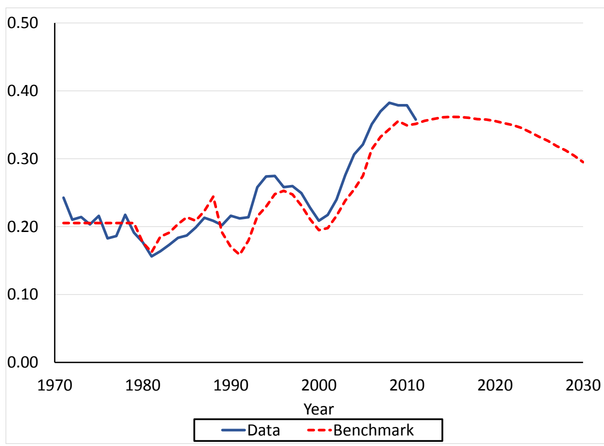
In this section, we present our main results where we examine the time path of the saving rate starting from the initial steady state and along the transition path to the new steady state. We shock the initial steady state in 1980 by imposing the one-child policy (i.e., the fertility rate is immediately reduced from 2.0 to 0.65). The transition is assumed to take 150 years while the effect of the one-child policy is felt 20 years later as one-child cohorts only start to enter the economy in the year 2000.[32] As described in the calibration section, we use the actual data from 1980-2011 on the TFP growth rate, government expenditures and taxes along the transition path and assume perfect foresight for all these components.[33] We compare the saving rates along the transition path generated by the model to the Chinese data to evaluate if the model is capable of accounting for the rise in the Chinese saving rate. Next, we evaluate the driving forces behind the rise in the Chinese saving rate by running counterfactual experiments to isolate the effect of the TFP growth rate, demographic changes, labor income risk, LTC risk, and government policy on the saving rate between 1980 and 2011.

[32]Note that by only reducing the fertility rate to its value at the final steady state, the demographic structure in the economy will never converge to a new stable structure. Thus, we assume that the size of each new cohort will start to decrease exogenously at the rate of $0.65^{1/35} - 1$ after a curtain number of years (70 years in the benchmark case). Here, the rate of $0.65^{1/35} - 1$ is simply the population growth rate in the final steady state. We also explore other assumptions as robustness checks for this issue.

[33]In Section 6, we examine the sensitivity of our results to the perfect foresight assumption, and find that this assumption does not have a large impact on our main results. Chen, İmrohoroğlu, and İmrohoroğlu (2006) also show a rather small impact of the perfect foresight assumption in a similar framework.

Figure 3 displays the saving rates generated by the benchmark economy versus the data starting in 1970. Overall, the time series path of the saving rate generated by the model mimics the data remarkably well. The model not only accounts for the rise in the saving rate from 1980 to 2011 but also captures the major fluctuations in the saving rate in the 1990s. In the data, as summarized in Table 7, the saving rate increases from 15.6% in 1981 to 27.5% in 1995. After a period of brief decline, the saving rate again rises, from 20.9% in 2000 to 37.9% in 2010. In the benchmark economy, the saving rate increases from 16.2% in 1981 to 24.8% in 1995 and from 19.5% in 2000 to 34.9% in 2010. In addition, some other key statistics along the transition path generated by the model are also consistent with the data, which we will discuss further in Section 4.3.

Figure 3: The Chinese Saving Rate: Model vs. Data



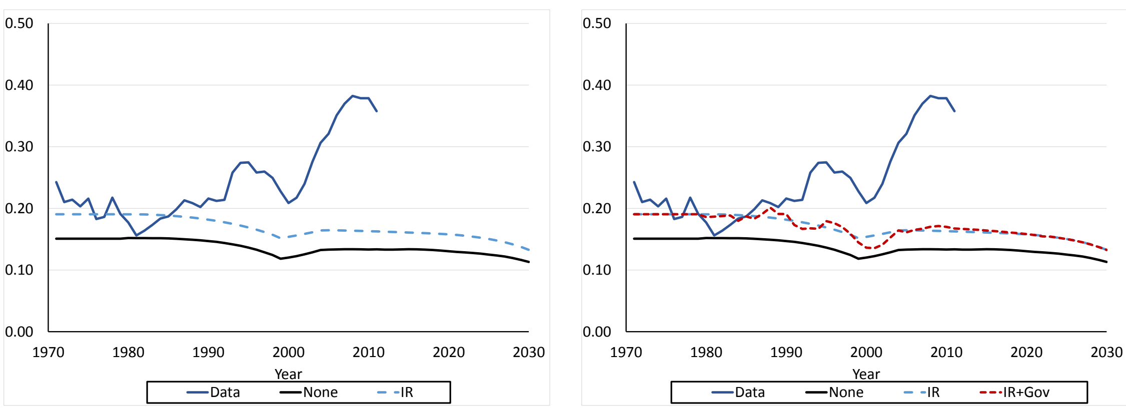
4.2.1 Decomposition of the Saving Rate

In this section, we examine the contribution of each of the exogenous factors to the increase in the saving rate by running counterfactual experiments. We start by generating the saving rate with only the assumed change in demographics playing a role. We use constant government expenditures (as a % of GDP) and constant TFP growth rates and eliminate the individual income and LTC risks. In the rest of the experiments we add each one of these components one by one to isolate their effects on the saving rate.

In the first experiment, we only feed in the changes in demographics due to the one-child policy to the model economy. We eliminate the risk associated with LTC by setting $h = 0$, which means that all the parents live a healthy life until they die. We set the

TFP growth rate from 1980 to 2050 to its average value for that period (5.8%) and fix government expenditures at their average rate from 1980-2011 along the entire transition path and eliminate government surpluses or deficits by assuming tax rates that exactly balance the government budget constraint. We label the saving rate generated in this case as “none” in the first panel of Figure 4. The results of this experiment reveal a declining pattern for the saving rate from 15.0% in the initial benchmark to 13.3% in 2010. This decline happens for two reasons. First, the increase in the share of elderly put a downward pressure on the saving rate. Second, bequests in this economy decline due to the one-child policy.

Figure 4: Decomposition of the Chinese Saving Rate



(a) Role of Individual Income Risk

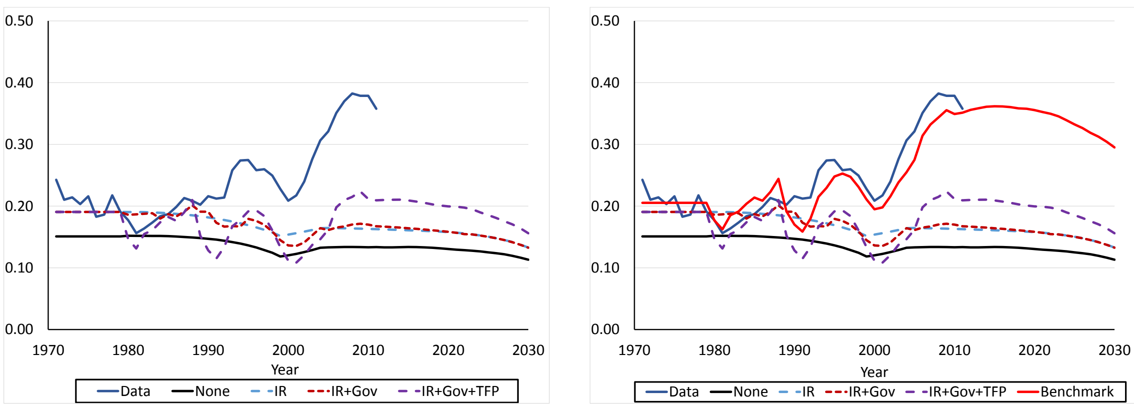
(b) Role of Fiscal Policy

In the second experiment, we add the individual income risk to the model. The saving rate labeled “IR” in the first panel of Figure 4, incorporates both the role of changing demographics and income risk on the saving rate. The difference in the saving rates between the first and the second experiments reveal the impact of the individual income risk quite clearly. It results in a parallel shift in the saving rate in all years by four percentage points. As we will discuss in more detail in Section 6, changing the assumption about the year at which individuals start facing the income risk mainly changes the year at which the saving rate jumps up.

In the third experiment, we add the time series path of the government expenditures and tax rates that yield a government surplus that mimics the data. The resulting saving rate labeled “IR+Gov” in the second panel of Figure 4 indicates that changes in government finances that took place in this time period do not seem to have played a major role in the time path of the national saving rate.

In the fourth experiment, we feed in the observed TFP growth rate between 1980 and 2011. China experienced a surge in productivity after the 1980s with several fluctuations in the 1990s and 2000s.[34] The results of this experiment, that are displayed in the first panel of Figure 5, suggest that changes in the TFP growth rate played an important role mostly in the major fluctuations in the Chinese saving rate observed in this time period.

Figure 5: Decomposition of the Chinese Saving Rate



(a) Role of TFP

(b) Role of LTC

Finally, adding the LTC risk generates the saving rate labeled "benchmark" in the second panel of Figure 5. The results suggest that LTC risks played an important role in the increase in the saving rate, especially during the period after 2000. Note that the differential impact of LTC risks, before and after 2000, found here highlights the importance of the interaction between the lack of old-age support and the demographic changes in China. The impact of LTC risks on precautionary saving largely depends on the availability of insurance against these risks. After the one-child policy was implemented in 1980, more and more one-child families enter the economy and the original family insurance against LTC risks is gradually destroyed; therefore, the impact of LTC risks on precautionary saving becomes larger over time.

Overall, we find that the benchmark economy is capable of accounting for more than 80% of the rise in the saving rate since the 1980s. Table 7 summarizes these results for some

[34]Figure 24 in Section 8 displays the time path of the TFP growth rate that is used in our simulations. We checked the sensitivity of our results to the TFP series provided by the Penn World Tables as well. Both TFP series display similar fluctuations leading to similar conclusions regarding the saving rates in this period.

selected years.

Table 7: The Saving Rates Along the Transition Path

Economy	Initial SS	1981	1995	2000	2010
Data	20.9	15.6	27.5	20.9	37.9
Benchmark	20.5	16.2	24.8	19.5	34.9
Decomposition					
Exp. 1: None	15.1	15.2	13.6	12.0	13.3
Exp. 2: Exp.1+IR	19.0	19.0	16.9	15.4	16.3
Exp.3: Exp.2+Gov	19.0	18.7	17.9	13.6	17.0
Exp. 4: Exp.3+TFP	19.0	13.1	19.1	11.2	21.2
Exp. 5: All three (= Bench)	20.5	16.2	24.8	19.5	34.9

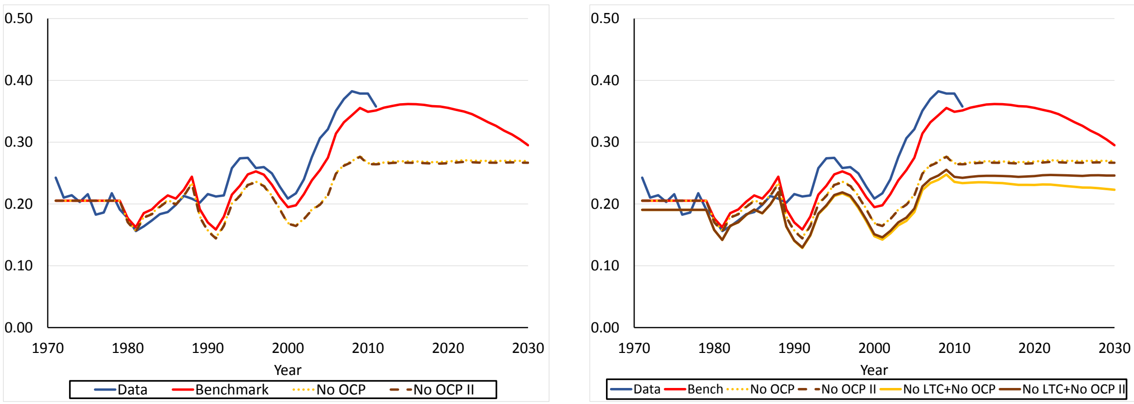
4.2.2 More on the LTC risk

Given the importance of the LTC risk in influencing the time-series path of the saving rate, we conduct three additional counterfactual experiments to understand the role of the LTC risk better. In the first case, we keep all the features of the benchmark economy the same except for the one-child policy. Since it is not obvious what the population growth rate would have been without the one-child policy, we work with two different assumptions. In the first assumption, we keep the fertility rate fixed at its initial steady state value of 2 children per parent. In the second assumption, we let the fertility rate decline gradually along the transition path until 2050 where it reaches the replacement rate of one child per parent.[35] Results of these experiments are displayed in Figure 6 as "No OCP" and "No OCP II", respectively. We find that the rise in the saving rate after 2000 is significantly smaller under both assumptions. The saving rate in 2010 for this case is 26.4% instead of the 34.9% in the benchmark. The intuition for this result is simply. Even though parents face LTC risks, they can still rely on their children to help them, and therefore the saving rate does not rise as dramatically.

Next, we examine a case where we eliminate both the LTC risk and the one-child policy from the benchmark economy. The results for this case are displayed together with the results from the first case in panel (b) of Figure 6. As the figure shows, the impact of LTC risks on the saving rate is substantially smaller in the economy without the one-child policy, and it does not significantly increase over time. The saving rate in 2010 is 24.4% in this case. These results suggests that LTC risks alone cannot generate a substantial rise in the saving rate if the one-child policy was not implemented.

[35] Ideally, we would want to have endogenous fertility choices. Given the computational burden that such a framework would entail, we instead examine the impact of these two different assumptions about the fertility rate. The second assumption is considered because the fertility rate in China would have declined even without the one-child policy due to the economic growth.

Figure 6: LTC Risks and Demographics



(a) No One-child Policy

(b) No One-child Policy and No LTC Risk

These two experiments reveal that the increase in the saving rate especially after 2000 is mostly due to the interaction between the LTC risk and demographics as more and more families with only one child have started entering the economy. The saving rate would have increased from 20% in the 1980s to around 25% in 2010 in the absence of the LTC risk or the one-child policy. The presence of these facts together, on the other hand, results in the saving rate to rise to around 35% in 2010.

Lastly, we conduct a counterfactual experiment to examine the extent to which the uncertainty about the LTC costs influence the saving rates. In our model, agents save for LTC expenses not only because these expenses are uncertain, but also because they occur in the later stage of life. That is, the saving effect of LTC expenses is motivated by both precautionary and life-cycle reasons. Which motive is key for driving the increase in the saving rates in China? To answer this question, we examine an economy in which everyone faces a deterministic stream of LTC expenses after age 55, and the amount of annual expenses is set to the population average cost of LTC in that age.[36]

[36]This counterfactual case can be thought of as an economy with a perfect LTC insurance market.

Figure 7: Uncertain LTC Cost and the Precautionary Motive

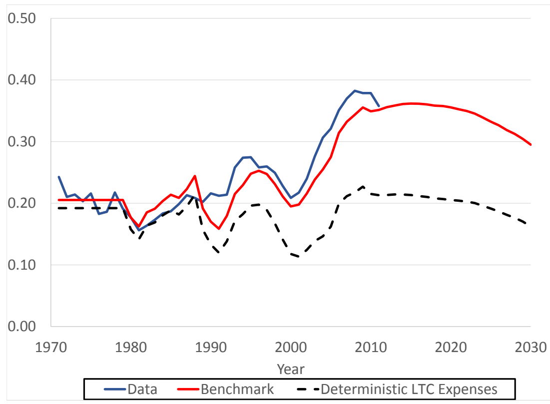
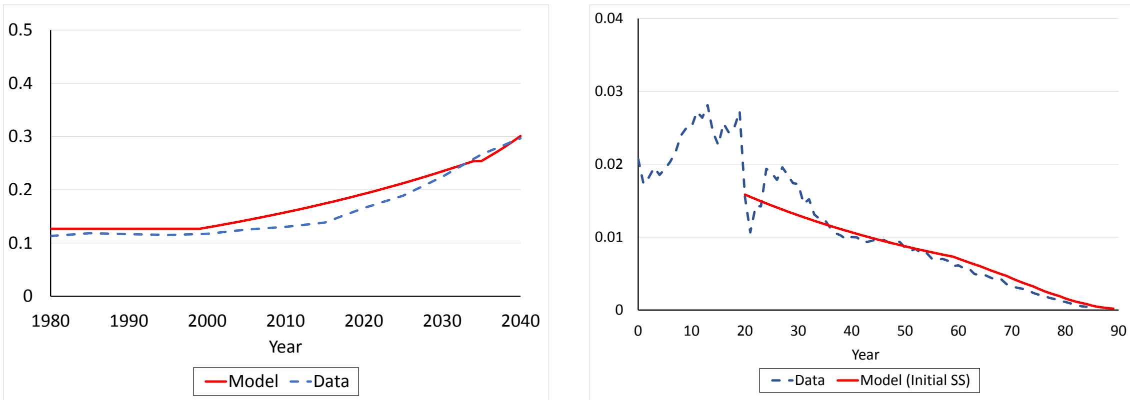


Figure 7 shows that saving rates generated in this counterfactual experiment, where the uncertainty of LTC expenses is assumed away, is significantly lower than the saving rates generated in the benchmark case. Also, the dramatic rise in the saving rate after 2000s almost completely disappears. This finding suggests that the precautionary motive of saving against the LTC is key for shaping the Chinese saving rates over the last several decades. It is worth noting that the finding from this counterfactual experiment distinguishes our model from several existing studies on China's saving rate that also incorporate changing demographics and intergenerational transfers, such as Curtis, Lugauer, and Mark (2015), and Choukhmane, Coeurdacier, and Jin (2013). These models emphasize the impact on life-cycle saving from expected changes in intergenerational financial transfers caused by demographic changes, while our model highlights the impact on precautionary saving from the loss of family insurance triggered by the one-child policy.

4.3 Additional Properties of the Benchmark Model

In this section, we investigate whether our model is capable of matching the aggregate data in other relevant dimensions, such as population dynamics, the return to capital, and the wage rate. In Section 5, we use The China Health and Retirement Longitudinal Study (CHARLS) and the Urban Household Survey (UHS) to provide further information about the performance of the model regarding the micro level data on intervivos transfers, and age and income specific saving rates.

Figure 8: Demographics



(a) Elderly (+65) Population Share

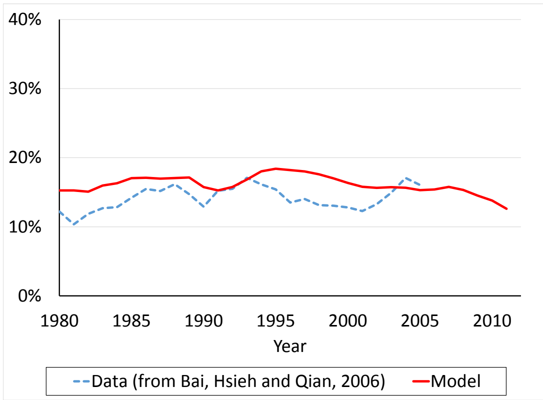
(b) Population Distribution by Age

The first panel of Figure 8 plots the elderly population share along the transition path. The share of population aged 65+ in the model is constant before 2000. This is simply due to the fact that one-child households did not enter the economy until 2000. As more and more one-child households enter the economy after 2000, this share increases and is projected to rise to 30% by 2040. The population dynamics along the transition path generated by the model is reasonably consistent with the data. The second panel of Figure 8 shows the population distribution by age at the initial steady state. The model is not able to match the fluctuations around the age of 20 in the population distribution precisely as they are a consequence of some earlier extreme events in the economy (such as the Chinese Great Famine between 1959-1961), which are not modeled here.

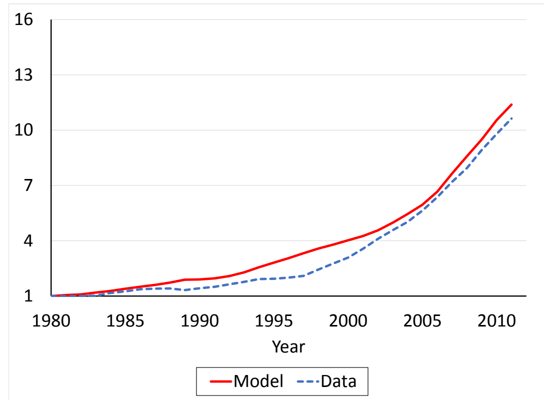
Next, we check the model generated return to capital and the wage rate against their counterparts in the data. Bai, Hsieh, and Qian (2006) carefully measure the net return to capital in China between 1978 and 2005 using data from China's national accounts. They address many of the potential measurement problems and provide data on the return to capital under different assumptions such as removing residential housing, agriculture and mining, or including inventories in the definition of the capital stock. The model generated net return to capital as well as the data obtained from Bai, Hsieh, and Qian (2006) are given in panel (a) of Figure 9.[37] Chang, Chen, Waggoner, and Zha (2015) provide long time-series data on nominal wages in China. Panel (b) in Figure 9 displays real wages constructed by using their wage and CPI data and the model generated wage rates, all normalized to one

[37] Our definition of the capital stock includes inventories; therefore, the relevant comparison with the data is given in Figure 8 of Bai, Hsieh, and Qian (2006) who were kind enough to provide the data.

Figure 9: Return to Capital and the Wage Rate



(a) Return to Capital



(b) Wage Rate

in 1980. Both of these endogenous variables track their counterparts in the data reasonably well.

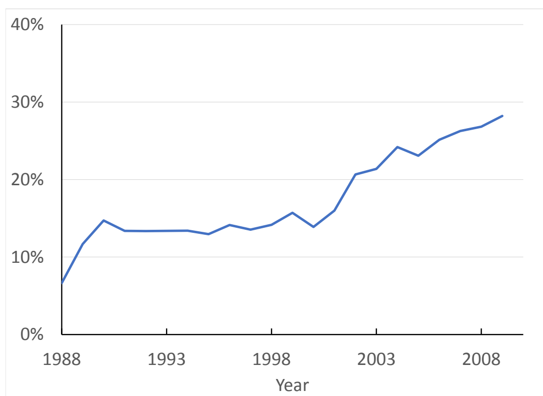
5 Micro-level Implications

Our framework has sharp implications for saving rates by specific household characteristics as well as intervivos transfers between parents and their children. In this section, we compare additional properties of the model with the micro level data provided by the Urban Household Survey (UHS) and The China Health and Retirement Longitudinal Study (CHARLS). There are a few caveats, however, that make the comparison between the data and the model imperfect. First, the concept of household saving in our model does not exactly correspond to that in the empirical literature. In our general equilibrium model, households own the corporations, and thus household saving also includes corporate saving, but micro-level data on household saving rates provided by UHS does not. As a result, the comparison between our model and the data on household saving rates is not perfect. Also, while CHARLS has been used extensively to document the level of intergenerational support and intervivos transfers in China, it only reports the transfers between parents and their non-cohabiting children. As transfers (or implicit transfers) also occur between parents and their cohabiting children, the net transfers estimated from the CHARLS data may not reflect what is captured in the model fully. Consequently, we refrain from trying to calibrate our model to these particular observations and instead use them to assess the qualitative aspects of the forces in place.

5.1 Household Saving Rates

To document micro-level evidence on household saving rates, we use the Urban Household Survey (UHS) data from 1988-2009, which has been widely used in the literature. We define household saving rate as household income net of consumption as a share of household income.[38] As shown in Figure 10, the average household rate in China increased substantially since 1988, i.e., from 7% in 1988 to 28% in 2009, while the net national saving rate increased from 21% to 38% during the same period according to Figure 1. This finding suggests that household saving was an important driving force behind the rising national saving rate in China. In the rest of the section, we investigate the increase in the average household saving rate by various of household characteristics.

Figure 10: Average Household Saving Rates in the UHS Data: 1988-2009

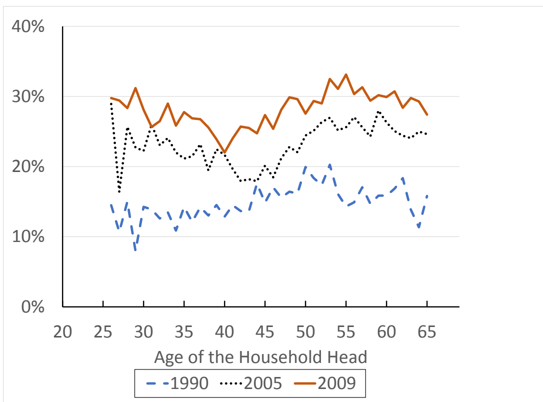


Chamon and Prasad (2010) provide documentation on household saving rates as a function of the age of the household head in the cross-section of households in China for a variety of years since 1990. According to their results, the rise in household saving rate since 1990 was much more pronounced among young and elderly households than middle-aged households. As a result, the age-household saving rate relationship in China became U-shaped in 2000s. Given the sizable literature on differential household saving behaviors by age that followed Chamon and Prasad (2010), we first decompose the increase in the saving rate by

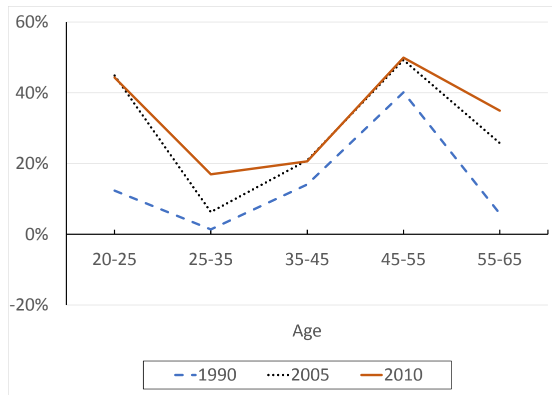
[38] To be consistent with the model concept, here household income is calculated as before-tax income minus income taxes and pension contributions.

different age groups. Similar to what has been found in the existing literature, panel (a) of Figure 11 shows that the increase in the saving rate in China was more pronounced among the young and the old households relative to the middle aged households.[39]

Figure 11: Age-Saving Rate Relationships



(a) The Data: UHS 1988-2009



(b) The Model

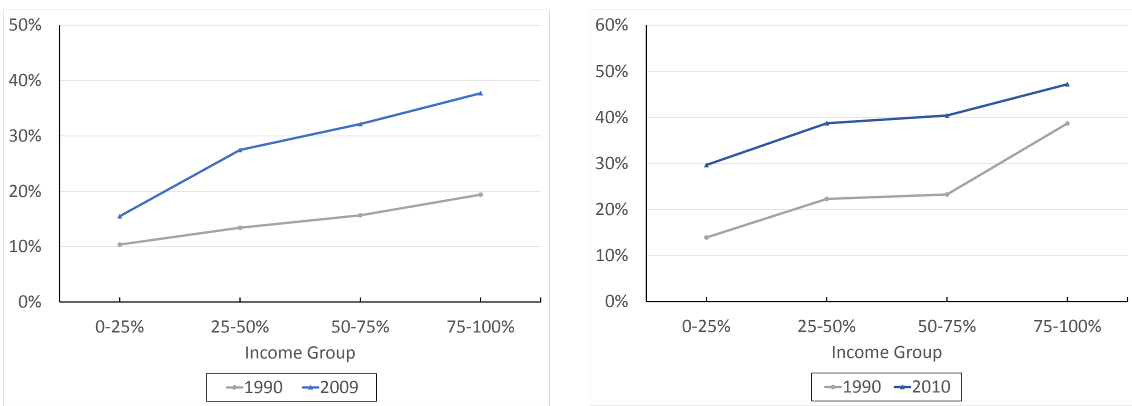
In panel (b) of Figure 11, we display the cross-sectional age-saving rate profiles generated by the model economy during the transition years of 1990, 2005, and 2010. We find that the changing shape of the age-saving rate profile in the model from 1990 to 2010 resembled the qualitative aspects of the data fairly well. The rise in saving rate since 1990 was much more pronounced for young and elderly agents than for middle-age agents. In the model, the reason for the differential increases in saving rate by age is twofold. First, the interaction between LTC risks and the one-child policy has differential effects on successive cohorts, and it has the largest impact on one-child households. Second, the family structures assumed in the model contain adult children and their elderly parent at the same time, and they share the same decision rules due to the two-sided altruism assumption. In the model, households with adult one child only show up after 2000, and therefore, in the 2010 model economy, only the households that contain 20-30 years old children and their 55-65 years old parents are the one-child households. As a result, agents in the age ranges of 20 to 30 and 55 to 65 experienced a much larger rise in saving rate than middle-age agents from 1990 to 2010 in the model. Our finding on the age-saving rate relationship is to some extent consistent with

[39]See for example, Song and Yang (2010), Ge, Yang, and Zhang (2012), Chamon, Liu, and Prasad (2013), Rosenzweig and Zhang (2014), among others.

several recent studies such as Rosenzweig and Zhang (2014), and Coeurdacier, Guibaud and Jin (2015). These studies suggest that the dramatic increase in saving rate for young agents was largely due to their strong family ties to their parents, and that their parents have substantially increased their savings. The quantitative implications of the model and the data are not aligned well due to the caveats discussed earlier.

Figure 12 displays the household income-saving rate relationships from 1990 to 2009 in the UHS data and their counterparts from our model. As can be seen, the saving rate rises as household income increases both in the data and in our model. In the data, the saving rate increased among all income groups since 1990, and the magnitude of the increase was similar across all income groups except the bottom 25%. The similar patterns are observed in our model except that in our model the increase in saving rate for the bottom 25% was as large as for other income groups.

Figure 12: Income-Saving Rate Relationships



(a) The UHS Data

(b) The Model

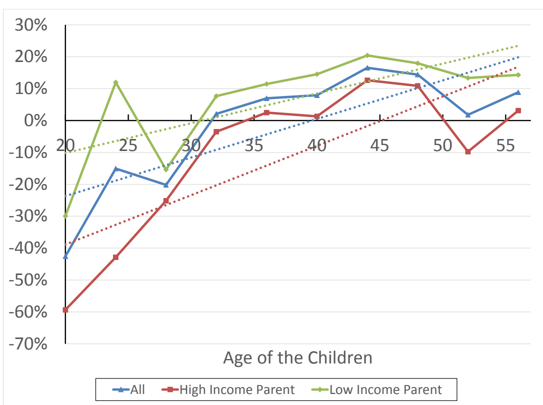
5.2 Intergenerational Transfers

We use the CHARLS 2013 wave dataset to examine whether the intervivos transfers generated in the model are in line with the observations in the data. CHARLS provides data on transfers between the parents (head of the household) and their children and information on their schooling, ages and income.

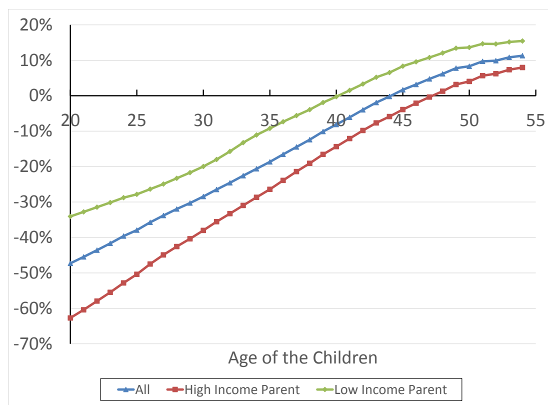
We construct the measure of the net transfers from children to their parents using the same strategy as in Choukhmane, Coeurdacier, and Jin (2013). The sample consists of

1625 families from urban areas.[40] Panel (a) of Figure 13 summarizes the profiles of the net transfers from children to parents for various of population groups in the CHARLS data, where the blue line in the middle is for the whole population. The vertical axis measures the average amount of transfers as a share of disposable income per person (where positive numbers indicate a net transfer from the children to the parent, and negative numbers indicate a net transfer from the parent to the children), and the horizontal axis measures the average age of the children. When the children are 20 years old, the parent is 55 years old. The parent retires at age 60, when the children are 25 years old. According to these results, in families where the average age of the children is 20, transfers to children on average constitute about 40% of income. As children get older, transfers to them decline, and when the average child turns 30s, net transfers turns positive indicating transfers from the children to their parents. After the children turn 40s, transfers to parents constitute approximately 10% of income.

Figure 13: Net Transfers from Children to Parents by Age



(a) The Data: 2013 CHARLS



(b) The Model

(Note: the dash lines are the linear trends.)

The CHARLS data also provides detailed information on the income of the parents. We break down the households into two subgroups based on this information, (1) households where the parent's income is at the top 50% of total income and (2) households where the parent's income is at the bottom 50%, and plot the transfer profiles for these two subgroups.

[40]As CHARLS only provides information on transfers between parents and their non-cohabiting children, we restrict our sample to families who do not have cohabiting children. We also exclude families in which the respondent reports zero income as many of them may simply reflect that they do not want to reveal their income information.

As shown in panel (a) of Figure 13, the income of the parents has a large impact on intervivos transfers between children and parents. While the shapes of the transfer profiles are similar across the two subgroups, transfers to parents in households with low-income parents are substantial higher than in households with high-income parents for each age group (or, transfers to children are lower if the net transfers to parents are negative). This finding is consistent with our two-sided altruism assumption, which implies that parents and children transfer resources to smooth consumption within family members.

Panel (b) of Figure 13 presents the counterparts of these empirical observations from our model. As can be seen, the transfer profiles generated in our model resemble those documented in the CHARLS data reasonable well. In particular, when children are 20, transfers to children also constitute around 40% of disposable income on average in the model. As children get older, they receive less transfers and eventually start to give transfers to their parents. When children reach age 50, transfers to parents are approximately 10% of income. In addition, the income of parents also has similar impacts on intergenerational transfers in the model. Low-income parents receive more transfers from their children for each age group in the model (or, give less transfers to children if the net transfers to parents are negative). These findings suggest that the qualitative properties of our model implications for intergenerational transfers resemble the data reasonably well, although the model does not exactly match the levels of transfers, or the age at which transfers turn positive, for every group of households.

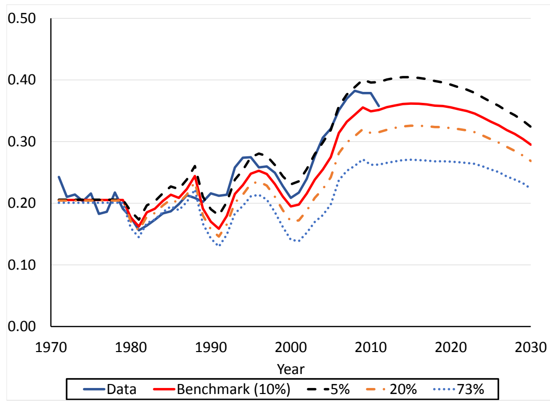
6 Sensitivity Analysis

In this section, we examine the sensitivity of our results to some of the parameters and the modeling choices we made.

6.1 Consumption Floor

An important parameter that is difficult to precisely estimate is the value assigned to $\underline{c}$. As we discussed in Section 3.5 De Nardi, French, and Jones (2010) find that the level of the consumption floor plays an important role in explaining the elderly's savings in the U.S. They estimate the consumption floor, which proxies for Medicaid and Supplemental Security Income (SSI) in the U.S, to be 73% of mean medical expenditures. Given the lack of programs like Medicaid in China, we set the consumption floor to 10% of mean medical expenses in our benchmark calibration. In Figure 14, we show the sensitivity of our results to three other values for the consumption floor: 5%, 20%, and 73% of medical expenditures. As expected, the consumption floor plays an important role in the time path of the saving

Figure 14: Role of the Consumption Floor

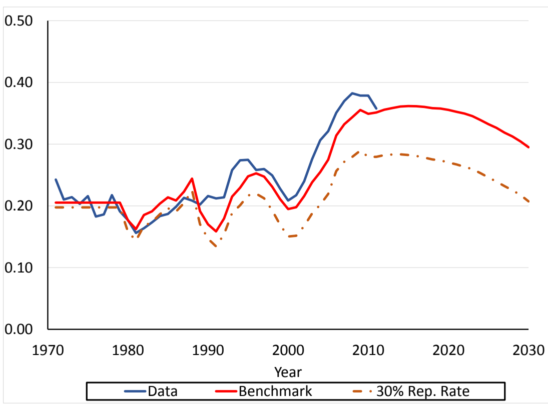


rate, especially in the increase since the 2000s. If the consumption floor were as high as it is in US, then the model-implied saving rate in China in 2010 would have been 26.2% in 2010 as opposed to the 34.9% found in the benchmark case. Quantitatively the saving rate in this case is very similar to the results of the experiment without the one-child policy. In other words, if the Chinese government were to provide an assistance program against the LTC risks that substituted for the informal care provided by the family, then the increase in the saving rate would have been much smaller. This case represents a lower bound for the quantitative importance of the LTC risks in the face of the demographic changes faced in China.

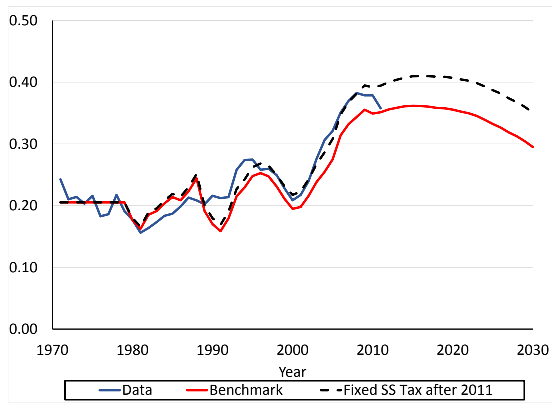
6.2 Social Security

Of course, LTC is only one component of the general issue about old-age insurance. Generosity of the social security system plays an important role in the saving behavior of the elderly. In our benchmark calibration, we set the replacement rate at 15%, along the transition path and at the new steady-state, which reflects the level of coverage at the national level in the mid-2000s. Given the aging of the population, the social security tax rate in the benchmark increases from 2.6% in 1980 to around 8.2% in 2080. In this section, we examine the results of two counterfactual experiments. First, we examine an alternative case where the replacement rate is set to 30% for the entire time period. In this case, the social security tax rate starts at 5.2% and reaches 16.4% by 2080. In the second case, we fix the social security tax rate after 2011 at 3%, consistent with our benchmark calibration, and adjust the social security benefits to balance its budget in each period. This case represents the concern that the Chinese government may not be able to provide the promised social security benefits in the future.[41] Replacement rates in this case decline from 15% in 2011 to around 6% by 2040.

Figure 15: Saving Rates and Social Security



(a) 30% Replacement Rate



(b) Lower Replacement Rate After 2011

The saving rate generated with a 30% replacement rate is plotted (together with the benchmark results) in panel (a) of Figure 15. As expected, higher social security benefits imply lower saving rates along the transition path. The saving rate in 2010 is 27.9% with a 30% replacement rate, as opposed to 34.9% in the benchmark case with a 15% replacement rate. In addition, similar to LTC risks, the impact of the social security replacement rate on saving is larger after 2000. This is due to its interaction with LTC risks as social security benefits provide partial insurance against LTC risks.

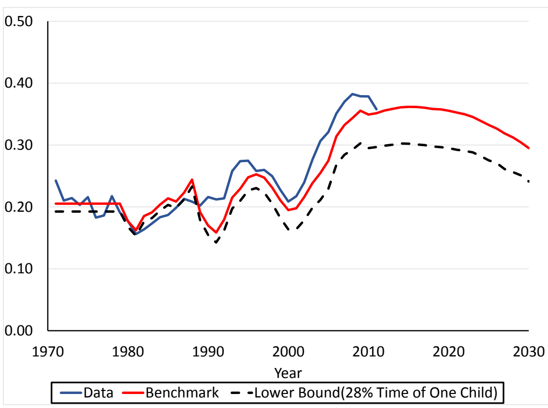
The saving rate generated for the second experiment where the social security tax rate is kept constant after 2011 while the replacement rate is allowed to decline to satisfy the social security administrations budget constraint is plotted in panel (b) of Figure 15. The results indicate that reduced social security benefits after 2011 do not only substantially increase the saving rates after 2011 but also increase the saving rates years before 2011 as individuals are forward-looking.

[41] Sin (2005) provides an extensive study of the challenges faced by the existing old age insurance system in China. Song, Storesletten, Wang, and Zilibotti (2014) also discuss that the current social security system does not seem to be sustainable and will require a significant adjustment in either contributions or benefits.

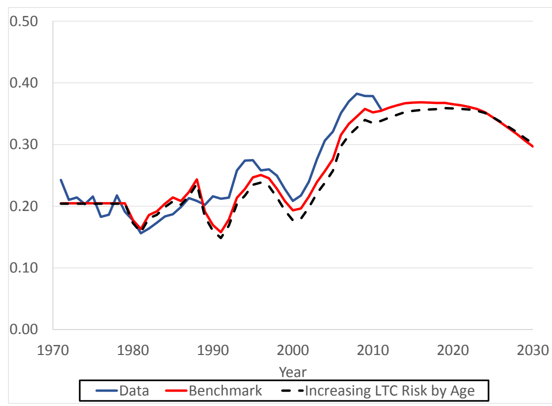
6.3 Different Calibrations of LTC Risk

As shown previously, the LTC risk plays a key role in shaping the Chinese saving rates since 1980. In this section, we show the sensitivity of our results to different calibrations of LTC risks. We consider two alternative cases: (1) the time cost of LTC is set to 28% of the time of one child, that is, the lower bound of our estimates for the time cost of LTC services from the CHARLS data; (2) the risk of having LTC needs increases by age.

Figure 16: Different Calibrations of LTC Risk



(a) Lower LTC cost



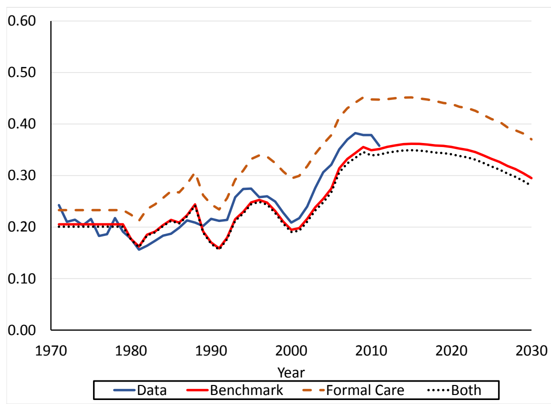
(b) Increasing LTC by age

Panel (a) of Figure 16 displays the results from the first case. As expected, a smaller time cost of LTC implies lower saving rates. With the time cost equivalent to one-third time of one child, the model implied saving rate in China in 2010 would have been slightly above 30% as opposed to the 35% found in the benchmark case. A well-observed feature about LTC risks is that the risk increases as individuals age. According to Gu and Vlosky (2008), an increase in each additional year of age increases the risk of having long-term care needs by 11% in China. In the second case, we capture this feature of LTC risks by assuming that the conditional risk of having LTC shock (i.e., Γ_{01}) increases by 11% as the age increases by one year. We then rescale these conditional probabilities of having LTC needs so that the fraction of the elderly population in LTC status is the same as in the benchmark case. Panel (b) of Figure 16 shows the results from this case. As can be seen, the results remain similar to the benchmark results.

6.4 The Role of Informal Care

There is a recently growing literature finding that uncertain medical expenditures, in particular LTC expenses, have large effects on savings in life-cycle models with incomplete markets.[42] However, most of the existing studies in the literature abstract from the role of family insurance. In this section, we investigate the role of informal care in understanding the saving impact of LTC expenses. Specifically, we consider the following two cases.

Figure 17: Informal and Formal Care



In the first case, we replace informal care with formal care in the benchmark model. That is, the time cost of LTC is replaced by the expenses for hiring formal caregivers. To be comparable with the benchmark model, we assume that the LTC services of one parent require half time of one formal caregiver. In addition, we assume that the wage rate of formal caregivers is equal to the average wage rate of the child population.[43] Figure 17 displays the saving rates along the transition path generated in this case as well as the benchmark results. We find that, when informal care is replaced with formal care, the saving rate in the initial steady state becomes higher. 23% compared to the benchmark case with 21% saving rate. The saving rate is also higher in most periods along the transition path, reaching beyond 40% in 2010s. The intuition for this result is simple. In the model with the option

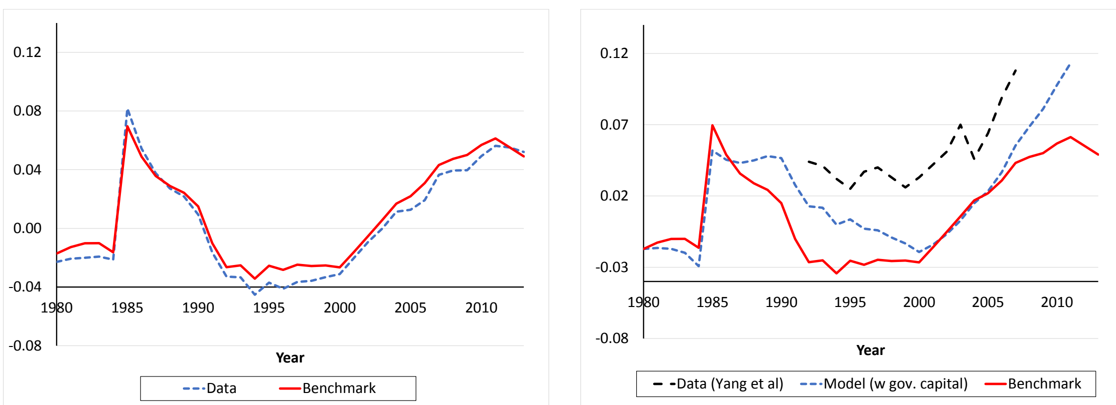
[42]Hubbard, Skinner, and Zeldes (1995); De Nardi, French, and Jones (2010); Kopecky and Koreshkova (2014), Zhao (2014, 2015), etc.

[43]It is worth noting that the time cost of informal care from children is their forgone after-tax labor income. Therefore, we use after-tax wage to calculate the cost of formal care so that it is more comparable to the benchmark case with informal care. This is equivalent to assume that where formal care expenses are tax deductible. We also replicate the experiment using before-tax wages to calculate the cost of formal care, and the results from this exercise are available upon request from the authors.

of informal care, a large fraction of the LTC costs are in terms of forgone earnings, and thus are positively correlated with idiosyncratic income shocks. This correlation provides partial self insurance against both LTC risks and idiosyncratic risks faced by households.

In the second case, we incorporate both options, informal and formal care, and let households choose between the two when hit by LTC shocks. In this case, when LTC services are needed, households with low-income children choose informal care as their opportunity cost is low. In contrast, households with high-income children choose to purchase formal care from the market. The saving rates generated in this case, labeled "both" in Figure 17, are similar to those in the benchmark case.

Figure 18: Government Budget



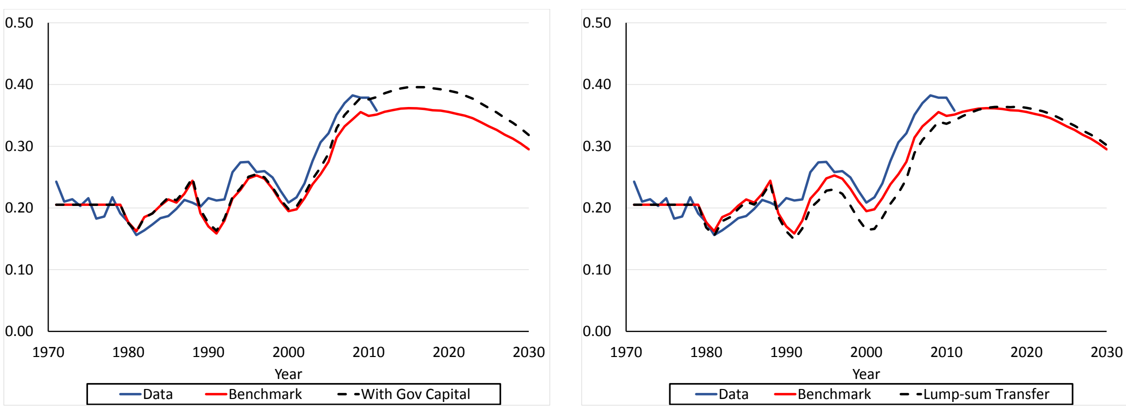
(a) Budget Deficit/Surplus (Benchmark) (b) Government Saving (Alternative)

6.5 Government Budget

In our benchmark model, government expenditures and tax revenues are not always equal to each other along the transition path, and a transfer proportional to labor income is used to balance the government's per period budget constraint. We interpret these transfers as government deficit/surplus and graph them in panel (a) of Figure 18 together with data obtained from China Statistical Yearbook-2014 on tax revenues and government consumption expenditures. Given that the tax rates were constructed using this data and the model can account for the path of the real return to capital and the wage rate reasonably well, it is not surprising that the model can account for the government budget deficit/surplus observed during this period well.

While this way of modeling the government substantially simplifies our analysis, it misses the actual saving done by the Chinese government who has been investing in financial and physical assets at home or abroad. Yang, Zhang, and Zhou (2011) measure government savings using the flow of funds data that accounts for other items such as the revenues of state-owned enterprises, for the time period 1992-2007 (the period for which there is consistent data on the relevant subcategories). While modeling state-owned enterprises is beyond the scope of this paper, we consider an alternative case in which the government does not redistribute government surplus/deficits and instead is allowed to accumulate capital over time. The implications of this case on government saving are displayed in panel (b) of Figure 18. While the model-generated government saving is still lower than the data presented in Yang, Zhang, and Zhou (2011), its impact on national savings, presented in panel (a) of Figure 19, is quite small.

Figure 19: Role of Government Capital and Form of Transfers



(a) Role of Government Capital

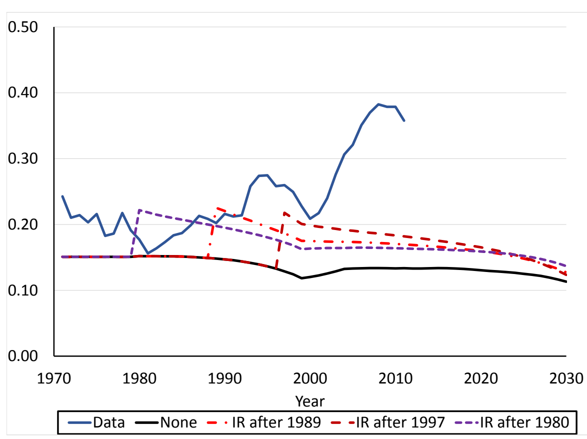
(b) Role of Transfers

We also check the sensitivity of our benchmark results to the assumption about distributing the government surplus in a proportional way to labor income. In the alternative case in which the transfer takes the lump-sum form, it provides relatively more insurance (especially for the poor) compared to proportional transfers. Panel (b) in Figure 19 shows the sensitivity of our results to this different way of redistributing back government surplus/deficits in each period. As expected, lump-sum transfers reduce the saving rate in the model, but only slightly compared to the benchmark case.

6.6 Different Individual Income Risk

In the benchmark model, the magnitude of income risk in China is constant over time, mostly due to the lack of data and relevant empirical estimates. There has been some evidence suggesting that the size of income risk facing Chinese has increased over time. In the early 1980s after the start of the Chinese economic reform, most jobs were government-related and came with great security (the so called "Iron Rice Bowls"). These "Iron Rice Bowls" were gradually broken as the Chinese economy went through a series of major reforms. He, Huang, Liu, and Zhu (2014) show that the large scale state-owned enterprise (SOE) reform in 1997 substantially increased the income risk facing Chinese. Chamon, Liu, and Prasad (2013) report trend growth in both the mean and the variance of total household income since 1997. Due to the lack of data, it is hard to precisely measure the annual increase in the magnitude of the income risk in China from the 1980s to the 2010s. However, the potential impact of increasing income risk in the model can be gleaned from the following exercise where we examine the sensitivity of our results to different assumptions about the year in which the individual income risk becomes operational. As shown in Figure 20, changing the year in which there is an unexpected increase in the income risk changes the year at which the saving rate jumps up. Therefore, it is expected that the time path of the saving rate in the model would simply become steeper if the magnitude of income risk increased gradually over time.

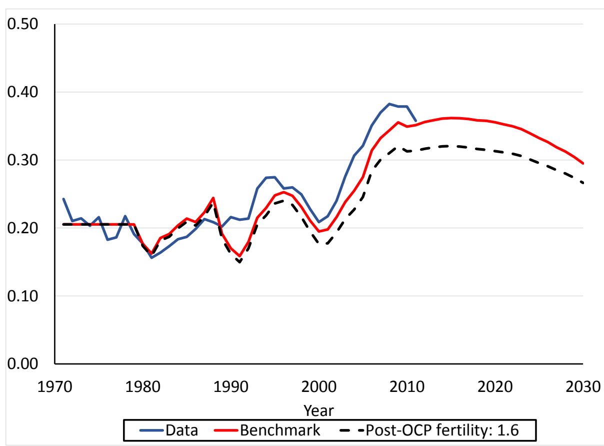
Figure 20: Income Risk Starting in Different Years



6.7 Alternative Fertility Rate After the One-child Policy

In the benchmark case, we assume that the fertility rate implied by the one-child policy is 1.3 per couple as this value is explicitly written in the policy rules. We argue that in general the policy is binding as its detailed rules impose strong incentives and penalties. However, it is worth noting that some special families, such as ethnic minorities and families facing special conditions (e.g, a disabled first child), were given permission to exceed the quota. Consequently, some estimates of the fertility rate after the one-child policy are equal to 1.6 per couple. In this section, we provide results for this case as a robustness check. As shown in Figure 21, when the fertility rate after the one-child policy is set to 1.6 per couple, the model implied saving rate in China in 2010 is slightly lower than in the benchmark case, while the time-series path of the saving rate remains the same.

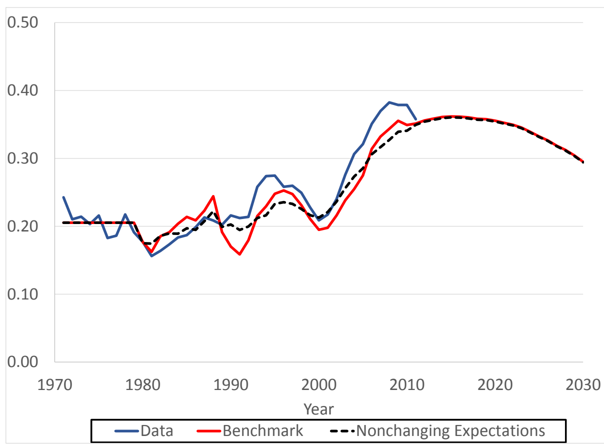
Figure 21: Alternative Fertility Rate After the One-child Policy



6.8 Perfect Foresight

In this experiment, we examine the sensitivity of our results to the assumption of perfect foresight by running the same experiment as in Chen, İmrohoroğlu, and İmrohoroğlu (2006). In this counterfactual experiment, we make the extreme assumption that households always expect the TFP growth rate to be 7.8% (i.e., the average value of the period 1980-2011) while getting hit with the actual TFP growth rates every period until 2011. After 2011, their expectations are aligned with the Goldman Sachs forecasts that are also used in our benchmark case. The results from this experiment are labeled "non-changing expectations" in Figure 22, which displays the extent to which expectations may play a role in the relationship between TFP and the saving rate. As shown in Figure 22, the effect of the perfect foresight assumption is rather small. When households are assumed to expect a constant TFP growth rate, the time-series path of the saving rate, while smoother, remains similar to the benchmark case.

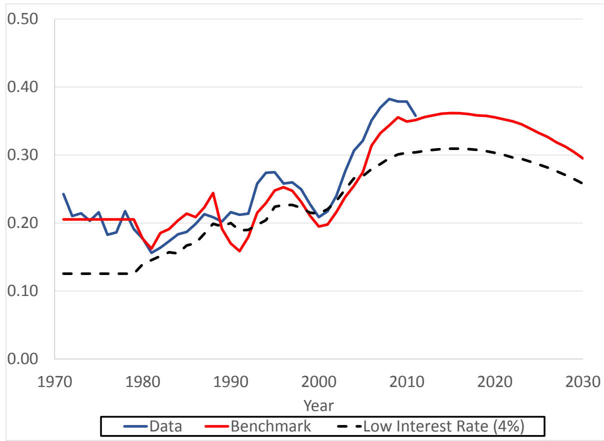
Figure 22: The Role of Perfect Foresight



6.9 Low Interest Rate

As estimated by Bai, Hsieh, and Qian (2006), the net returns to capital in China were high since 1978. Our general equilibrium model is able to generate high returns to capital along the transition path that are consistent with their data counterparts (see in panel (a) of Figure 9). However, it is known that the Chinese households may not get full access to the high returns to capital due to a variety of reasons including imperfect financial markets, government regulations, etc. In this section, we examine the sensitivity of our results to the high interest rates on savings implied in our general equilibrium model. Specifically, we consider a partial equilibrium economy with fixed low interest rates along the transition path. In this experiment, we set the interest rate to 4% along the whole transition path and in the steady states. In addition, the average wage growth rate in China was about 5%

Figure 23: Fixed Low Interest Rate



per year according to Curtis et al. (2015). Therefore we assume the wage rate grows at 5% annually along the transition path in the model.

The results from this experiment are labeled "Low Interest Rate (4%)" in Figure 23, which displays the extent to which high interest rates may play a role in shaping China's saving rates. As shown in Figure 23, the model with fixed low interest rate is also able to generate an increase of similar magnitude in the saving rate. On the other hand, the saving rate series generated in this economy is much more smooth than in the benchmark economy. This is simply because the partial equilibrium model is not able to capture the general equilibrium effects of the changing TFP growths. This finding in this section suggests that our main results are robust to the possible low interest rates facing the Chinese households.

7 Conclusion

In this paper, we use a model economy that is populated with altruistic agents, calibrate it to the Chinese economy, and examine the role of demographics, fiscal policy, long-term care costs, individual income risk, and the productivity growth rate in generating changes in the saving rate. Our results indicate that the interaction between the LTC risk and demographics plays an important role in the increase in the saving rate especially after 2000 as more and more families with only one child have started entering the model economy. We find that the saving rate would have increased from 20% in the 1980s to around 25% in 2010 in the absence of the LTC risk or the one-child policy. The presence of these facts, on the other hand, results in the saving rate to rise to around 35% in 2010. Changes in the TFP growth rate account for most of the fluctuations in the saving rate during this period.

Our experiments reveal that the possibility of inadequate insurance during old age, by the government or the family members, is capable of generating large increases in the saving rate in China. While it is difficult to calibrate the risks faced by the elderly in China precisely, it is not likely that we have exaggerated these risks. There are several issues we have abstracted from, such as medical costs other than LTC costs, increases in LTC costs due to longevity, or the sustainability of the social security system, which contribute to concerns about old-age insurance in China. Going forward, as the Chinese government enacts measures to help the problems faced by the elderly, the saving rate will likely decline.

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8 Online Appendix

In this section, we present the data that is used in our simulations. We use annual data from the China Statistical Yearbook-2014 released by China's National Bureau of Statistics (NBS), http://www.stats.gov.cn/tjsj/ndsj/2014/indexeh.htm, starting from 1978, for GDP by expenditure, Consumption, Government Expenditures, Investment, and Net Exports in the construction of the time-series data on TFP and the net national saving rate.[44] Employment data (persons employed) is from The Conference Board Total Economy Database (January 2014, http://www.conference-board.org/data/economydatabase/).

We construct the capital stock using the Perpetual Inventory Method given by:

$$K_{t+1} = (1-\delta)K_t + I_t$$

where I_t is investment and the depreciation rate, δ is assumed to be 10%. The initial capital stock is calculated using:

$$K_0 = I_0/(\delta + g)$$

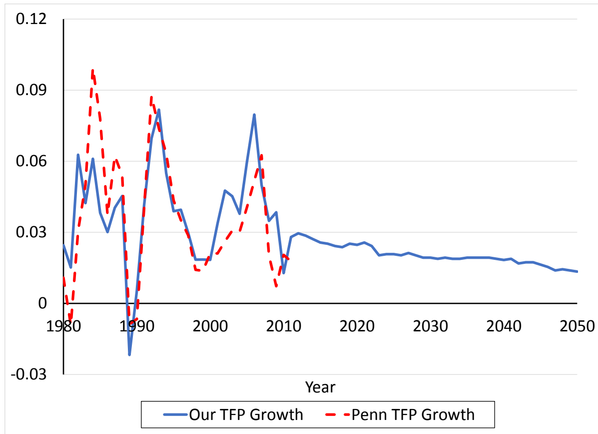
where g is the average growth rate of GDP between 1960 and 2011. For investment series, we use "Gross Capital Formation" series (which is inclusive of inventories) from NBS as recommended by Bai, Hsieh, and Qian (2006). We deflate all nominal series by the GDP deflator (base year 2000) from the World Bank, World Development Indicators. TFP series, A_t, is calculated as: $A_t = \frac{Y_t}{K_t^{\alpha} N_t^{1-\alpha}}$. Figure 24 displays the resulting TFP series between 1980 and 2010 as well as the projections used until 2050 in our simulations.[45] In the same figure, we also provide the TFP series obtained from Penn World Tables for comparison reasons (https://www.conference-board.org/data/economydatabase/index.cfm?id=27762).

It is challenging to measure the average effective capital and labor income tax rates in China accurately due to lack of detailed data. We have experimented with several different possibilities. In the benchmark results, we use the findings in Liu and Cao (2007) for the capital income tax rate. They measure the average effective tax rate at the firm level, using a panel data on 425 listed companies in China's stock market between 1998 and 2004. Based on their findings, we set the capital income tax rate to be 15.28% from 1980 onwards. Next, we calculate the capital income tax revenues as the capital income tax rate times capital income. Capital income is calculated as capital share times GDP net of depreciation. Capital share is provided by Bai and Qian (2010) for the 1978-2007 period, carefully accounting for several data related issues. Capital depreciation rate is assumed to be 10% and capital stock is from Berleman et al (2014). Labor income tax revenues are calculated as total tax

[44]The series we employ are consistent with Chang, Chen, Waggoner, and Zha (2015) who provide macroeconomic time series on China both at the annual and quarterly levels.

[45]TFP forecasts are obtained from Goldman Sachs (2003)

Figure 24: TFP Growth Rate



revenues minus the capital income tax revenues where labor income is calculated as labor share (from Bai and Qian (2010)) times GDP. Lastly, labor income tax rate is calculated as labor income tax revenues divided by labor income.

Table 8 displays the data for the TFP growth rate, government expenditures as a share of GDP, and the tax rates that are used in our simulations.

Table 8: TFP Growth, Government Expenditure and Tax Rates Since 1980

Year	Growth Rate of TFP Factor ($\gamma - 1$)	TFP Growth Rate ($\gamma^{1-\alpha} - 1$)	Government Exp. (% of GDP)	Constructed Labor Income Tax Rate
1980	0.05	0.025	14.7	16.7
1981	0.03	0.015	14.6	17.4
1982	0.13	0.063	14.5	17.8
1983	0.09	0.042	14.4	17.4
1984	0.13	0.061	15.0	17.2
1985	0.08	0.038	14.3	32.9
1986	0.06	0.030	14.5	29.1
1987	0.08	0.040	13.7	24.9
1988	0.09	0.045	12.8	21.7
1989	-0.04	-0.022	13.6	22.4
1990	0.01	0.005	13.6	20.8
1991	0.08	0.042	14.9	18.5
1992	0.14	0.070	15.2	15.7
1993	0.17	0.082	14.9	15.2
1994	0.11	0.055	14.7	12.7
1995	0.08	0.039	13.3	11.6
1996	0.08	0.040	13.4	11.3
1997	0.06	0.030	13.7	12.6
1998	0.04	0.018	14.3	13.7
1999	0.04	0.019	15.1	15.5
2000	0.04	0.018	15.9	17.0
2001	0.07	0.034	16.0	19.4
2002	0.10	0.048	15.6	20.7
2003	0.09	0.045	14.7	21.1
2004	0.08	0.038	13.9	21.8
2005	0.12	0.060	14.1	23.3
2006	0.17	0.080	13.7	24.2
2007	0.10	0.050	13.5	26.2
2008	0.07	0.035	13.2	26.5
2009	0.08	0.038	13.1	27.1
2010	0.03	0.013	13.2	28.8
2011	0.06	0.028	13.4	30.4
2012-2021	Goldman Sachs Forecasts	Goldman Sachs Forecasts	Converges to its final SS value	Converges to its final SS value
2022-2050	..	..	Final SS value	Final SS value
2050+	0.02	0.01	..	..