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Precautionary Saving of Chinese and U.S. Households

We employ a model of precautionary saving to study why household saving rates are high in China and low in the United States. The use of recursive preferences gives a convenient decomposition of saving into precautionary and nonprecautionary components. Over 80% of China's saving rate and nearly all U.S. saving arises from the precautionary motive. The difference between U.S. and Chinese household income growth rates is vastly more important than income risk for explaining the saving rates. The key mechanism is that precautionary savers have target wealth-to-income ratios, and rapid income growth necessitates high saving rates to maintain the ratio.

JEL codes: E2, J1
Keywords: precautionary saving, recursive preferences, China.

FROM 1989 TO 2009, THE HOUSEHOLD saving rate in China averaged slightly over 20% of disposable income. This saving rate is high by international standards and contrasts sharply with the 4% average in the United States over roughly the same time period. Both policymakers and academics have developed an interest in understanding the divergent saving rates in the world's two largest economies. In China, the high saving rate helps to drive investment-led growth, contributes to its

We thank two anonymous referees and Pok-sang Lam (the Editor) for many constructive suggestions. We thank Jim Sullivan and Yi Huang for assistance with the data and Wenqi Wu for efficient research assistance. This paper also has benefitted from presentations at the Hong Kong Institute for Monetary Research, the 2013 Midwest Economics Association Meetings (Columbus), the University of Notre Dame, the University of Nebraska at Omaha, the 2013 Society for Economic Dynamics Meetings (Seoul), and the 2014 Chinese Economics Society Australia Conference (Melbourne).

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Received December 23, 2014; and accepted in revised form July 19, 2016.

Journal of Money, Credit and Banking, Vol. 49, No. 4 (June 2017)

external imbalance, and presents a challenge to its goal of "rebalancing" growth toward consumption. The low saving rate in the United States, on the other hand, presents its own set of challenges for adequate provision of old-age support and a deepening of international indebtedness. What accounts for such a large discrepancy in saving rates between the two countries, and can a single model provide an explanation? In this paper, we study the extent to which a model of precautionary saving can answer these questions.

In the policy domain, Bernanke (2005) identifies the precautionary motive as the underlying source of high Asian saving rates and for generating external imbalances that depressed the world interest rate. This so-called savings glut also may have contributed to the subprime crisis. When opportunities for unsecured borrowing and risk-sharing are limited, the story goes, households use asset accumulation to serve as a precautionary buffer against zero or very low income states of nature. We show that both income growth and income risk at the household level are much higher in China than in the United States. Since the observed differences in the properties of household income for the two countries are stark and conspicuous, it seems reasonable to ask whether these differences in income characteristics can generate the divergent saving rates observed in the data.

Our structural model of saving decisions endows households with recursive Epstein–Zin–Weil preferences (Epstein and Zin 1989, Weil 1989). These preferences generalize power utility by treating the intertemporal elasticity of substitution (IES) and the coefficient of relative risk aversion (RRA) as separate parameters. Following the precautionary saving literature (originally developed for and applied to the United States), households in the model hold a positive "buffer" of assets and face idiosyncratic income risk.

We find that riskier income does induce higher saving rates in the model, which is no surprise. What is surprising is that the differential income risk between China and the United States explains a relatively small portion of the Chinese–U.S. saving rate gap. It turns out that the difference in the household income growth rates across countries is a much more important factor. We show this relationship between income growth and saving by embedding estimates of U.S. and Chinese income dynamics into simulations of our model of household saving.

Our analysis of the data and model yields a number of insights. To help organize the discussion, we refer to the following list of six results, with number 6 as the main finding.

1. Chinese households save a far higher share of their income than U.S. households.
2. Household income in China grows at a faster rate than in the United States.
3. Chinese households face more severe income shocks than U.S. households.
4. A large portion of saving in both China and the United States is precautionary saving (in the model).
5. Income growth and income risk (and IES and RRA parameters) affect the amount of precautionary saving.

6. The difference in income growth rates between China and the United States is quantitatively more important than the difference in income risk as an explanation for the U.S.–China gap in household saving rates.

Result 1 is widely known, and explaining this big difference in aggregate household saving rates (20.5% versus 4%) motivates our analysis. We arrive at results 2 and 3 by estimating income growth, transitory and permanent income shocks, and the probability of a large negative income shock separately for each country following the procedure laid forth in Carroll (1992). The data used to estimate the income dynamics for Chinese households come from the China Health and Nutrition Survey (CHNS). The analogous estimation for U.S. households employs the Panel Study for Income Dynamics. The findings are striking; Chinese households enjoy much higher income growth rates on average (7.3% versus 0.6%) yet face more severe income shocks along each dimension.

We use our model of household saving decisions to assess the role played by income dynamics (results 2 and 3) in explaining saving behavior (result 1). The online appendix (https://jmcb.osu.edu/) characterizes the relationships analytically. Complete closed-form solutions are not available, but the model equations suggest that additional income risk increases precautionary saving. The effect of income growth on saving is not necessarily monotone, and the IES and RRA preference parameters also have an ambiguous impact on saving. Therefore, we simulate the model economy for a wide range of parameter values, taking the income dynamics as exogenous.

The model's recursive utility structure provides a convenient way to quantify the size of the precautionary component of the saving rate. The nonprecautionary part of saving equals the implied saving rate when people are risk neutral. The gap between the actual and risk-neutral saving rate is then due to the precautionary motive. By this accounting, the risk-neutral saving rate in the United States is nearly zero. Almost all of the U.S. saving rate can be attributed to the precautionary motive in our model. Risk-neutral saving by Chinese households is also small relative to their large total saving. Thus, result 4 is that most of the saving within the model is precautionary.

We also use the simulations to calculate how saving rates change in response to varying the parameters governing the income process and preferences. Result 5 is, in short, that these parameters matter. Further, the precautionary saving model can replicate the observed aggregate Chinese and U.S. household saving rates using several configurations of the IES (σ) and RRA (γ) parameters. Thus, to further discipline the model, we estimate the preference parameters by the method of simulated moments using cross-sectional consumption data from the Urban Household Survey for China.

For China, we estimate (γ, σ) to be (3.8, 2.2). For the United States, we set the preference parameters (γ, σ) to (7.5, 1.5), estimates found in the literature (see Bansal and Yaron 2004).[1] At these parameter values, the model predicts a saving

1. In Choi, Lugauer, and Mark (2014), we also estimate the U.S. parameters via the method of simulated moments, obtaining values close to Bansal and Yaron (2004).

rate of 26.5% for China and 3.6% for the United States. Again, most of the saving is precautionary in nature for both countries, at these specific parameter values. Moreover, the large U.S.–China saving rate gap is driven primarily by the difference in income growth rates. For example, if we resimulate the model with Chinese households receiving only the low, U.S. rate of income growth (and keep all other parameters fixed at their Chinese values), then the Chinese saving rate falls to 4.3% (near the U.S. rate). To reiterate, the difference in income growth rates (0.6% versus 7.3%) can account for nearly all the difference in saving within the model. This finding is result 6, our main finding.

Result 6 is surprising, and the intuition behind it requires illumination. Precautionary savers, as discussed by Carroll (1992, 1997), have a target asset to income (or consumption) ratio. If this target ratio is relatively insensitive to the rate of income growth, the saving rate in a high-growth country must be high in order for assets, in the numerator, to grow at the same rate as income, in the denominator. This mechanism connecting household income growth to saving accounts for a large part of the difference in saving rates across the two countries.

Note, though, the relationship between income growth and saving is not always monotonic. Our analysis of the model equations show (and the model simulations confirm) that higher income growth can potentially decrease household saving, depending on the IES and RRA parameter values. Two additional channels interact to push down saving in response to income growth. First, agents expecting higher income in the future want to save less because of the consumption smoothing motive. Second, income growth makes households less vulnerable to some types of income risk leading them to lower their target wealth-to-income ratio. In our simulations at the estimated parameter values, however, the accumulation of assets for precautionary saving offsets the two effects in the other direction, especially for China.

The model predicts that China's household saving rate will decrease when income growth begins to taper. On the flip side, the analysis indicates that the U.S. saving rate could be increased substantially if household income growth could be raised—admittedly, not an easy task. Our findings also help explain why saving rates are often high in high growth countries, as observed in Japan during the 1960s to 1970s, Korea during the 1980s to 1990s, and currently in China. The positive empirical relation between growth and saving has posed a puzzle in the sense that consumption smoothing arguments lead us to expect higher future income growth to depress current saving (Carroll, Overland, and Weil 2000).

The high Chinese household saving rate has generated an active area of research. As saving is a multifaceted phenomenon, research has also formed a multifaceted approach. Mechanisms studied include capital market imperfections in China (Coeurdacier, Guibaud, and Jin 2012, Horioka and Terada-Hagiwara 2012), rapidly increasing housing prices (Wang and Wen 2012, Wan 2015), and a speculative bubble more generally (Wan 2016). Kraay (2000) and Meng (2003) incorporate precautionary saving aspects into their empirical analyses and Chamon and Prasad (2010) estimate the effects of the shifting state-to-private burden of educational and medical expenditures on the urban saving rate. More closely related to our paper is Chamon, Liu, and Prasad (2013). They show that the observed increase in the volatility of transitory income shocks (from downsizing of the state-owned sector) has led to over a 5 percentage point increase in the saving rate. He et al. (2014) use China's large-scale reform of state-owned enterprises in the late 1990s as a natural experiment to identify exogenous variation in income uncertainty and to estimate the importance of precautionary saving in China. Their estimation suggests that precautionary saving accounts for about 30% of the wealth accumulation by urban households. We also find that precautionary saving is quantitatively important but using a different methodology. Thus, our results are similar to He et al. (2014) in this regard.

We do not attempt to incorporate all these theories explicitly into a single model; rather, our estimates capture the income process faced by households in a reduced form way, without taking a particular stance on how the income uncertainty and income growth arise. Other research has examined the relationship between income growth and saving rates. Carroll, Overland, and Weil (2000) show that saving rates can increase with income growth when households have preferences with habit persistence, so when income growth accelerates, households that are accustomed to a low level of consumption increase their saving. Chen, Imrohoroglu, and Imrohoroglu (2006) build a general equilibrium model in which the rate of technology growth affects saving via the interest rate. In contrast, we show that increased growth induces higher saving rates for a given interest rate. Song and Yang (2010) focus on saving and income by age in China, in the cross-section. Additionally, several studies have focused on the role of life-cycle effects and demographic variation on the saving rate. Modigliani and Cao (2004), Horioka and Wan (2007), and Horioka (2010) undertake empirical analyses that test for the significance of these channels; whereas Banerjee, Meng, and Qian (2010), Curtis, Lugauer, and Mark (2015), Song et al. (2015), and Choukhame, Coeurdacier, and Jin (2014) quantitatively model how demographic changes affect China's saving rate through life-cycle channels. Wei and Zhang (2011) argue that the high saving can be partly explained by the sex-ratio imbalance that has emerged as an unintended consequence of the population control measures.

These competing explanations are complementary rather than exclusive. Each makes some contribution to explaining high Chinese saving rates, but it is unlikely that any single mechanism is the sole explanation. In our study of the importance of the precautionary saving motive, one might ask if our mechanism is robust to alternative explanations proposed in the literature. While it is not feasible (or necessarily desirable) to build a model that incorporates all facets of saving, we can establish robustness of the interaction between precautionary saving and income growth to demographic, family size, and life-cycle considerations. To do this, we modify the baseline model to include both the demographic structure and age-dependent heterogeneity in income risk. To impose the observed age distribution for each country, we give the model agents finite life-times and calculate their saving at different ages. Agents spend their last periods of life in retirement living off of accumulated assets and a pension. We also modify the utility function to incorporate explicit care of dependent children (following Curtis, Lugauer, and Mark 2015). As in the previous studies mentioned above, the age distribution has a large effect on saving. However, the precautionary component to saving remains large, too. Both channels contribute to China's high household saving rate.

While work that focuses directly on precautionary saving in China is relatively thin, it has been and continues to be a richly studied topic for U.S. households. Gourinchas and Parker (2002) combine life-cycle and precautionary motives in a quantitative model, while Parker and Preston (2005) use cross-sectional data to estimate an empirical decomposition of the saving rate into precautionary and nonprecautionary components. The general methodology of our paper aligns with the analyses of Zeldes (1989), Deaton (1991), and Carroll (1992, 1997). These studies work with constant RRA utility. Therefore, an additional contribution of our analysis comes from using the more general Epstein–Zin–Weil preferences.

The remainder of the paper is laid out as follows. The next section discusses the aggregate household saving rates for China and the United States, which we take as target values for the model simulation exercises. Section 2 presents the model for infinitely lived Epstein–Zin–Weil households who face risky income streams. Section 3 studies properties of the model through simulations. In Section 4, we estimate the preference parameters for China by the simulated method of moments in order to discipline the model. Then, we assess the ability of the model to explain the data when preference parameters are set to the point estimates. Section 5 studies the version of the model modified to include population age and family size demographics. Section 6 concludes.

1. HOUSEHOLD SAVING RATES IN CHINA AND THE UNITED STATES

Before sweeping economic reforms began in 1978, saving was relatively low in China. From 1959 to 1978, American households saved a higher fraction of income than Chinese households. This changed dramatically after 1980. Since that time, Chinese saving rates have climbed enormously while U.S. saving rates have trended down.[2] Between 1980 and 1986, China's saving rate increased from 12% to 16% then fell to 11% in 1989 and has increased more or less steadily thereafter. In the United States, on the other hand, the saving rate averaged 9.1% from 1959 to 1984, trended downward for 23 years reaching a low of 2.4% in 2007, before rising somewhat as people deleveraged during the great recession.

Broadly speaking, China underwent two sets of economic reforms during this time period. The first round of postcentral planning reforms began in 1978 and progressed through the 1980s. The initial reforms, directed at agriculture, led to increases in farm productivity and a surplus in farm labor. The labor released from the land fueled an explosion of private entrepreneurship formed by Township and Village Enterprises, self-employment businesses, and private-run firms often located in rural areas and leading to a rapid rise in rural income (Huang 2008, chapter 2).

2. Personal saving rate as a percentage of disposable income. Sources: U.S. Department of Commerce, Bureau of Economic Analysis and various issues of the *China Statistical Yearbook*.

TABLE 1
Aggregate Household Saving over the Time Span of Interest

	China	United States
Average saving rate	20.5	4.0

The Tiananmen Square protests in 1989 marked a critical point after which many policies were reversed and focus shifted away from the rural economy toward the urban areas. This second phase of reform centered on regulatory and administrative restructuring of key market sectors. Of special relevance to our study was the significant downsizing of the state-owned sector, which resulted in the loss of generous health, retirement, education, and housing benefits. The transition away from state provision of services and income insurance has been referred to as the dismantling of the "iron rice bowl," and the changes have created new incentives for precautionary saving by households (Chamon and Prasad 2010, He et al. 2014). This phase of the reform process is still ongoing.

The Chinese household survey panel data that we use to estimate the income dynamics are available from 1989 to 2009. Hence, we focus on the saving rate over this span of time, the period covered by the second set of Chinese economic reforms. To facilitate a comparison over (approximately) the same time period, we select waves of panel data from 1992 to 2007 for U.S. households. During these periods, as a percentage of income, the average aggregate Chinese household saving rate was 20.5% whereas the average U.S. rate was a much lower 4.0%. Table 1 summarizes result 1.

Result 1. *Chinese households save a far higher share of their income than U.S. households.*

The question we ask of the model is whether it can explain these average saving rates. Our focus is not on the evolution of saving rates over time, as the model is not equipped for transition dynamics.[3] However, the potential factors (e.g., income growth and risk) that we consider also may have contributed to the observed patterns in the time series. For example, both household income volatility and wage growth have increased along with China's saving rate.[4] In our model simulations, the difference in saving rates between China and the United States is primarily driven by China's high income growth rate. Lower growth generally (but not always, depending on the exact parameters used) leads to less saving in the model, which is consistent with the time series facts. Next, we present the model.

3. For analyses that do focus on the evolution of the saving rate in China, see Curtis, Lugauer, and Mark (2016), Coeurdacier, Guibaud, and Jin (2012), and Song and Yang (2010).

4. Note, the pattern of household income and wage growth has been quite distinct from GDP growth in China. In recent years, wage growth has generally increased while output growth has slowed. See Yang, Chen, and Monarch (2010) for more on wages within China. Similarly, Chamon, Liu, and Prasad (2013) show that the variance of income has been increasing in China.

2. A MODEL OF HOUSEHOLD SAVING

We begin with a description of the household's exogenous income process. We estimate the income process using micro data. The large disparity in the estimates of the income growth rates and income shocks across the two countries comprise results 2 and 3. Section 2.2 presents household preferences. The online appendix (https://jmcb.osu.edu/) explores the household saving decisions analytically within the model and shows how the model is transformed to induce stationarity for the simulation exercises.

2.1 The Income Process

We use the permanent–transitory income component model of Zeldes (1989) and Carroll (1992, 1997). Households draw different realizations of exogenous labor income from the same initial distribution. The expected income growth rate is common across individuals within a country. Households are infinitely lived and experience idiosyncratic realizations of permanent and transitory income shocks in each period t.[5]

Markets are implicitly incomplete in the model; agents cannot borrow, nor can they purchase contingent claims or other insurance instruments to diversify away from the labor income risk. In reality, insurance markets and other social safety nets are well developed in the United States. Therefore, what we seek to measure in the data below (for both the United States and China) are shocks to income net of all such transfers (including those between family members). The household income risk faced by the model agents should be interpreted as driven by those remaining shocks that cannot be diversified away.[6]

Let $Y_{i,t}$ be "household income" for individual $i \in [1, N]$. Income is comprised of a permanent part $P_{i,t}$ and a transitory part $e^{u}_{i,t}$ and evolves according to

$$Y_{i,t} = P_{i,t} e^{u_{i,t}}. \tag{1}$$

Log permanent income $\ln(P_{i,t})$ follows a random walk with drift. In levels, it evolves according to

$$P_{i,t} = e^{g} P_{i,t-1} e^{n_{i,t}}, \tag{2}$$

where g is the common growth rate of household income.[7] The term $e^{n_{i,t}}$ represents the log normally distributed innovation to permanent income where $n_{i,t} \overset{iid}{\sim} N(\mu_n, \sigma_n^2)$ with $\mu_n = -\sigma_n^2/2$.

5. See Aiyagari (1994) for a related model with only transitory income.

6. This interpretation of income volatility is used in most of the precautionary saving literature. See Carroll (1992, 1997). Zeldes (1989) makes similar arguments concerning borrowing constraints.

7. Following the literature, we keep g fixed. A key for our results is that g has been much lower in the United States than China over an extended period of time and that households expect income growth to stay more or less the same in the near future. We think this is a reasonable set of assumptions on g.

The transitory component is drawn from a mixture of a lognormal variate and a low probability event, which translates into zero income for that year. It evolves according to

$$u_{i,t} = \begin{cases} N\left(\mu_u, \sigma_u^2\right) & \text{with probability } (1-p) \\ -\infty & \text{with probability } p \end{cases},$$

where p is the probability of drawing zero income and $\mu_u = -\sigma_u^2/2 - \ln(1-p)$.[8] This mixture of distributions is often employed in analyses of precautionary saving because the income data appears to be distributed log normally except for a concentration of observations at the lower tail of the income distribution.[9] The permanent and transitory shocks are assumed to be orthogonal to each other, $Cov(u_{i,t}n_{i,t}) = 0$. We estimate the four parameters $(g, \sigma_n, \sigma_u, p)$ governing the income process from household-level data separately for the United States and China.

Household survey data. The Chinese data come from the CHNS, which contains income information for a panel of households in the years 1989, 1991, 1993, 1997, 2000, 2004, 2006, and 2009. The survey relies on a multistage random cluster process to track about 4,400 households, varying in terms of geography and socioeconomic status.[10] We set "labor income" equal to total household noncapital income, including income earned by any family member and any transfer payments.[11] This measure of income most closely resembles the concept of income in the model developed below. We restrict observations to households in which the same individual was the head of the household for each year (for which data exist) and for which the head was older than 24 and younger than 60, with complete data on education and occupation.

The U.S. data come from the Panel Study of Income Dynamics (PSID). We impose the same data restrictions used for the Chinese data. To make the time spans covered for U.S. households roughly comparable to the Chinese data, we use data from the 1992, 1994, 1998, 2001, 2005, and 2007 waves of the PSID.

Estimates of the income process parameters. Estimation of the income process parameters $(g, \sigma_n, \sigma_u, p)$ follows Carroll (1992). The strategy is to remove aggregate time trends, predictable life-cycle or occupation dependent fluctuations, and household fixed effects (hence the need for panel data) from the income data, then use the remaining variation to estimate the parameters (σ_n, σ_u, p) characterizing the shocks to the income process. The growth rate (g) of household income is calculated as the

8. We follow Carroll (1997) by setting the mean of $n_{i,t}$ to $-\sigma_n^2/2$ so that $E(e^{n_{i,t}}) = e^{\mu_n + \frac{\sigma_n^2}{2}} = 1$ and by adjusting the mean of the transitory shock so that $E(e^{u_{i,t}}) = 1$.

9. Carroll (1992) contains a more complete explanation for this income process. Both the U.S. and Chinese data we employ appear to be distributed log-normally except at the lower end of the distribution.

10. Detailed information on the survey can be found at www.cpc.unc.edu/projects/china. The survey contains information at the individual and household level. We aggregate to the household level for our analysis.

11. Total household income includes family transfers, unemployment insurance, social security, means-tested welfare, etc. The specific public policy details surrounding these programs could affect saving behavior. We abstract from such issues and focus on the properties of the realized income stream.

TABLE 2

Estimated Income Process

		Our Calculations		Chamon et al. (2010)	Carroll (1992)
		China 1989–2009	United States 1992–2007	China 2006	United States 1968–1985
g	Income growth (%)	7.30	0.60	n.r.	2.00
p	$\text{Prob}(e^u) = 0$ (%)	2.24	0.10	n.a.	0.65
σ_u	Transitory	0.580	0.410	0.604	0.160
σ_n	Permanent	0.127	0.121	0.121	0.126

Notes: n.r.: not reported. n.a.: not applicable.

average real growth of income across households over the entire sample period (see the online appendix [https://jmcb.osu.edu/] for more detail). Table 2 reports parameter estimates for the income process and compares our estimates to those reported by Carroll (1992) for an earlier time period (1968–1985) in the United States and by Chamon, Liu, and Prasad (2013) for China.[12]

Our estimated average income growth g for the Chinese households is 7.3% per year. China's income growth is high and evidently quite risky. The estimated probability of suffering a near zero income event p is 2.24%.[13] The estimated standard deviation for shocks to the transitory and permanent components of income are $\sigma_u = 0.580$ and $\sigma_n = 0.127$. Our estimates of the income shock process are similar to those reported in Chamon, Liu, and Prasad (2013) based on the same data, but a different estimation methodology.

In sharp contrast, households in the U.S. PSID sample experienced very low real income growth but were exposed to much less risk. Over our sample, the estimated growth rate g is just 0.60% per year from 1992 to 2007. The estimated probability of experiencing zero or near zero income is 0.10%, which is only 4% as large as the probability in China. These big differences encapsulate results 2 and 3.

Result 2. *Household income in China grows at a faster rate than in the United States.*

Result 3. *Chinese households face more severe income shocks than U.S. households.*

Carroll (1992) also used data from the PSID to characterize the income uncertainty of U.S. households for the years 1968–1985 (also see Meghir and Pistaferri 2004). Thus, we can see how the income process has changed over time in the United States. Compared to the 1968–1985 numbers reported in Carroll (1992), our results indicate that the probability of near-zero income has decreased. However, our estimated transitory income shock volatility σ_u is more than twice as large as Carroll's estimate

12. Chamon, Liu, and Prasad do not incorporate the near-zero income events.

13. Following Carroll (1992), a near-zero income event is defined as annual noncapital income of less than 10% of the specific household's average annual income.

(0.41 versus 0.16). Our estimate of the standard deviation of the shock to permanent income ($\sigma_n = 0.12$) is about the same as from the earlier period. According to our estimates, about one third of households in a given year experience a positive or negative transitory shock of at least 40% of their income, while a (different) third experience at least a 12% shock to their permanent income.

The estimated income process for Chinese households sharply differs from that for U.S. households. Chinese households have enjoyed an income growth rate over 10 times higher than for the United States (7.3% versus 0.6% annually). However, Chinese households face a much higher probability of a zero income shock (2.2% versus 0.1%), as well as larger shocks to transitory and (to a lesser extent) permanent income. The remainder of the paper focuses on quantifying how much of the large difference in household saving (result 1) can be accounted for by the differences in income growth (result 2) and income volatility (result 3) within a model of precautionary saving.

2.2 *Preferences and Budget Constraints*

We model household saving decisions with the Epstein–Zin (1989) and Weil (1989) recursive, nonexpected utility, model of household preferences. Use of these preferences allows us to decompose saving into precautionary and nonprecautionary motives, compare U.S. and Chinese saving rates, and evaluate the relative quantitative importance of each component of the income process in generating the saving rate.

Let $C_{i,t}$ be consumption of household $i = 1, \dots, N$ at time t. We write the utility of the infinitely lived household as

$$V_{i,t} = \left\{ C_{i,t}^{1-\frac{1}{\sigma}} + e^{-\delta} \left[E_t \left(V_{i,t+1}^{1-\gamma} \right) \right]^{\frac{1-\frac{1}{\sigma}}{1-\gamma}} \right\}^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

where $\delta > 0$ is the subjective discount rate, V is recursively defined utility and E_t is the conditional expectations operator, $\sigma > 0$ is the IES, and $\gamma \geq 0$ is the coefficient of RRA.

Household resources can be consumed ($C_{i,t}$) or invested in an asset ($A_{i,t}$) with gross return e^r. Households cannot borrow and face the sequence of budget constraints

$$A_{i,t+1} = \left(A_{i,t} + Y_{i,t} - C_{i,t} \right) e^r, \tag{4}$$

$$A_{i,t} \geq 0. \tag{5}$$

The household's problem is to maximize (3) subject to (4) where the exogenous "labor income" Y, is generated according to (1).

The model does not in general emit analytical solutions, so in the next section we turn to model simulations. However, in the online appendix (https://jmcb.osu.edu/), we derive some properties of the model. We find that a household's saving rate increases with the size of the income shocks (σ_n, σ_u, p). The impact of income growth (g) and the IES and RRA parameters (σ and γ) is nonmonotonic. The online appendix (https://jmcb.osu.edu/) also details how we transform the model to achieve stationarity.

3. QUANTITATIVE IMPLICATIONS

This section reports the simulated saving rates generated by embedding the income process estimates from Section 2.1 into the model presented in Section 2.2. Policy functions of the stationary model are obtained by value function iteration. The implied levels of the variables (income, assets, consumption, and saving) are then obtained by "un-normalizing" the variables—that is, multiplying them by permanent income. Details are contained in the online appendix (https://jmcb.osu.edu/).

We first study the model's properties using parameter values with ranges typically assumed or estimated in the literature. In doing so, we are able to find admissible parameter values under which the model households save at rates similar to those observed in the data.

3.1 Preference Parameter Values

The parameters for the income process (g, σ_n, σ_u, p) come from the estimates based on the U.S. and Chinese household survey data as reported in Table 2. To simulate the model, we also need values for the three preference parameters (σ, γ, δ) and the interest rate r. There exists a large literature aimed at estimating RRA and IES but without much agreement and mostly using Constant Relative Risk Aversion (CRRA) utility. The choices for σ and γ draw on estimates reported in the literature.

We consider values of the risk-aversion coefficient γ between 0 and 8 to be admissible. Studies using survey data generally find γ to be in this range—$0 < \gamma < 10$ in Dohmen et al. (2005), $7.18 < \gamma < 8.59$ in Eisenhauer and Ventura (2010), and $5 < \gamma < 10$ in Vissing-Jøgensen and Attanasio 2003. Studies that use asset-pricing data and constant RRA utility (which cannot separate risk aversion from intertemporal substitution) typically obtain vastly larger values, which we ignore.

Studies that estimate the IES typically report values between 0.2 and 1. Table 3 lists a collection of IES estimates reported in the literature. A restrictive feature of most existing studies, however, is the assumption of CRRA utility. Among these, the Beaudry and Van Wincoop (1996) and Gruber (2006) studies obtain relatively high estimates of the IES. Recent studies by Bansal and Yaron (2004), Chen, Favilukis, and Ludvigson (2007), Colacito and Croce (2011), and Bansal and Shaliastovich (2013) employ recursive preferences and all feature values greater than 1. On the basis of these empirical studies, we consider three values for the $IES = (0.5, 1.5, 2.0)$.

We take the real interest rate for China to be 1.6% per annum. This figure is the average real interest rate on bank deposits from 2003 to 2012 provided by the World Bank's *World Development Indicators*. For the United States, we set the real interest rate at 1.19%, which we obtain from the average real 3-month treasury bill rate from

TABLE 3

ESTIMATES OF THE INTERTEMPORAL ELASTICITY OF SUBSTITUTION FROM THE LITERATURE

Authors	Special features	Range of estimates
Biederman and Goenner (2007)	30-year investment horizon	(0.2, 0.8)
Felices (2005)	British Household Panel Survey	(0.05, 0.17)
Hall (1988)	Aggregate U.S. consumption	0.2
Noda and Sugiyama (2010)	Japanese data	(0.2, 0.5)
Ogaki and Reinhart (1998a)	Long-run data	(0.27, 0.77)
Ogaki and Reinhart (1998b)	Durable goods	(0.32, 0.45)
Patterson and Pesaran (1992)	UK and U.S. data	0.3
Skinner (1985)		(0.2, 0.5)
Vissing-Jørgensen (2002)	Holders of stocks, bonds, and no assets	stocks: (0.3, 0.4) bonds: (0.8,1) no assets: 0.2
Beaudry and Van Wincoop (1996)	State-level consumption	1
Gruber (2006)		2
Chen, Imrohoroglu, and Imrohoroglu (2007)	Recursive preferences	(1.11, 2.22)
Bansal and Yaron (2004)	Recursive preferences	1.5
Colacito and Croce (2011)	Recursive preferences	2
Bansal-Shaliastovich (2004)	Recursive preferences	1.81

1992 to 2007. We use the standard rate of time preference $\delta = 0.0417$ for the United States, and in anticipation of our own parameter estimate, we set $\delta = 0.022$ for China, situating households to be relatively impatient.[14]

3.2 *Simulated Saving Rates*

For each experiment, we simulate income and saving decisions for $N = 20,000$ households. Household saving equals the aggregate of total income (summed over the 20,000 households) minus aggregate consumption, where total income equals the sum of labor income and interest income on assets. Households begin with zero wealth and build up their target wealth-to-income ratios over time. The saving rate is initially high as households accumulate toward their target asset-to-income ratio. For China, saving and asset ratios stabilize relatively quickly after about 20 periods. For the United States, stabilization of the ratios requires 50 to 60 periods. The ratios we report are stabilized values and reflect the steady-state saving rates and asset ratios.[15] Compared to China, households in the United States have an income process with a lower chance of receiving zero income, a slightly smaller variance in the permanent shock, a smaller variance in the transitory income shock, and a much lower income growth rate.

Table 4 reports the model generated household saving rates and asset to consumption ratios. For China, the saving rate-risk-aversion profile is such that for a given value of σ, the saving rate is generally increasing in γ (the exception being at γ equal

14. High impatience has often been assumed in models of precautionary saving. We will actually generate an estimate for China below, but for now we impose the values for δ.

15. We, somewhat imprecisely, use the terms "steady-state" or "stabilized" to mean that the moments of interest for the distribution do not vary much from one period to the next, that is, it is ergodic.

TABLE 4

Implied Saving Rates and Target Asset Ratios

	China					
	Saving rate			Assets to consumption		
	σ			σ		
γ	0.5	1.5	2.0	0.5	1.5	2.0
0	0.047	0.056	0.087	0.656	0.683	0.651
2	0.068	0.075	0.056	0.990	0.992	0.676
3	0.077	0.094	0.107	1.128	1.348	1.714
4	0.090	0.129	0.206	1.355	2.073	4.955
5	0.112	0.228	0.326	1.783	4.668	10.046
6	0.125	0.307	0.362	1.994	7.364	12.674
7	0.153	0.345	0.367	2.582	8.907	13.260
8	0.195	0.362	0.378	3.640	9.775	14.944

	United States					
	Saving rate			Assets to consumption		
	σ			σ		
γ	0.5	1.5	2.0	0.5	1.5	2.0
0	0.005	0.003	0.003	0.978	0.432	0.382
2	0.013	0.005	0.005	2.625	0.837	0.750
3	0.028	0.009	0.008	5.809	1.664	1.356
4	0.033	0.018	0.016	6.756	3.534	3.036
5	0.035	0.027	0.024	6.909	5.134	4.613
6	0.036	0.033	0.029	6.877	6.288	5.568
7	0.037	0.036	0.034	7.011	6.799	6.467
8	0.035	0.037	0.034	6.581	7.058	6.464

to 0). The same pattern is present in the asset-consumption ratio. For China, this ratio is monotonic over the range of γ considered. For the United States, the saving rate begins to display a mild hump shape with respect to γ at the higher RRA values. As the United States has smaller volatility in income shocks, the consumption and utility volatility is relatively lower than that in China. Thus, consistent with our analytical findings in the online appendix (https://jmcb.osu.edu/), the saving rate can exhibit a hump shape with respect to γ. When risk aversion is high enough in China ($\gamma \geq 3$) and the precautionary motive is strong, increasing the IES (σ) leads to higher saving. For the United States, increasing σ tends to decrease saving at low levels of γ.

The model can match the observed aggregate household saving rates for alternative pairs of σ and γ. For China, $\sigma = 1.5$ and $\gamma = 5$ and $\sigma = 2$ and $4 < \gamma < 5$ both produce saving rates in the neighborhood of 21%. For the United States, $\sigma = 0.5$ or 1.5 and $\gamma \geq 5$ gives a saving rate nearing (but still a little below) 4%.

Many studies have used σ and γ values within the ranges that allow the model to match the saving rates. However, the results are somewhat sensitive to the parameterization, and some researchers have favored different values. For example, Hubbard, Skinner, and Zeldes (1995) and De Nardi, French, and Jones (2010) consider lower values.[16] The disagreement in the literature over the IES is one reason why, in the next section, we will further discipline the analysis by estimating σ and γ using our specific model and the simulated method of moments.

The simulation results in Table 4 also imply that nearly all of the U.S. household saving in the model is driven by the precautionary motive. When risk aversion is shut off, the implied saving rate is basically nil, in contrast to the corresponding 4.7%–8.7% rate for Chinese households.[17] With the smaller variance in transitory shocks, there is less need for U.S. households to save for consumption smoothing purposes. The relatively low rate of income growth is also a factor. Recall that we are looking at saving rates at the steady state. U.S. households have built up large stocks of assets, but because of the low growth rate, they do not have to save much to maintain their desired wealth ratios. Note, that at 4.7%–8.7% percent, nonprecautionary saving is still only a small part of saving for Chinese households, too. Thus, we conclude that saving (in our model) is primarily due to the precautionary saving motive, result 4.

RESULT 4. *Most saving in both China and the United States is precautionary.*

The remainder of the paper considers several additional variations in the key parameters governing the model. A main take away from all the simulation exercises is that the household saving rate depends on the parameters governing both the income process and preferences.

RESULT 5. *Income growth and income risk and the preference parameters affect precautionary saving.*

Variations in growth. While the riskiness of transitory income between China and the United States differs substantially, perhaps the most dramatic contrast is in the expected growth rate of income. U.S. households expect almost no growth in labor income, whereas Chinese households expect over 7% growth per year.

We examine how income growth affects saving by varying g from 0.5% to 7% while holding all other parameters of the income process at their estimated values. We consider $\sigma = 1.5$ and various values of γ. Results for $\sigma = 0.5$ and 2.0 are similar and not reported to save space. Table 5 reports the household saving rates and asset ratios for China. The saving rate displays a slight hump-shaped pattern with respect to g for $\gamma = 2$, 4, or 6, but saving is generally increasing in g.

Table 6 shows the analogous results for the United States. The saving rate displays a hump for $\gamma = 6$ and 8 but is nondecreasing in g for $\gamma = 0$,2, and 4. It is possible to get Americans to save a higher fraction of income with more rapid income growth. For example, at an annual growth rate of 4% and $\gamma = 8$, the U.S. household saving ratio is predicted to be 15.1%.

16. These papers do not use Epstein–Zin (1989) and Weil (1989) preferences, so the comparison may not be exact.

17. This interpretation might seem stark because the model abstracts from other saving motives. However, the comparison is informative on the relative contribution to saving of risk aversion versus smoothing and also as a way to illustrate how income growth works through risk aversion to affect saving.

TABLE 5

VARIATIONS IN CHINA'S INCOME GROWTH, IMPLIED SAVING RATES, AND ASSET–CONSUMPTION RATIOS

			γ		
g	0	2	4	6	8
Panel A. Saving rate					
1.005	0.007	0.034	0.040	0.039	0.036
1.01	0.013	0.056	0.075	0.077	0.071
1.02	0.023	0.080	0.140	0.139	0.131
1.03	0.029	0.081	0.176	0.191	0.174
1.04	0.033	0.074	0.188	0.224	0.206
1.05	0.041	0.073	0.183	0.248	0.231
1.06	0.043	0.075	0.157	0.257	0.245
1.07	0.048	0.076	0.133	0.254	0.253
Panel B. Asset–consumption ratio					
1.005	1.606	8.039	9.706	10.728	11.945
1.01	1.366	7.164	9.743	11.172	12.590
1.02	1.174	5.291	9.938	11.416	13.401
1.03	0.964	3.290	8.969	11.712	13.753
1.04	0.797	2.000	7.419	11.379	13.890
1.05	0.797	1.477	5.778	10.910	13.985
1.06	0.691	1.252	3.901	9.987	13.777
1.07	0.658	1.060	2.531	8.641	13.062

NOTE: Calculations assume $\sigma = 1.5$.

If households were to maintain a constant target wealth-to-income ratio, precautionary saving needs to rise with higher income growth.[18] But notice that the relative size of the buffer stock (assets to consumption ratio) generally declines with the growth rate, which generates a trade-off. Higher income growth makes households less vulnerable to income risk, leading them to reduce their target wealth-to-income ratio (and hence their saving rate declines). This countervailing effect can be seen in Table 6, Panel B; the asset–consumption ratio decreases with g. The first effect (maintaining the target wealth-to-income ratio) dominates for low income growth, and the second effect dominates only when the income growth rate is high enough. The potentially positive relationship between growth and saving is noteworthy as it provides an explanation for why high-growth economies tend to have high saving rates.[19]

Table 5 begins to show that the difference in income growth rates can account for a large portion of the U.S.–China saving gap (result 6). Consider $\gamma = 6$ and $g = 1.07$ (near the estimate for China) as a specific example; these parameters generate a

18. Using slightly different terminology, Wen (2010) makes a similar point about accumulating a buffer stock of wealth in a model of uninusurable risk and borrowing constraints. Wen argues that the liquidity premium from additional saving increases with income growth, leading to a positive correlation between growth and saving and working against the permanent income hypothesis.

19. The relationship also might be informative for the closely related allocation puzzle outlined in Gourinchas and Jeanne (2013). Other mechanisms could also link growth to household saving, such as the habit formation highlighted in Carroll, Overland, and Weil (2000). An analysis of alternative models lies beyond the scope of this paper.

TABLE 6

VARIATIONS IN U.S. INCOME GROWTH, IMPLIED SAVING RATES, AND ASSET–CONSUMPTION RATIOS

	γ				
g	0	2	4	6	8
Panel A. Saving rate					
1.005	0.002	0.004	0.017	0.026	0.031
1.01	0.004	0.007	0.027	0.049	0.059
1.02	0.008	0.013	0.034	0.080	0.099
1.03	0.010	0.016	0.035	0.093	0.151
1.04	0.012	0.018	0.035	0.093	0.151
1.05	0.013	0.021	0.036	0.082	0.158
1.06	0.015	0.023	0.037	0.072	0.159
1.07	0.016	0.025	0.038	0.067	0.146
Panel B. Asset–consumption ratio					
1.005	0.405	0.930	4.135	6.196	7.236
1.01	0.382	0.733	3.138	5.857	7.105
1.02	0.366	0.643	1.906	4.931	6.188
1.03	0.307	0.522	1.236	3.866	5.730
1.04	0.286	0.442	0.891	2.838	5.048
1.05	0.258	0.408	0.711	1.901	4.257
1.06	0.247	0.355	0.594	1.313	3.559
1.07	0.224	0.330	0.512	1.010	2.717

NOTE: Calculations assume $\sigma = 1.5$.

saving rate of 25.4%. If, however, g is set to 1.005 (near the estimate for the United States), then the saving rate collapses to 3.9%. Similarly, allowing U.S. households to receive China's income growth rate ($g = 1.07$) can increase U.S. saving.

As already noted, though, the size (and sometimes even the direction) of growth's effect on saving depends on the IES and RRA parameters. The relationship between income growth and saving is nonmonotonic. Tables 5 and 6, panel B shed further light on the hump-shaped relationship. Asset holdings relative to consumption decline when the income growth rate is increased to 7% for both China and the United States and for all values of γ. In other words, the target wealth-to-income ratio falls, short-circuiting the precautionary reason to accumulate more wealth (i.e., to save).

Finally, note that risk-neutral ($\gamma = 0$) saving in China exceeds that of the United States for any of the growth rates considered. Chinese households desire to save more (buffer stock saving) on account of the higher volatility of their income. The difference in income growth rates, however, is quantitatively more important for explaining the difference in saving.[20]

Variations in near-zero income event probability. Table 7 shows the results of varying the probability of receiving zero income p for Chinese households under alternative

20. We have also run the model under CRRA utility, restricting $\gamma = 1/\sigma$. A risk-aversion coefficient between 3 and 4 allows the model to match the U.S. saving ratio, but this model does not come close to explaining the Chinese saving ratio for any value of γ. See Choi, Lugauer, and Mark (2014).

TABLE 7

VARIATIONS IN p AND CHINESE SAVING RATIOS

	Percent chance of receiving zero income, p				
γ	0.8	1.2	1.6	2.0	2.4
0	0.036	0.046	0.039	0.053	0.062
2	0.048	0.064	0.053	0.073	0.081
4	0.099	0.113	0.107	0.125	0.132
6	0.297	0.306	0.298	0.308	0.281
8	0.353	0.365	0.356	0.364	0.322

NOTE: Calculations assume $\sigma = 1.5$.

values of γ and $\sigma = 1.5$.[21] Increasing p can increase the saving rate; however, the effect is relatively small. Increasing p from 0.8% to 2.4% only increases the saving rate by about 3 percentage points for an RRA less than 6 and has little or no effect for γ equal to 6 or 8. These results are similar to those reported in Carroll (1997).[22] Since zero income shocks are rare and agents literally have forever to recover, the effect on saving is not large (although not necessarily trivial).

4. SIMULATED MOMENTS ESTIMATES OF PREFERENCE PARAMETERS

The analysis of the previous section investigated the general quantitative properties of the model by treating (δ, σ, γ) as free parameters. In this section, we estimate the preference parameters for China via the simulated method of moments and investigate the extent to which the estimated model can explain the observed saving behavior. For the United States, we draw on parameter values estimated in the literature (based on alternative approaches) because U.S. households have greater access to financial markets.

Our estimation employs only consumption data. Other research estimating the recursive utility function, for example, Chen, Favilukis, and Ludvigson (2007) and Bansal and Shaliastovich (2013), combine consumption and asset returns data. As is well known, risk aversion must be very high to be consistent with asset returns data. Chen, Favilukis, and Ludvigson's estimates of the IES range between 1.11 and 2.22 while their estimates of the risk-aversion coefficient are above 60. Bansal and Shaliastovich's estimates of (γ, σ) equal (20.9, 1.81). Our estimation approach is consistent with our model, which only has implications for consumption moments. Therefore, we do not necessarily generate super high estimates of γ.

21. We also have experimented with different values for the variances of the shocks to permanent and transitory income. The results are straightforward; larger variances induce higher precautionary saving. Since this channel is clear and quantitatively not as important as income growth for determining saving rates, we do not report the full results.

22. In Carroll (1997), raising p from 0.1% to 1% increases the saving rate by 0.6 percentage points from 0.4% to 1%.

TABLE 8

Simulated Moment Estimates of Chinese Preference Parameters

δ (se)	σ (se)	γ (se)	Crit
0.022 (0.000)	2.160 (0.046)	3.780 (0.056)	1.498

The data come from a single cross section consisting of 15,039 observations from the 2007 Urban-Rural Household Survey.[23] The four moments used in the estimation are the mean, variance, skewness, and kurtosis of the cross-sectional distribution for household consumption. We simulate $N_s = 50,000$ individuals over many periods, t. The simulated moments are computed at $t = 20$.[24] The online appendix (https://jmcb.osu.edu/) provides further details.

Table 8 shows the estimation results. Households are impatient in the sense that the rate of time preference exceeds the interest rate, $\delta > r$. The risk-aversion coefficient is not estimated to be exceedingly high (as is the case when using asset returns). The point estimate for the IES is substantially greater than 1.

Our estimates of σ make contact with the literature on long-run risk (Bansal and Yaron 2004). Models of long-run risk employ recursive preferences and can explain several asset-pricing anomalies including the equity premium puzzle, the low risk-free rate, and their volatilities, provided two key ingredients are present. First, some long-run risk must exist to vary the expected growth rate of consumption over time. Second, the size of σ matters since people must prefer early resolution of uncertainty ($\gamma\sigma > 1$). Chen, Favilukis, and Ludvigson (2007) also estimate this elasticity to be greater than 1.[25] Interestingly, although we employ different data sets, our point estimates of σ are similar in magnitude to studies using asset returns and are consistent with the long-run risk framework.

For the United States, we use the σ and γ estimates from Bansal and Yaron (2004), $\sigma = 1.5$ and $\gamma = 7.5$.[26] We set δ to yield an annual discount factor of 0.96.

Saving rates and decomposition under estimated parameters. Next, we ask to what extent the observed saving rates in China and the United States can be explained by the model at the parameter values above, and what part of that saving rate is driven by the precautionary motive (result 4). Table 9 summarizes the findings.

23. Yi Huang kindly provided the data.

24. Recall that convergence to steady-state ratios takes 20 periods for China.

25. However, the Chen, Favilukis, and Ludvigson estimates of the risk-aversion coefficient are much larger and range between 17 and 60, depending on whether they use aggregate consumption or consumption of stock holders.

26. We also conducted the simulated moments estimation for the U.S. preference parameters based on Consumer Expenditure Survey data, obtaining values, $\sigma = 1.9$ and $\gamma = 9.1$, close to Bansal and Yaron (2004).

TABLE 9

Total and Risk-Neutral Saving Rate Implied by Estimated Parameters

	Parameter settings			Saving
Country	γ	σ	δ	rate
China	3.78	2.16	0.022	0.265
	0	2.16	0.039	0.032
	0	1.5	0.022	0.044
United States	7.5	1.5	0.042	0.036
	0	1.5	0.042	0.002

For China, the saving rate implied by the estimated parameters is 26.5%. The model overpredicts the average saving rate during the time span of the CHNS data but nearly matches the saving in 2007, the year of the consumption data used to estimate the preference parameters.

The model does not converge when risk aversion is shut down holding σ and δ at the estimated values because the utility blows up. Although we are unable to obtain the exact risk-neutral ($\gamma = 0$) saving rate, we approximate that measurement from two directions. Our first approach is to raise the rate of time preference until convergence is achieved. Doing this gives a risk-neutral saving rate of 3.2%. Our second approximation is to lower the IES to 1.5, which gives risk-neutral saving of 4.4%. These experiments allow us to reasonably conclude that China's risk-neutral saving does not exceed 5.0% and that the precautionary component of the saving rate is over 20% of income in the model.

For the United States, the 3.6% saving rate is a little below the 4.0% average from 1992 to 2007. Raising γ to about 9 would allow the model to match the 4% rate. The implied risk-neutral ($\gamma = 0$) saving rate is basically zero, suggesting that most of the household saving rate in the United States is driven by the precautionary motive.[27] Hence, result 4 continues to hold.

Finally, we consider how the Chinese saving rates change as the rate of income growth is decreased, while keeping the other parameters at the estimated values for China. Table 10 lists the implied saving rates. When the rate of income growth is at the U.S. level ($g = 1.005$), Chinese household saving is only 4.3%. Nearly all the difference between the aggregate saving rates in the United States and China can be accounted for by the difference in income growth. The quantitatively large effect of income growth once again supports result 6, our main finding.[28]

Result 6. *The difference in income growth rates between China and the United States is quantitatively more important than the difference in income risk as an explanation for the U.S.–China gap in household saving rates.*

27. Again, we are abstracting from life-cycle and other related saving motives. See the next section.

28. Note, increasing the U.S. income growth rate (while holding all other parameters at their U.S. values) greatly increases the U.S. saving rate, but not all the way to the Chinese level of saving.

TABLE 10

VARIATIONS IN CHINA'S INCOME GROWTH AND THE IMPLIED SAVING RATES AT THE ESTIMATED PARAMETER VALUES

g	Saving rate
1.005	0.043
1.01	0.082
1.02	0.150
1.03	0.223
1.04	0.233
1.05	0.248
1.06	0.295
1.07	0.265

NOTE: $\sigma = 2.16$, $\gamma = 3.78$.

Overall, the relationship between growth and saving is hump shaped in Table 10. Saving rates begin to decrease at high levels of growth because the consumption smoothing channel inherent in the permanent income hypothesis begins to dominate.[29]

5. INCORPORATING DEMOGRAPHICS, LIFE-CYCLE SAVINGS, AND PENSIONS

The precautionary motive is just one of several reasons for saving. Is it robust to alternative mechanisms proposed in the literature? It is beyond the scope of this paper to control for every saving motive the literature has explored. However, we can show that the precautionary saving mechanism is robust to most of the demographic-based explanations, including the age distribution, family size, pensions, and life-cycle effects. These are some of the most salient alternative explanations for China's high saving rate: those related to population demographics. As discussed in the introduction, several recent papers have argued that the age distribution, working through standard life-cycle saving channels, has had a large impact on China's aggregate household saving rate over time. Changing family sizes and old-age pension support may also have affected saving behavior over time. Our paper does not consider transition paths; however, the current demographic profiles differ between China and the United States, as do their pension systems. In this section, we show that our main findings are robust to the inclusion of these micro and macro demographic and life-cycle channels.

To incorporate the observed age distributions for the United States and China, we make two key changes to our precautionary saving model. First, model agents have only finite life-times. Second, the utility function for working age agents explicitly includes the consumption by their dependent children. These two changes allow us

29. We also have experimented with shocking income growth and wealth holdings. See Choi, Lugauer, and Mark (2014) for these impulse response functions.

to impose the observed age distributions in a simple way. We calculate the model agents' savings at different ages. Then, the aggregate household saving rate equals a weighted average of the age-specific saving rates, where the weights are determined by the actual age distribution in the cross-section for each country as calculated from United Nations population data. Adult agents choose the amount of consumption to give to their dependent children, but the age distribution is taken as given.

We write the utility of the finitely lived household as

$$V_{i,t} = \left\{ \left(1 + \mu N_{i,t}^{\alpha+1}\right)^{\frac{1}{\sigma}} C_{i,t}^{1-\frac{1}{\sigma}} + e^{-\delta} \left[E_t \left(V_{i,t+1}^{1-\gamma} \right) \right]^{\frac{1-\frac{1}{\sigma}}{1-\gamma}} \right\}^{\frac{\sigma}{\sigma-1}}, \quad (6)$$

where C is total household consumption (including consumption by dependent children), N is the average number of dependent children per family, parameters μ and α govern the preferences over consumption by dependent children, and all other variables are defined as before. Following Curtis, Lugauer, and Mark (2015), consumption by dependent children enters parental utility via the Barro–Becker (1989) functional form. The budget constraint is

$$A_{i,t+1} = \left(A_{i,t} + Y_{i,t} - C_{i,t}\right) e^{r}, \quad (7)$$

$$A_{i,t} \geq 0. \quad (8)$$

Income level Y varies by age (estimated using the same CHNS and PSID data and procedure as for the income process), creating an age–income profile. The rest of the model, including income growth and the shock process, remains unchanged except that a portion of each agents' life is spent in retirement. In the model, retirees in China receive 25% of their preretirement income as a pension; U.S. retirees receive 75%. The model agents live 85 years in total. The first 20 years are spent as dependent children, consuming only what their parents provide. At age 20, children become adults and form their own household. From age 22 to 51, adults have dependent children to support. At age 63, agents enter retirement and live off their accumulated assets and pension until death.

To run the simulations, we need to select values for the Barro–Becker parameters, μ and α. We use values that map into the estimates in Manuelli and Seshadri (2009); $\mu = 0.68$ and $\alpha = -0.56$. See Curtis, Lugauer, and Mark (2015) for an extended discussion of these parameters. With this new set-up, we have redone all the previous simulations (except the parameter estimation based on the method of simulated moments), including using the many different combinations of IES, RRA, and income growth parameters.

Overall, results 4–6 continue to hold in the finite-lived version of the model (results 1–3 are unchanged). To conserve space, we do not report the full details, but a few points are worth stressing. First, for all the relevant combinations of the parameters, the finite-lives version of the model generates higher saving rates. The higher saving occurs because both China and the United States have a significant portion of their population in their saving years. The life-cycle saving motive (i.e., saving for retirement) pushes up saving rates. The effect is particularly large for China; as has been argued in the papers noted above, demographics have contributed to China's high saving rate. Related to this, the new model can match the observed saving rates at lower RRA values.

Second, while the precautionary component of saving is still large in the new version of the model, considerable life-cycle saving remains even when the RRA parameter (γ) is set to zero. Recall that in the infinite-lives version changing γ to equal zero in the U.S. simulations reduced saving by nearly 100%. In the new version, eliminating the precautionary motive to save (setting $\gamma = 0$) reduces saving by 50% to 60%, depending on the parameter values. In other words, the saving rate is cut in half rather than falling to zero. The same pattern holds for China; a large portion of saving is precautionary (result 4), but the demographic structure effect is present, too.

Third, income growth, working through the precautionary saving motive, continues to have a large impact on household saving decisions. For example, changing the growth rate faced by Chinese households from the observed 7% to the U.S. value of 0.5% decreases Chinese household saving by 10 to 16 percentage points for RRA values above 2. However, in the finite-lives model, a substantial gap (as much as 10 percentage points) in saving rates remains between the United States and China, even in simulations in which each country has the same income growth rate. The demographics of China pushes its saving rate higher because China has a larger share of its population in its high saving years and smaller family sizes.

Finally, the impact on saving from altering the (transitory and permanent) shocks to income or the chance of obtaining zero income remains quantitatively small relative to income growth. In other words, the difference in income growth accounts for a much larger share of the U.S.–China saving rate gap than does the difference in income volatility (result 6), as in the infinite-lives model.

6. CONCLUSION

This paper presents six key findings:

1. Chinese households save a higher share of their income than U.S. households.
2. Household income in China grows faster than in the United States.
3. Chinese households face larger income shocks than U.S. households.
4. A large part of saving in both China and the United States is precautionary within our model.
5. Income growth and income risk and the IES and RRA parameters affect the amount of precautionary saving.
6. The difference in income growth rates explains much of the U.S.–China gap in saving rates.

The difference in household saving rates (result 1) is well known, and we investigate this stylized fact by embedding country-specific household income dynamics into a model of saving decisions by infinite-lived households with Epstein–Zin–Weil recursive preferences. We use survey data to estimate the income process and find that Chinese households have experienced a higher rate of growth (result 2) along with more volatility (result 3) in their income relative to households in the United States. Since the social safety net in China is less comprehensive than in the United States, Chinese households face substantially higher transitory income risk.

The model's recursive preference structure allows a convenient decomposition of the saving rate into precautionary and nonprecautionary components. According to this decomposition, the precautionary motive drives most of the saving rate in China and nearly all the saving in the United States (result 4) within our baseline model. Model simulations also demonstrate how the growth and riskiness of income, along with the preference parameters, determine the amount of precautionary saving (result 5). However, the relationship among these parameters and the household saving rate is potentially nonmonotonic.

The model can generate the high current level of Chinese saving and the low level of U.S. saving. Somewhat surprisingly, however, the higher income growth rate in China, and not the elevated income risk, accounts for most of the China–U.S. saving rate gap (result 6). In the model, saving is increasing over a range of income growth rates as households save aggressively to maintain a desired asset-to-income ratio. This result sheds some light on the somewhat puzzling empirical fact that countries with high income growth (like China) often have high saving rates.

Our relatively simple set-up generates powerful insights into why household saving is so high in China and so low in the United States. We also show that including the population age distribution and life-cycle saving does not qualitatively alter the main findings. Our analysis does abstract from a few relevant factors, and the model could be tailored further to consider other specific aspects of China's economy such as the dismantling of old-age income security and shifting medical and educational expenditures from the state to households. However, we leave this to future research.

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