Demographic Patterns and Household Saving in China*

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Abstract

This paper studies how demographic variation affects the aggregate household saving rate. We focus on China because it is experiencing an historic demographic transition and has had a massive increase in household saving. We conduct a quantitative investigation using a structural perfect foresight overlapping generations model that incorporates parental care through support for dependent children and financial transfers to retirees. When we present agents in the parameterized model with the future time path of demographics, interest rates, and wages, their saving decisions mimic many of the features observed in the Chinese household saving rate time series from 1955 to 2009. Demographic change alone accounts for about half of the saving rate increase.

Keywords: Saving Rate, Life Cycle, China, Demographics, Overlapping Generations

JEL: E2, J1

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1 Introduction

This paper studies how demographic change affects the aggregate household saving rate. We focus on China because it has experienced large variations along both these dimensions. Moreover, China now plays a major role in the global economic system, and, during the last three decades, its economy has grown to become the world's second biggest in terms of aggregate GDP. China's saving rate also has grown and exceeds that of nearly every other country. The household component of Chinese saving, which in 2009 was 27 percent of income, contributes heavily to the country's investment led growth and helps to finance purchases of foreign currency denominated assets. An associated emergence of an external surplus has led to calls for 'rebalancing' growth from investment to consumption (which necessarily means lowering the saving rate). We believe that the effective design of rebalancing policies requires an accurate understanding of the factors responsible for the high saving rate. This paper aims to contribute to such an understanding.

China's aggregate household saving rate has not always been high. From 1955 to 1977 the household saving rate fluctuated around an average of less than 5 percent. Then starting in 1978, the saving rate began to rise. The timing of this change in saving behavior coincides with the beginning of an equally dramatic demographic transition. The population began to shift from mostly young to predominantly middle-aged. At the peak of China's baby boom in the 1960s and 1970s, nearly half of the population was under 20. Then, largely as a result of the government's one-child policy, fertility rates plummeted. Today, less than 25 percent of the population is under 20, and the age distribution will continue to skew older for the foreseeable future.

To quantify the effects of China's demographic transition on its household saving rate, we build a perfect foresight model of overlapping generations (OLG) of households that incorporates parental support for dependent children and transfers to retirees. In the model, individuals live for 85 years. From birth through age 19, individuals make no decisions and depend on their parents for consumption. At age 20, individuals begin making their own consumption and saving decisions. From 20 to 49 they work and raise children. Dependent children's and parent's consumption both enter into parent's (household) utility, and parents choose the consumption level of their young. Individuals aged 50 to 63 continue to work but no longer have children to support. Working age agents save for their own retirement and transfer a portion of their labor income to current retirees. The income transfer is meant to capture both the formal pension system (which currently has a low participation rate in China) and the informal family network. Retirees (ages 64 and older) live off of accumulated assets and transfers from current workers.

Our first set of model simulations isolate the effect of China's changing demographic structure. We present households in the parameterized model with the future time path of the demographics data and observe their saving decisions from 1955 to 2009, holding interest rates and wages constant. The demographic changes alone generate about half of the observed increase in China's household saving rate with the simulated saving rate starting out low and rising at the same point observed in the data. The quantitative effect of China's demographic changes on the saving rate within this more or less standard life cycle model is our main finding.

We emphasize three channels through which demographics affect the saving rate. The first channel is the dependent children effect, which refers to the decline in family size brought about by the one-child policy. All else equal, a household with relatively few children devotes a smaller share of household income to support dependents and therefore has more to save. When we hold the number of dependent children constant at the (relatively large) 1970 level, the household saving rate in 2009 is 6 percentage points smaller than in the simulation that allows family size to vary. The reduction in family size has a large impact on household saving.

The second demographic channel works through the composition effect. The composition effect occurs because most saving is created from unconsumed labor income earned by the working age population. The prime working age group (20-63) in China has increased from 46 percent of the population in 1970 to 65 percent today. All else equal, the increased prevalence of this age group mechanically raises the aggregate saving rate.

The third channel operates through intergenerational transfers and the projected decline in workers per retiree. In the model, the amount of old age support per retiree depends on the relative size of the working age cohort. Since current workers in China have few children, the current working age population should save more aggressively because they will be supported in retirement by relatively few working people. In the model simulations, these latter two demographic channels matter for saving, but their impact is quantitatively smaller than the dependent children effect.

We primarily focus on the demographic channels; however, China experienced many institutional and policy shifts over the period of our study that also may have affected household saving. The most prominent of these include the Great Leap Forward from 1958 to 1961, the de-collectivization of agriculture in the 1980s, the reform of state-owned enterprises in the 1990s, and the ongoing rural-urban migration. Explicitly modeling all of these phenomena would be challenging, to say the least, and is not pursued in the paper. Instead, we try to incorporate these events by capturing their effect on wages and interest rates. Thus, we run several versions of the model that allow the interest rate and wage to vary over time in accordance with the data. When households are presented the future time path of demographics, interest rates, and wages, the model can account for almost all of the observed changes in the household saving rate from 1955 to 2009.

Several theories have been put forth concerning Chinese household saving.[1] These include the precautionary saving motive in conjunction with relatively high income risk and changes in the social safety net (Meng 2003; Chamon et al. 2010; Chamon and Prasad 2010), unintended sex-ratio imbalances resulting from the one-child policy (Wei and Zhang 2011), and changes in the age-earnings profile (Song and Yang 2010). A few papers have also examined life-cycle considerations and demographic variation (Modigliani and Cao 2004; Horioka and Wan 2007; Horioka 2010; Banerjee et al. 2010); however, these studies deduce channels of influence from econometric specifications rather than from quantitative models.[2] In all likelihood, these mechanisms have all

[1] The literature has focused on Chinese household saving, while abstracting from corporate and government saving. Section 5.3.1 discusses this point further. Yang (2012) is an important exception dealing with China's external imbalance.

[2] Horioka and Terada-Hagiwara (2011) find that demographics help explain the evolution of saving rates in a panel of Asian countries, again using reduced form regressions. Recent work that employs the OLG framework outside

helped to determine the saving rate. In this paper, we focus on the demographic dimension.

The next section presents data on the unprecedented changes to China's age distribution and aggregate household saving rate. We also examine household survey data, which further motivates the connections between family size and saving decisions that we embed in the model. Section 3 presents the model of household saving, and Section 4 discusses our parameterization. Section 5 reports the results of the quantitative analysis. Section 6 concludes.

2 China's Household Saving and Demographic Data

This section draws out connections in the data between demographics and the saving rate. Section 2.1 documents the time-series correlation between China's demographic profile and aggregate household saving rate at the macro level. Section 2.2 presents evidence from micro data that shows a negative relationship between family size and household saving.

2.1 Macro Data

Figure 1 plots China's aggregate household saving rate (household saving divided by household income) from 1955 to 2009. The data comes from Modigliani and Cao (2004) and various issues of the China Statistical Yearbook. We use the available information as provided by these sources without modification.[3] The saving rate is relatively low until 1978. Then, it begins to increase dramatically. At present, China saves at a rate that greatly exceeds every other large country.[4] The evolution of China's saving rate has, however, been punctuated by sizable fluctuations. In a short 6 year span between 1978 and 1984 the saving rate increased by 15 percentage points. Then, saving fell to 10 percent in 1988, after which it resumed a more or less upward course.

Over this same time period, China underwent a considerable demographic transition. Using historical and projected estimates from the United Nations *World Population Prospects*, Figure 2 displays the evolution of the age distribution from 1950 to 2050 by dividing the population into three age groups. The lower line (bottom, light section) is the fraction of the population under 20, which we take as a coarse measure of the share of dependent children. The top line (middle, dark section) is the fraction of the population 64 and older and is an approximation for the number of retirees. The last category, the share of people aged 20 to 63, is a measure of the working age

of China to study saving includes Ferrero (2010), who finds an important role for demographics in explaining the long run trend in US capital flows relative to other G6 countries. Krueger and Ludwig (2007) and Fehr et al. (2007) show the importance of demographic change in multi-country OLG models. Chen et al. (2007) argue that the decline in population growth has had only a small effect on the Japanese saving rate. Our approach differs from these in that we enter consumption by children directly into household utility as in Barro and Becker (1989). Our paper also makes contact with the broader literature on how demographic changes affect the macroeconomy. Shimer (2001) details how the age distribution impacts unemployment rates; Feyrer (2007) relates demographic change to productivity growth; and Jaimovich and Siu (2009) and Lugauer (2012) connect the age distribution to the magnitude of business cycles.

[3] See Curtis and Mark (2010) for more about Chinese data and studying China using standard economic models. Ma and Yi (2010) also discuss the data and provide some empirical evidence suggesting that demographic change has helped increase the Chinese household saving rate.

[4] For example, the OECD reports 2007 household saving of 4.1 percent of GDP in the US and 5.8 percent in Japan, compared to 22.2 percent in China.

population. Beginning in 1970, the age distribution has become increasingly older. The share of China's population over 63 could surpass the fraction under 20 before 2035, an event not expected to occur in the US until 2075.

We hypothesize three principal channels through which the demographic changes depicted in Figure 2 might affect household saving. The first is the dependent children effect which works through changes in family size. The dependent children share shrank from 49 percent of the population in 1970 to 25 percent in 2009. As family size declines, the saving rate should increase since having fewer children to support (all else constant) frees up household resources, which can be saved. As an indication of this channel at work, Figure 3 shows that the ratio of parents (ages 20-50) to dependent children (ages 0-19) tracks the aggregate household saving rate quite closely over the 55 year period.

The decline in the dependent children share has been brought about by a rapid decline in the fertility rate. Figure 4 plots the fertility rates for China, the US, and Japan. Whereas the average Chinese woman had slightly more than 6 children in the early 1950s, the Chinese fertility rate currently lies below the US rate. Much of the decline in China's fertility rate was due to government policies on family planning. China's one-child policy began in earnest in 1979 and officially remains in effect although enforcement differs among jurisdictions and rural and urban areas. Even before the one-child policy, other lesser known (and less rigorously enforced) fertility reduction programs were implemented. As can be seen in Figure 4, fertility rates had already begun to decline in response to the 1971 "Later-Longer-Fewer" campaign in which the government asked that families be limited to two children in urban areas and three in rural areas (Kaufman et al. (1989)).

The second demographic channel works through the composition effect, which refers to the change in the saving rate induced by the change in the relative size of the working age population. Again looking at Figure 2, the share of the working age population increased from less than half of the population in 1970 to over 65 percent in 2009. Since the largest component of an economy's saving is unconsumed labor income, we expect an increase in the share of the working age group to raise the household saving rate.

The third demographic channel concerns old-age support through intergenerational transfers and the projected aging of the population. The proportion of working age people peaks in 2012, and the share of the oldest group will grow for the foreseeable future (Figure 2). Upon retirement, the current relatively large working age cohort will have to rely on relatively fewer workers for financial support. A 30 year old today is projected to have a support ratio (number of working age people divided by those 64 and older) of less than 3 upon retirement; whereas, current retirees enjoy a support ratio of 7. Thus, those currently working should increase saving for retirement because they expect to receive relatively smaller old-age support due to the projected future age distribution.[5]

[5] See Attanasio and Brugiavini (2003) for evidence on how personal savings substitute for pension wealth in the case of Italy. Cai, Giles, and Meng (2006) examine whether children act as insurance against low pensions in China.

Table 1: The Effect of the Number of Children on the Household's Saving Rate, 2007

	Dependent Variable: Saving Rate	
Explanatory Variable	(1)	(2)
Number of Children	-0.052 (0.015**)	-0.046 (0.020*)
Further Restrictions	None	Omit HH with Children Age > 19
Observations	3234	2200
R^2	0.142	0.127

NOTES: Saving rate is defined as (Income-Consumption)/Income. The data is restricted to nuclear families. Additional controls include income, age, age squared, and education. Standard errors are reported in parentheses. Stars denote significance at the * 5 percent and ** 1 percent level.

2.2 Micro Data

The discussion above draws inferences about household (micro-level) saving decisions from macro data. Here, we look directly at micro data for evidence on the relationship between family size and household saving by running a cross-sectional regression of the household saving rate on the number of children in the household. The data comes from the 2007 Urban Household Survey of China, which is part of the Rural-Urban Migration in China and Indonesia survey (RuMCI). The survey reports household income from all sources and total consumption expenditures from which we construct the saving rate as (Income-Consumption)/Income. To compare across similar households, we follow Banerjee et al. (2010), who use the same data. We restrict the sample to nuclear families (that may or may not contain dependent children) in which the head of household is less than 64 years old.[6] The regressions also include the log income, education, age, and age squared of the household head as control variables.

Table 1 reports the results. Column (1) shows that having an additional child is associated with a reduction of household saving by 5.2 percentage points, which is statistically significant at the 1 percent level. In Column (2), we omit families that have children living at home that are older than 19. Again, having an additional child living at home is associated with a reduction of the household saving rate by 4.6 percentage points which is statistically significant at the 5 percent level.

This regression evidence is based on a correlation. We are not asserting the direction of cause and effect here; that is the job of our quantitative model. Our estimates are, however, in line with others in the literature. Banerjee et al. (2010) estimate that an additional child lowers a Chinese household's saving rate by 7-11 percentage points, depending on the exact specification used. Ge et al. (2012) and Gruber (2012), using a different data source, also find a negative relationship between the number of minor children in a household and the saving rate.[7] While these cross-

[6]We restrict the sample because we do not necessarily want saving behavior associated with multigenerational households since that type of family structure is not part of the model and older people may be at a different stage in the life cycle.

[7]Interestingly, Gruber (2012) reports evidence that adult children positively affect saving rates. Similarly, in our model, household saving increases once children leave the home.

sectional regressions do not map directly into variation across successive generations, they provide supplementary motivation for incorporating family size into the modeling strategy.

To summarize, the patterns exhibited in the macro data between the large increase in the aggregate household saving rate and the dramatic demographic transition represent our main stylized facts. Life-cycle considerations predict that household saving should increase in response to exogenously mandated reductions in family size because having fewer mouths to feed frees up resources that can be saved. The micro data also exhibits this inverse relationship between the number of children and saving at the household level. The saving rate also should depend on the proportion of the working age population simply through changes in the composition (or share) of life cycle savers. Looking ahead, fewer children today means there will be fewer workers in the future to provide old age support, so the current working age cohort needs to save more aggressively for retirement. We use these observations to inform the specification of the structural model, to which we now turn.

3 A Life Cycle Model of Household Saving

This section presents the model of household saving used in the quantitative analysis. The model economy is populated by 66 overlapping generations of decision making agents. People live 85 periods or years, but only those aged 20 to 85 make decisions. All agents of the same age are identical, and the perfect foresight agents take the current and future age distribution as given by the data.

We classify the population into four not necessarily disjoint groups: children (age 0 to 19); workers (age 20 to 63); parents of dependent children (age 20 to 49); and retirees (age 64 to 85). Let N_t^c,N_t^w, N_t^p, and N_t^r be the number of people in these respective groups at time t. For the first 19 years, people live as children dependent on their parents. They consume what their parents choose for them and do not save. A distinguishing feature of the model is that parental and dependent children's consumption both enter separately into household utility as in Barro and Becker (1989). People supply labor inelastically and receive labor income from ages 20 to 63. From age 50 to 63 people continue to work, but children have left home. Retired people live off of accumulated assets and transfers from their adult working children (which we model a pay-as-you-go pension scheme). People die with certainty at age 85. In the last year of life, utility depends only on consumption in that year.[8]

3.1 Budget Constraints

Let $c_{t,j}$ be the year t consumption of an individual with decision-making age $j \in [0, 65]$, where $j = 0$ corresponds to real-life age 20. For $j \in [0, 29]$, the number of dependent children in the

[8]We experimented with variations of the model including either an explicit bequest motive or accidental bequests due to early death. The simulation results were similar to the model without bequests because the size of bequests is quantitatively small compared to workers wage income. To maintain simplicity in the model, we proceed without bequests.

household is $n_t = N_t^c / N_t^p$, each of whom consume $c_{t,j}^c$.[9] During the parenting years, agents choose their own consumption $c_{t,j}$, their dependent children's consumption $c_{t,j}^c$, and assets $a_{t+1,j+1}$ to take into the next period. We require asset holdings to be non-negative (consumers are not allowed to borrow). Working age people take the gross return on savings $1 + r_t$ and labor income w_t as given and give a fraction τ of their wages to support current retirees. The flow (period-by-period) budget constraints for households with children are

$$c_{t,j} = \ (1-\tau)\, w_t + (1+r_t)\, a_{t,j} - a_{t+1,j+1} - n_t c_{t,j}^c, \qquad j \in [0, 29]. \tag{1}$$

Children leave home when parents turn 50 ($j = 30$). People continue working until age 63 ($j = 42$). The budget constraints for 'empty nester' working people are

$$c_{t,j} = \ (1-\tau)\, w_t + (1+r_t)\, a_{t,j} - a_{t+1,j+1}, \qquad j \in [30, 42]. \tag{2}$$

Retirees consume out of accumulated assets and support from current workers. The per-retiree transfer received in year t is $P_t = \frac{N_t^w}{N_t^r} \tau w_t$. People consume remaining assets and die at age 85 ($j = 65$). The budget constraints for retirees are

$$c_{t,j} = \ P_t + (1+r_t)\, a_{t,j} - a_{t+1,j+1}, \qquad j \in [43, 65], \tag{3}$$

with $a_{t+1,66} = 0$.

We can see elements of the three demographic channels at work through the budget constraints. First, in Equation (1) a decline in the number of dependents (n_t) frees up resources for asset purchases ($a_{t+1,j+1}$). Second, a large cohort with ages $j \in [0, 42]$ increases the saving rate through increased numbers of people who are saving from labor income. Finally, a declining support ratio ($\frac{N_t^w}{N_t^r}$) means there will be a relatively small transfer ($P_t = \frac{N_t^w}{N_t^r} \tau w_t$) for the current working age cohort when they retire. People can overcome this shortfall by aggressively accumulating assets during their working years.

3.2 Preferences

Preferences for households with dependent children are a variation of Barro and Becker (1989) in which consumption of parents and children enter separately into household utility. The per-period utility function for a household head of decision-making age $j \in [0, 29]$ in year t is

$$u_{t,j} = \mu \left(n_t\right)^{\eta} \frac{\left(c_{t,j}^c\right)^{1-\sigma}}{1-\sigma} + \frac{c_{t,j}^{1-\sigma}}{1-\sigma}, \quad j \in [0, 29].$$

The parameter σ is the inverse of the elasticity of inter-temporal substitution, and the parameters $\mu \in (0, 1)$ and $\eta \in (0, 1)$ characterize the weight parents put on utility from children's consumption. The number of children n_t is expressed on a per-person basis as households are interpreted as single-

[9] Even though parents support and have children in their utility function for 30 years, children who leave the household after age 19 no longer receive consumption from their parents.

parent families. Beginning at age 50, individuals stop supporting children and have the flow utility function

$$u_{t,j} = \frac{c_{t,j}^{1-\sigma}}{1-\sigma}, \quad j \in [30, 65].$$

Let $\beta \in (0,1)$ be the subjective discount factor. A 20 year old in year t chooses a sequence of consumption, consumption for children, and asset holdings in order to maximize lifetime utility,

$$\begin{aligned} U_t = & \sum_{j=0}^{29} \beta^j \left(\mu \left(n_{t+j}\right)^{\eta} \left(\frac{\left(c_{t+j,j}^c\right)^{1-\sigma}}{1-\sigma} \right) + \left(\frac{c_{t+j,j}^{1-\sigma}}{1-\sigma} \right) \right) \\ & + \sum_{j=30}^{65} \beta^j \left(\frac{c_{t+j,j}^{1-\sigma}}{1-\sigma} \right), \end{aligned} \tag{4}$$

subject to the budget constraints in Equations (1) - (3). People make decisions taking the current and future demographic structure and family size (n_t) as exogenous and known. The observed fertility response to the one-child policy provides justification for this assumption.

3.3 Family Size and Saving Behavior

The following proposition helps to show how family size affects saving through preferences.

PROPOSITION 1 *(Effective Weight on Parental Utility): Let $\bar{c}_{t,j}$ be total household consumption by parents and their children, $\bar{c}_{t,j} = n_t c_{t,j}^c + c_{t,j}$. Then, lifetime utility for an individual at age 20 can be rewritten as*

$$U_t = \sum_{j=0}^{29} \gamma_{t+j,j} \frac{\bar{c}_{t+j,j}^{(1-\sigma)}}{(1-\sigma)} + \sum_{j=30}^{65} \beta^j \frac{c_{t+j,j}^{(1-\sigma)}}{(1-\sigma)}, \tag{5}$$

where the effective weight on parental utility

$$\gamma_{t,j} = \beta^j \left(1 + \left[\mu n_t^{\eta+\sigma-1} \right]^{1/\sigma} \right)^{\sigma}, \tag{6}$$

is increasing in n_t if $\eta + \sigma > 1$.

Proposition 1 exploits the Euler equation for the parent and child consumption choice to rewrite the lifetime utility function to look more like the standard model with no children.[10] The difference is that the effective weight on the utility during parental years, γ, depends on the number of dependent children per household, n. Note, if $n_t = 0$ or $\mu = 0$, then $\gamma_{t,j} = \beta^j$. In our calibrated model, people aged 20-49 have $\eta + \sigma > 1$. Therefore, according to Proposition 1, the effective weight on parental utility (γ) is increasing with family size, which makes the household with more children act as if it is less patient.

To see how this works, consider two household heads, A and B, of the same age. A has many children and values current consumption with weight γ_t^A while B has few children such that

[10]The Appendix A.1 contains a proof of Proposition 1.

Table 2: Parameter Values

Parameter	Symbol	Value
weight on children	μ	0.65
concavity for children	η	0.76
discount factor	β	0.97
coef. of relative risk aversion	σ	1.50
transfer share	τ	0.05
interest rate	r	0.04

$\gamma^B_{t,j} < \gamma^A_{t,j}$ for $j < 30$. A places relatively more weight on utility during parental years while B places relatively more weight on utility during the child-free stage of life. The result is that A will save less for retirement than B.[11] Thus, family size affects saving by altering the household's effective weight on utility during the parental years.[12] Next we discuss the parameter values before using the model to quantify the size of the demographic effect.

4 Parameterization

Table 2 reports the parameter values used in the model simulations. In specifying parent's attitudes towards children, we follow Manuelli and Seshadri (2009) who set $\mu = 0.65$ and $\eta = 0.76$ to match US birth rates in a model featuring the Barro-Becker children in utility function and fertility choice. We use the same values under the premise that the representative Chinese parent has the same attitude towards children as the representative US parent. The time discount factor β is set to 0.97, and the inter-temporal elasticity of substitution $(1/\sigma)$ is set to 0.67.

We set the share of labor income transferred to retirees τ to 0.05, which generates a replacement rate of about 40 percent for an individual retiring in 2012.[13] Like most of China's economy, the formal pension system has been in transition. A social system aimed at covering the urban workforce is in place *de jure*, but it is unfunded and broken *de facto*. The 1997 pension reform stipulates that most employees at urban state owned enterprises contribute to individual accounts (forced saving) and upon retiring receive additional transfers equal to a 20 percent replacement rate, with larger transition payments for older workers (Sin 2005). Prior to the 1997 reform, a government run program provided workers retiring from urban state-owned enterprises with more generous benefits, but this was a small portion of the population (Dunaway and Arora 2007). In 2004, the replacement rate in the formal pension system was a generous 75-80 percent of an individual's final working wage (Trinh 2006). However, Sin (2005) estimates that less than 25

[11] That the consumer, B, with the lower γ saves more may seem counterintuitive. Note, though, household head B puts relatively more weight on future consumption than A does because both A and B have the same discount factor β upon turning 50.

[12] Choi et al. (2008) show that variation in the time discount factor (β) across countries can explain the trending current accounts in Japan and the US. Our model is consistent with the Choi et al. hypothesis, in that the age structure affects choices in a similar way to the time discount factor.

[13] The replacement rate is the percent of final working year ($j = 42$) wages received as a pension in the first year of retirement ($j = 43$), $\frac{P_{t+1}}{w_t}$.

percent of the working population participated in the formal pension system. Assuming wages are the same for all workers and an 80 percent replacement rate for those who are covered works out to an aggregate replacement rate of less than 20 percent for the representative retired agent. The majority of people must rely on personal savings and the Chinese family system, whereby children, especially males, are expected to care for elderly parents. Indeed, children are legally obligated to care for their parents in old age (Naughton 2007, p.176).

Data on intergenerational transfers during the pre-reform period is scarce. As noted by Lee and Xiao (1998), in pre-reform days, most people lived in rural areas and belonged to collective production units with elderly persons receiving resources directly from the collectives. We view payments from collectives as intergenerational transfers. Lee and Xiao (1998) use a 1992 survey covering children's support for elderly parents to study transfers, and their results imply a value for τ around 0.08 in urban areas. Based on a survey conducted in 1998, Xie and Zhu (2008) find that the (unconditional) fraction of income contributed by urban men to their parents is 0.03. Xie and Zhu (2009) also note that a nontrivial proportion of adults in urban areas receive financial support from their elderly parents, making net transfers small. Our choice for τ is meant to capture both the government and family transfers. Section 5.1.3 experiments with alternative values of τ and Section 5.4.3 investigates the model with a constant replacement rate social security system.

To isolate the quantitative effects of the demographic channels, we first simulate the model economy with fixed wages and interest rates. The wage is set to the level observed in 1970 and the interest rate is set to 4 percent. Although the real return on personal saving accounts is currently less than 4 percent, our choice for r is intended to capture the return on all savings, including for example, housing and other investments. In Sections 5.3 and 5.4 we allow the interest rate and wage to vary exogenously (as given by the data).

5 Quantitative Results

We simulate the economy from 1955 to 2009. Initial assets equal zero for each 20 year old (decision-age $j = 0$). To solve the utility maximization problem, a 20 year old must take into account the next 65 years of demographic observations, which we take from United Nations estimates. The demographic data consists of annual observations by single year age groups. We begin in subsection 5.1 by presenting model predictions generated by only this demographic variation. Then, we conduct several experiments that turn on and off various components of the model. The model is able to explain the low saving rates in the pre-reform period and the high and rising saving rates in the post-reform period. This result constitutes our main finding; demographics have a large effect on the aggregate household saving rate within the model economy. Section 5.2 examines the cross-sectional implications of the model. Finally, Sections 5.3 and 5.4 discuss versions of the model that incorporate time varying wages and interest rates.

5.1 Demographic Change Only

Figure 5 compares the Chinese data from 1955 to 2009 to the model economy's aggregate household saving rate when only the demographic composition and family size varies. This stripped-down version of the model generates the low saving rate in the pre-reform period and an upward trend during the post-reform period. Between 1970 and 2009, the implied saving rate increases by 15 percentage points (compared to 24 percentage points in the data). By 2009, the implied saving rate of 18 percent is about two-thirds the size of the 27 percent rate observed in the data. The timing of the trend break in the model's saving rate also corresponds with the data. However, the model misses the decline in household saving in the early 1960s and the big increase and decrease during the 1980s. The age distribution evolves too slowly to, by itself, explain these short and medium run fluctuations.

Clearly, institutional and societal factors beyond demographics have affected the saving rate in China. In Section 5.3, we add time varying wages and interest rates to partially account for some these factors; doing so improves the model's performance on several dimensions. However, exploiting only the demographic variation, the model does a good job in explaining the low-frequency movements in the household saving rate. We conclude that the demographic structure has a large effect on the aggregate household saving rate within this model economy.

Next, we separately examine the role of the three demographic channels on the saving rate: the impact of the decline in the family size (the dependent children effect), the changing composition effect, and declining intergenerational transfers through the projected decline in workers per retiree. In the following simulations, the model's characteristics (utility functions, parameter values, demographic data, intergenerational transfers, etc.) remain unchanged except for the particular channel studied.

5.1.1 Dependent Children

To assess the importance of explicitly modeling dependent children in preferences, we shut off this channel by setting $\mu = 0$, which sets parent's valuation of children's utility from consumption to zero. Figure 6 shows the result. Ignoring dependent children causes the saving rate implied by the model to overstate saving (sometimes considerably) before 1996. The implied saving rate becomes much less variable and changes only by 4 percentage points between 1955 and 2009.

Next, we restore parental valuation of children's consumption (setting $\mu = 0.65$) but consider the effect of alternative and counterfactual family sizes n_t. Figure 7 shows the saving rates generated by assuming that the number of children per household remains constant at 1970 and at 2009 levels. Two-parent households in 1970 had 1.6 more children on average than in 2009. The saving rate for the economy with large family households is about 5 percentage points lower on average than in the simulation with smaller families. In both cases, the increase in the saving rate between 1955 and 2009 is much smaller than when family size evolves according to the data.

Proposition 1 gives additional insight as to why smaller households appear to be more patient. To reduce notational clutter, we drop the j subscript from the effective weight on the utility during parenting years (see Equation (6)). Recall that under our parameterization, the effective weight

γ_t for a given cohort increases with family size (since $\sigma + \eta = 2.26 > 1$). We can write the Euler equation for a household during parenting years as

$$\left(\frac{\bar{c}_{t+1}}{\bar{c}_t}\right)^{\sigma} = \frac{\gamma_{t+1}}{\gamma_t}(1 + r_{t+1}), \tag{7}$$

where $\bar{c}_t = n_t c_t^c + c_t$ is total household consumption. When the current number of children is high relative to the future ($\gamma_t > \gamma_{t+1}$), the right hand side of (7) is low; therefore, consumption growth is low, and saving is low. We connect this to the demographic data in Figure 8 which traces γ for two cohorts from age 20 to 49.[14] The solid line is the effective weight γ for the cohort aged 20 in 1970, and the dashed line is for the cohort aged 20 in 1990. The 20 year olds in 1970 face a steep slope for γ, causing savings for this cohort to be low. In comparison, the relatively flat γ series for 20 year olds in 1990 implies a higher value for $\frac{\gamma_{t+1}}{\gamma_t}$, which induces households in this cohort to save more.

The model predicts that a one child reduction per (two) parent household would have raised the saving rate by 5.5 percentage points in 1970 and by 4.2 percentage points in 2009. These numbers are similar to the 5.2 percentage point value implied by the cross-sectional regression estimate reported in Section 2.2. The two results may not be directly comparable because the model is dynamic in nature while the regression is from a single cross section. However, both the model and the data support our main point; reducing the number of dependent children raises the household saving rate, and the variation in household size over time has been a significant factor governing the evolution of China's household saving rate.

5.1.2 Composition Effect

To assess the quantitative importance of the composition effect, we decompose the model's implied saving rate in 2009 into contributions by age group. We then compare the implied 2009 saving rate to the 'counterfactual' saving rate implied by the 1970 demographic composition (holding the age-specific saving rates constant). Let the model's aggregate saving rate in 2009 be SR_{2009}, $N_{t,j}$ be the number of people with age j in year t, $\varphi_{t,j}$ be the age group's per-capita income share, and $sr_{t,j}$ be the age specific saving rate. The decomposition of the aggregate saving rate for 2009 is

$$SR_{2009} = \sum_{j=0}^{65} N_{2009,j}\left(\varphi_{2009,j}\right)\left(sr_{2009,j}\right). \tag{8}$$

To construct the counterfactual aggregate saving rate, we keep the age-specific saving rates at their 2009 values but set the age and income distributions to their 1970 values

$$\hat{SR}_{2009} = \sum_{j=0}^{65} N_{1970,j}\left(\varphi_{1970,j}\right)\left(sr_{2009,j}\right). \tag{9}$$

[14]At age 50, the effective weight collapses to the subjective discount factor β because households no longer have dependent children.

We expect that an increase in the share of those who save out of labor income will lead to an increase in the saving rate, and the share of the population aged 20-63 increased from 46 to 64 percent between 1970 and 2009. However, when we compute the difference $SR_{2009} - \hat{SR}_{2009}$, we obtain an implied increase of only 2.6 percentage points in the saving rate, or 17 percent of the model generated increase in the saving rate from 1970 to 2009.

While not trivial, the composition effect makes a relatively small contribution to the overall increase in the saving rate. Instead, the change in saving rates (sr) over time for all age groups is responsible for the increase in saving within the model. We return to this point in Section 5.2, when we discuss the cross-sectional implications of the model.

5.1.3 Retirement Support Ratio

Next, we consider how the decline in the retirement support ratio (workers per retiree) affects the saving rate. From 1970 to 2009, the support ratio declined from 9 to 7 and it is projected to fall below 3 by 2032. In our model, households foresee the plummeting retirement support ratio, which implies smaller future transfers and heavier reliance on personal savings for retirement. The projected low support ratio captures the so-called '4-2-1' problem in China as consecutive generations have now been affected by the one-child policy.

In Figure 9, the model is simulated holding the support ratio constant at the 1970 level throughout. Here, people who currently work save less because they can count on many (a support ratio of 9) workers for old-age support. After 1980, the resulting saving rate is much lower than in the simulations with varying support ratios, and by 2009, the saving rate is only 9 percent.

In Figure 10, we increase old-age support by increasing τ from 0.05 to 0.10. This change in the transfer rate (share of labor income given to retirees) lowers saving for two reasons. Workers must transfer a larger share of their income leaving fewer resources from which to save, and workers have less incentive to save because they anticipate more generous old-age support in retirement. Not surprisingly, variations in the transfer rate have a significant effect on the saving rate.

Notice that the choice of τ primarily affects the level of the saving rate rather than the trend. Thus, the overall increase in saving between 1955 and 2009 generated via the demographics channels is not sensitive to the value of τ. Given the documented evidence on transfers from children to the elderly and a lack of a comprehensive pension system, $\tau = 0.10$ seems unrealistically high.[15] We revisit this point after introducing time varying interest rates and wages, where we also consider a pension scheme in which retirees receive a fixed share of their final working year's wage (age 63). Before that, however, we discuss the model's cross-sectional implications for saving rates.

5.2 Saving by Age Group

The standard life-cycle model predicts the often observed upward sloping age-saving profile where the saving rate increases throughout people's working life. Recent data from China challenges this aspect of the life-cycle model as Song and Yang (2010) and Chamon et al. (2010) report that the

[15] In 2009, for example, retirees would receive about a 70 percent replacement rate from transfers alone, a much larger benefit than discussed in Section 4.

age-saving profile of working-age Chinese households is not upward sloping but is either flat or U-shaped. Although our research question centers on understanding the time series of the aggregate household saving rate, in this section we discuss how the cross-sectional implications of our model can confront these data.

The present set-up of the model delivers the standard life-cycle upward sloping pattern because model agents begin their decision making life (age 20) with children, who depress saving from the outset.[16] However, delaying the age of child birth produces a U-shaped saving profile that qualitatively matches the cross-sectional evidence while leaving the time-series predictions largely unchanged. We introduce the delay in childbirth by letting the number of children in the household vary with the age of the household head, producing a hump shaped age-to-family-size profile (i.e., 20 year olds and 49 year olds have fewer children to support than 40 year olds within any given year). Using the 2007 RuMCI data, we weight the number of children supported by parents by dividing the average number of dependent children for each household head (by age j) by the average aggregate number of dependent children. Call this weight Λ_j. Then, $\Lambda_{20} = 2.4$ means that a 40 year old has 2.4 times as many dependent children as the average for all households aged 20-64, and $\Lambda_j n_t$ is the number of children in the household at time t for parents with age j. We then rewrite utility for parents in decision making years $j \in [0, 43]$ as

$$u_{t,j} = \mu \left(\Lambda_j n_t\right)^{\eta} \frac{\left(c_{t,j}^{c}\right)^{1-\sigma}}{1-\sigma} + \frac{c_{t,j}^{1-\sigma}}{1-\sigma}, \qquad j \in [0, 43],$$

with corresponding adjustments in the budget constraint.[17]

Figure 11 shows the U-shaped age-saving profile given by the 2007 RuMCI data and a corresponding year 2007 U-shaped profile implied by the delayed childbearing model. The saving rate of young households is relatively high since they have few children to care for. In the middle working years (ages 26-50) the saving rate declines because of relatively high children-related expenses. The saving rate rises in the later working years as children leave the household.[18]

Figure 12 shows that the time-series behavior of the saving rate is fairly robust to this modification to the model. That is, modifying the model to qualitatively match the U-shaped cross-sectional saving pattern does not change our main result that demographic change alone accounts for over half of the increase in saving. In light of the small composition effect detailed above, this result is perhaps not surprising. The change in the aggregate household saving rate over time in the model is driven primarily by changes in the saving rates for all age groups and not the differences across age groups.

Returning to the time-series dimension, the experiment in Figure 12 was generated using data from 2007 to construct the weights Λ_j. Hence, the delayed childbirth model features a U-shaped

[16]Saving jumps at age 50 because the household no longer has children to support.

[17]The budget constraint (1) for these years becomes

$$c_{t,j} = (1-\tau)w_t + (1+r_t)a_{t,j} - a_{t+i,j+1} - \Lambda_j n_t c_{t,j}^{c},\ j \in [0, 43].$$

Setting $\Lambda_j = 1$ for all j would return us to the previous set-up.

[18]The RuMCI survey is a sample of urban households only and is not representative of all households. The saving rate is lower than the data for each age in the cross section because the model continues to generate about two-thirds of the observed aggregate saving rate.

saving pattern in all years. While data on Chinese saving rates by age group prior to the 1990s is difficult to come by, Song and Yang (2010) and Chamon and Prasad (2010) argue that the saving profile has flattened; it used to be upward sloping but only recently became U-shaped. This presents a problem, since data to inform the weighting pattern in earlier years is unavailable.

While we cannot construct weights over time from the data, we can make a crude approximation by setting Λ_j to 1 before 1995 and to the values underlying Figure 12 after 1995. This simulation produces an upward sloping age-saving profile in the first sub period and the U-shape in the second sub period, but importantly, the implied time series for the saving rate remains close to the 'Only Demographic Change' simulations.[19]

We have shown how the model can generate a U-shaped age-saving profile; although, we do not claim that fertility patterns are the exclusive explanation. Our point is that the evolution of the cross-sectional saving pattern implied by our model is relatively unimportant for explaining the time series of the aggregate household saving rate. This robustness is important for our story; the failure of the unweighted model ($\Lambda_j = 1$) to match the cross section does not invalidate the model's predictions for the time series.

5.3 Complete Model with Time Varying Interest Rates and Wages

From this point on, the model simulations allow the interest rate r_t and the wage w_t to vary over time. Households take the time series of r_t and w_t as given, and the analysis remains one of partial equilibrium. The idea behind introducing variation in r_t and w_t is to capture, in a simple way, many of the institutional and policy changes (in addition to demographic change) that may have influenced household saving decisions throughout this time period via wage and interest rates.

We use data from various issues of the *China Statistical Yearbook* and other sources to inform us about w_t and r_t. We estimate the capital stock using the perpetual inventory method (with a depreciation rate of 0.10) and take the stock of labor as the number of individuals aged 20-63. Using a representative firm with a constant returns to scale production function, the wage is set equal to the marginal product of labor and the interest rate is set to the marginal product of capital less depreciation (MPK). Future values are generated by assuming a gradual transition of output growth to a steady state rate of 1.0 percent with a half-life of adjustment equal to 3.1 years and with the slowdown beginning in 2012.[20] Since we are focused on explaining the trend of the household saving rate rather than the cyclical component, we smooth the annual wage series with the Hodrick-Prescott filter (smoothing parameter $\lambda = 100$).[21] Sections A.2 and A.3 of the Appendix provide further details.

Figure 13 plots the log wage that we construct. In the 1955 to 1978 pre-reform period, real wage growth averaged 3 percent per year. Subsequent to the implementation of a series of economic

[19] These results are not reported to save space but are available upon request.

[20] We think that the inevitable slowing of growth will happen sooner rather than later, as does (apparently) the Chinese leadership. The Wall Street Journal (March 5, 2012) reports that Chinese Premier Wen Jiabao set the 2012 growth target at 7.5 percent, significantly lower than the actual growth rate in 2011 of 9.2 percent.

[21] The trend in saving rates generated without smoothing the wages looks similar to those generated with smoothing, except that the swings in the model saving rate during the 1960's Great Leap Forward time frame are much larger than in the data.

reforms beginning in 1978, the Chinese economy has grown at a torrid pace with real wage growth averaging 6.9 percent per year from 1979 to 2009.

Figure 14 shows the constructed interest rate series. The marginal product of capital in China might seem high relative to more developed countries. Despite years of heavy investment, China remains a relatively capital poor country. Moreover, our estimated return on capital series post-1979 is in line with estimates by other researchers. For example, Bai et al. (2006) estimates an average of about 20 percent per year from 1978 to 2005. Our interest rate measure is intended to go beyond saving account interest and reflect returns on other saving vehicles, such as housing, investment in private businesses, and equity investments that have become available over time. Households, who may own and have decision making authority over only a fraction of the nation's capital stock will still have access to the returns from the marginal product of capital less depreciation. However, under the central planning period from 1955 to 1978, the capital stock was primarily state owned and households probably did not have access to returns driven by the marginal product of capital. Thus for this period, we assume that the interest rate available to households is 0.04, which lies below the implied rate of return on capital.

Figure 15 shows the simulated saving rates from the complete model economy. Incorporating time varying r_t and w_t improves the model's predictions by raising the saving rate in the more recent years. As in the data, aggregate household saving before the mid-1970s is relatively low and in 2005 the model exactly matches the data. While the implied trend break toward high saving in this model leads the data, the model now generates a saving boomlet and bust in the 1980s.[22] By 2009, households in the model save 29 percent of their income, slightly more than the observed 27 percent. As we saw above, more than half of the rise in the saving rate is due to the changing age distribution alone. The rest of the increase in the household saving rate comes from the interest rates and wages, and their interaction with the changing demographics.

5.3.1 Corporate Saving

Thus far, our discussions have excluded corporate saving, which in China, has been relatively but not anomalously high. Bayoumi et al. (2010) report that corporate gross saving as a percent of GDP has, from 1995 to 2007, been comparable to the rate in the UK and consistently 5 to 10 percentage points below rates in Japan and Korea. As with much of the literature, we have focused on modeling saving at the household level because over most of the sample period households did not own the firms and therefore did not exercise decision making over retained earnings. Certainly during the central planning period, households did not own the firms, and even today China is to degree still dominated by state-owned enterprises (SOEs).[23] The investment / saving choices

[22] The run-up starts earlier than in the data, mostly because wage growth was high from 1969 to 1979 (see Figure 13). Households with perfect foresight hold off saving until they have fewer dependent children to support and higher wage income. Interest rates also matter.

[23] See Curtis (2012) for more on the Chinese transition from SOEs to private companies. As of 2012, over half of both output and employment was still in SOEs or firms in which the government retained majority ownership. Wang (2010) reports that "...the state still controls more than two-thirds of most listed companies, either through the holding of state shares by GAs and SOEs, or indirectly through legal-person shares." Additionally, many Limited Liability Corporations are partially owned by SOEs or by subsidiaries owned by SOEs. In response to declining profits, many SOEs were restructured through privatization and issued shares in domestic markets. However, the

made by SOEs may not impact household decisions because the (virtually nonexistent) dividend policy is controlled by government appointed managers.

We can compare the saving rate from the model to total private saving (corporate plus household) in the post-SOEs (1992) reform period. To do this, we normalize saving from the model by GDP to make it comparable to the private saving rate data. Figure 16 shows the result. With our partial equilibrium setup, which does not force assets accumulated by households to equal the nation's capital stock, the implied saving ratio falls well short of the private saving ratio from 1992 to 2009. We note that the private saving rate includes saving by many SOEs and other companies wholly or partially owned by the state, thereby overstating private saving controlled by households. Discerning the fraction of business retained earnings that are under discretionary control of the households is a thorny problem that is beyond the scope of this paper.

5.4 Additional Experiments

This section reports on additional experiments that explore the sensitivity of our results. We consider variations in the wage and interest rate sequences and alternative retirement transfer plans.

5.4.1 Variations in Wage Growth

Figure 17 shows simulations when the wage growth is reduced by 20 percent from the historical experience. As one might expect from standard income/consumption smoothing arguments, slower wage growth increases the saving rate. High wage growth permits people to defer saving for retirement to a later time when wages are high. Hence a slowing down of that growth raises current saving. Clearly, wage growth affects saving behavior, but the time pattern of low pre-reform growth and high post-reform growth works against explaining the time-path of the saving rate. In light of this, demographic considerations seem to be a critical component in understanding the saving rate.

5.4.2 Variations in Interest Rates

Figure 18 shows the model saving rate when the interest rate is set as the marginal product of capital less depreciation throughout the entire sample (instead of $r = 0.04$ during the pre-reform period). With this higher interest rate before 1980, the model generates a saving rate that lies substantially above the data. This scenario is unrealistic, however, because nearly all production was owned and carried out by SOEs and other collectively owned enterprises.

5.4.3 Variations in Old-age Support

Our treatment of old-age support was a simple τ transfer of labor income from the working to the retired. Here, we assess the sensitivity of the model to implementation of a constant replacement

state continues to hold shares of these companies either directly or indirectly through other state owned legal entities (Wang 2010), and dividend payments by listed firms are limited (Kuijs 2006).

rate social security system. Under this system, retirees receive a constant fraction of their final working year's wage throughout retirement. The transfer rate τ is adjusted each period to equate payments from workers and designated benefits for retirees. We run the model with both a constant 20 percent replacement rate and a 50 percent rate. Figure 19 plots the saving rates under these two cases. The saving rate is inversely related to the replacement rate; when the replacement rate is relatively high, households save less for retirement. Overall, the increase in saving from 1955 to 2009 is still big even when the retirement transfers are larger.[24]

6 Conclusion

This paper investigates the quantitative impact of demographic change on the household saving rate. Because China has experienced large variation in both variables, it provides a fertile laboratory for such an investigation. Some of the more conspicuous facets of China's saving rate include its relatively low level prior to the economic reforms, its upward trend beginning in the late 1970s, and its current high level.

A few explanations have been proposed for the increasing Chinese saving rate, including the precautionary saving motive in conjunction with relatively high income uncertainty, persistent cultural differences, changes in the social welfare structure, features of the age-earnings profile, the male:female sex imbalance, and life-cycle considerations combined with demographic changes. These mechanisms are not mutually exclusive, and each probably has at least some quantitative significance for understanding this complex issue. We have focused on the last mechanism by examining the ability of standard life-cycle considerations combined with demographic changes to explain the evolution of household saving in China from 1955 to 2009.

We find that demographic variation alone explains over half of the current household saving rate. Using only changes to the demographic profile, the model generates low household saving rate in the pre-reform era and a dramatic increase during the post-reform period, which is largely in line with the data. Projecting forward, our model predicts that the household saving rate should moderate as the Chinese population ages, and it is aging quite rapidly. The Chinese external surpluses currently observed, to the extent that they are driven by household saving, may also be a temporary phenomenon.

Two aspects of the model are central to the analysis. The first is that consumption by dependent children enters into household utility. The second is the changing demographic distribution over time. We conclude that a large component of the increased saving rate can be attributed to the reduction in family size brought about through population control policies and that the model mechanisms linking demographics to household saving behavior are quantitatively important for explaining the time path of the saving rate. We have refrained from modeling specific events in recent Chinese history and other structural changes to the Chinese economy except through

[24]We also ran simulations with a declining transfer share over time. Chamon et al. (2010) argue that the effective support for the aged, which was high during central planning (the 'iron rice bowl') has declined over time and will continue to do so. These simulations (not reported, but available upon request) produce saving dynamics that are almost identical to the constant replacement exercises, except saving stays near zero until 1972.

their impact on interest rates and wages. We think demonstrating that demographics have a large quantitative effect on household saving within a relatively simple life cycle model is, in itself, an important step toward understanding the massive rise in the Chinese household saving rate.

References

[1] Attanasio, Orazio P. and Agar Brugiavini, (2003). "Social Security And Households' Saving," *Quarterly Journal of Economics,* 118 (3). pp. 1075-1119.

[2] Bai, Chong-en, Chang-Tai Hsieh, and Yingyi Qian, (2006). "The Return to Capital in China," Brookings Papers in Economic Activity, 2:2006.

[3] Banerjee, Abhijit, Xin Meng, and Nancy Qian, (2010). "The Life Cycle Model and Household Savings: Micro Evidence from Urban China," mimeo, Yale University.

[4] Barro, Robert J. and Gary S. Becker, (1989). "Fertility Choice in a Model of Economic Growth," *Econometrica*, 57(2), pp. 481-501.

[5] Bayoumi, Tam, Hui Tong, and Shang-Jin Wei, (2012). "The Chinese Corporate Saving Puzzle: A Firm-Level Cross-Country Perspective," in Joseph P.H. Fan and Randall Morck, eds., *Capitalizing China*.

[6] Cai, Fang, John Giles, and Xin Meng, (2006). "How Well do Children Insure Parents Against Low Retirement Income? An Analysis using Survey Data from Urban China," *Journal of Public Economics*, Vol. 90, pp. 2229-2255.

[7] Chamon, Marcos, Kai Liu, and Eswar Prasad, (2010). "Income Uncertainty and Household Savings in China," International Monetary Fund Working Paper, WP-10-289.

[8] Chamon, Marcos and Eswar Prasad, (2010). "Why Are Saving Rates of Urban Households in China Rising?" *American Economic Journal: Macroeconomics* 2010, 2(1), 93-130.

[9] Chen, Kaiji, Ayşe İmrohoroğlu, and Selahattin İmrohoroğlu, (2007). "The Japanese Saving Rate Between 1960 and 2000: Productivity, Policy Changes, and Demographics," *Economic Theory*, 32, pp. 87-104.

[10] Choi, Horag, Donggyu Sul, and Nelson C. Mark, (2008). "Endogenous Discounting, the World Saving Glut, and the US Current Account," *Journal of International Economics*, 75, pp. 30-53.

[11] Chow, Gregory C., (1993). "Capital Formation and Economic Growth in China," *The Quarterly Journal of Economics*, 108(3), pp. 809-842.

[12] Curtis, Chadwick C., (2012). "Economic Reforms and the Evolution of China's Total Factor Productivity," Working Paper, University of Richmond.

[13] Curtis, Chadwick C. and Nelson C. Mark, (2010). "Business Cycles, Consumption and Risk-Sharing: How Different Is China?" in Yin-WongCheung,Vikas Kakkar and Guonan Ma, eds., *The Evolving Role of Asia in Global Finance* Vol. 9.

[14] Dunaway, Steven, and Vivek Arora, (2007). "Pension Reform in China: The Need for a New Approach," IMF Working Paper No. 07/109.

[15] Fehr, Hans, Sabine Jokisch, and Laurence J. Kotlikoff, (2007). "Will China Eat Our Lunch or Take Us to Dinner? Simulating the Transition Paths of the United States, the European Union, Japan, and China," *Fiscal Policy and Management in East Asia, NBER-EAS*E, Volume 16, University of Chicago Press, pp. 133-193.

[16] Ferrero, Andrea, (2010). "A Structural Decomposition of the US Trade Balance: Productivity, Demographics, and Fiscal Policy," *Journal of Monetary Economics*, 57(4), pp. 478-490.

[17] Feyrer, James, (2007). "Demographics and Productivity," *Review of Economics and Statistics*, 89(1), pp. 100-109.

[18] Ge, Suqin, Dennis Tao Yang, and Junsen Zhang, (2012). "Population Policies, Demographic Structural Changes, and the Chinese Household Saving Puzzle," IZA Discussion Paper 7026.

[19] Gruber, Noam, (2012). "Keeping Up with the Zhangs: Household Saving Behavior as a Function of Relative Wealth," mimeo, University of Michigan.

[20] Hoiroka, Charles Yuji and Junmin Wan, (2006). "The Determinants of Household Saving in China: A Dynamic Panel Analysis of Provincial Data," *Journal of Money, Credit, and Banking*, 39(8), pp. 2077-96.

[21] Horioka, Charles Yuji, (2010). "Aging and Saving in Asia," *Pacific Economic Review,* 15, pp. 46-55.

[22] Hoiroka, Charles Yuji and Akiko Terada-Hagiwara, (2011). "The Determinants and Long-Term Projections of Saving Rates in Developing Asia," NBER Working Paper 17581.

[23] Hsieh, Chang-Tai and Peter J. Klenow, (2009). "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics* 124(4), pp. 1403-1448.

[24] Hu, Zuliu F. and Mohsin S. Khan, (1997). "Why is China Growing So Fast?" *Staff Papers*--International Monetary Fund, 44(1), pp. 103–131.

[25] Jaimovich, Nir and Henry E. Siu, (2009). "The Young, the Old, and the Restless: Demographics and Business Cycle Volatility" *American Economic Review*, 99 (3), pp. 804-826.

[26] Karabarbounis, Loukas and Brent Neiman, (2012). "Declining Labor Shares and the Global Rise of Corporate Savings," mimeo, University of Chicago.

[27] Kaufman, Joan, Zhang Zhirong, Qian Zinjian and Zhang Yang, (1989). "Family Planning Policy and Practice in China: A study of Four Rural Counties," *Population and Development Review*, 15 (4), pp. 707-29.

[28] Kuijs, Louis, (2006). "Investment and Saving in China," World Bank Policy Working Paper 3633.

[29] Krueger, Dirk and Alexander Ludwig, (2007). "On the Consequence of Demographic Change for Rates of Returns to Capital, and the Distribution of Wealth and Welfare," *Journal of Monetary Economics*, 54(1), pp. 49-87.

[30] Lee, Jean-Yu and Zhenyu Xiao, (1998). "Children's support for elderly parents in urban and rural China: Results from a national survey," *Journal of Cross-Cultural Gerontology* 13, pp. 39-62.

[31] Lugauer, Steven, (2012). "Estimating the Effect of the Age Distribution on Cyclical Output Volatility Across the United States," *Review of Economics and Statistics*, 94(4), pp. 896-902.

[32] Ma, Guonan and Wang Yi, (2010). "China's High Saving Rate: Myth and Reality," BIS Working Paper, Number 312.

[33] Manuelli, Rodolfo and Ananth Seshadri, (2009). "Explaining International Fertility Differences," *Quarterly Journal of Economics*, 124 (2), pp. 771-807.

[34] Meng, Xin, (2003). "Unemployment, Consumption Smoothing, and Precautionary Saving in Urban China," *Journal of Comparative Economics* 31(3), pp. 465-485.

[35] Modigliani, Franco and Shi Larry Cao, (2004). "The Chinese Saving Puzzle and the Life-Cycle Hypothesis," *Journal of Economic Literature*, 42, pp. 145-170.

[36] Naughton, Barry, (2007). *The Chinese Economy: Transitions and Growth*, MIT Press.

[37] Shimer, Robert, (2001). "The Impact of Young Workers on the Aggregate Labor Market," *Quarterly Journal of Economics*, 116(3), pp. 969-1007.

[38] Sin, Yvonne, (2005). "Pension Liabilities and Reform Options for Old Age Insurance," World Bank working paper No. 2005-01.

[39] Song, Zheng Michael and Dennis Tao Yang, (2010). "Life Cycle Earnings and Saving in a Fast-Growing Economy," mimeo, Chinese University of Hong Kong.

[40] Trinh, Tamara, (2006). "China's Pension System: Caught Between Mounting Legacies and Unfavourable Demographics." Deutch Bank Research Current Issue, 17 February.

[41] Wang, Jiwei (2010). "A Comparison of Shareholder Identity and Governance Mechanisms in the Monitoring of CEOs of Listed Companies in China." *China Economic Review* 21(1), pp. 24-37.

[42] Wei, Shang-Jin and Xiaobo Zhang, (2011). “The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings Rates in China,” *Journal of Political Economy*, 119 (3), pp. 511-564.

[43] Xie, Yu and Haiyan Zhu, (2009). "Do Sons or Daughters Give More Money to Parents in Urban China?" *Journal of Marriage and Family*, 71, pp. 174-186.

[44] Yang, Dennis Tao, (2012). "Aggregate Savings and External Imbalances in China" *Journal of Economic Perspectives*, 26 (4), pp. 125-146.

A Appendix

A.1 Proof of Proposition 1

The lifetime Lagrangian for a household at age 20 is given as

$$L = \sum_{j=0}^{29} \beta^j \left(\mu \left(n_{t+j}\right)^\eta \left(\frac{\left(c^c_{t+j,j}\right)^{1-\sigma}}{1-\sigma} \right) + \left(\frac{c^{1-\sigma}_{t+j,j}}{1-\sigma} \right) \right) + \sum_{j=30}^{65} \beta^j \left(\frac{\left(c_{t+j,j}\right)^{1-\sigma}}{1-\sigma} \right)$$

$$+\sum_{j=0}^{29} \lambda_{t+j,j} (n_{t+j} c^c_{t+j,j} + c_{t+j,j} + a_{t+j+1,j} - (1-\tau_{t+j}) w_{t+j} - (1+r_{t+j}) a_{t+j,j})$$

$$+\sum_{j=30}^{42} \lambda_{t+j,j} (c_{t+j,j} + a_{t+j+1,j} - (1-\tau_{t+j}) w_{t+j} - (1+r_{t+j}) a_{t+j,j})$$

$$+\sum_{j=43}^{65} \lambda_{t+j,j} (c_{t+j,j} + a_{t+j+1,j} - P_{t+j} - (1+r_{t+j}) a_{t+j,j}).$$

The first order conditions of consumption for households in cohort ages $j \in (0, 29)$ with dependent children are

$$c^{-\sigma}_{t+j,j} - \lambda_{t+j,j} = 0, \tag{10}$$

$$\mu \left(n_{t+j}\right)^\eta \left(c^c_{t+j,j}\right)^{-\sigma} - n_{t+j} \lambda_{t+j,j} = 0. \tag{11}$$

Equating the marginal utility of individual and children's consumptions, (10) and (11), implies

$$c^c_{t+j,j} = n_{t+j}^{\frac{\eta-1}{\sigma}} \mu^{\frac{1}{\sigma}} c_{t+j,j}.$$

We next denote the total household consumption as $\bar{c}$ for households with dependent children as

$$\bar{c}_{t+j,j} = n_{t+j} c^c_{t+j,j} + c_{t+j},\ j \in (0, 29). \tag{12}$$

This allows us to express utility for households with dependent children in terms of total household consumption.

Equating the marginal utility of parent's and children's consumptions from (10) and (11), and incorporating (12) gives

$$c_{t+j,j} = \frac{\bar{c}_{t+j,j}}{\left[1 + \mu^{\frac{1}{\sigma}} n_{t+j}^{\frac{\eta-1+\sigma}{\sigma}}\right]}, \tag{13}$$

$$c^c_{t+j,j} = \frac{\mu^{\frac{1}{\sigma}} n_{t+j}^{\frac{\eta-1}{\sigma}} \bar{c}_{t+j,j}}{\left[1 + \mu^{\frac{1}{\sigma}} n_{t+j}^{\frac{\eta-1+\sigma}{\sigma}}\right]}. \tag{14}$$

These are the optimal consumptions for household decision makers and children for all $j \in (0, 29)$. We can therefore rewrite lifetime utility of an agent at age 20 (4) using (13) and (14) as

$$U_t = \sum_{j=0}^{29} \beta^j \left(\mu \left(n_{t+j}\right)^{\eta} \left(\frac{\left(\frac{\mu^{\frac{1}{\sigma}} n_{t+j}^{\frac{\eta-1}{\sigma}}}{1+\mu^{\frac{1}{\sigma}} n_{t+j}^{\frac{n-1+\sigma}{\sigma}}} \bar{c}_{t+j,j} \right)^{1-\sigma}}{1-\sigma} \right) + \left(\frac{\left(\frac{\bar{c}_{t+j,j}}{1+\mu^{\frac{1}{\sigma}} n_{t+j}^{\frac{\eta-1+\sigma}{\sigma}}} \right)^{1-\sigma}}{1-\sigma} \right) \right) \tag{15}$$
$$+ \sum_{j=30}^{65} \beta^j \left(\frac{c_{t+j,j}^{1-\sigma}}{1-\sigma} \right).$$

Algebraically, (15) can be rearranged and simplified to be expressed as

$$U_t = \sum_{j=0}^{29} \gamma_{t+j,j} \frac{\bar{c}_{t+j,j}^{1-\sigma}}{1-\sigma} + \sum_{j=30}^{65} \beta^j \frac{c_{t+j,j}^{1-\sigma}}{1-\sigma}$$

where

$$\gamma_{t+j,j} = \beta^j \left(1 + \left[\mu n_{t+j}^{\eta+\sigma-1} \right]^{1/\sigma} \right)^{\sigma}.$$

This last expression is increasing in n as long as $\eta + \sigma > 1$.

A.2 The Data

In the text, we use the model to predict the saving rate beginning in 1955 but this requires that the model simulations begin in 1890, which is when an 85 year old in 1955 begins his or her economic life. Data that covers 1890 to 2007 are drawn from multiple sources. From 1952 to 1978, GDP, investment, and the price index are from the *China Statistical Data Compilation* and from 1979 to 2009 are from various issues of the *China Statistical Yearbook*. GDP from 1890 to 1952 are from *Angus Maddison Historical Data* on GDP data (http://www.ggdc.net/maddison/oriindex.htm) with linear interpolation for missing values (primarily in years between 1890-1930). Demographic data are from the *United Nations Population Prospects* database which reports annual population by age from 1950 to the present and projections to 2050. To arrive at population by age back to 1890, we assume that population shares between 1890-1949 were constant at their 1950-1955 averages and then applied them to backcasted total population using annual population growth rates given from the *Angus Maddison Historical data* on population.

A.3 Interest Rates and Wages

In the simulations with time varying factor prices, interest rates and wages are set equal to the marginal product of capital and labor that we calculated from the data. A representative firm with Cobb-Douglas technology produces output Y using the available workers N and capital K

rented from an intermediary bank

$$Y_t = A_t K_t^{1-\alpha} N_t^{\alpha}, \tag{16}$$

where A is total factor productivity, and α is labor's share. The partial equilibrium model does not require that assets held by the households equal the capital stock. We assume a national intermediary bank holds the difference.

Taking prices as given, working age agents N^w supply labor inelastically, so the age distribution exogenously determines the labor supply $N_t = N_t^w$. The wage w is given by the marginal product of labor

$$w_t = \alpha \frac{Y_t}{N_t^w}, \tag{17}$$

and the interest rate r is given by the marginal product of capital less the depreciation rate δ

$$r_t = (1-\alpha)\frac{Y_t}{K_t} - \delta. \tag{18}$$

The national bank finances the capital stock and clears excess supply or demand for capital on an (unmodeled) international market. Changes in the intermediary's foreign asset position do not correspond to the actual current account because the model only considers household or private saving. The household's problem remains exactly as described in Section 3.

We estimate the capital stock (K) using the perpetual inventory method with $\delta = 0.10$. We backcast pre-sample investment observations and forecast post-sample observations. From 1890 to 1952, we assume that labor's share $\alpha = 0.60$ and the interest rate $r = 0.04$. This gives a capital-output ratio of 2.87, close to Chow's (1993) estimate of 2.97 for 1952.

From 1955 to 2009, the calculations become more involved due to the decline in labor's share over this time period (see Karabarbounis and Neiman (2012)). As a result, labor income has not kept pace with GDP growth in recent years. Hu and Kahn (1997) estimate labor's share during the post-reform era (post 1978) to be 0.4. Hsieh and Klenow (2008) examine Chinese data from 1998 to 2005 and find that the median labor share across all state-owned firms and large non state-owned firms (revenues in excess of 5 million yuan) to be 0.3. Informed by these estimates, which are substantially lower than the 0.66 share in the US, we set $\alpha = 0.6$ in the pre-reform years (1955-1978) which then decreases by 0.02 per year between 1979 and 1988 until it reaches 0.4 where it remains from 1989 onwards. The choice of labor's share affects the saving rate only through its effect on interest rates and wages.

The youngest cohort in 2009 makes its forward looking consumption and saving decisions based on observations extending to 2074. To provide households with these future values, we forecast demographics beyond the United Nations projections by holding the number of newborns constant at the 2050 level and assuming that age-specific survival rates are constant at their 2050 rates. The saving rates in our time frame of 1955-2009 are largely unaffected by alternative assumptions on future (after 2050) demographic compositions. Future values of GDP are generated by assuming a gradual transition of output growth to a steady state rate of 1.0 percent with a half-life of adjustment equal to 3.1 years and with the slowdown beginning in 2012.

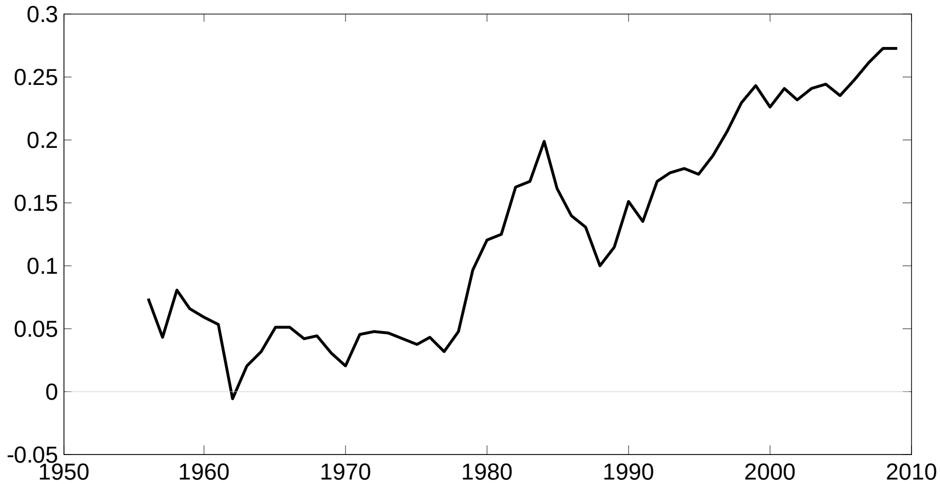

Figure 1: Saving as a share of household income, 1955-2009. Source: Modigliani and Cao (2004) and the *China Statistical Yearbook* (various issues).

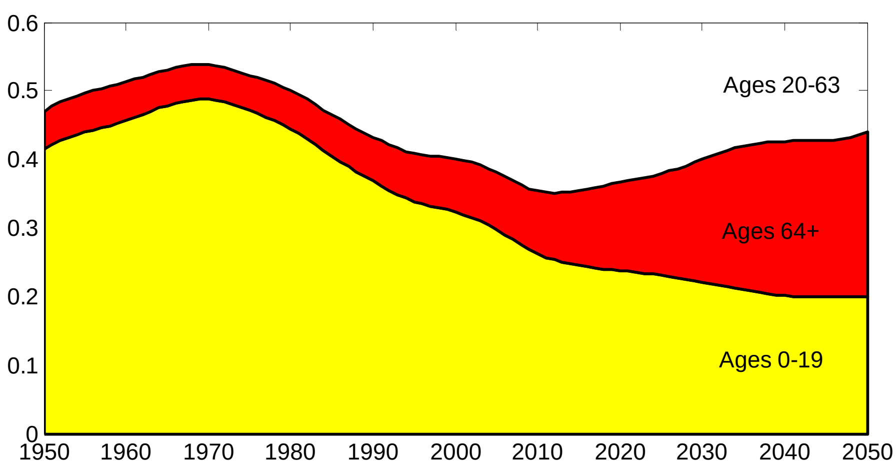

Figure 2: Youth (0-19), retirees (64+) and working age (20-63) as a share of population, 1950-2050. Sum of the three groups equals one but figure is truncated above at 0.60. Source: *United Nations World Population Prospects 2010.*

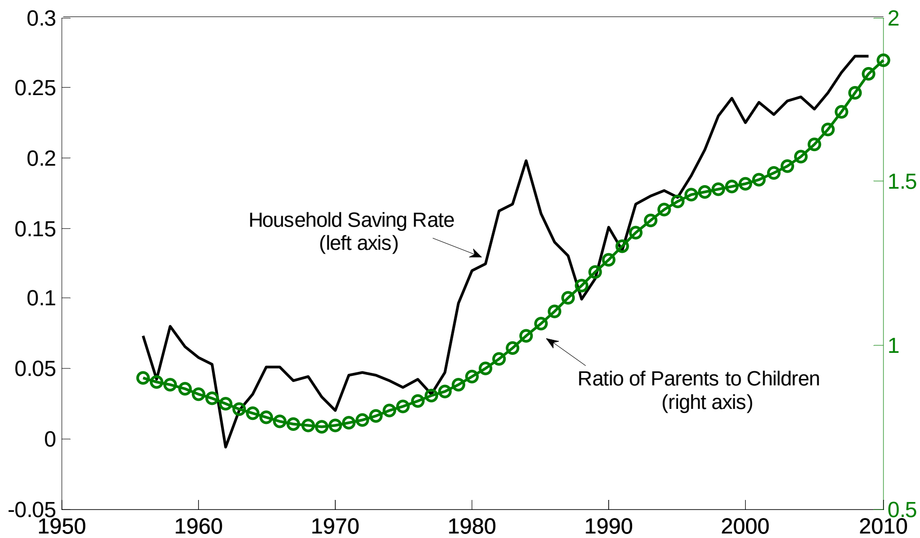

Figure 3: Household saving rate (left axis) and ratio of parents, age 20-50, to children, age 0-19 (right axis).

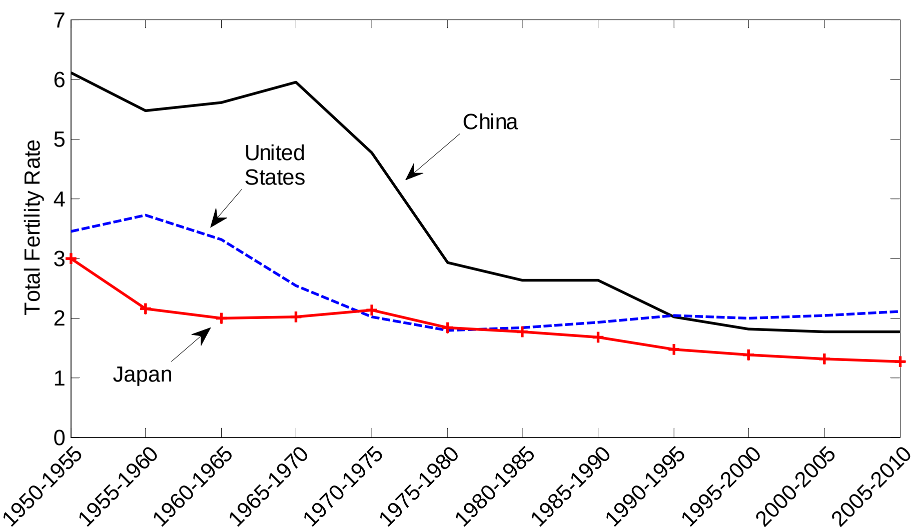

Figure 4: Total fertility rates, 1950-2010. Source: *United Nations World Population Prospects 2010.*

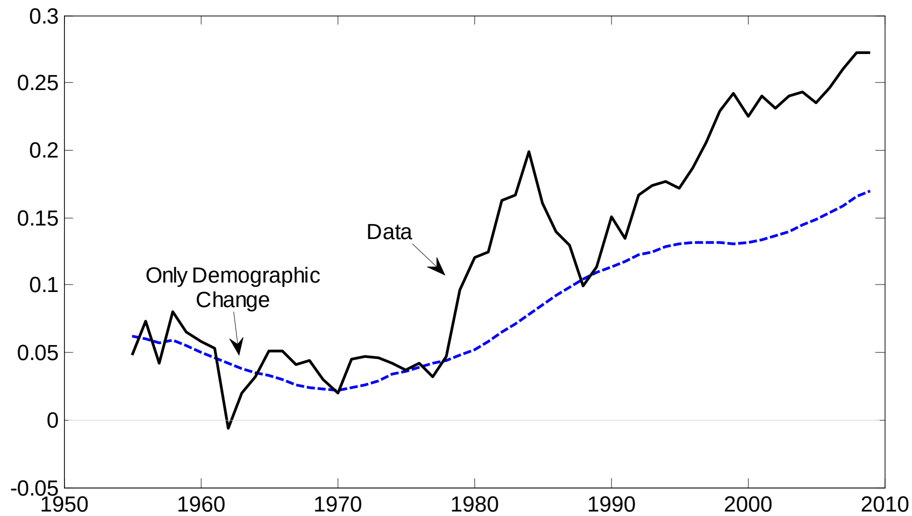

Figure 5: Household saving rates from 1955 to 2009 in the Chinese data and in the model with demographic change only. In the Only Demographic Change exercise wages are fixed at their 1970 level and $r = 0.04$.

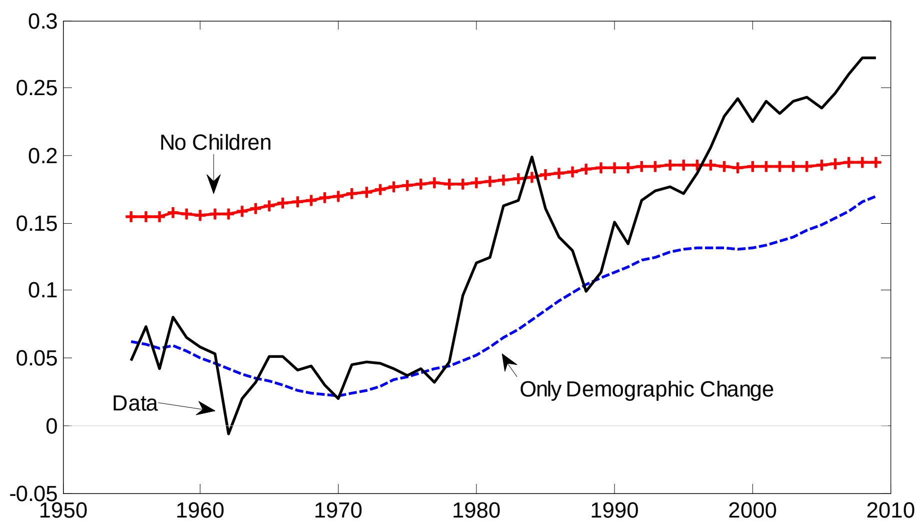

Figure 6: Household saving rates with no children. All components from the Only Demographic Change exercise remain except parents do not support dependent children (i.e. $\mu = 0$).

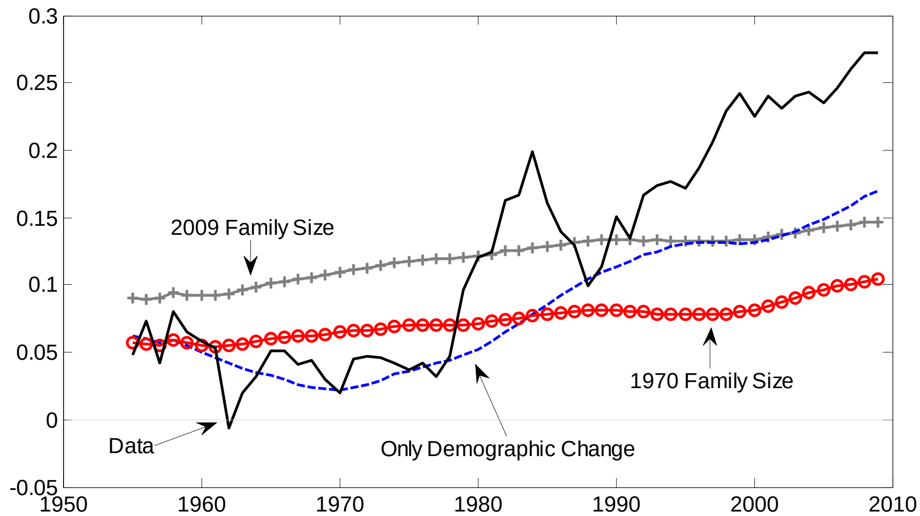

Figure 7: Household saving rates with variations in family size. The number of dependent children per household is held constant at 1970 and 2009 levels.

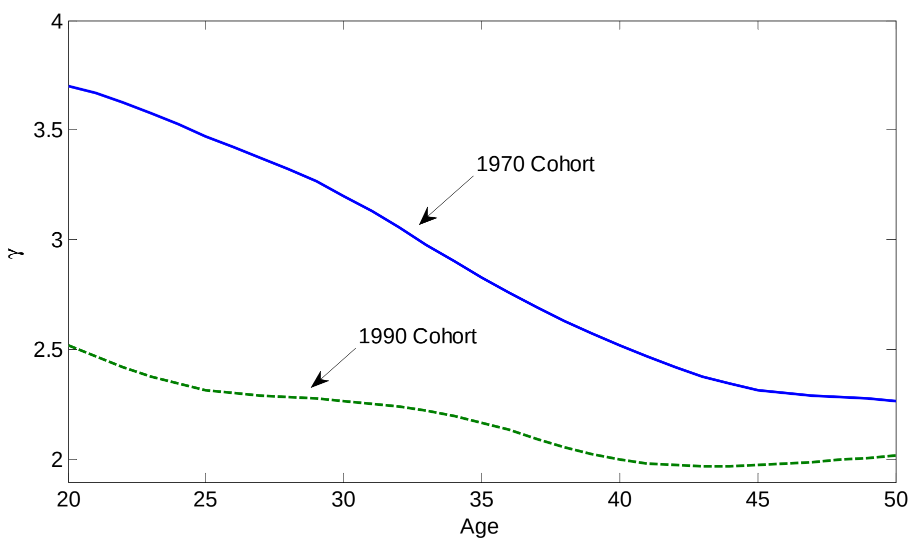

Figure 8: Evolution of γ from age 20-49 for cohorts who were age 20 in 1970 (solid line) and age 20 in 1990 (dashed line).

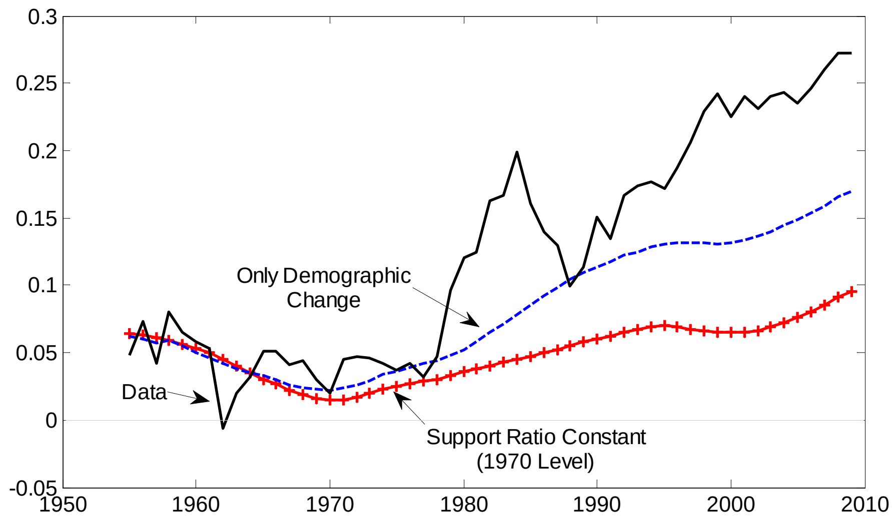

Figure 9: Household saving rates with the old age support ratio held constant at 1970 level: 9 workers per retired individual.

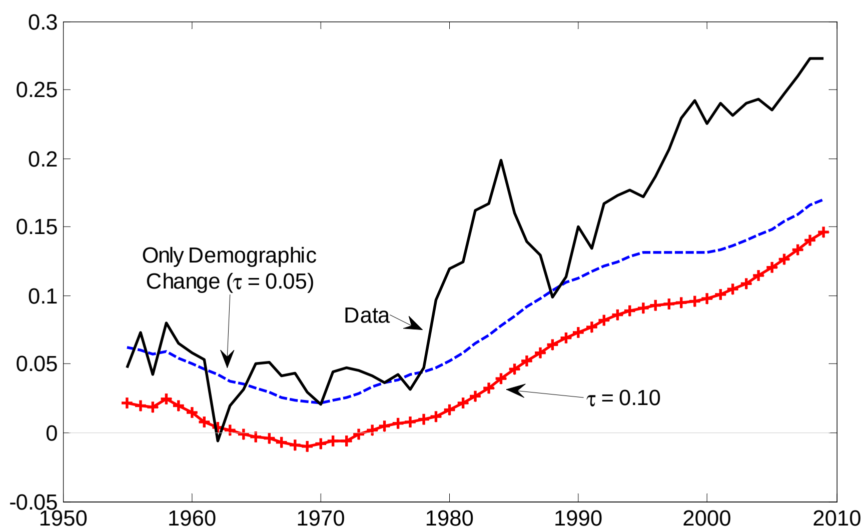

Figure 10: Household saving rates with variations in old age support: $\tau = 0.10$ and $\tau = 0.05$.

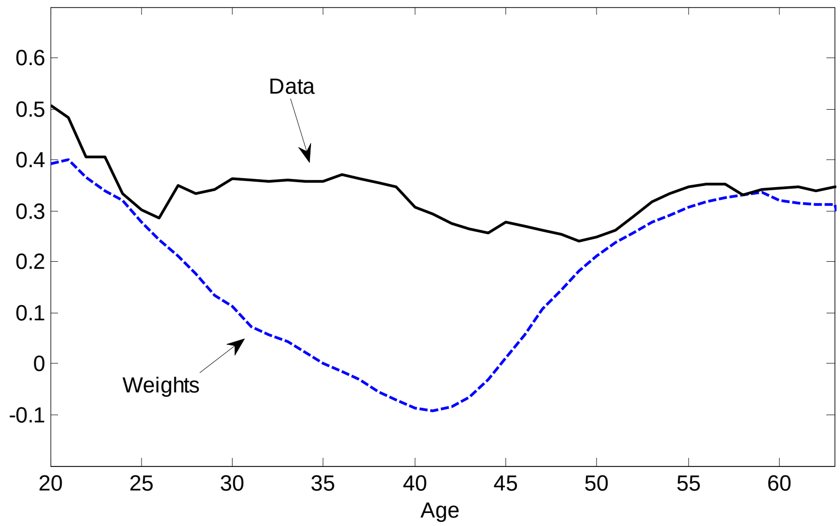

Figure 11: Cross-sectional saving rates by age in 2007. The data comes from the RuMCI household survey. The dashed line shows the cross-sectional saving profile in the model with age-specific weights (Λ_j) for the number of dependent children.

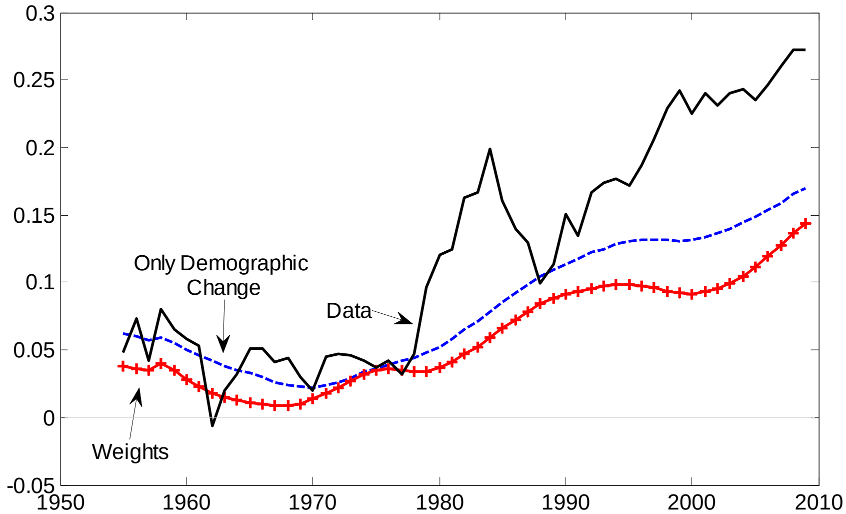

Figure 12: Household saving rates with weights (Λ_j) for the number of dependent children by age. Only Demographic Change (dashed line) parents have dependent children from age 20 to 49. With 'Weights', the number of dependent children varies with age from 20 to 64.

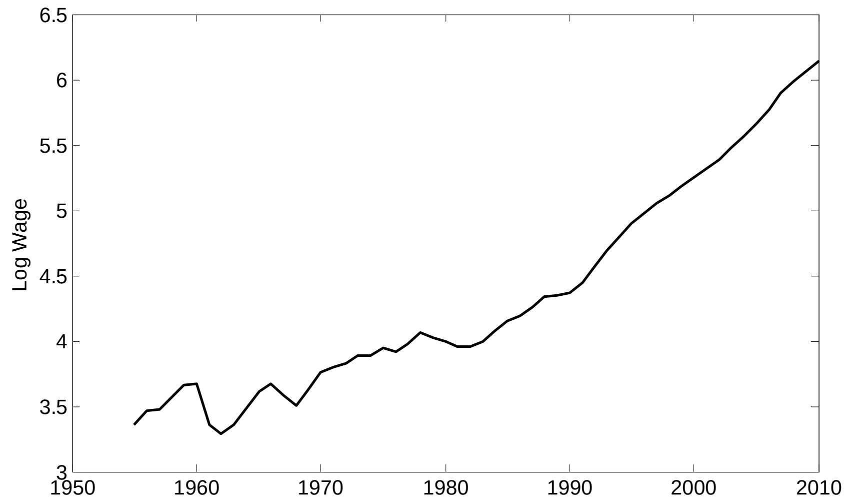

Figure 13: Log real wage, 1955-2009.

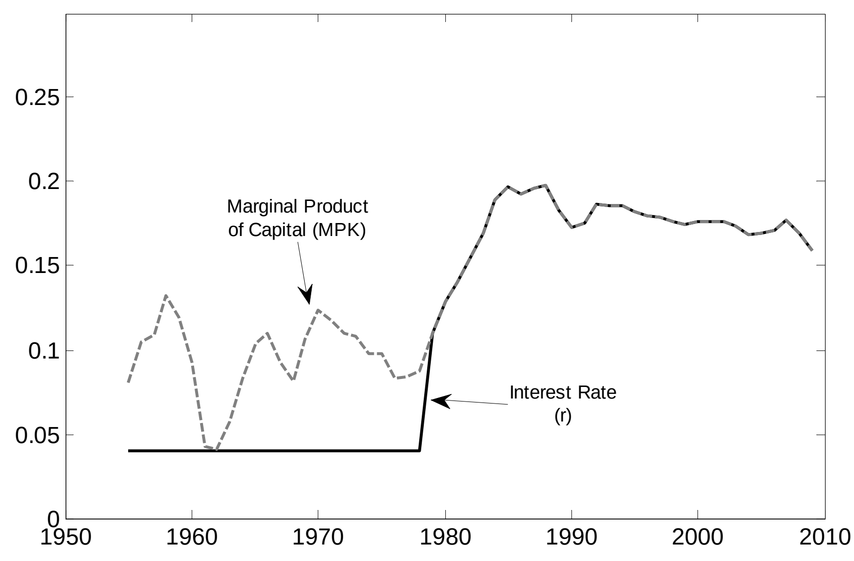

Figure 14: Interest rates, 1955-2009. The dashed line is the constructed marginal product of capital (MPK). The solid line is the interest rate the households face in the Complete Model simulations.

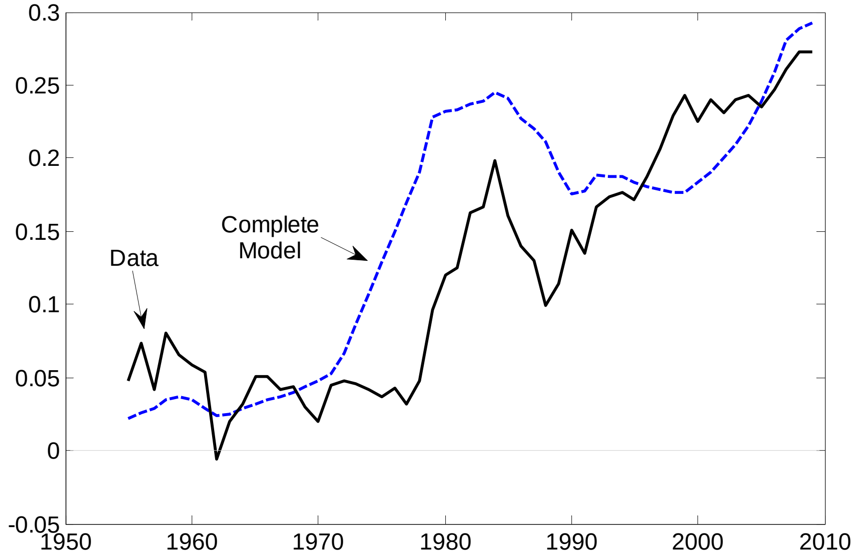

Figure 15: Household saving rates from 1955-2009 in the Chinese data and in the model with time varying wages and interest rates.

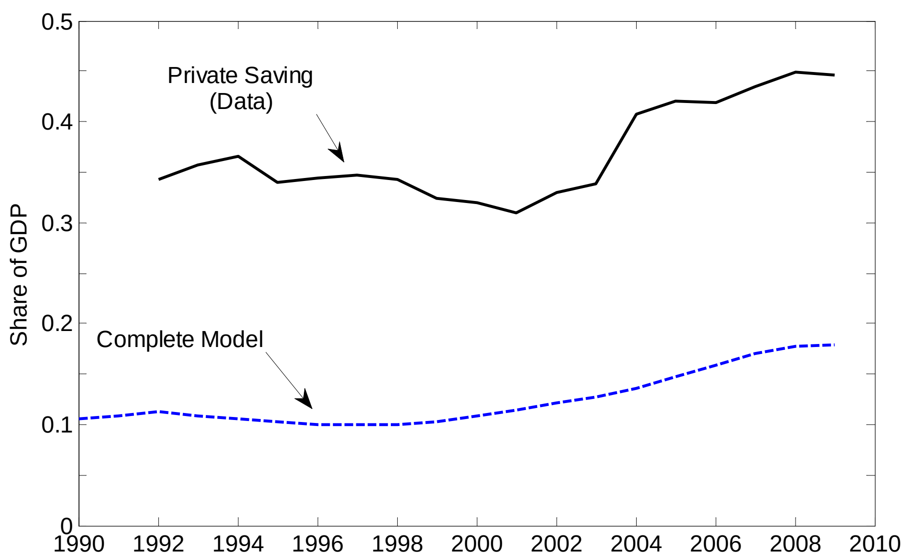

Figure 16: Private Saving as a share of GDP and household saving from the complete model as a share of GDP.

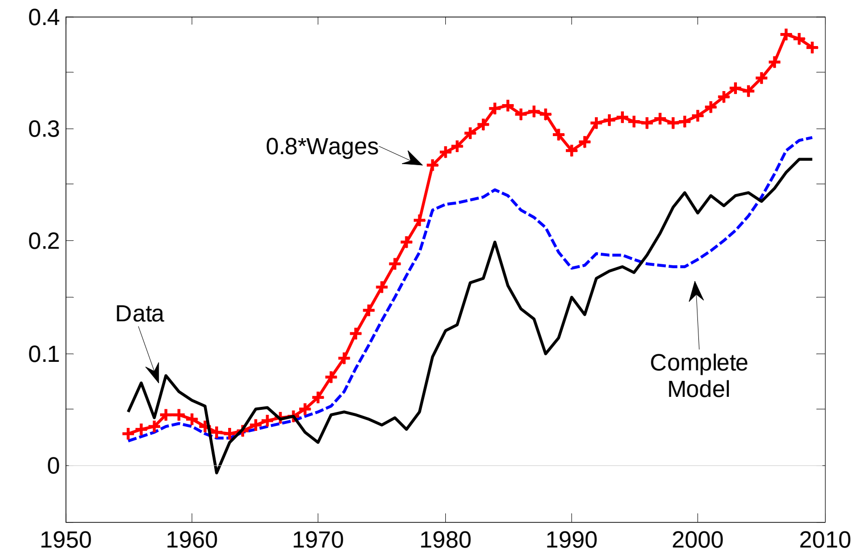

Figure 17: Household saving rates with variations in real wage growth. Wage growth is reduced to 80 percent of observed wage growth.

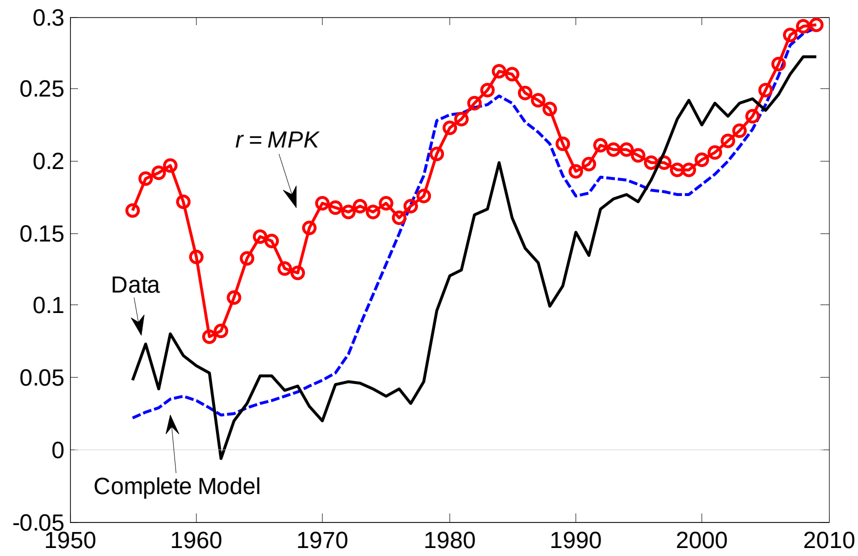

Figure 18: Household saving rates with variations in interest rates. In the series '$r = MPK$', the interest rate equals the marginal product of capital. In the Complete Model simulation, $r = 0.04$ prior to 1979 and $r = MPK$ thereafter.

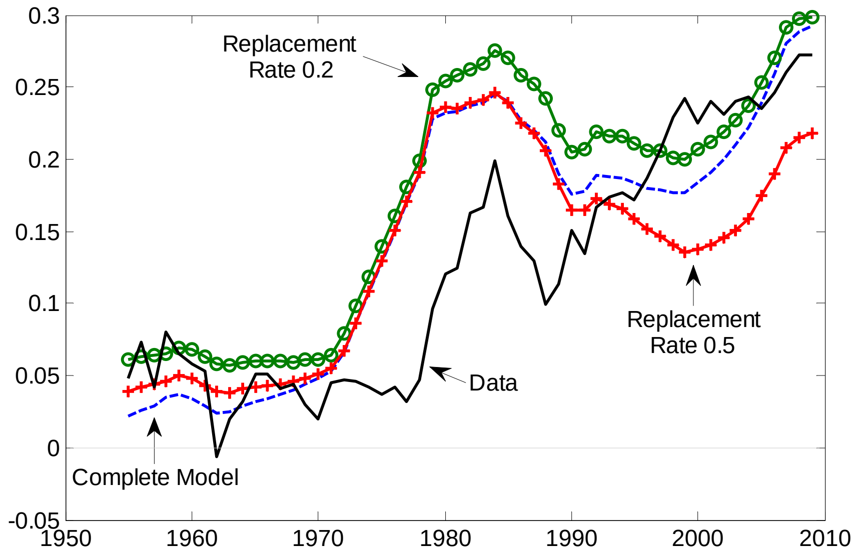

Figure 19: Household saving rates with constant replacement rate retirement plans. Retirement transfers are a fixed percentage of the last working year's (age 63) wage.