The Size of the Precautionary Component of Household Saving: China and the U.S. *

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Abstract

[Preliminary and incomplete. A legitimate and vastly improved draft will be available well before the SED meetings.] We decompose the household saving rate into precautionary and non-precautionary components. When applied to Chinese households, who save 30% of disposable income, the precautionary motive accounts for two-thirds of that saving rate. For some admissible parameter values, the saving rate increases with the growth rate of income thus helping to explain why fast growing economies also have high saving rates. A finite-lifetimes version of the model produces the U-shaped age-saving rate profile observed in Chinese household data. Comparative calculations for U.S. households indicate that to match the U.S. data, the non-borrowing constraint must be relaxed.

Keywords: Precautionary saving, Epstein-Zin preferences, China

JEL: E2, J1

*Preliminary. Please do not quote.

1 Introduction

In this paper, we decompose the household saving rate into precautionary and non-precautionary components. When we apply this decomposition to Chinese households, who save about 30 percent of disposable income, we find that about two-thirds of this saving rate is accounted for by the precautionary motive alone. A parallel decomposition is conducted for U.S. households both as a robustness check on the model but also because it is interesting in its own right. There are large and stark differences between U.S. and China household saving rates and in the environment that people face. The saving rate, income risk, and income growth are all much higher in China than in the U.S. We are able to learn more by confronting the model with variation in the environments and comparing than by studying either country alone. The role of income risk and income growth goes a long way in explaining the difference in Chinese and U.S. household saving rates.

The topic of the Chinese saving rate is a matter of concern to policy makers as China seeks to 'rebalance' its economic model away from investment towards consumption. China's high saving is pivotal in suppressing consumption and in supporting the country's investment-led growth, its current account surplus, and accumulation of international reserves. A popular explanation for China's high saving rate is to point at the precautionary motive. This idea was articulated in the policy domain by Bernanke (2005) as the underlying cause of external imbalances and low interest rates. Indications that Chinese households face relatively high economic risk, due to the transitional nature of the Chinese economy, an underdeveloped financial environment, the downsizing of state owned enterprises, the withdrawal of public funded medical, educational and housing expenses for SOE employees, and disappearance of the government pension system. In the absense of a well-functioning social safety net and opportunities for risk-sharing, precautionary saving will be high. Quantifying how high that precautionary saving actually is, is the primary focus of this paper.

We model give households recursive preferences of Epstein-Zin-Weil preferences (Epstein and Zin 1989, Weil 1989). These preferences generalize power utility by treating the intertemporal elasiticity of substitution (IES) and the coefficient of relative risk aversion (RRA) as separate parameters. Individual's exogenous 'labor income' is modeled as Carroll's representation of permanent and transitory income dynamics. Parameters of the income process are estimated using data from the *China Health and Nutrition Survey* for China and from the *Panel Study of Income Dynamics* for the U.S. We then draw on the literature to establish an admissible range of parameter values (the IES and RRA) for preferences. To achieve the decomposition, we first ask and ask if the model is able to match the saving rate observed in the data. Having done so, we then compute the implied saving rate with risk aversion shut off. The precautionary component of the saving rate is then the difference between the two.

We we study two environments–one in which households are infinitely lived, and one of finite lifetimes. The finite lifetimes environment is the conventional setting in studies of precautionary saving. However, in addition to understanding the pure precautionary saving motive, we are also interested in understanding the determination of the aggregate household saving rate. Because the infinitely-lived environment is unable to capture the interaction between life-cycle considerations and the demographic profile, which are important factors in determining the national saving rate, we also study the saving rate generated in a finite lifetimes setting. Here, the economy is populated by 65 overlapping generations of households ranging from 20 to 85 years of age. Households aged 20 to 45 are also tasked with raising children, whose consumption enters separately into household utility. The implied aggregate saving rate is computed as the cohort-weighted sum of household saving divided by the cohort-weighted total of income. This environment allows demographic influences to matter across countries and over time in the sense that older cohorts arrive at current decision making from saving decions made in the past when family sizes were larger. Unlike Curtis et al. (2012) who studied the role of changing demographics on the time-path of Chinese household saving rate, our analysis focuses on understanding the saving rate at a particular point in time.

In addition to the decomposition of the saving rate into precautionary and non-precautionary components, we have two additional noteworthy results. First, we show that for Chinese households, it is possible higher income growth to induce higher saving rates. Previously it was thought that the growth rate and saving rate were inversely related for precautionary savers. Precautionary savers, as discussed by Carroll (1992, xxx), have a target asset to income ratio. If this ratio were invariant to the rate of income growth, the saving rate would have to rise with growth to keep the assets in the numerator growing at the same rate as income growth in the denominator. In fact, the ratio declines with the growth rate so that in many environments the saving rate decreases as the growth rate rises. This has been the case for income processes calibrated to U.S. data and is what we find as well. However, for the Chinese income process, which is somewhat riskier, the target wealth to income ratio may be sufficiently less sensitive to variations in the growth rate to allow the saving rate to be increasing in the growth rate.

This result may be useful in helping to understand the empirical observation that saving rates tend to be high in high growth countries. This is what we observed in Japan in the 1960s-1970s and in Korea during the 1980s-1990s, **[Singapore? other examples**?] This empirical regularity has posed a puzzle in the sense that consumption smoothing arguments lead us to expect higher future income growth might to depress current saving. Carroll, Overland and

Weil (2000) solve the growth-rate puzzle obtain by giving households preferences that exhibit habit persistence so when income growth accelerates, households that are accustomed to a low level of consumption find it optimal to increase saving. Yi (xxxx) addresses the growth-rate puzzle in a general equilibrium setting whereby an increase in the rate of technology growth raises the interest rate. The increase in interest induces a higher saving rate, Yi shows that the effect is magnified when agents save also for precautionary reasons due to limited risk-sharing opportunities. In contrast, our paper shows that increased growth induces increased saving rates for given interest rates.

The other result that we mention at this point is our finite-lifetimes model is generates a U-shaped age-saving rate profile. The U-shaped profile was first documented in the Chinese data by Chamon and Prasaad (2010) and is a puzzle because standard life-cycle considerations predict a hump-shape for the saving rate.[1] Research by Chamon et al. (????) and Yang and Song (20??) attempt to explain the U-shape. The mechanism in our setup is because young households enter the world with zero assets they begin saving aggressively early on to build up their precautionary buffer stock of assets. Due to the costs of feeding and caring of children, the saving rate declines for cohorts around age 30 and increases again when children leave the household.

The Chinese household saving rate has attracted the attention of many researchers. Banerjee et al. (2010), Curtis et al. (2012) investigate life-cycle and demographic factors. Chamon et al. (2010) exploit rising income uncertainty and a decline in the pension replacement rate to study the U-shaped age-saving profile. Chamon and Prasad (2010) estimate effects of demographics, rising private burden of educational and medical expenditures. Song and Yang. Dynan, Skinner and Zeldes (2004) find that the rich save a larger fraction of income than the poor. **[Need to fill in references]**

The remainder of the paper is organized as follows. The next section discusses recent household saving rates for China and the U.S. which become the target values that we want the model to explain and to decompose. Section 3

2 Household saving rates

The saving rate in China has more or less risen steadily since implementation of economic reforms in 1978. The saving rate in the U.S. has more or less steadily declined over the past several decades. However, our interest is in understanding the very high Chinese and very low

[1] That is, the saving rate is relatively low for young and older households and relatively high for middle-aged households who are in their peak earning years.

U.S. saving rate in the very recent period as opposed to the historical time-path of the saving rate. Table 1 shows household saving rate for China, broken into urban and rural households and for U.S. households from 2005 to 2011. The contrast is quite stark. The average saving rate in China is 28% for urban households, 33% for rural households. In the U.S., the average saving rate was 2.8 percent.

A crude calculation gives a two-standard deviation band on Chinese household saving rate to be [28.1% − 33%] for Chinese households and [2% − 3.6%] for U.S. households. We take these bands to be the target range of the saving rate that the model should explain.[2]

3 Infinite horizon environment

We study saving in both an infinite horizon and in a finite horizon environments. This section first describes the model of household's exogenous 'labor income' process that we employ and our estimates of the process parameters. The next subsection presents the household's problem. Results are presented in Subsection 3.3.

3.1 Income process for infinite horizons

This is the permanent-transitory income component model of Carroll (1992, 1997). In the infinite-horizon environment, individuals draw different realizations of exogenous 'labor' income from the same distribution. The expected rate of income growth is common across individuals. Individuals $i \in [1, N]$ live forever and experience different realizations of permanent and transitory income shocks. The log of the permanent (trend) part of income is a random walk with drift g

$$\ln(P_{i,t}) = g + \ln(P_{i,t-1}) + n_{i,t},$$

where $n_{i,t} \overset{iid}{\sim} N(0, \sigma_n)$ is the permanent income shock. Log observed income is the sum of the log permanent and log transitory income $u_{i,t}$,

$$\ln(Y_{i,t}) = \ln(P_{i,t}) + u_{i,t}.$$

Log transitory income is drawn from a mixture of a normal distribution and a realization of a very small number which translates into a zero-income realization in levels. Let p be the

[2] About half the Chinese population now lives in urban areas. Giving equal weights to urban and rural areas, results in an average saving rate over these 7 years of 30.5%. Assuming away the serial dependence of these saving rates, a two-standard deviation bound on Chinese household saving is 28.1% to 33%.

probability of drawing a zero-level of income. The (log) transitory income process is given by

$$u_{i,t} = \begin{cases} N(0, \sigma_u) & \text{with probability } (1-p) \\ -\infty & \text{with probability } p \end{cases}.$$

Expressing exogenous labor income in levels gives

$$\begin{aligned} Y_{i,t} &= P_{i,t} e^{u_{i,t}} \\ P_{i,t} &= P_{i,t-1} e^{g} e^{n_{i,t}} \end{aligned} \tag{1}$$

where $p = \Pr(e^{u_{i,t}}) = \Pr(Y_{i,t}) = 0$ is the probability that an individual experiences a year with no labor income and $g = E(ln(Y_{i,t}/Y_{i,t-1}))$ is the (common across individuals) expected income growth rate.

Estimation of the income process follows Carroll et al. (1992). We begin with estimation for Chinese households. The data we use is the *China Health and Nutrition Survey,* 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.[3] Income is measured by total household non-capital income, including income earned by any family member and any transfer payments. Observations are restricted to households in which the same individual was the head of the household for each year (for which there exists data) and the head was older than 24 and younger than 60, with complete data on education and occupation. The sample is also split between households residing in urban areas and rural areas.[4]

For the U.S., we employ the *Panel Study of Income Dynamics* (PSID). Carroll, Hall, and Zeldes (1992) (hereafter CHZ) used individual-level data from the PSID to characterize the income uncertainty of US households for the years 1968-85. We follow the estimation procedure laid out by CHZ to estimate the income uncertainty faced by US households in more recent years and by Chinese households. To make as close of a comparison to the U.S. as possible, we sample the data from the CHNS and the PSID to match the time-frame as closely as possible. From the CHNS, we use data from the 1991, 1993, 1997, 2000, 2004, and 2006 waves and from the PSID we use data from the 1992, 1994, 1998, 2001, 2005 and 2007 waves.

Parameter estimates of the income process, and a comparison to those obtained by Carroll (????) using the PSID but from an earlier time-span from ours and by Chamon et al. (????)

[3] 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 most of our analysis.

[4] Sometimes the sample was restricted to households where the head never changed marital status or in which the head was never a business owner as a primary occupation. These restrictions eliminate sources of income uncertainty, so our results should err on the side of under-estimating uncertainty.

for China, are reported in Table 2. Estimates of the volatility (standard deviation) of the permanent income shock is quite similar between China and the U.S. across studies. Our estimate of transitory income shock volatility for Chinese households is similar to Chamon et al. Our PSID sample gives a large (relative to Carroll's estimate) of transitory income volatility but still is substantially lower than the estimate for China. We estimate that 2.24% of Chinese households will experience a year with zero labor income in any given year. Using the PSID, only $\frac{1}{10}$ of 1% of U.S. households are estimated to experience a year with zero income, which is lower than Carroll's estimate of $\frac{7}{10}$ of a percent. Transitory zero-income risk is several orders of magnitude higher for Chinese households. Although U.S. households experience greater income security, it is balanced by much lower expected income growth. Expected income growth in the U.S. is a nearly impercptable $\frac{6}{10}$ of a percent per year compared to 7.3% per year in China.[5]

3.2 Infinite-horizon problem

Preferences are given by the Epstein-Zin-Weil two-parameter model of recrusrive, non-expectex utility. The parameters are $\rho = 1 - \frac{1}{\text{IES}}$, which is 1 minus the inverse of the intertemporal elasticity of substitution (IES), and $\theta = 1 - \text{RRA}$ which is 1 minus the relative risk aversion (RRA) coefficient,

$$V_{i,t} = \left\{ C_{i,t}^{\rho} + \beta \left[E_t V_{i,t+1}^{\theta} \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}}. \tag{2}$$

Household resources can be invested in a single asset $A_{i,t}$ to earn the exogenous and fixed gross return R, or consumed $C_{i,t}$. As is typical in this literature, we begin by assuming that households are subject to a non-borrowing constraint. The household faces the sequence of budget constraints

$$\begin{aligned} A_{i,t+1} &= \left(A_{i,t} + Y_{i,t} - C_{i,t} \right) R \\ A_{i,t} &\succeq 0 \end{aligned} \tag{3}$$

The household's problem is to maximize and solves the problem to maximize (2) subject to (3). Due to non-zero drift in log permanent income, the problem is non stationary. To reformulate as a stationary problem, we normalize variables by permanent income. Let lower case denote normalized values so that $a_{i,t} = A_{i,t}/P_{i,t-1}$, $c_{i,t} = C_{i,t}/P_{i,t-1}$, and so forth. The normalized budget constraint is,

$$a_{i,t+1} G e^{n_{i,t+1}} = \left(a_{i,t} + e^{u_{i,t}} - c_{i,t} \right) R$$

[5]It is probably not fair to compare our results restricted to no business owners with CHZ. Owning a business is difficult to define in our data set, and these results should probably be interpreted with caution.

Similarly, the normalized utility of the household is,

$$v_{i,t} = \left\{ (c_{i,t})^{\rho} + \beta \left[E_t \left(G e^{n_{i,t+1}} \right)^{\theta} \left(v_{i,t+1} \right)^{\theta} \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}}$$

where $v_{i,t} = V_{i,t}/P_{i,t-1}$.

Precautionary saving motive is absent when households are risk-neutral $\theta = 1$. Any saving beyond this risk-neutral level of saving obtained under risk-aversion will be due to the precautionary motive.

3.3 Preference parameter values

With three free parameters (β, θ, ρ), it should be no problem to exactly match the targeted saving rates in the data. To discipline the model, we draw on estimates reported in the literature establish the set of admissible preference parameter values.

Regarding relative risk aversion (RRA), studies that use asset pricing data and constant relative risk aversion utility (which cannot separate risk aversion from intertemporal substitution) obtain unreasonably large estimates, which we will ignore. Studies using survey data estimate the RRA to be below 13 ($0 < RRA < 10$ in Dohmen et al. (2005) and $7.18 < RRA < 8.59$ in Eisenhauer and Ventura (2010)) $5 < RRA < 10$ in Vissing-Jorgensen and Attansio (2003). Consequently, we follow Mehra and Prescott (1985) and consider RRA values between 0 and 10 to be admissible.

Studies that estimate the IES generally find values between 0.2 and 1. We are aware of only three studies (Chen et al. (2007), Vissing-Jorgensen and Attansio (2003), and Gruber (2005) that obtain IES estimates exceeding 1. A summary of IES estimates from the literature is presented in Table 3. Drawing on these estimates, we consider a range of values for the IES between 0.1 and 1.5 to be admissible.[6]

3.4 Implied saving rates and their decomposition

We simulate income processes and saving decisions for 20,000 individuals over time. Household saving is aggregate household income (summed over the 20,000 individuals) minus aggregate consumption. Total income is the sum of labor income and interest income on assets. Scaled net wealth is current assets plus labor income minus consumption as a proportion of permanent income. Scaled assets is the steady state asset to permanent income ratio. The gross real interest rate is set to $R = 1.02$. The subjective rate of time preference is set equal to the real

[6] Bansal and Yaron (2002) require $RRA = 9.5$ and $IES = 1.5$ to solve the equity premium puzzle.

interest rate such that $\beta = R^{-1}$. In the simulations, households begin with zero wealth and build up their target wealth-to-income ratios over time. The saving rate initially varies over time then stabilizes. The saving rates that we report are those obtained after they stabilize. These are approximations to the steady-state saving rates.

3.4.1 Results for China

The experimental results for Chinese households are shown in Table 5.The first question we ask is if there is a combination of IES$\in [0, 1.5]$ and RRA$\in [0, 10]$ that generate a saving rate in the 25% to 30% range for Chinese households. The difference between this target saving rate and the implied saving rate when the RRA is zero is our estimate of the precautionary saving rate component. Our initial set of results are shown in Table 4.

Several combinations of admissible IES and RRA values allows the model to generate saving rates within the $25\% - 30\%$ target values. With IES$= 1.5$, we hit the target Chinese household saving rate with RRA between 4 and 5. With IES$= 0.8$ and RRA$= 8$, we obtain an implied saving rate of 29%.

The saving rate is increasing in both the IES and the RRA. At low levels of RRA the saving rate is only moderately affected by the IES but becomes more sensitive to the IES at higher levels of RRA. A story of the dependence of the saving rate on the IES might go like this: Precautionary savers have a target wealth-to-income ratio. They also expect income to grow rapidly–about 7% per year. Now consider two households, 'A' who has a low IES and 'B' who has a high IES, both of whose wealth-to-income ratios are below their targets. It will be costlier for A to sacrifice current consumption in building up that wealth to income ratio and will do so more gradually than B. The result is that A's saving rate is lower than B's. He knows income will grow over time and finds it relatively more difficult to sacrifice current consumption.

Now to estimate the size of the precautionary component of the saving rate, we obtain the implied non-precautionary saving by shutting off risk aversion and setting the RRA to 0. Doing so shows that non-precautionary saving in China is quite low and is always less than 3%. The model implies nearly all of the saving rate is induced by the precautionary motive. That is, precautionary saving accounts for a saving rate of 27% of disposabile income.

3.4.2 Results for the U.S.

When we run the model for U.S. households, implied saving rates are generally a good deal lower than those for Chinese households. The benchmark results for U.S. households are shown in Table 5. The model implies that nearly all of the (admittedly paltry) U.S. saving rate is driven by the precautionary motive. When we shut-off risk aversion, the implied saving rate is nil. As can be seen, even with IES= 1.5 and RRA= 10, the model predicts a 17% saving rate (in contrast to the implied 51% rate for Chinese households). The positive dependence of the saving rate on the IES and the RRA is present also in the U.S. case.

While the model is able to match the target saving rates in the 2% to 3% range under admissible values of the IES and RRA, they are not the same values as for Chinese households. U.S. households are predicted to save in the target range for RRA values of 1.2 or less. An IES= 0.8 and RRA= 8 (which matched China's saving rate) predicts U.S. saving rate to be 15%.

We note that the no-borrowing assumption may be less suitable for U.S. households and conjecture that this may be one reason that U.S. saving rates are lower than the model predictions. We investigate this conjecture by allowing U.S. households to engage in unsecured borrowing of a modest amount. Modifications to the model are as follows.

Households are allowed to borrow up to 10% of their permanent income. To force households to recognize that they cannot live forever in debt and must eventually repay, agents are confronted with a household planning problem with a horizon of 20 years. The houshold can borrow up to 10% of permanent income in periods 1 through 19, but in the terminal period (date 20), assets must be non-negative. Policy functions are obtained as of period 1 are used in the simulations. If a household goes into debt, it believes it has an additional 19 years before it must repay.

Results are shown in Table 6. Just allowing a small borrowing option dramatically lowers the saving rate at all admissible parameter values. The model generates targeted saving rates for $RRA = 5$, $IES = 0.8$.

While there are differences in estimated income risk between China and U.S. households, perhaps the most significant difference is in the income growth rate. U.S. households expect almost no growth in labor income, whereas Chinese households expect over 7% growth per annum. How does the growth rate affect precautionary saving?

Effect of growth on saving rate

These results are preliminary and subject to change, In some cases do not agree with those in Tables 1 and 2. While there are substantial differences in the riskiness of income between China and the U.S., perhaps the most salient contrast is in the expected growth rate of income. Here, we investigate the effect of varying expected income growth g, on the saving rate. The values of all the other parameters governing the income process are fixed at their estimated values while we vary the growth rate g from 0.01 to 0.07. Calculations are done for IES=0.5 and RRA values of 4 and 10. Results are reported in Table 7.

For U.S. levels of income risk, the saving rate is declining in the growth rate (there appears to be some non-monotonicity for RRA= 4 which requires further investigation). This is the standard result. However, for Chinese levels of income risk, the saving rate appears to be increasing in the growth rate in some regions of the admissible parameter space.

The reason that the saving rate can be increasing in the growth rate is this. Precautionary savers have a target asset to income ratio. Suppose this ratio is fixed. Then to maintain this target ratio, households in a high growth economy need to have a higher saving rate. The denominator of the ratio increases rapidly so saving has to be high to get the numerator to increase at the same rate as the denominator. The target asset-to-income ratio is not invariant to the growth rate, however. It is declining in growth. For U.S. levels of permanent and transitory income risk, the target asset-to-income ratio, and hence the saving rate, is declining in the growth rate. The relatively high implied saving rates for the U.S. is generated in part by the extremely low growth rate of U.S. labor income.

For China, the high rate of growth helps generate high implied saving rates. This is a noteworthy finding as it helps us to understand the observation that high-growth economies tend to have high saving rates. This was the puzzle that Carroll, Overland, and Zeldes solved by using preferences with habit persistence.

4 Finite lifetimes

Analses of precautionary saving are usually conducted in the infinite-lived agent framework, which cannot take into account life-cycle considerations which we know to be important in saving decisions. In this section, we extend our analysis to an enviornment where 66 different age cohorts are alive and exercising saving decisions at a point in time.

While we have overlapping generations, it is all done in partial equilbrium. There are no inter-generational transfers. We employ the model to explain the saving rate at a point in time. The model is not dynamic in the sense that we do not attempt to explain the time-path of the saving rate.

In the finite-horizon environment, many overlapping generations of decision makers from are present in the current time period. Under this sort of heterogeneity, individuals of different cohorts expect different rates of income growth depending on their position in the age-earnings profile. This section describes the model of exogenous income under both environments and estimation of the income process parameters. We begin with the process for infinitely lived agents.

4.1 The model

People live for 85 years (periods). At any point in time, 85 generations are present but only those aged 20 to 85 (66 cohorts) make decisions. People work and earn labor income from ages 20 to 63. From age 50 to 63 consumers continue to work, but do not have children living at home. During retirement, people live off of their accumulated assets and transfers received from their working adult children (modeled 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.

In the current time period, there are 66 decision making cohorts alive aged 20 to 85. Index the cohorts as $c = 20, ..., 85$. Each cohort is populated by $i = 1, ..., N_{c,t}$ households. For households with dependent children, we use a variation of Barro and Becker (1989) preferences in which consumption of parents and children enter separately into household utility. For the 26 cohorts aged 20 to 45, let parent's consumption be $C_{c,i,t}$ and per child consumption be $\tilde{C}_{c,i,t}$. Fertility (the number of children in the household) is treated as exogenous. Utility of these households is defined recursively as

$$V_{c,i,t} = \left\{ C^{\rho}_{c,i,t} + \mu n^{\eta}_{c,t} \tilde{C}^{\rho}_{c,i,t} + \beta \left[E_t \left(V^{\theta}_{c,i,t+1} \right) \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}}$$

where parameters $\mu < 1$ and $\eta < 1$ determine the weight parents put on their children's consumption. Variation in the number of dependent children (family size) alters available household resources for saving. A household with relatively few children devotes a smaller share of household income to support dependents and therefore has more to save. We use historical and projected demographic estimates from the United Nations *World Population Prospects* to determine the number of children in the household of cohort c at time t, $n_{c,t}$, expressed on a per-person basis. In this way, households can be interpreted as single-parent families. When children leave the houshold, people live as 'empty nesters' from age 46 to 85. For $c \in [46, 84]$, utility is $V_{c,i,t} = \left\{ C^{\rho}_{c,i,t} + \beta \left[E_t \left(V^{\theta}_{c,i,t+1} \right) \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}}$ and in the terminal period (age 85) is the constant-relative risk aversion function $\frac{1}{\theta} \left((C_{85,i,t})^{\theta} - 1 \right)$.

The budget constraint facing households are

$$V_{c,i,t} = \begin{cases} C_{c,i,t} = Y_{c,i,t} + RA_{c,i,t} - A_{c,i,t+1} - n_{c,t}\tilde{C}_{c,i,t} & c \in [20, 45] \\ C_{c,i,t} = Y_{c,i,t} + RA_{c,i,t} - A_{c,i,t+1} & c \in [46, 60] \\ C_{c,i,t} = P_{c,i,t} + RA_{c,i,t} - A_{c,i,t+1} & c \in [61, 84] \\ C_{c,i,t} = P_{c,it,} + RA_{c,i,t} & c = 85 \end{cases}$$

$P_{c,i,t}$ is the retiree pension which is set with a replacement rate of 40% of income in the last year of work.

Thus, households solve the life-time planning problem

$$V_{c,i,t} = \begin{cases} \max \left\{ C^{\rho}_{c,i,t} + \mu n^{\eta}_{c,t} \tilde{C}^{\rho}_{c,i,t} + \beta \left[E_t \left(V^{\theta}_{c,i,t+1} \right) \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}} & c \in [20, 45] \\ \max \left\{ C^{\rho}_{c,i,t} + \beta \left[E_t \left(V^{\theta}_{c,i,t+1} \right) \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}} & c \in [46, 84] \\ \frac{1}{\theta} \left(\left(C_{c,i,t} \right)^{\theta} - 1 \right) & c = 85 \end{cases}$$

subject to the budget constraints.[7]

Each living cohort as of 2009 solves their life-time planning problem. The 85 year old people solve a problem with terminal date $T = 2009$, first year of decision making at age 20, and $t = 1944$, had children living in his / her household from 1944 to 1969. The number of children

The youngest cohort in 2009 are 20 years old. They will have children living in the household through 2034. They retire at age 60 in year 2049. Obtain the policy functions for all living cohorts at 2009, simulate decisions of a population of $6,000$ individuals per cohort (for a total of $(6000)(65) = 390,000$ individuals).

Assume $R = 1.02$, $\beta = R^{-1}$. Pension replacement rate is 40%. Young households (aged 20) begin with no assets. In specifying parent's attitudes towards children, we set the Barro-Becker children in utility parameters to $\mu = 0.65$ and $\eta = 0.76$. Here, we follow Curtis et al. (2012) who in turn draw on Manuelli and Seshadri (2009) choose these values to match U.S. fertility rates in a model with fertility choice.

Age-specific earnings growth profile: Age-specific earnings growth is assumed identical for all cohorts. Economy-wide growth is set at 1% before 1978 and set at the estimated value of ???? from 1978 onwards.

[7] When this problem is normalized by permanent income, it becomes

$$v_{i,t} = \begin{cases} \max \left\{ \left(c_{i,t} \right)^{\rho} + \beta \left[E_t \left(G e^{n_{i,t+1}} \right)^{\theta} \left(v_{i,t+1} \right)^{\theta} \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}} & \text{no children} \\ \max \left\{ c^{\rho}_{i,t} + \mu n^{\alpha}_{i,t} \tilde{c}^{\rho}_{i,t} + \beta \left[E_t \left(G e^{n_{i,t+1}} \right)^{\theta} \left(v_{i,t+1} \right)^{\theta} \right]^{\frac{\rho}{\theta}} \right\}^{\frac{1}{\rho}} & \text{children} \\ \frac{1}{\theta} \left(\left(c_{i,t} \right)^{\theta} - 1 \right) & t = T \end{cases}$$

subject to

$$a_{i,t+1} \left(G/R \right) e^{n_{i,t+1}} = \left(a_{i,t} + e^{u_{i,t}} - c_{i,t} \right)$$

4.2 Results for China

Results for China reported in Table 8. There are many combinations of IES and RRA under which the model is able to hit the target saving rate. As we found for infinitely-lived households, when IES< 1, the model requires relatively high RRA to generate saving in the 25% to 30% range. When the IES$= 1.5$, the model generates a saving rate in the targeted range with RRA between 5 and 6. One notable difference here, in comparison to the finite lifetimes model however, is the estimated precautionary saving rate is cut by about a third. Non-precautionary saving rate is about 10% of disposible income. The precautionary motive thus generates a saving rate of approximately 20%. The 10% non-precautionary saving rate is driven by standard life-cycle saving motives to provide for old age.

The stylized life-cycle saving profile (saving rate by cohort) is hump-shaped. Life-cycle theory predicts that people will borrow early in life when income is low, and save heavily during high income years and dissave during retirement. Chamon and Prasaad (2010) report, somewhat surprisingly, that in Chinese households, the age-saving profile is U-shaped, which is a puzzle. Song and Yang (2010) address the U-shaped saving profile by focusing on the effects of a flattening of the age-earnings profile for Chinese workers whereas Chamon and Prasaad (2010) emphasize shifting responsibilities for education, housing and medical care away from the state onto individuals.

Our model also is able to get the U-shaped saving profile of the Chinese. The inability of households to borrow helps to overcome the puzzle. When a household is formed, it has no assets. As a precautionary saver, the household wants to quickly build up its buffer stock so the saving rate is high in the early years. High expenses of supporting a family lowers the saving rate through age 46. When children leave the household, saving rate surges until retirement. A plot of implied saving rates by cohort for IES$= 0.5$, RRA$= 5$ is shown in Figure 1. The raw saving rates are a bit jagged because children leave the household abruptly. The solid line depicts saving-rate profile smoothed by the HP filter.

Does the positive relation between aggregate growth and the saving rate hold up in the finite-lifetimes economy? Yes and No. In Table 9, we vary the aggregate growth rate for Chinese households setting IES$= 0.5$. For low values of RRA, the saving rate is decreasing in aggregate growth. For RRA$= 8$ and 10, the saving rate has a hump shape initially increasing when growth is low and decreasing when growth is high.

4.3 Results for the U.S.

[In progress]

Running the model calibrated to U.S. income dynamics implies saving rates that are much too high. These results are shown in Table 10. Non-precautionary life-cycle saving considerations generate saving rates in excess of 10%. In general, predicted saving rates are in line with those for Chinese households.

Table 11 shows the beginning of some results that allow U.S. households to borrow up to 3.5 times their permanent income. What is clear from this table is that we cannot simply use a given and fixed borrowing amount for all values of the IES and RRA.

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Figure 1.

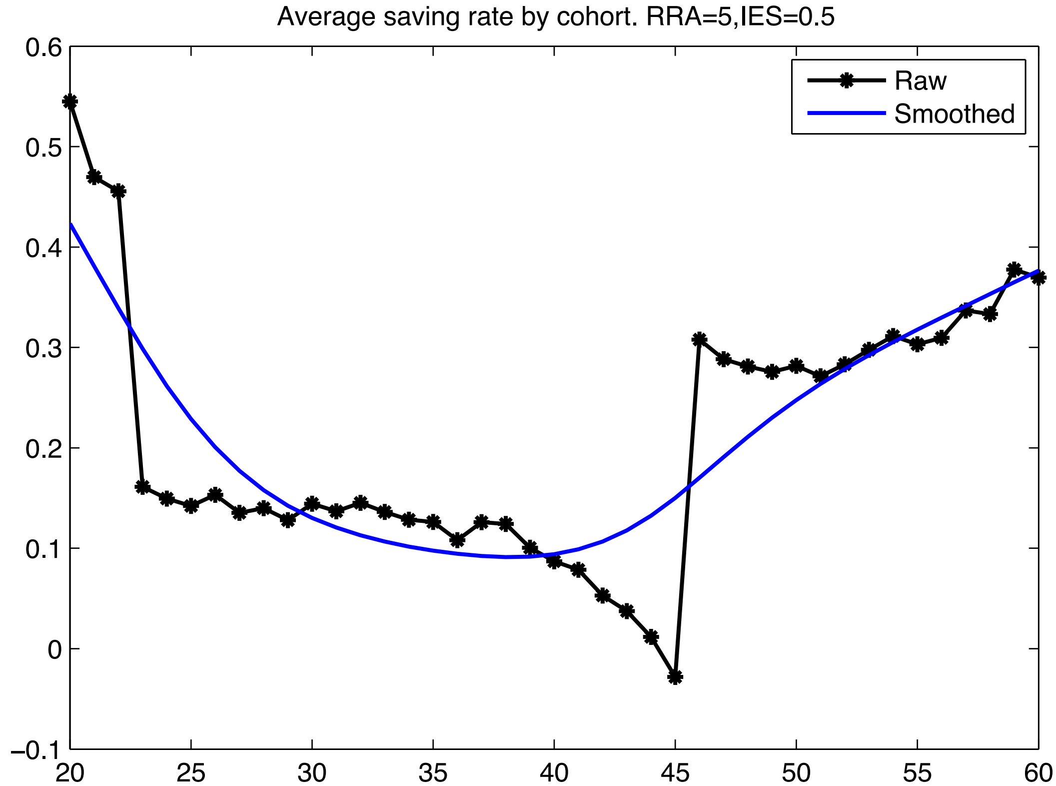
Average saving rate by cohort. RRA=5,IES=0.5
Raw
Smoothed
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
20
25
30
35
40
45
50
55
60

Table 1: Household Saving Rates

	China		
Year	Urban	Rural	USA
2005	24.3	34.4	1.4
2006	26	32.7	2.4
2007	27.5	33.2	1.7
2008	28.8	33.6	2.7
2009	28.6	32	4.3
2010	29.5	34.8	3.4
2011	30.5	32.2	3.6
Average	27.9	33.3	2.8

Table 2: Estimated Income Process

				China	
	Carroll	Chamon et al	USA	Urban	Rural
g	0.02		0.006	0.073	
$\text{Prob}(e^u) = 0$	0.0065	n.a.	0.001	0.0224	
σ_u : Transitory	0.16	0.604	0.41	0.58	
σ_n: Permanent	0.126	0.121	0.121	0.127	

Table 3: Estimates of the Intertemporal Elasticity of Substitution from the Literature

Authors	Special Features	Estimates
Beaudry and Van Wincoop (1994)	State-Level Consumption	close to 1
Biederman and Goenner (2007)	30 Year Investment Horizon	$0.2 < IES < 0.8$
Felices (2005)	British Household Panel Survey	$0.05 < IES < 0.17$
Gruber (2005)		$IES = 2$
Hall (1988)		$IES <= 0.2$
Noda and Sugiyama (2010)	Japanese data	$0.2 < IES < 0.5$
Ogaki and Reinhart (1998b)	Long-run Data	$0.27 < IES < 0.77$
Ogaki and Reinhart (1998a)	Durable goods	$0.32 < IES < 0.45$
Atkeson and Ogaki	Subsistence Consumption	IES bigger for rich.
Patterson and Pesaran (1992)	UK and US data	$IES = 0.3$
Skinner (1985)		$0.2 < IES < 0.5$.
Vissing-Jørgensen (2002)	Holders of Stocks, Bonds, and None	stocks: $0.3 < IES < 0.4$
		bonds: $0.8 < IES < 1$
		no assets: $IES = 0.2$
Chen et al. (2007)	Recursive preferences	$1.11 < IES < 2.22$

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Table 4: Infinite Horizon Saving Rate China

	IES					
RRA	0.1	0.3	0.5	0.8	1.2	1.5
0	0.042	0.051	0.056	0.055	0.052	0.050
0.8	0.050	0.061	0.064	0.060	0.067	0.068
1.2	0.056	0.066	0.067	0.063	0.061	0.060
2	0.068	0.077	0.076	0.071	0.070	0.072
3	0.085	0.093	0.088	0.082	0.087	0.099
4	0.102	0.108	0.100	0.099	0.126	0.223
5	0.118	0.123	0.116	0.128	0.241	**0.388**
6	0.134	0.140	0.136	0.186	**0.345**	0.459
7	0.150	0.157	0.167	0.259	0.404	0.494
8	0.166	0.177	0.212	**0.314**	0.438	0.513
9	0.189	0.202	0.255	0.350	0.458	0.523
10	**	0.190	**0.283**	0.372	0.469	0.529

Notes: /Volumes/Porsche/Precaution01/Output/Chn_Out_01, HP filtered average saving rate PSR, then averaged 50:298

.

Table 5: Infinite Horizon Saving Rate USA

	IES					
RRA	0.1	0.3	0.5	0.8	1.2	1.5
0	0.002	0.002	-0.001	-0.001	**0.002**	**0.002**
0.8	0.009	0.011	**0.021**	**0.025**	**0.037**	**0.047**
1.2	**0.023**	**0.027**	**0.038**	0.053	0.069	0.079
2	0.043	0.054	0.069	0.078	0.092	0.101
3	0.058	0.081	0.086	0.104	0.111	0.121
4	0.070	0.090	0.102	0.108	0.125	0.123
5	0.077	0.100	0.102	0.117	0.130	0.146
6	0.087	0.100	0.110	0.126	0.127	0.136
7	0.090	0.111	0.134	0.129	0.142	0.156
8	0.098	0.113	0.121	0.132	0.137	0.147
9	0.098	0.116	0.119	0.148	0.147	0.164
10	0.102	0.115	0.124	0.131	0.156	0.164

Note: 400:800. /Volumes/Precaution01/output/USA_Out_01_*. Averaged 400:800 of HP Filtered average saving rate.

Table 6: U.S. Household Saving Rate with Borrowing

20 Year Horizon

$r = 0.02$	IES					
CRRA	0.1	0.3	0.5	0.8	1.2	1.5
0	0.004	0.004	0.005	0.005	0.005	0.005
0.8	0.006	0.006	0.007	0.009	0.007	0.008
1.2	0.007	0.007	0.007	0.010	-0.001	-0.001
2	0.009	0.009	0.011	0.013	-0.001	-0.001
3	0.013	0.013	0.015	**0.020**	-0.001	-0.001
4	0.016	0.017	**0.021**	**0.024**	-0.001	-0.001
5	0.022	0.020	**0.024**	**0.026**	-0.001	-0.001
6	0.018	**0.023**	**0.026**	**0.027**	-0.001	-0.001
7	**0.022**	**0.031**	**0.025**	**0.030**	-0.001	-0.001
8	**0.024**	**0.029**	**0.030**	**0.033**	-0.001	-0.001
9	**0.030**	**0.031**	**0.030**	0.037	-0.001	-0.001
10	0.027	**0.032**	**0.036**	0.041	-0.001	-0.001

$r = 0.02$	IES: No Borrowing					
CRRA	0.1	0.3	0.5	0.8	1.2	1.5
0	0.0048	0.0044	0.0043	0.0046	0.0047	0.0046
0.8	0.0066	0.0063	0.0067	0.0072	0.0081	0.0084
1.2	0.0072	0.0071	0.0079	0.0094	0.0125	0.0112
2	0.0093	0.0107	0.0120	0.0134	0.0156	0.0176
3	0.0139	0.0149	0.0174	0.0198	0.0218	0.0270
4	0.0170	0.0184	0.0197	0.0231	0.0249	0.0307
5	0.0182	0.0221	0.0242	0.0297	0.0275	0.0341
6	0.0228	0.0260	0.0277	0.0296	0.0326	0.0383
7	0.0245	0.0265	0.0297	0.0334	0.0348	0.0396
8	0.0229	0.0286	0.0316	0.0324	0.0367	0.0391
9	0.0281	0.0289	0.0340	0.0381	0.0434	0.0456
10	0.0293	0.0315	0.0334	0.0368	0.0426	0.0420

EZ_NoBor_20.m

No Borrowing but Finite Horizon 20 periods. Precaution01/.../USA_Out_02. Out_USA_NoBor_20_*

Table 7: Saving rate and growth. Still want to redo

IES=0.5	China RRA (50:180)				
growth	0	2	4	6	10
0.01	0.024	0.101	0.111	0.100	0.078
0.02	0.034	0.079	0.165	0.162	0.138
0.03	0.041	0.065	0.162	0.201	0.184
0.04	0.046	0.066	0.122	0.219	0.217
0.05	0.050	0.069	0.102	0.196	0.240
0.06	0.053	0.072	0.099	0.157	0.253
0.07	0.055	0.075	0.100	0.138	0.281
IES=1.2	0	2	4	6	10
0.01	0.022	0.124	0.135	0.132	0.120
0.02	0.030	0.152	0.217	0.225	0.213
0.03	0.037	0.107	0.261	0.291	0.289
0.04	0.041	0.078	0.271	0.335	0.350
0.05		0.071	0.244	0.359	0.398
0.06	0.048	0.070	0.186	0.366	0.434
0.07	0.051	0.070	0.134	0.352	0.462

IES=0.5	USA RRA (200:600)				
growth	0	2	4	6	10
0.01					
0.02	0.004	0.026	0.113		0.234
0.03	0.005	0.031	0.086		0.259
0.04	0.004	0.026	0.050		0.215
0.05	0.005	0.019	0.053		0.211
0.06	0.006	0.022	0.061		0.207
0.07	0.006	0.011	0.070		0.179
IES=1.2	0	2	4	6	10
0.01					
0.02					
0.03					
0.04					
0.05					
0.06					
0.07					

/Volumes/Porsche/Precaution01/Output/Chn_Out_02 for China.

/Volumes/Porsche/Precaution01/Output/USA_Out_03 for U.S.

Table 8: Saving Rate for Finite Lifetimes of Overlapping Generations of 66 Cohorts for China

$r = 0.02$	IES					
CRRA	0.1	0.3	0.5	0.8	1.2	1.5
0	0.089	0.100	0.106	0.107	0.109	0.113
0.8	0.102	0.113	0.117	0.118	0.121	0.126
1.2	0.110	0.120	0.124	0.124	0.128	0.133
2	0.127	0.136	0.136	0.136	0.143	0.152
3	0.151	0.157	0.156	0.156	0.167	0.181
4	0.174	0.179	0.175	0.178	0.198	0.220
5	0.198	0.201	0.197	0.204	0.234	**0.266**
6	0.222	0.223	0.220	0.233	**0.273**	**0.307**
7	0.244	**0.268**	0.245	**0.265**	**0.308**	0.340
8	**0.268**	**0.291**	**0.271**	**0.295**	0.337	0.367
9	**0.291**	**0.315**	**0.296**	0.322	0.360	0.387
10	**0.315**	0.315	0.322	0.346	0.381	**

Table 9: Implied Saving Rate and Income Growth under Finite Lifetimes, China

$r = 0.02$	RRA				
g	0	2	4	8	10
1.005	0.111	0.160	0.216	0.282	0.293
1.01	0.111	0.157	0.215	0.295	0.311
1.02	0.111	0.151	0.206	0.306	0.334
1.03	0.109	0.146	0.195	0.305	0.343
1.04	0.108	0.142	0.187	0.297	0.342
1.05	0.107	0.139	0.181	0.284	0.335
1.06	0.106	0.136	0.176	0.272	0.324
1.07	0.105	0.135	0.173	0.263	0.313

Table 10: Saving Rate for Finite Lifetimes of Overlapping Generations of 66 Cohorts for U.S.

$r = 0.02$	IES					
RRA	0.1	0.3	0.5	0.8	1.2	1.5
0	0.129	0.125	0.122	0.118	0.112	0.109
0.8	0.141	0.137	0.133	0.128	0.122	0.120
1.2	0.147	0.144	0.139	0.134	0.129	0.126
2	0.161	0.157	0.153	0.147	0.144	0.142
3	0.180	0.175	0.172	0.167	0.164	0.162
4	0.202	0.196	0.193	0.187	0.180	0.177
5	0.226	0.218	0.211	0.203	0.194	0.187
6	0.250	0.238	0.228	0.216	0.203	0.195
7	0.272	0.254	0.243	0.227	0.210	0.201
8	0.293	0.269	0.255	0.237	0.216	0.205
9	0.313	0.279	0.264	0.245	0.222	0.208
10	0.328	0.286	0.271	0.250	0.226	0.211

Table 11: Saving Rates under Finite Lifetimes for U.S. Households with Borrowing

$r = 0.02$	IES=0.5, CRRA =3			
aL	-2.5	-3	-3.5	-4
AggSave	0.1428	0.13794	0.0222	-0.1471

$r = 0.02$	$aL = -3.5$, IES					
CRRA	0.1	0.3	0.5	0.8	1.2	1.5
0	0.079	0.080	0.078	0.075	0.034	0.033
0.8	0.102	0.103	0.102	0.100	0.062	0.061
1.2	-0.120	-0.136	-0.146	-0.149	-0.157	-0.157
2	0.101	-0.104	-0.135	-0.146	-0.157	-0.157
3	0.134	0.133	0.022	-0.125	-0.157	-0.157
4	0.164	0.162	0.159	0.021	-0.157	-0.157
5	0.189	0.186	0.181	0.174	-0.157	-0.157
6	0.214	0.206	0.199	0.187	-0.157	-0.157
7	0.239	0.226	0.214	0.200	-0.157	-0.157
8	0.260	0.239	0.227	0.210	-0.157	-0.157
9	0.281	0.252	0.238	0.219	-0.157	-0.157
10	0.297	0.261	0.246	0.226	-0.157	-0.157
output files: olgub01_*						

Table 12: Frequency of Zero Non-Capital Income Events, China

Head of Household	Observations	Near-Zero Events	% Near-Zero Events
Urban Chinese	$4,550$	69	1.52
Rural Chinese	$12,163$	307	2.52

Appendix

Estimation of the Labor Income Process

Procedure for estimating the probability of zero (transitory) income is as follows:

1. For each year, divide actual household income by the cross-sectional mean of income. Call the result detrended household income. Normalization by the mean is intended to remove cycle and trend components.

2. Regress detrended income on age, occupation, education, the interactions of these terms, age squared, and gender. Use this regression to predict life-cycle (age-specific) movements in income for each household.

3. Divide detrended income by predicted income. Call this $YL_{i,t}$.

4. Take the average income over all observations for household i. Call this average permanent income.

5. Take $YL_{i,t}$ and divide by average permanent income. This creates up to 8 observations per household for a total of $4,550$ observations on urban households.[8] Categorize a zero-income event as occuring when YL divided by average permanent income is less than 0.1.A substantial portion of the observations are concentrated near zero income.[9] A total of 69, about 1.5%, of the observations of urban households occur at or below 0.10 (i.e. 90% below trend income). The percentage for rural households is 2.5%. A weighted average across urban and rural housholds gives $p = 0.0225$.

[8] The entire precedure was repeated separately for rural households.

[9] As in CHZ, there are some observations with negative income, which have been counted as zero income.

Estimating the other parameters

To determine the relative magnitudes of the transitory and permanent shocks, we further restrict the sample to heads of households whose marital status never changed, who never ran a business as their primary occupation, and who never experienced a near-zero income event. These restrictions should all reduce variability.

The variance of the shocks are estimated by regressing the sample variance of $\ln YL_{it-m} - \ln YL_{it}$ on m and a constant for all values of m that can be calculated. From the urban sample, we estimate a standard deviation for the transitory shock of 0.523 and an estimated standard deviation for the permanent shock of 0.146. [10] In the rural sample, the shocks's standard deviations equal 0.121 (permanent) and 0.604 (transitory).[11]

CHZ estimated the standard deviation of permanent income shocks to be 0.126 and transitory to be 0.163, based on US PSID data. We have also redone the PSID analysis using similar years to those available in the Chinese data. We obtain a probability of a near-zero income event (p) of 0.99%, standard deviation of permanent income of 0.114, and standard deviation of temporary shock of 0.323.

A summary of the income process parameters used by Carroll (1997), Chamon et al., plus our estimates from the PSID and CHNS is given in Table

Convergence of the saving rate for infinitely lived households. Low RRA, China saving rate builds over time. High RRA, saving rate starts out high. Convergernce of saving rate converges relatively fast, by observation 50. Hence take the mean aggregate saving rate over 60:180. For USA, convergence is slower. Taking average from 150:395.

[10] Chamon, Liu, and Prasad (2010) used a slightly different mehodology and do not include the 2009 data. They estimate the standard deviation to the permanent income shock to be 0.134 and the transitory component to be 0.402 in 2004 urban Chinese households, the most recent year for which they have calculations.

[11] We have also run the exercise without dividing income by the national trend (annual mean). We obtain xx near zero events, standard deviation to permanent income of 0.xxx, and a standard deviation of temporary income of 0.xxx, for the urban sample.

Table 13: Convergence of saving rates.