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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 risks in old age, 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 findings suggest that the combination of the risks faced by the elderly and the deterioration of family insurance due to the one-child policy may account for approximately half of the increase in the saving rate between 1980 and 2010. 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, 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 amount of public and family insurance the Chinese households have, and therefore affect their saving behaviors.

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 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 approximately half 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

[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.

economically active. We find that the saving rate would have increased from about 21% at the initial steady state to around 22-26% in 2010 in the absence of the LTC costs or the one-child policy. Their presence, on the other hand, results in the saving rate to rise to around 31% 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 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. This implies that saving behavior of families with one versus two children, especially in areas with high LTC costs is likely to be very different. We confront the implications of the model against the micro data provided by the Chinese Longitudinal Healthy Longevity Survey (CLHLS), the China Health and Retirement Longitudinal Study (CHARLS), and the Urban Household Survey (UHS). First, as in Choukhmane, Coeurdacier, and Jin (2013), we document that saving rates of households with twins versus one child differ significantly. More importantly, we show that these differences are more pronounced in provinces with high LTC costs. Our regression results confirm the importance of the interaction between the number of children and the LTC costs as driving the differences in saving rates across households. Next, we present evidence on the importance of intervivos transfers in China and show that the dynastic model provides a good approximation for the transfers between parents and children in the Chinese economy. We also compare the age saving profiles and income saving profiles that are generated by the model against their data counterparts. The model's implications against some macro facts are also quite encouraging. The real rate of return to capital as well as the wage rate mimic their counterparts reasonably well.

In our benchmark case, the model is capable of accounting for 57% of the rise in the saving rate between 1980 and 2010. We find the impact of the LTC risks accounts for 47% of the increase while the other factors such as the individual income risk or the TFP growth rate account for the remaining 10%. We show that any increase in the risks (higher LTC costs) or decline in government provided insurance (lower social security replacement rates either currently or expected) result in higher saving rates in 2010. On the other hand, increasing government-provided help for the most unfortunate lowers the saving rate in 2010. We provide an extensive set of sensitivity analysis to many of these factors in Section 8.

While the performance of the model in accounting for the data quantitatively is reasonably good, the qualitative implications of our findings are equally important. The picture that emerges from our experiments is the importance of the interaction between the decline in the family insurance and the uncertainty about certain risks that the elderly face in generating the high saving rates in China. These findings differ from several important papers in the literature. For example, in Curtis, Lugauer, and Mark (2015), who study the

[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.

impact of changing demographics on China's household saving rate, children are treated as pure consumption goods and thus play no role in the old-age security of the parent. However, we document in the CHARLS and CLHLS data that there exist substantial transfers from children, both financial and in terms of time, during the old age of parents. The expected decline in this family insurance plays an important role in our findings. Another important study from Choukhmane, Coeurdacier, and Jin (2013) examines the impact of the one-child policy on China's saving rate. They emphasize the role of children as old-age support for their parents by modeling financial transfers from children to their parents. However, in their model, these transfers are assumed to be an exogenous function of children's income (or education) and the number of siblings they have. This modeling strategy implies that the transfers from children in their economy are independent of the state of parents (such as their financial and health statuses). Consequently, children have no insurance role in their model. However, we document in the data that the transfers from children (both financial and in terms of time) are highly correlated with the financial and health status of parents. Our dynastic model with two-sided altruism implies that the transfers from children are dependent on the parent's financial and health status, and thus children provide substantial insurance for their parent. Our quantitative results show that the one-child policy partially destroys this type of family insurance, and the changing family insurance is important for understanding China's saving rates. 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 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.

Our results also highlight the importance of the government-provided safety nets in impacting the saving rate. We show that an increase in the social security replacement rate or government-provided programs, similar to Medicaid or Supplemental Security Income in the U.S, aimed at helping the most unfortunate elderly have a significant impact on the aggregate saving rates. Comparing saving rates in countries with similar family structures and demographics, such as China, Japan, or South Korea, would have to take into account the differences in such government programs as well as differences in productivity, taxes, and the risks faced by the elderly. For example, according to OECD (2006), net replacement rates (individual net pensions relative to individual net earnings) were 60% and 44% in Japan and South Korea for the average earner and 80% and 65% for the lowest earners. In China, by contrast, 40-50% of the elderly in cities and more than 90% of the elderly in rural areas did not have a pension in 2002 and 2005.[3] In light of our findings, the differences in the saving rates between Korea, Japan, and China need not be surprising even if these

[3]Gu and Vlosky (2008).

countries are experiencing similar changes in demographics.[4]

Overall, the implications of our findings for future saving rates in China are quite different from the literature. For example, the expected increase in government provided social insurance is likely to have a different impact on the future saving rates in China 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 or the reduced child-raising expenses (such as education costs) resulting from the one-child policy, or the changes in demographics. 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 China's saving glut that has impacted the world economy.[5]

Of course, measuring precisely the risks faced by the elderly is challenging. Nevertheless, our calibration is unlikely to have exaggerated 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 or 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.

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.[6] 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 the lack of public programs such as Medicaid insuring against these risks. In addition, as Chinese households have 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.

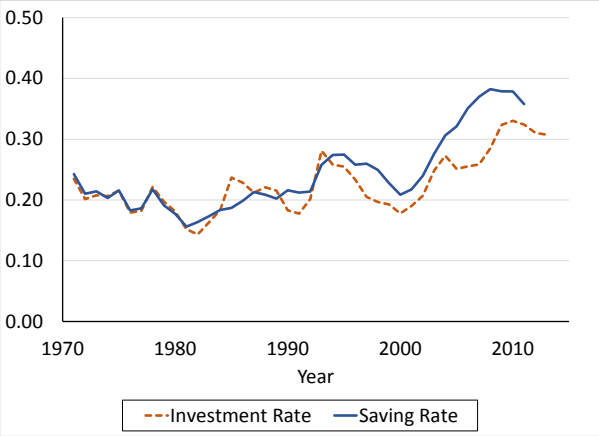
It is important to note that we treat China as a closed economy. While this assumption may not seem very desirable, as can be gleaned from Figure 1, saving and investment rates in China have both been increasing during this time period. Clearly, the current account surplus of China since the 1990s has 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. Since Chamon and Prasad (2010), there is the impression that the increase in the gross domestic savings in China were driven by corporate and government savings. However, as Bayoumi, Hui, and Wei (2010) also comment on, flow of funds data in China is subject to large revisions and the 2012 data that is presented in Section

[4]See Chen, İmrohoroğlu, and İmrohoroğlu (2006 and 2007) for a detailed study of the Japanese saving rate.

[5]In addition, a large strand of this literature has focused 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. Moreover, 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.

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

Figure 1: Saving and Investment



9.2 of the online appendix shows that household savings have been higher than corporate and government savings during most of the 1990s and 2000s. In fact, after hovering around 20% in the 1990s, the household saving rate as a percent of GDP increases to 25% by 2010. In addition, it is important to note that while we are not able to distinguish between household and corporate saving rates, corporate savings are a part of total private savings since households own the corporations in the model economy. In a companion paper (İmrohoroğlu and Zhao (2017)), we separately distinguish between household and corporate saving rates by extending our model to include a corporate sector facing financial frictions, and we use the extended model to study the causes of the current account surplus in China.

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 and macro level implications of the model against the data, and Section 6 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}.[7] 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.[8] In Section 8, 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 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.[9]

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

[7] Both budget constraints are provided in Section 2.4.

[8] See, for example, Ma and Yi (2010).

[9] This setup with perfect altruism provides an upper bound for the role of insurance provided by the family members. Mommaerts (2016) and Ko (2016) examine the role of family care in explaining the limited demand for long-term insurance in the U.S. They use models where parents and children do not fully insure each other. Ko (2016) reports that children strategically reduce informal care in response to their parents' insurance coverage. Nevertheless, even in the United States where Medicaid covers over 60% of the formal care expenses, Ko (2016) reports that 62 % of individuals with long-term care needs receive help from children.

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 $\Theta < 1$ 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 $T + 1$.

After-tax earnings, e_j, of the household with age-j children is given by:

$$e_j = \begin{cases} [w\varepsilon_j\mu_j z_s(n - \xi h) + w\varepsilon_{j+T} z_f(1 - h)](1 - \tau_{ss} - \tau_e) & \text{if} \quad j + T \leq R \\ \\ w\varepsilon_j\mu_j z_s(n - \xi h)(1 - \tau_{ss} - \tau_e) + dSS & \text{if} \quad j + T > R, \end{cases} \tag{2}$$

where τ_e is the labor income tax rate and τ_{ss} is the payroll tax rate to finance the social security program.

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

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

where r is the before-tax interest rate, 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.[10] The second component (κ_2) guarantees a consumption floor for the most destitute.[11] Following De Nardi, French, and Jones (2010) and Hubbard, Skinner, and Zeldes (1995), the value of κ_2 is determined as follows:

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

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 mortality d states faced by the elderly.[12] 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

$$\tilde{V}_{j+1}(x') = \begin{cases} V_{j+1}(a', z_f', z_s', \mu', h', d') \text{ for } & j = 1, 2, ..., T-1 \\ nV_1(\frac{a'}{n}, z_f', z_s', \mu', h', d') \text{ for } & j = T \end{cases} . \tag{6}$$

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.

[10] 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.

[11] 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.

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

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.

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:

$$\sum_{j=R-T+1}^{T} \sum_{x} d(SS_j + \kappa_2) X_j(x) = \tau_{ss} [\sum_{j=1}^{R-T} \sum_{x} e_j X_j(x) + \sum_{R-T+1}^{T} \sum_{x} w \varepsilon_j \mu_j z_s (n - \xi h) X_j(x)].$$

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 $\left(\frac{Y_t - C_t - G_t - \delta K_t}{Y_t - \delta K_t}\right)$.[13] The detrended steady-state saving rate is given by $\frac{(\gamma g - 1)\tilde{k}}{\tilde{y} - \tilde{\delta} \tilde{k}}$ 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

[13] 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.

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).[14] In Section 6, we provide the data used to calculate the net national saving rate as well as a comparison of our TFP series with the one provided by the Penn World Tables.

There are important differences in demographics, public pensions, life-expectancy, and the fertility rates across the rural versus urban households in China. Since our purpose is to represent some of the key challenges faced by an average household in China, we use weighted averages of these statistics to represent the average household in China in the benchmark model. In our sensitivity analysis, we explore the implications of some of these differences in the saving rates of households in different regions.

3.1 Demographics

The model period is a year. Individuals enter the economy when they are 20 years old and live, at most, to 89 years old.[15] They become a parent at age 55 and face mandatory 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.[16]

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. Given that the urban population was approximately 40% of the Chinese population, the average fertility rate explicitly specified by the policy rules should be 1.3 children per couple ($0.4 \times 1 + 0.6 \times 1.5 = 1.3$). However, despite the strong penalties imposed in the implementation of the one-child policy, the "above-quota" children are not unusual.[17] The estimates of the the realized fertility

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

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

[16] 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.

[17] 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

rate after the one-child policy are approximately 1.6 per couple.[18]

In our benchmark calibration, we use the conservative value, 1.6 per couple (or $n = 0.8$), as the fertility rate after the one-child policy and in the final steady state. The implied population growth rate at the final steady state is -0.6% (i.e., $n^{1/35} - 1 = -0.6\%$). Since adulthood starts at age 20, one-child households enter the economy only after 20 years into the transition. With this calibration, the population shares of each age group (i.e., ages 20-40, 40-65, and 65+) generated by the model along the transition path mimic the data reasonably well (see Figure 2).

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.[19]

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.[20] For the period after 2011, we use the GDP long-term forecasts provided by OECD.[21]

3.3 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 Chinese Longitudinal Healthy Longevity Survey (CLHLS), we document substantial LTC risks facing the Chinese elderly. LTC-related expenditures are concentrated on individuals who are disabled in at least one of the six daily living activities. As shown in Table 2, the average expenditures of individuals in LTC status range from RMB 4,466 to RMB 9,124 during 2005-2011, that is, 26-

general, strong incentives and penalties were imposed. According to Liao (2013), single child families were given rewards such as child allowance and 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. See, for example Lu, He, and Piggott (2014).

[18] For instance, see the data reported by the World Bank.

[19] 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 focus of the paper.

[20] We construct the TFP series using $A_t = \frac{Y_t}{K_t^{\alpha} N_t^{1-\alpha}}$. In Section 6, we provide detailed information about the data sources.

[21] The GDP growth data from 2012-2050 can be found at the following webpage: https://data.oecd.org/gdp/gdp-long-term-forecast.htm. As for the forecasts after 2050, we simply fix the growth rate of the TFP factor at 2%.

37% of GDP per capita in the year.[22] As emphasized in Gu and Vlosky (2008), these reported expenditures for LTC do not include the time spent by family members who provide informal care. According to the CLHLS data, individuals also receive a significant number of hours of informal care from their children and grandchildren. For those in LTC status, the average amount of informal care from children and grandchildren is approximately 40 hours per week during 2005 to 2011. Similar results are found in other related data sources on LTC risks facing the Chinese elderly. In the 2013 CHARLS data set, the average number of hours of care received is approximately 149 per month for individuals in LTC status. Based on this information, we set the goods cost of LTC services m as 33% of GDP per capita in a given year in the model. As the total number of available hours (net of sleeping) is approximately 100 hours per week, we set the time cost of LTC, ξ, to 0.42.

Table 2: Expenditures and Informal Care for Individuals in LTC

Year	Annual expenditures on caregiving (% of GDP per capita)	Hours of informal care (weekly)
2005	RMB 4466 (36%)	39
2008	RMB 8921 (37%)	47
2011	RMB 9124 (26%)	41
Average	33%	42

Even in the United States where Medicaid covers over 60% of the formal care expenses, long-term care expenditures are considered to be one of the largest risks facing the elderly. 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. Barczyk and Kredler (2016) document that even in the U.S. a large fraction of the elderly continue living at home and receive informal care. While their definition of LTC is different from ours, the number of hours provided by a caregiver that exceed 20 hours a week constitute one-third of the cases in their sample.[23] The hours of informal care received in China are higher partly because in the U.S disabled individuals end up in nursing homes receiving institutional care, which is more efficient. Using the CHARLS 2011 wave, Lu, Liu, and Piggott (2015) document findings similar to ours where, conditional on receiving informal care, the average informal care elders receive is 153 hours per month (135 hours in the rural sector and 187 hours in the urban sector). In addition, 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 in China.

[22] While these costs are high for individuals in LTC status, average expenditures per person (including those not in LTC status) for individuals aged 65+ range from approximately RMB 253 in 2005 to RMB 1,490 in 2011.

[23] Note that their constructed data sample includes all individuals who receive help due to functional limitations. This criteria is less restricted than the LTC definition we use here that restricts to individuals who are disabled in at least one of the six key activities of daily living. Based on their own definition of disability, Barczyk and Kredler (2016) find that among their sample disabled singles/widowers living in the community receive approximately 50 hours of care per week.

Therefore, we suspect our calibration of the LTC risk and expenditures is not likely to be exaggerated.

Another important feature of the LTC risks is that they increase substantially as individuals age. Table 3 displays the fractions of individuals in LTC status by age groups in 2011 CLHLS data (and in 2013 CHARLS data). While 10.2% of individuals aged 65 and above were in LTC status, this fraction was only 7.9% for individuals aged 65 to 75, and 13.0% for the population aged between 75 and 85. However, for individuals aged 85 and above, it rose to 28.4%. As shown in the last column of Table 3, similar results are found in the CHARLS data. In addition, the LTC risks are highly persistent. For instance, among individuals aged 65-75 who are currently in LTC status, 32% of them will stay in this status for more than three years.[24] We assume that the probabilities of receiving the LTC shock, $\Gamma_j(0,1)$, are age-specific, and we calibrate their values to match the fractions of individuals in LTC by age.[25] The probability of exiting from the LTC status, $\Gamma_j(1,0)$, is assumed to be constant across the age groups and is calibrated so that the probability of staying in LTC for more than three years in the model matches the data. The resulting age distribution of individuals in LTC status in the benchmark model are reported together with their data counterparts in Table 3.

Table 3: Fraction of Individuals in LTC by Age

Age group	Model	CLHLS data 2011	CHARLS data 2013
55-65	5.6%		5.5%
65-75	8.2%	7.9%	10.8%
75-85	13.6%	13.0%	16.8%
85+	27.1%	28.3%	28.4%
65+	10.4%	10.2%	13.5%

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 urban seniors', and 94% of rural elders' medical expenses were paid for by their children or themselves. The pension system, which used to provide about 75-100% of the last wage earned, has also gone 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.

[24] Here we measure the probability of staying in the LTC status by measuring the percentage of individuals who remained in that status between the two waves of the survey, CLHLS 2005 and 2008. We restrict our calculations to the group of individuals who are still alive after 3 years.

[25] To this end, we assume that the probability is the same across agents within each age group, 55-75, 75-85, and 85+.

3.4 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.[26] 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.[27] 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 4.

Table 4: Income Shock

$\Gamma_{\mu\mu'}$	$\mu' = 1$	$\mu' = 2$	$\mu' = 3$
$\mu = 1$	0.9259	0.0741	0
$\mu = 2$	0.0235	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, 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 5.

Table 5: Labor Ability Shock

$\pi_{zz'}$	$z' = L$	$z' = H$
$z = L$	0.83	0.17
$z = H$	0.20	0.80

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

[26] 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.

[27] 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.

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.[28] 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.[29] 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.[30] 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.

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 about $2,700 in 1998 dollars, that is approximately 8% of GDP per capita. 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

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

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

[30] 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., $l = j - 5$.

institutions.[31] 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. According to Hubbard, Skinner, and Zeldes (1995), the consumption floor has a large crowding-out effect on the saving behaviors of low-income households because they are more likely to fall on the floor. In our benchmark calibration, we set the consumption floor to be 0.3% of output per capita, which implies that the average wealth held by agents in the bottom half of the distribution is approximately 57.1% of the median wealth in the model. This value is consistent with the Chinese data. According to Zhong et al. (2010), the average net value of assets held by the Chinese households in the bottom half of the distribution was approximately 56.7% of the median value in 1995. In Section 8, we provide sensitivity of our results to this parameter, including a consumption floor equal to that used for the U.S. in De Nardi, French, and Jones (2010).

Table 6: 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	33% of GDP per capita
ξ	time cost of LTC services	0.42
$z \in \{H, L\}$	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	0.8

Table 6 summarizes the main results of our calibration exercise and Table 12 provides the data on the construction of the net national saving rate, the TFP growth rate, government expenditures, and the constructed tax rates that are used along the transition.

4 Results

We start this section by examining the properties of the calibrated economy at the initial and the final steady states and along the transition. 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

[31] 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)).

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 followed by a large number of sensitivity analyses in Section 4.2.2. In Section 5.1, we examine the performance of the model economy against the micro data on household saving rates.

4.1 Properties of the Model Economy

We start this section by presenting several key aspects of the calibrated model and their data counterparts. The saving rate is 21.2% 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 14.6%, 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.[32] The demographic structure at the initial steady state is also consistent with the Chinese data. For instance, the share of the population aged 65+ at the initial steady state is 12.7%, while the share of the Chinese population aged 65+ was about 11% in 1980.

The final steady state of the economy is generated by simply changing the fertility rate from 2.0 to 0.8 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.[33] The net saving rate at the final steady state is much lower (11.8%) than that at the initial steady state. This is largely due to the dramatic change in the population structure triggered by the one-child policy. That is, elderly individuals save much less than working-age individuals, and the one-child policy substantially increases the elderly population share, i.e., from 12.7% at the initial steady state to 25.1% at the final steady state. Note that in this model 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 composition effect. Our calibrated model implies that the second channel dominates the first channel at the final steady state. In addition, the lower TFP growth rate at the final steady state also contributes to its lower saving rate by lowering the return to capital.

[32] Please see panel (a) in Figure 10 (in Section 5.2) 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 for a variety of reasons including imperfect financial markets, government regulations, etc. However, in a general equilibrium setting, these returns will eventually accrue to individuals in the economy. Nevertheless, In Section 8.7, we examine the sensitivity of our results by considering a partial equilibrium economy with fixed (world) interest rates.

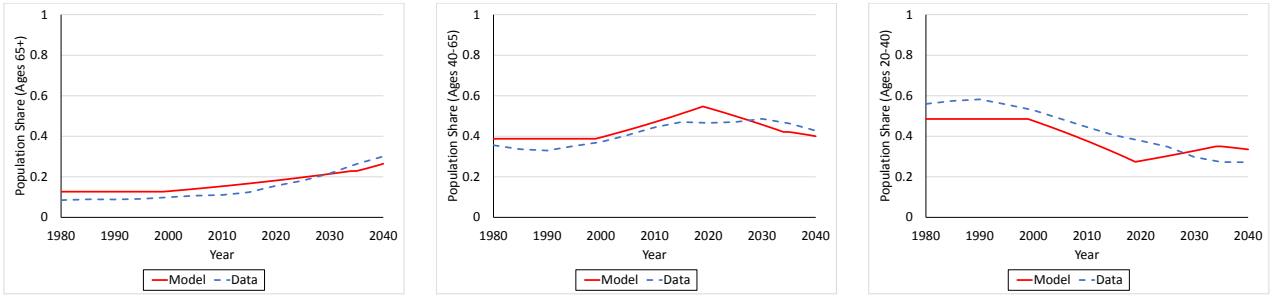
[33] The payroll tax rate is also different between the two steady states. In the initial steady state, the social security replacement rate is set at 15%, which results in a payroll tax rate of 2.1%. At the final steady state, a higher payroll tax rate (4.7%) is needed to balance the budget due to a much larger share of the elderly population.

Table 7: Properties of the Steady States

Statistic	Data	Initial steady state	Final steady state
The saving rate	20.9%	21.2%	11.8%
Elderly population share (65+)	11%	12.7%	25.1%
Share of the elderly (65+) in LTC	10.2%	10.4%	11.0%
Return to capital (r)	12%	14.6%	1.4%
Social security payroll tax (τ_{ss})	..	2.1%	4.7%
Capital-output ratio	2.1	2.1	4.7

Next, we examine if the population dynamics generated by the model along the transition path are consistent with the data. Panel (a) of Figure 2 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 do 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. Panel (b) of Figure 2 shows the population shares of 40-65-year-olds, and panel (c) displays the share of 20-40-year-olds. Overall, the populations dynamics generated by the model are in line with their counterparts in the data.

Figure 2: Demographics Along the Transition Path



(a) Population Share (Ages 65+) (b) Population Share (Ages 40-65) (c) Population Share (Ages 20-40)

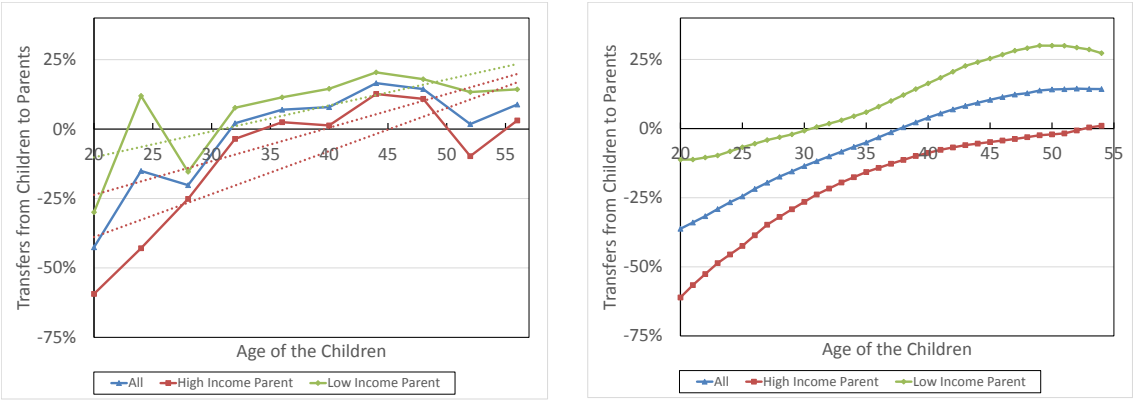
Finally, we use the CHARLS 2013 wave dataset to examine whether the intervivos transfers generated in the model are in line with the observations in the data. CHARLS provides data on transfers between the parents (head of the household) and their children and information on their schooling, ages, and income.[34]

We construct the measure of the net transfers from children to their parents using the same strategy as

[34]There are few caveats to be aware of in comparing the model and the data, however. 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.

in Choukhmane, Coeurdacier, and Jin (2013).[35] The sample consists of 1625 families from urban areas.[36] Panel (a) of Figure 3 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 and the dashed lines are the linear trends. 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 3: Net Transfers from Children to Parents by Age



(a) The Data: 2013 CHARLS

(b) The Model

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. As shown in panel (a) of Figure 3, the income of the parents has a large impact on intervivos transfers between children and parents. While the shapes of the transfer

[35] That is, the net transfers are measured as the sum of net financial transfers (both regular and non-regular) and net non-monetary transfers (such as gifts and other in-kind benefits) from non-coresident children to parents.

[36] 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.

profiles are similar across the two subgroups, transfers to parents in households with low-income parents are substantially 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 3 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 reasonably 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 fewer 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 fewer transfers to children if the net transfers to parents are negative).

These findings suggest that the implications of our model for the share of age groups and the behavior of intergenerational transfers resemble the data reasonably well. Next, we use this model to examine the time path of the saving rate in China.

4.2 Saving Rate

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 0.8). The transition is assumed to take 150 years.[37] 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.[38] 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, and LTC risk on the saving rate between 1980 and 2011.

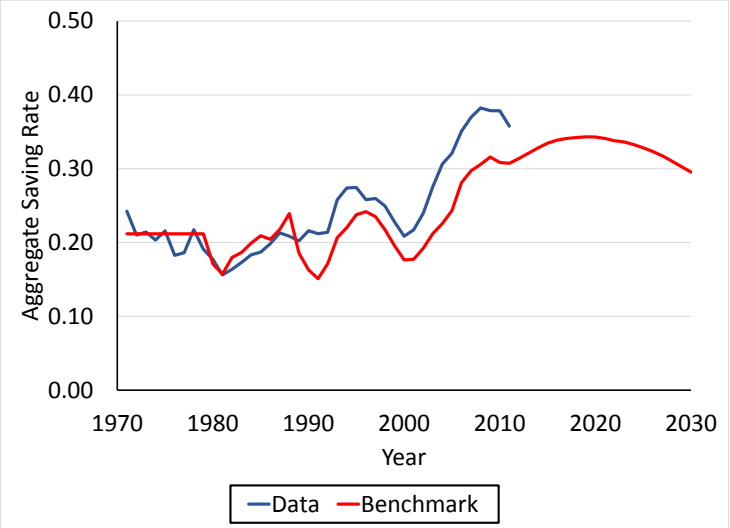
Figure 4 displays the saving rates generated by the benchmark economy versus the data starting in 1970. Overall, the time series path of the saving rate generated by the model mimics the data remarkably well. The model not only accounts for the rise in the saving rate from 1980 to 2011 but also captures the major

[37] 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 $0.8^{1/35} - 1$ after a certain number of years (70 years in the benchmark case). Here, the rate of $0.8^{1/35} - 1$ is simply the population growth rate in the final steady state. We also explore other assumptions as robustness checks for this issue.

[38] In Section 8, 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.

fluctuations in the saving rate in the 1990s. In the data, as summarized in Table 8, 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 15.7% in 1981 to 23.8% in 1995 and from 17.6% in 2000 to 30.8% in 2010.[39] 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 5.2.

Figure 4: The Chinese Saving Rate: Model vs. Data



4.2.1 Decomposition of the Saving Rate

In this section, we decompose the elements that play a major role in shaping the time-series path of the saving rate. 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 two 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.[40] Results of these experiments are displayed in Figure 5 as "No OCP" and "No OCP II", respectively.

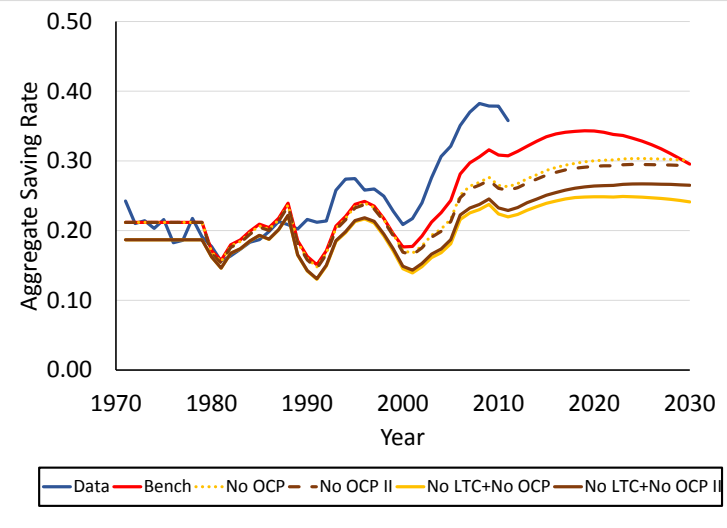
[39] The alternative calibration of the fertility rate with $n = 0.65$ results in higher saving rates, especially after 2000. The saving rate in that case increases from 16.2% in 1981 to 24.8% in 1995 and from 19.5% in 2000 to 34.9% in 2010. The results from this alternative calibration are available from the authors upon request.

[40] 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.

We find that the rise in the saving rate after 2000 is significantly smaller under both assumptions. The saving rate in 2010 for these cases is about 26% instead of the 30.8% in the benchmark. The intuition for this result is simple. 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 Figure 5. As the figure shows, the impact of LTC risks on the saving rate is substantially smaller in the economy without the one-child policy. The saving rate in 2010 is about 22% in this case.

Figure 5: No One-child Policy and No LTC Risk



These two experiments reveal that an important cause of the increase in the saving rate is the interaction between the LTC risk and the changing demographics triggered by the one-child policy. We find that. the saving rate would have increased from 21% at the initial steady state to around 22%-26% 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 rising to 30.8% in 2010. In Section 5.1.1, using micro data from CLHLS and UHS, we confirm that the magnitude of these differences in saving rates are consistent with the differences in saving rates of households with twins versus one child only, and in addition we find that the differences in saving rates are heavily influenced by the LTC costs that the households face.

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.[41]

Figure 6: Uncertain LTC Cost and the Precautionary Motive

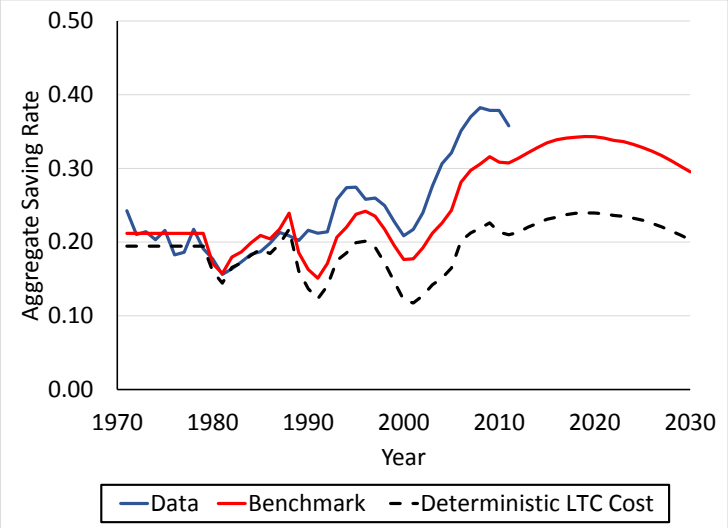


Figure 6 shows that saving rates generated in this counterfactual experiment, where the uncertainty of LTC expenses is assumed away, is significantly lower than the saving rates generated in the benchmark case. Also, the dramatic rise in the saving rate almost completely disappears. This finding suggests 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 emphasizes the insurance role of children and highlights the impact on precautionary saving from the loss of family insurance triggered by the one-child policy.

Table 8 summarizes results of several counterfactual experiments for some selected years.[42] In the first

[41] This counterfactual case can be thought of as an economy with a perfect LTC insurance market.
[42] In Section 7 of the online appendix, we present the graphical illustration of all these cases.

experiment, we only feed in the changes in demographics due to the one-child policy to the model economy. We assume away the individual income risks and 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." The results of this experiment reveal a declining pattern for the saving rate from 14.5% in the initial benchmark to 13.8% 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. In the second experiment, we add the individual income risk to the model. The difference in the saving rates between the first and the second experiments reveals 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 8, 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.[43]

In the data, the saving rate increases by 17 percentage points between the initial steady state and 2010. In the model, the saving rate increases by 9.6 percentage points, thus accounting for 57% of the observed increase in the data. The counterfactual experiments allow us to separately identify the effects of LTC risks and the other factors on the increase in the saving rate. For instance, Experiment 4, that includes all factors but the LTC risks, results in an increase of 1.7 percentage points in the saving rate (that is, from 18.7% to 20.4%). This result suggests that only 10% of the 17 percentage points increase in the saving rate observed in the data can be attributed to factors other than the LTC risks faced by the elderly. We conclude that the mechanisms via LTC risks are responsible for 47% of the observed increase in the data, while changes in TFP growth together with individual income risks and government expenditures/taxes account for approximately 10% of the observed increase. It is important to emphasize that while the factors other than LTC do not play a large role in the increase in the saving rate, they are important for the level of the saving rate in 2010. The economy without any of theses factors results in a saving rate of 13.8% in 2010. With the addition of the individual income risk, government, and TFP growth rate, the saving rate in 2010 increases by 6.6 percentage points reaching 20.4%. Thus, all the factors except LTC risks account for 21% of the total saving rate in the benchmark for 2010 (6.6/30.8) while LTC costs account for 34%.

[43] The labor ability shocks play a very similar role as the labor income shocks, resulting in a level shift in the saving rate.

Table 8: 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	21.2	15.7	23.8	17.6	30.8
Decomposition					
Exp. 1: None	14.5	16.0	14.1	12.6	13.8
Exp. 2: Exp.1+IR	18.7	20.3	17.8	16.5	16.9
Exp.3: Exp.2+Gov	18.7	19.9	18.8	14.6	17.6
Exp. 4: Exp.3+TFP	18.7	14.5	19.7	11.8	20.4
Exp. 5: All three (= Bench)	21.2	15.7	23.8	17.6	30.8

4.2.2 Sensitivity Analysis

In Section 8 of the online appendix, we present an extensive set of sensitivity analyses to many parameters used and modeling choices made in the benchmark economy. In particular, we examine the results with different assumptions about the consumption floor, the availability of formal care for LTC, perfect foresight, different social security replacement rates, the role of government capital, and more. In Table 9, we summarize the results from some of these cases where each row represents a deviation from the benchmark in that particular feature or parametrization.

The time path of the saving rate, in particular its level towards the end of the period is sensitive to several parameters such as the value of the consumption floor, future social security payments, and the expenditures associated with LTC. All of these cases highlight the importance of the risks faced by the elderly in shaping the time path of the saving rate. In our sensitivity analysis, we find that the saving rate increases as the risks increase and the saving rate decreases as the government-provided resources increase. Since it is challenging to precisely measure all the risks present in the Chinese economy and since our model abstracts from some obvious risks such as out-of-pocket medical costs, we view these results as providing support for the importance of the mechanism that leads to high savings in China. In addition, there are several modeling assumptions that the results are not particularly sensitive to. For example, while the difference between rural versus urban areas has interesting cross-sectional implications, its role on the time-path of the saving rate is limited. Allowing for formal care for LTC needs also highlights some interesting dynamics about which families choose to pay for informal care but do not impact the time path of the saving rate.[44] All these results are explained in detail in the online appendix.

An important parameter that is difficult to estimate with confidence is the value assigned to $\underline{c}$. In our benchmark, we set the consumption floor to 10% of mean medical expenses. In Experiments 1 and 4, we

[44] Our results are also not sensitive to increasing longevity. Bohn (2006) shows that the impact of population aging on capital-accumulation and interest rates differs across life-cycle and dynastic models because of their different assumptions about bequests. In a life-cycle model, population aging gives rise to an increase in the saving rate as individuals expect to live longer. In a dynastic model, on the other hand, fewer births imply a lower weight in dynastic preferences for future generations and results in lower saving rates. In our model, changes in longevity have a small effect on the saving rate. For more discussion of these issues, see İmrohoroğlu and Zhao (forthcoming).

summarize the results for consumption floors of 5% and 20%. A lower consumption floor results in a higher saving rate, 34.2%, in 2010 while the higher consumption floor results in a lower saving rate, 28%. These results not only serve as a sensitivity analysis, but are also important because they show the potential changes in the saving rate that may occur as a result of the changes in government policy, helping insure the risks faced by the elderly. These findings are at odds with the conclusions drawn about the Chinese saving rate based on the skewed sex ratio as in Wei and Zhang (2011) or expected changes in demographics as in Curtis, Lugauer, and Mark (2015) or Choukhmane, Coeurdacier, and Jin (2013). In those models, providing more insurance against risks does not play a role in the saving behavior since the saving rate is not a consequence of the risks faced by the agents.

Social security programs in China face important challenges in the future due to the aging of the population. In Experiment 3, we summarize the results of a counterfactual case where we fix the social security tax rate after 2011 and adjust the social security benefits to balance its budget in each period.[45] Even though the replacement rates in this case continue to be around 15% in 2011, the expected decline in the future benefits results in a slightly higher saving rate in 2010 (32.3%) compared to the benchmark 30.8%.

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 of the individuals is used to balance the government's per period budget constraint. This way of modeling the government substantially simplifies our analysis but misses the actual saving done by the Chinese government, which has been investing in financial and physical assets at home or abroad. 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. In experiment 4, we present the results for this case. Notice that the saving rate in 2010 increases from 30.8% in the benchmark to 36.8%. In this case, since the budget surplus is not distributed back to the individuals, their disposable incomes are lower, which necessitates higher savings to insure them against the LTC costs. While the treatment of government savings is rather simplified in our framework, it indicates the potential importance of government savings in national saving rates, which we leave for future work.

We also abstract from the distinction between the rural and urban population in our benchmark model. This modeling strategy simplifies our analysis, but one may worry that this assumption may bias the estimates of the average effects on the whole population because the rural and urban population face substantially different social insurance policies. In addition, their fertility rates have evolved quite differently after the implementation of the one-child policy. In experiments 5 and 6, we show the results where we conduct separate simulations for the two types of population. In particular, we emphasize the rural-urban difference along two dimensions: fertility rates and the social security replacement rates. We assume that the fertility rate was three per couple from 1980 to 1990, and it dropped to two per couple after 1990 for the rural population. For

[45] 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.

the urban population, we assume that the fertility rate dropped to one per couple immediately after 1980.[46] In addition, we set the social security replacement rates to be 6% and 30% for rural and urban population, respectively.[47] As can be seen, the relatively higher fertility rates among the rural population result in a lower saving rate in 2010 for them compared to the urban population. However, the rural-urban difference in the saving rate is not large because the different social security replacement rates they face partially offset the impact of different fertility rates on saving. The saving rate generated in the "Rural" experiment is 30.1% in 2010, while it is 33.8% in the "Urban" experiment. The rural-urban difference in the saving rate generated in our simulations is consistent with the data (2011 China Statistical Yearbook). While the average saving rate in 2010 was 26.0% for the Chinese rural households, it was 29.5% for the urban households.[48]

Another issue worth discussing is the age gap between generations (or the timing of giving birth). The age gap between the parent and his children is assumed to be 35 years in our benchmark model, which may seem large for typical Chinese households. This assumption is made mainly for technical reasons. In our dynastic model with two-sided altruism, the length of the life cycle is implicitly determined by the value of this gap T (i.e., the length of life is $2T$) unless we want to model the complication of multi-generation family structure, which is out of the scope of this paper. Therefore, a generation gap of 35 years is a convenient choice for the purpose of our study because it implies 70 years of adulthood, which is long enough to properly capture the late in life health risks and meanwhile cover the entire working period. In experiment 6, we check the sensitivity of our results to this choice by assuming that the parent gives birth to the children at age 25 ($T = 25$). As we explained, the limitation of this alternative choice is that the length of life becomes much shorter (agents can only live up to age 70); therefore, the model misses a major portion of the LTC risks late in life. To deal with this limitation, we scale all LTC risks so that the fraction of the population needing LTC in this experiment is the same as in the benchmark case. The results from this experiment are also summarized in Table 9. The saving rates along the transition path remain similar with a slightly higher saving rate in 2010 compared to the benchmark results.[49]

[46] As is documented in the literature, the fertility rate among the rural population did not drop immediately after the implementation of the one-child policy. It stayed around three per couple during the entire 1980s, and then dropped further and stabilized slightly below two (see Peng and Guo (2000), and Zhang, (2017)). On the other hand, as documented in Choukhmane, Coeurdacier, and Jin (2013), the fertility rate among the urban population dropped close to one per couple immediately after 1980 and has been stable since then.

[47] Gu and Vlosky (2008) document that 40-50% of the elderly in cities and more than 90% of the elderly in rural areas did not have a pension. Therefore, we assume that 50% of the urban population and 10% of the rural population are covered by a public pension, which can be converted into average replacement rates of 30% and 6% for the urban and rural populations respectively.

[48] These numbers are based on authors' calculations from the data. There are differences in the level of the saving rates obtained in the model versus the data. This is expected since the definition of the saving rate in the model is different from its counterpart in the data. We explain these differences further in Section 5.1 where we compare the implications of our model against the micro-level data.

[49] The higher saving rate in 2010 is simply because in this experiment the model does have age 70+ population, and therefore the one-child households in 2010 (consisting of parents aged 45-55 and children aged 20-30) account for a larger share of the model population.

Table 9: The Saving Rate: Sensitivity

Economy	Initial SS	1981	1995	2000	2010
Data	20.9	15.6	27.5	20.9	37.9
Benchmark	21.2	15.7	23.8	17.6	30.8
Sensitivity					
Exp. 1: Low $\underline{c}$	21.5	16.3	25.4	19.9	34.2
Exp. 2: High $\underline{c}$	20.3	15.3	22.6	16.0	28.0
Exp. 3: SS after 2011	21.2	15.8	24.2	18.3	32.3
Exp. 4: Gov Capital	21.2	16.0	25.5	20.1	36.8
Exp. 5: Rural	22.1	16.4	24.7	18.8	30.1
Exp. 6: Urban	19.8	16.6	24.2	18.6	33.8
Exp. 7: 25 yrs Gen. Gap	21.2	17.6	25.9	20.4	33.0

5 Additional Implications

In this section, we examine additional implications of the model economy. First, we use the CHARLS and the UHS data sets 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. Next, 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.

5.1 Micro-level Implications

Our framework has sharp implications for saving rates by specific household characteristics. In this section, we compare additional properties of the model with the micro-level data provided by UHS and CHARLS. There are a few caveats, however, that make the comparison between the data and the model imperfect. In particular, 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.

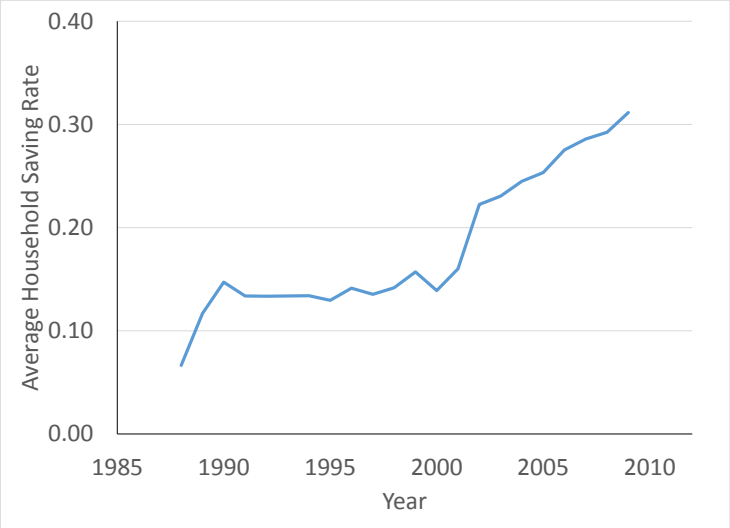
5.1.1 Household Saving Rates

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.[50] As shown in Figure 7, the average household rate in China increased substantially since 1988, i.e., from 7% in 1988 to 31% in 2009, while the

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

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 looking at various household characteristics.

Figure 7: Average Household Saving Rates in the UHS Data: 1988-2009



Twins Experiment

One of the most compelling empirical manifestation of the saving rate differences between households with one child versus two children is demonstrated by Choukhmane, Coeurdacier, and Jin (2013). They estimate that twin households save on average 6-7 percentage points less, as a percent of their income, than only-child households. After controlling for many characteristics, including educational costs, they conclude that the main difference in the saving rates of the two groups is due to the transfer channel where parents shift their investment from children towards financial assets when forced to have fewer children.

In order to investigate the implications of the forces we are interested in, we enhance the twins experiment in Choukhmane, Coeurdacier, and Jin (2013) by introducing LTC costs to it. We start by presenting summary statistics on household saving rates across different types of households and LTC costs. In Table 10, we separate the sample of provinces as high and low LTC costs based on the average LTC costs observed in these provinces.[51] According to the CLHLS data, individuals with only one disability spent approximately

[51] The data on LTC costs are from CLHLS and includes years 2005, 2008, and 2011. In order to identify the differences related

Table 10: Saving Rates Across Households

	HH-Twins	HH-One Child
All HHs		
# of obs	1077	87098
saving rate	20.0	25.7
HHs in high LTC		
# obs	671	52804
saving rate	19.4	27.4
HH in low LTC		
# obs	406	34294
saving rate	21.1	23.0

RMB2,000 annually on caregiving in low cost provinces from 2005 to 2011, while this number was about RMB3,600 in high cost provinces. There are notable differences in the saving rates of households with twins versus one child only in provinces with high LTC costs. While one-child households save 27.4% of their incomes, households with twins save 19.4%, a difference of 8 percentage points. In provinces with low LTC costs, the differences are quite small, 21.1% for households with twins versus 23% for households with one child.

Note that these findings are quite consistent with the counterfactual experiments carried out in Section 4.2.1. Our model, with average LTC costs, implies that in the absence of the one-child policy, the saving rate in 2010 would have been 26% instead of the 30.8% in the benchmark, a difference of 4.8 percentage points.

In order to examine the statistical importance of the impact of LTC costs on the household saving rate, we run a set of regressions for household h living in province p at a date t:

$$s_{h,p,t} = \alpha_t + \alpha_p + \beta_1 D_{h,t}^{Twins} + \beta_2 LTC_p + \beta_3 D_{h,t}^{Twins} \times LTC_p + \gamma Z_{h,t} + \varepsilon_{p,h,t}$$

where $s_{h,p,t}$ is the saving rate of the household, and α_t and α_p are time and province fixed effects. $D_{h,t}^{Twins}$ is a dummy variable that equals one if the household has twin children. LTC_p represents the log of the average LTC cost of province p and $Z_{h,t}$ represents the household level control variables including the average age of the parents, log income, and the age of the children. In regression I, we only include $D_{h,t}^{Twins}$ as in CCJ. Our theory predicts that the saving rates of households facing different levels of family insurance should be different, and this cross-family type difference in the saving rate should be larger in provinces with higher LTC risks. That is, as the LTC costs rise, the difference in the saving rate across family types should increase. To see the impact of this interaction, we run regression II where the interaction term $D_{h,t}^{Twins} \times LTC_p$ is included in the analysis.

to costs and not to the characteristics of the people in long-term care, we examine the data across provinces for individuals who suffer from only one disability. In addition, to account for the difference in income across provinces, we look at the the ratio of the average LTC costs over the average income in a province. The low cost provinces include Beijing, Shanxi, Liaoning, Shanghai, Guangdong, Chongqing, and Sichuan. The high cost provinces include Heilongjiang, Jiangsu, Anhui, Jiangxi, Shandong, Henan, and Hubei.

The results of regressions I and II are summarized in Table 11. The results of the first regression (I) are similar to the findings in CCJ that show that having twin children has a significant negative impact on the saving rate of the households. The estimated coefficients on $D_{h,t}^{Twins}$ show that under the one-child policy, households with twins saved (as a share of disposable income) on average 6.5 percentage points less than households with an only one child. Results of the second regression (II) show that the estimated coefficient on the interaction term is negative and significant, which means that the difference of the saving rate between the two types of households is larger as the LTC costs increase. The findings from the second regression are consistent with our theoretical implications that as children are an important source of insurance for LTC risks, the negative saving impact of twinning should be larger in provinces with higher LTC costs.

One concern for the results from regression II is that the LTC costs of a province may be positively correlated with the household saving rates in that province via unobservable factors, and the saving impact of twinning is larger in provinces with higher saving rates. To address this concern, we conduct the third regression (III), in which we include an additional term, Twin $\times$ SR_{prov}, that interacts with the twin dummy and the average provincial saving rate. If the significant coefficient on the interaction between twinning and the LTC cost in regression II is driven by the spurious correlation between the level of the LTC costs of a province and the saving rates in the province, one should expect the results to weaken or go away as we include the other interaction term. The results of the third regression are also reported in Table 11. We find that the coefficient on the interaction between twinning and the LTC cost remains negative and significant. In addition, the coefficient on the other interaction term between twinning and the average provincial saving rate is not significant. These results suggest that the spurious correlation between the LTC costs and the saving rates should not be an important concern for our analysis.

We repeat the three regressions with a set of standard household level control variables, $Z_{h,t}$, and the results of these regressions are reported in the columns labeled as regressions IV, V, and VI in Table 11. We find that while the R squares increase substantially as the set of control variables are included in the regressions, the coefficients on the key variables of interest remain quantitatively similar.

Table 11: Household Saving Rate

Variables	Saving Rate					
	I	II	III	IV	V	VI
Twin	-0.065***	0.220	.098	-0.059***	0.200	.086
	(0.022)	(0.131)	(0.125)	(0.020)	(0.122)	(0.110)
Twin×LTC cost		-0.072*	-0.101*		-0.066*	-0.093*
		(0.036)	(0.048)		(0.034)	(0.046)
Twin × SR_{prov}			0.891			0.841
			(0.636)			(0.591)
Control variables				X	X	X
Province FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X
Observations	95577	88174	88174	94789	87423	87423
R-squared	0.0052	0.005	0.0048	0.0687	0.0679	0.0681

Note: in parentheses are the standard errors clustered at province level.
*** p<0.01, ** p<0.05, * p<0.1.

We consider these results as providing supporting evidence for the importance of LTC costs and their interaction with the availability of family insurance in impacting the household saving rates.

Age-saving Profiles

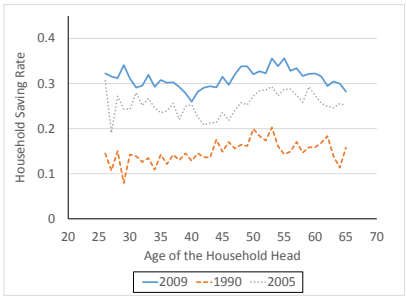
Chamon and Prasad (2010) provide documentation on household saving rates as a function of the age of the household head in the cross-section of households in China for a variety of years since 1990. According to their results, the rise in household savings rates since 1990 was much more pronounced among young and elderly households than middle-aged households. As a result, the age-household saving rate relationship in China became U-shaped in the 2000s. Explanations for this observation include the role of shifts in earnings uncertainty, incomplete pension reforms and the changes in life cycle earnings profiles, co-residence and intergenerational support, and changes in the demographic structure, among others.[52] Coeurdacier, Guibaud, and Jin (2015), however, document that constructing age-specific saving rates based on the household approach contains several biases especially if a large fraction of households comprise members that are at very different life-cycle stages. Given the large literature that followed the original findings in Chamon and Prasad (2010), we present the age-saving rate profiles generated in our model.

Similar to what has been found in the existing literature, panel (a) of Figure 8 shows the increase in the saving rate in China was more pronounced among the young and the old households relative to the middle-aged households. In panel (b) of Figure 8, we display the average cross-sectional age-household saving rate profiles generated by the model economy during the years of 1988-1992, and 2005-2010. We find that the changing shape of the age-saving rate profile in the model between these periods resembled the qualitative

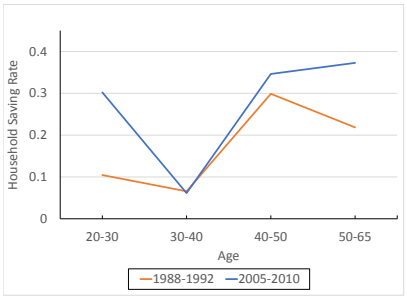
[52]See for example, Song and Yang (2010); Ge, Yang, and Zhang (2012); Chamon, Liu, and Prasad (2013); and Rosenzweig and Zhang (2014).

aspects of the data fairly well.

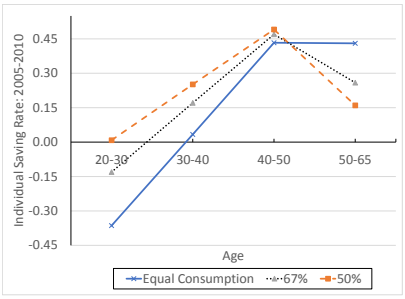
Figure 8: Age-Saving Rate Relationships



(a) The Data: UHS



(b) The Model-Household



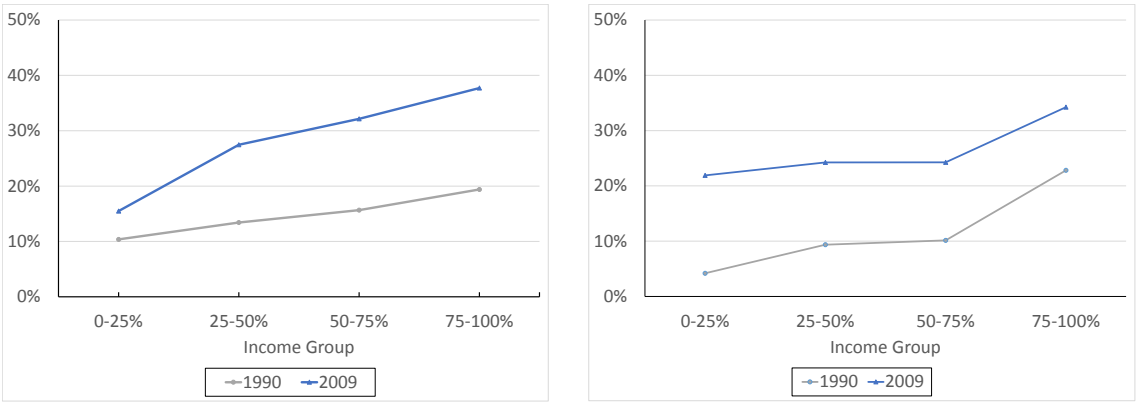
(c) The Model-Individual

In the model, the reason for the differential increases in household 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 one adult child only show up after 2000, and therefore, in the 2010 model economy, only the households that contain 20-30-year-old children and their 55-65-year-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 the saving rate than middle-aged agents between these time periods in the model.

Note that the household saving rates generated in our model reflect the joint decisions by all family members within a household, and therefore they do not necessarily coincide with the individual saving rates of any family member. Coeurdacier, Guibaud, and Jin (2015) recover the individual saving rates by age in the data using a projection method proposed by Chesher (1997, 1998) and Deaton and Paxson (2000). This method allows them to disaggregate household consumption into individual consumption using cross-sectional variations in the composition of households as a source of identification. Using this method, they estimate a hump-shaped age-individual saving rate profile.[53] In our model, in order to recover the individual age-saving profiles, one has to make some assumption about how household consumption is divided between the parent and the children. In panel (c) of Figure 8, we display the individual saving rate-age profiles during 2005-2010 generated by the model under three different assumptions: equal consumption between family members, consumption of a child 2/3 that of the parent, and consumption of a child 0.5 that of the parent. These results confirm that individual saving rates by age are indeed hump-shaped.

[53] However, they also point out that their estimates may be biased by the existence of intergenerational transfers.

Figure 9: Income-Saving Rate Relationships



(a) The UHS Data

(b) The Model

Income-saving Profiles

Figure 9 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.

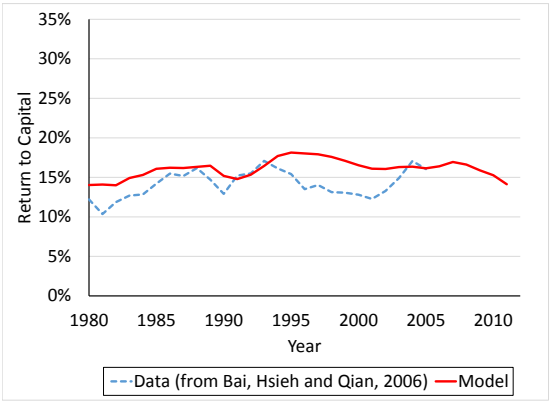
5.2 Macro-level Implications

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 10.[54] Chang, Chen, Waggoner, and Zha (2015) provide long time-series data on nominal wages in China. Panel (b) in Figure 10 displays real wages constructed by using their wage and CPI data and the model-generated wage rates, all normalized to one in 1980. Both of these endogenous variables track their

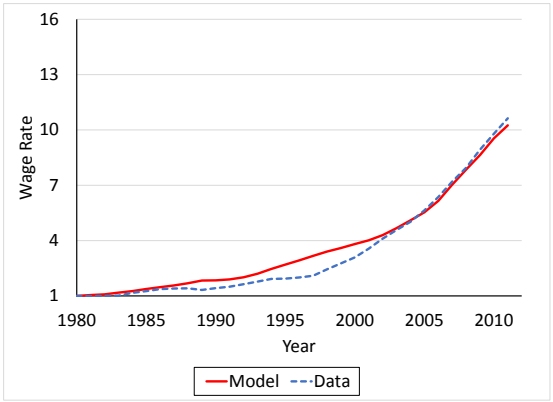
[54] Our definition of the capital stock includes inventories; therefore, the relevant comparison with the data is given in Figure 8 of Bai, Hsieh, and Qian (2006) who were kind enough to provide the data.

counterparts in the data reasonably well.

Figure 10: Return to Capital and the Wage Rate



(a) Return to Capital



(b) Wage Rate

6 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, long-term care risks, fiscal policy, individual income risk, and changes in 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 21% in the 1980s to around 22-26% 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 31% 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 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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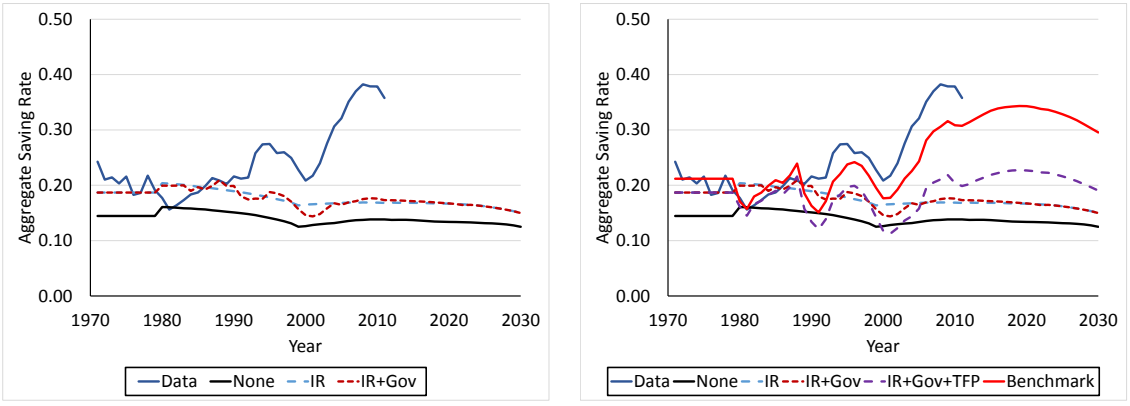
Online Appendix

7 Examining the Exogenous Factors

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 percentage 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 assume away the individual income risks and 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 11. The results of this experiment reveal a declining pattern for the saving rate from 14.5% in the initial benchmark to 13.8% 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 11: Decomposition of the Chinese Saving Rate



(a) Role of Individual Income Risk and Fiscal Policy

(b) Role of TFP and LTC

In the second experiment, we add the individual income risk to the model. The saving rate labeled "IR" in the first panel of Figure 11, 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 reveals 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 8, 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.[55]

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 first panel of Figure 11 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.[56] The results of this experiment, displayed in the second panel of Figure 11, 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.

Finally, adding the LTC risk generates the saving rate labeled "benchmark" in the second panel of Figure 11. The results suggest that LTC risks played an important role in the increase in the saving rate. Note that the increasing impact of LTC risks on the saving rate 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.

8 Sensitivity Analysis

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

8.1 Consumption Floor

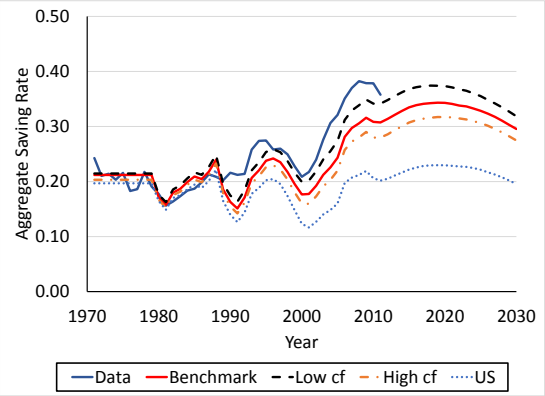
An important parameter that is difficult to precisely estimate is the value assigned to $\underline{c}$. As we discussed in Section 3.5, De Nardi, French, and Jones (2010) find that the level of the consumption floor plays an important role in explaining the elderly's savings in the U.S. They estimate the consumption floor, which proxies for Medicaid and Supplemental Security Income (SSI) in the U.S, to be 8% of GDP per capita. Given

[55] The labor ability shocks play a very similar role as the labor income shocks, resulting in a level shift in the saving rate.

[56] Figure 20 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.

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. Based on the findings in Hubbard, Skinner, and Zeldes (1995), we set the consumption floor in the benchmark model so that the lower tail of the wealth distribution in the model matches the Chinese data. In Figure 12, we show the sensitivity of our results to three other values for the consumption floor: (1) low consumption floor (i.e. half of the benchmark value), (2) high consumption floor (i.e. twice the benchmark value), and (3) the U.S. floor (i.e. 8% of GDP per capita). As expected, the consumption floor plays an important role in the time path of the saving rate, especially in the increase since the 2000s. If the consumption floor were as high as it is in the U.S., then the model-implied saving rate in China in 2010 would have been 20.6% in 2010 as opposed to the 30.8% found in the benchmark case. In other words, if the Chinese government were to provide an assistance program against the LTC risks (like the U.S. Medicaid program) that substituted for the informal care provided by the family, then the increase in the saving rate would have been much smaller.

Figure 12: Role of the Consumption Floor

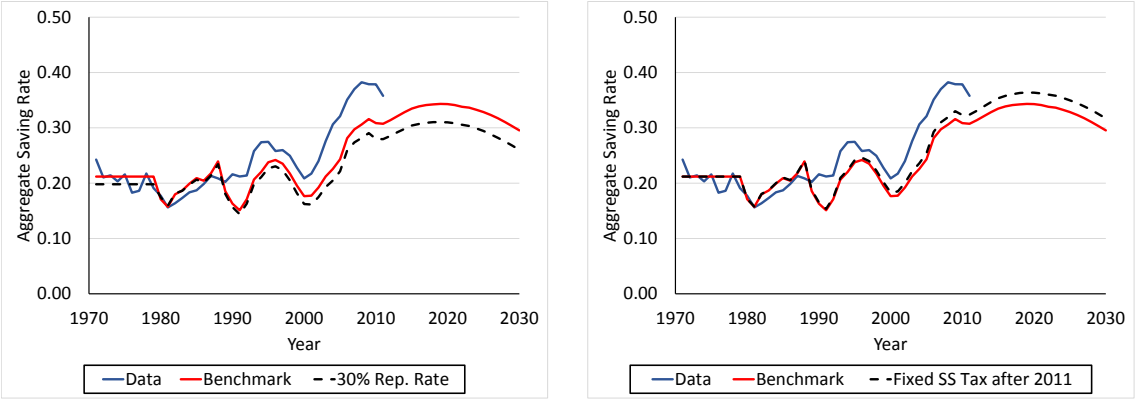


8.2 Social Security

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 2.1% in 1980 to around 4.7% 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 4.1% and reaches 9.0% by 2080. In the second case, we fix the social security tax rate after 2011 at 2%,

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.[57] Replacement rates in this case decline from 15% in 2011 to around 7% by 2040.

Figure 13: 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 13. As expected, higher social security benefits imply lower saving rates along the transition path. The saving rate in 2010 is 28.0% with a 30% replacement rate, as opposed to 30.8% 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 increases over time.

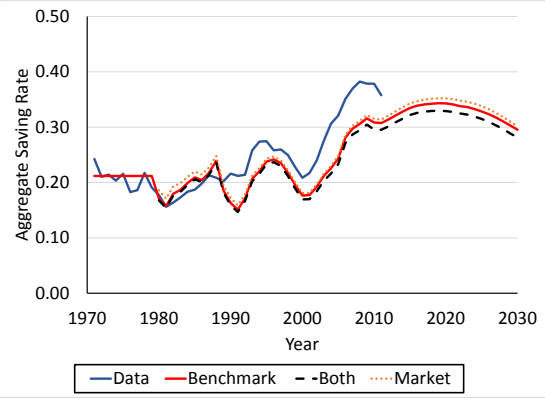
The saving rate generated for the second experiment where the social security tax rate is kept constant after 2011 while the replacement rate is allowed to decline to satisfy the social security administrations budget constraint is plotted in panel (b) of Figure 13. The results indicate that reduced social security benefits after 2011 not only raise the saving rates after 2011 but also increase the saving rates years before 2011 as individuals are forward-looking.

[57] 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.

8.3 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.[58] 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 14: Informal and Formal Care



In the first case, we replace informal care with care purchased from the market 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 a 0.42 fraction 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.[59] Figure 14 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 rates are slightly higher in most periods along the transition path, compared to the benchmark results. The intuition for this result is simple. In the model with the option 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.

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

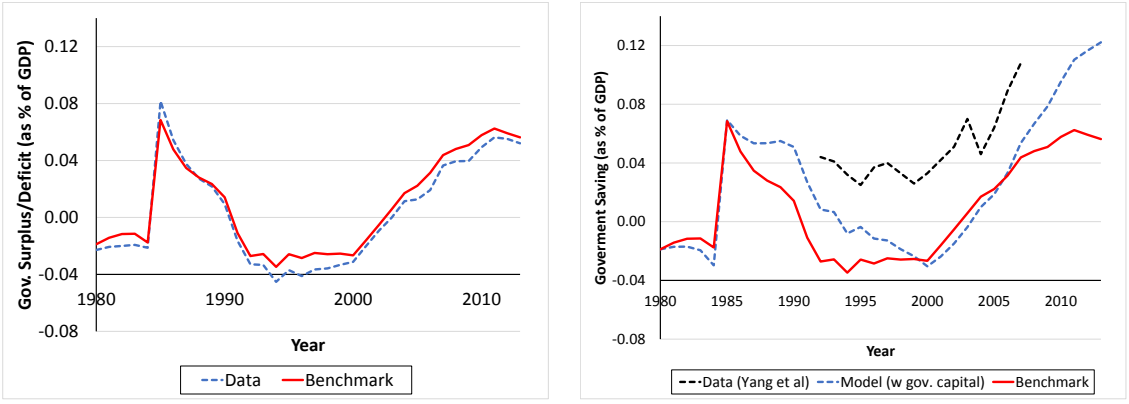
[59] It is worth noting that the time cost of informal care from children is their forgone after-tax labor income. Therefore, we use the after-tax wage to calculate the cost of formal care so that it is more comparable to the benchmark case with informal care. This is equivalent to assuming that formal 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.

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.[60] The saving rates generated in this case, labeled "both" in Figure 14, are slightly lower than those in the benchmark case. This result is because in this alternative case, households have the option to reduce the LTC costs by purchasing care from the market when their children have relatively high income, and therefore save less.

8.4 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 15 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.

Figure 15: Government Budget



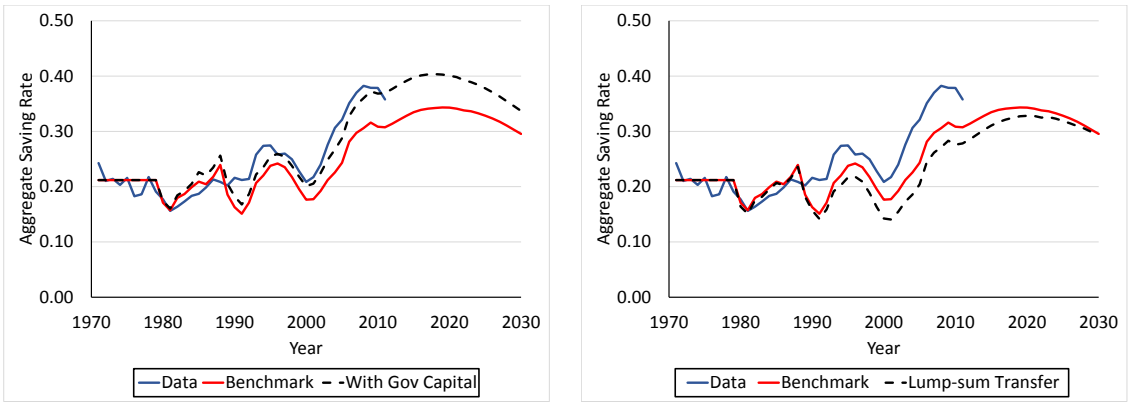
(a) Budget Deficit/Surplus (Benchmark)

(b) Government Saving (Alternative)

[60] These results are consistent with the findings in Barczyk and Kredler (2016) who report that children's education has a large negative effect on the informal care provided to parents in the U.S.

While this way of modeling the government substantially simplifies our analysis, it misses the actual saving done by the Chinese government that 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 15. Panel (a) of Figure 16, presents the results for the national saving rate when we include government capital in this particular fashion. The saving rate in 2010 increases to 36.8% as opposed to the 30.8% found in the benchmark. This finding indicates that the role of the government saving can be quantitatively important.

Figure 16: Role of Government Capital and Form of Transfers



(a) Role of Government Capital

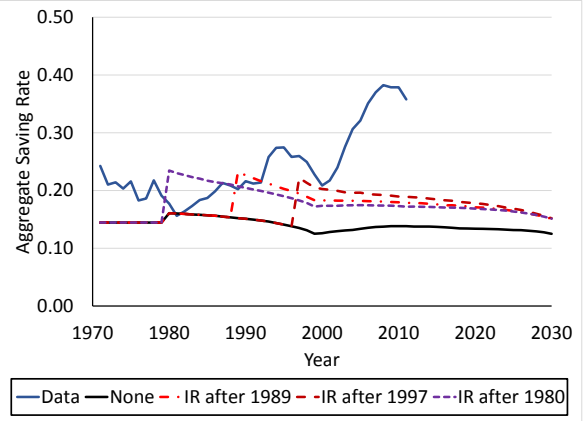
(b) Role of Transfers

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 16 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.

8.5 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 the 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 the 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 17, 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 17: Income Risk Starting in Different Years

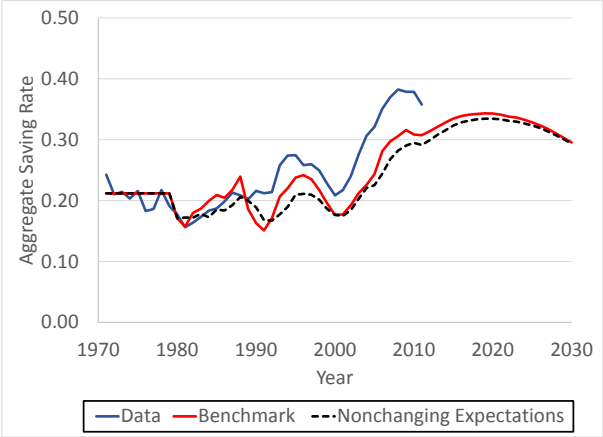


8.6 Perfect Foresight

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 18, which displays the extent to which expectations may play a role in the relationship between TFP and the saving rate. As shown in Figure 18, 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 18: The Role of Perfect Foresight

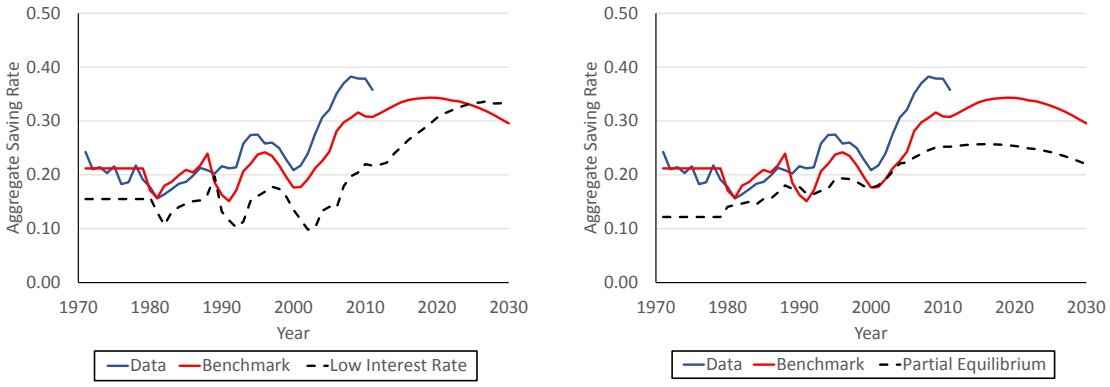


8.7 Low Interest Rate

As estimated by Bai, Hsieh, and Qian (2006), the net returns to capital in China have been 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 panel (a) of Figure 10). However, it is known that the Chinese households may not get full access to the high returns to capital for 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 two cases. First, we simply assume that households only receive one tenth of the actual return to capital implied in general equilibrium (which on average results in about a 4% effective return to capital for households) but keep the general equilibrium feature of the economy. As can be seen from panel (a) of Figure 1, this simply lowers the entire saving rate schedule. The qualitative properties of the saving rate is unchanged, however.

Second, we examine the results in a partial equilibrium economy with fixed low interest rates and fixed wages rates along the transition path. We set the interest rate to 4% along the whole transition path and in the steady states and set the average wage growth rate to 5% per year. The results from this experiment, labeled "Partial Equilibrium," are presented in panel (b) of Figure 1. In this case, the fluctuations and the overall increase observed in the saving rate are smaller than the benchmark results. There is no particular reason, however, to imagine that this case provides a better description of the Chinese economy. The general equilibrium framework captures that fact that some individuals must have access to the high interest rates in the economy.

Figure 19: Role of Lower Interest Rates



(a) Lower Interest Rate

(b) Partial Equilibrium

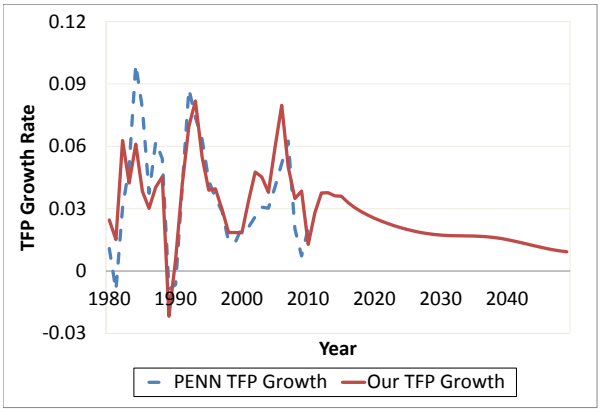
9 Data

9.1 Data for Simulations

In this section, we present the data we used in our simulations. We use annual data from the China Statistical Yearbook-2014 released by China's National Bureau of Statistics (NBS) 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.[61] Employment data (persons employed) is from The Conference Board Total Economy Database (January 2014, http://www.conference-board.org/data/economydatabase/).

[61] 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.

Figure 20: TFP Growth Rate



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%. We calculate the initial capital stock using:

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

where g is the average growth rate of GDP between 1960 and 2011. For the 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 20 displays the resulting TFP series between 1980 and 2010 as well as the projections used until 2050 in our simulations.[62] 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 onward.

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

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 and Wesselhöft(2014). Labor income tax revenues are calculated as total tax 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.

In Table 12, we present the growth rate of the TFP factor, $(\gamma_t - 1)$, the labor income tax rate, and the ratios of consumption, government expenditures, and capital to GDP that are used to calculate the net national saving rate $\left(\frac{1-c_t-g_t-\delta k_t}{1-\delta k_t}\right)$.[63]

[63] Lower case letters represent the ratios of the variables with respect to GDP.

Table 12: Saving Rate

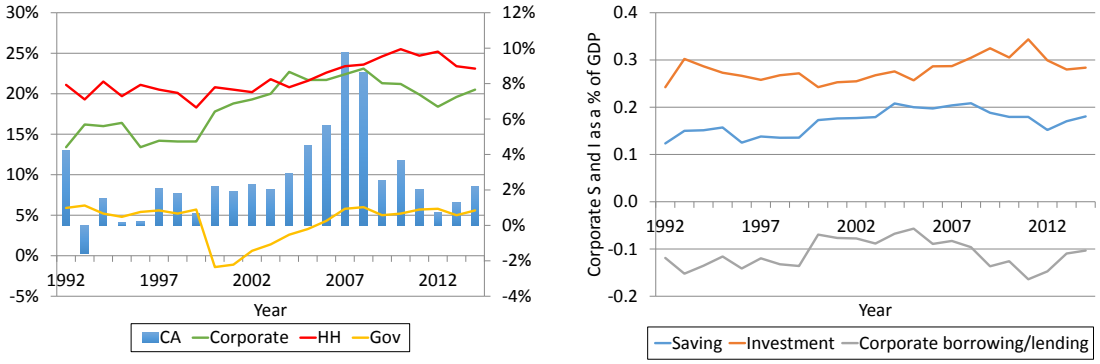
Year	TFP factor growth rate	Labor income tax rate	C/Y	G/Y	K/Y	Net National saving rate
1980	0.05	16.7	0.508	0.147	2.041	0.177
1981	0.03	17.4	0.525	0.146	2.047	0.156
1982	0.13	17.8	0.519	0.145	2.053	0.164
1983	0.09	17.4	0.520	0.144	1.971	0.173
1984	0.13	17.2	0.508	0.150	1.939	0.183
1985	0.08	32.9	0.516	0.143	1.888	0.187
1986	0.06	29.1	0.505	0.145	1.900	0.199
1987	0.08	24.9	0.499	0.137	1.922	0.213
1988	0.09	21.7	0.511	0.128	1.920	0.209
1989	-0.04	22.4	0.509	0.136	1.916	0.202
1990	0.01	20.8	0.488	0.136	2.029	0.216
1991	0.08	18.5	0.475	0.149	2.078	0.212
1992	0.14	15.7	0.472	0.152	2.061	0.214
1993	0.17	15.2	0.444	0.149	2.010	0.258
1994	0.11	12.7	0.435	0.147	1.980	0.274
1995	0.08	11.6	0.449	0.133	1.986	0.275
1996	0.08	11.3	0.458	0.134	2.018	0.258
1997	0.06	12.6	0.452	0.137	2.036	0.260
1998	0.04	13.7	0.453	0.143	2.056	0.250
1999	0.04	15.5	0.460	0.151	2.093	0.228
2000	0.04	17.0	0.464	0.159	2.128	0.209
2001	0.07	19.4	0.453	0.160	2.157	0.217
2002	0.10	20.7	0.440	0.156	2.159	0.240
2003	0.09	21.1	0.422	0.147	2.147	0.276
2004	0.08	21.8	0.405	0.139	2.158	0.306
2005	0.12	23.3	0.389	0.141	2.192	0.321
2006	0.17	24.2	0.371	0.137	2.176	0.351
2007	0.10	26.2	0.361	0.135	2.128	0.370
2008	0.07	26.5	0.353	0.132	2.138	0.382
2009	0.08	27.1	0.354	0.131	2.188	0.379
2010	0.03	28.8	0.349	0.132	2.245	0.379
2011	0.06	30.4	0.357	0.134	2.353	0.358

9.2 Data on the Decomposition of Savings

Most of the research dealing with saving rates in China relies on flow of funds data to separate the saving rate between corporate, household, and the government. Using this data, Chamon and Prasad (2010) conclude that between 1993 and 2005, household savings have not increased as a percentage of national income. However, flow of funds data is subject to large revisions and, based on the 2012 data, there appears to be an increase in household savings as a percentage of GDP, as displayed in panel (a) of Figure 21. That is,

household savings as a percentage of GDP increased from about 20% in the 1990s to 25.5% in 2010. It is also important to note that this is despite the fact that the household income as a share of GDP has been declining in this time period. Consequently, the household saving rate (household savings as a percentage of household income) has been increasing at even faster rates.

Figure 21: Corporate, Household, and Government Savings



(a) Saving Rates

(b) Corporate Saving and Investment

On a related topic, panel (a) of Figure 21 also shows that the increase in China's current account surplus between 2004 and 2009 coincides with a period of flat corporate savings and increasing household savings. In addition, panel (b) of Figure 21 shows that corporate investment rates have been higher than corporate saving rates since the 1990s. That is, all throughout this period, corporations in China have been net borrowers. These results cast doubt on the role of corporate saving rates in accounting for the large current account surpluses in China. In a companion paper (İmrohoroğlu and Zhao (2017)), we separately distinguish between household and corporate saving rates by extending our model to include a corporate sector facing financial frictions, and we use the extended model to study the causes of the current account surplus in China.