Life Cycle Earnings and the Household Saving Puzzle in a Fast-Growing Economy*

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Abstract

Rising saving rate, prominent among young households, is a typical feature of rapidly growing economies. This observation presents a puzzle, however, because the standard representative agent model implies low saving when a household anticipates high income growth. In this paper, we propose a resolution of the puzzle by documenting dramatic flattening of age-earning profiles using a unique national household survey from the fast-growing economy of China. Our quantitative analysis shows that, once the observed changes in earning profiles are incorporated, an otherwise standard life-cycle model can account for the recent surge in household saving in China as well as the U-shaped increase in saving rates over the life cycle.

Keywords: Household saving, age-earning profile, income growth, intertemporal choice, life-cycle model, China.

JEL classification: E21, D91, O53

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1 Introduction

Fast-growing economies are observed to have high saving rates. The respective experiences of the East Asian economies, such as Japan in the 1970s and Korea and Taiwan in the 1980s, attest to this regularity. The recent rise in saving rate in the rapidly growing BRIC countries (Brazil, Russia, India, and China) lends further support. However, this observation presents a puzzle because the standard representative agent model suggets that forward-looking consumers with standard preference should save less in a high-growth environment as they tend to anticipate a higher level of earnings in the future relative to their present incomes (e.g., Tobin, 1967; Summers, 1981; Carroll and Summers, 1991). Although growth may increase saving rates in a life-cycle model through an aggregateion effect (e.g., Modigliani, 1970), the quantitative magnitude of the effect has shown to be small (e.g., Paxson, 1996). This leaves an unresolved high-saving puzzle with regards to fast-growing economies even from the life cycle perspective.[1]

A more puzzling observation is about age-saving profiles in fast-growing economies. As Deaton and Paxson (1994) and Paxson (1996) document, the saving rate of young cohorts was high in Taiwan from 1976 to 1990, a period in which the growth rate of GNP per capita averaged at about 7 percent per year. China provides an even more striking picture. The average saving rate of households with their heads aged at 25 increased by 15 percentage points from 1990 to 2005 (Chamon and Presad, 2009). The increase in the saving rate of the young in fast-growing economies contrasts sharply with the hump-shaped or relatively flat life-cycle saving profiles in developed market economies. This is particularly difficult to reconcile with the mainstream thinking that productivity growth leads to earnings growth for everyone. In that circumstance, young households would have lower saving rates because of the expected future income growth.

This paper examines empirically and theoretically the foregoing puzzling observations in the life cycle context. Our work is based on a unique and comprehensive Chinese Urban Household Survey dataset (UHS henceforth) covering 1992 to 2007.[2] The post-market-reform era of China provides an execellent laboratory for research on saving and growth. Since 1992, China's GDP

[1] Alternative explanations for the positive relationship between growth and saving include habit formation (e.g. Carroll et al., 2000) and buffer-stock hypothesis (e.g., Deaton, 1991; Carrol, 1992). For the analysis of national saving (rather than household saving), high saving and high growth can co-exist in the neoclassical growth model due to the channel linking TFP growth, the rate of return to capital and the aggregate investment/saving rate (Chen et al. 2006).

[2] Access to the full dataset is highly restricted. Previous studies have either used the UHS data drawn from selected provinces or covering shorter time periods.

per capita has grown at a remarkably high annual rate of 8.5 percent, substantially higher than the average rate of 5 percent before 1992. Meanwhile, Chinese households have saved much more. The aggregate household saving rate increased from 14 percent in 1992 to about 26 percent in 2007. In addition, as Chamon and Presad (2009) show, the Chinese household saving rates feature a U-shape over the life cycle in the most recent years. This is partly because the young households save more, as documented above, and partly because the elderly also save more. The U-shaped pattern becomes more pronounced when fixed life-cycle effects are eliminated by taking the difference of saving rate profiles across periods. The average saving rates of the young (household head aged between 25 and 40), middle-aged (between 41 and 50) and old (between 51 and 60) increased by 10.8, 4.4 and 7.4 percentage points, respectively, from 1992-1994 to 2005-2007. These facts from China pose a higher criterion for theory to match the data, and any proposed theoretical mechanism should be able to explain, in a consistent manner, not only the sharp increase in saving rate, but also the U-shaped life-cycle saving profile.

The success of life-cycle models to explain saving behavior hinges on how economic growth manifests itself in individual life-cycle earnings profiles. Using the UHS data, we find two striking changes to earnings profiles. First, much of the earning growth is realized as upward shifts in the level of life-cycle earnings profiles for successive young worker cohorts. Moreover, opposite to the main view of the existing literature, earnings profiles have actually become flattenned cohort by cohort in the fast-growing economy of China. The standard Mincer's regression on cross-sectional data reveals a dramatic flattening process of age-earnings profiles. The rate of return to experience dropped by half over the sample period, and similar results have been found in the cohort-based analysis.

We then investigate how these changes in life-cycle earings profiles affect household saving decisions. To make the underlying mechanism highly transparent, we adopt a simple four-period overlapping generation (OLG) model with closed-form solutions. The much flattened earnings profiles encourage younger cohorts to save more for consumption smoothing and, therefore, provides a novel factor for explaining high saving rates of the young. At the aggregate level, high saving rates of the young can actually enhance the life-cycle interpretation on saving and growth. The aggregate saving rate increases not only because younger cohorts earn more, but also because they save more. On the other hand, the anticipated, moderated income growth in the future also contributes to the rising aggregate saving rate. More importantly, this anticipation increses the saving rate of those close to retirement age more than the others, resulting in an increase in saving rate of the old. This, together with the higher saving rates of the young, generates a U-shaped life-cycle saving profile as observed in the data.

The remaining question is quantitative: To what extent can the observed flattening earnings profiles and the anticipated moderation of income growth explain the rise of saving rate at the aggregate level as well as the U-shaped increase of saving rates over the life cycle? To this end, we turn to a more sophisticated OLG model in which one period corresponds to one calendar year. Once incorporating the estimates on earnings profiles, the model can generate an increase in aggregate saving rate, with a trend as well as a magnitude comparable to its empirical counterpart. Under standard parameterization, the model predicts a take-off of aggregate saving rate since 2000, a year that features an accelerated increase in aggregate saving rate observed in the data. The predicted aggregate saving rate increases by 9.03 percentage points over the period 1992 to 2007, matching the increase of 8.95 percentage points in the data. Moreover, the predicted increases of saving rate over the life cycle fit well the U-shape pattern the data. In the simulation, the saving rate of household head of age 25 in 2007 is about 16 percentage points higher than that in 1992, quantitatively close to the increase of 15 percentage points in the data. The simulated increase in saving rate falls with age, reaching a minimum of 5 percentage points at age 48. The data feature the same pattern, with a minimum increase of 4 percentage points at age 50. The simulated increase of saving rate rises again for those close to retirement age, so as to that in the data.

Aside from addressing directly the U-shaped increase in saving rates over the life cycle, our model is internally consistent with other facts regarding Chinese household saving behaviors. It has been well documented in the literature that saving rates are positively correlated with income and education levels (e.g., Yang, Zhang and Zhou, 2009). To shed light on this observation, we classify the UHS sample by education. Two main findings are reported in order. First, households with college educated heads aged between 25 and 50 (i.e., the young and middle-aged) experience a 9 percentage point increase in their average saving rate. This yields a three-percentage-point increase in aggregate saving rate, about one third of the total increase over the sample period. Second, we find a much more pronouced flattening of the life-cycle earnings profile for the college educated, with a magnitude of two times larger than the high-school educated. These two empirical findings are indeed consistent with our interpretation: The college educated save more simply because their earnings profiles have become flatter. Our quantitative exercise shows that the changes in saving rates of the college educated are the main driving forces for the surge of aggregate saving rate and the U-shaped shift of life cycle saving profile.

Our paper is closely related to the literature on household saving and growth. Earlier theoretical work has been devoted to understanding how growth affects saving from the life cycle perspective. For instance, in a series of papers, Modigliani and his coauthors (Modigliani, 1970, 1986; Modigliani and Cao, 2004) argue that a higher growth rate expands the lifetime wealth of younger cohorts relative to that of older cohorts. This would increase the aggregate saving rate since the young tend to save more than the old. However, the predicted positive correlation between saving and growth can easily be reversed if all cohorts benefit equally from growth (e.g., Tobin, 1967; Carroll and Summers, 1991). Moreover, even if growth changes only the level of life-cycle earnings profiles, Paxson (1996) and Deaton and Paxson (2000) have illustrated a quantitatively small aggregation effect due to the rather flat saving rates over the life cycle observed from countries including U.K. and U.S. When the life-cycle interpretation encounters these problems, economists start looking into alternative channels such as habit formation (e.g. Carroll, Overland and Weil, 2000) and precautionary saving under borrowing constraints (Wen, 2009). The channel for saving to affect growth has also been re-examined (Aghion, Comin, Howitt and Tecu, 2009), though empirical evidence overwhelmingly supports the opposite direction of causality.

Different from recent theoretical approaches, our work can be considered an effort of reviving the life-cycle interpretation. First, we provide empirical evidence in line with Modigliani's specification on earnings growth across cohorts: The younger cohorts earn much more than the older in the fast-growing economy of China. Second, opposite to the mainstream prediction, Chinese household life-cycle earnings profiles have actually been flattening substantially. Based on this empirical finding, we propose a novel mechanism to reconcile high saving rates with high growth rates in the life cycle context. The flattening of earnings profiles affects aggregate saving rate by encouraging younger cohorts to save more. The corresponding increase of aggregate saving rate is more than proportional since younger cohorts also earn more. In other words, the celebrated aggregation effect of Modigliani's life cycle hypothesis can be reinforced by the flattening of earnings profiles. This new explanation is not only qualitatively consistent with facts in China, but quantitatively important: The flattening of life-cycle earnings profiles alone can explain most of the increase in aggregate saving rate from 1992 to 2007.

Our work is also related to the literature on life-cycle eanings profiles. Interestingly, a similar pattern of change in life-cycle earnings profiles can be found in mature economies. Beaudry and Green (2000) and Kambourov and Manovskii (2005) document the flattening of earnings profiles in Canada over the period 1971 to 1993 and in the U.S. over the period 1968 to 1997, respectively. Nevetheless, the same method reveals a much more prominent flattening of earnings profiles in China, with a magnitude times larger than that in mature economies.

A simple comparison between China and Canada or U.S. might be misleading as they are fundamentally different in many aspects. Still, our finding has a potential of being generalized to address whether the flattening of life-cycle earnings profiles tends to be more pronounced as the economy grows faster. This is worth being examined in future research.

We conduct our quantitative exercise in a heterogeneous agents model with dynamic optimization on saving. Although such framework has been widely adopted in macroeconomics, life-cycle earnings profiles are typically assumed stationary.[3] The assumption runs counter to the above empirical evidence on the flattening of earnings profiles (even for workers in Canada and U.S.). To the best of our knowledge, the present paper is the first to incorporate changing earnings profiles into quantitative analysis on intertemporal decision. A fundamental issue associated with the extension is how to specify expectation on future earnings when earnings profiles are changing over time. In this paper, we present two alternative extreme approaches, perfect foresight and myopic expectation. Although our main findings are robust to these two expectation specifications, how individuals form their expectations on future earnings in fast-growing economies remains to be an interesting question. More sophisticated expectation rules associated with learning (e.g. Guvenen, 2007) can be introduced and estimated. We will leave it as a direction of future research.

Finally, this paper contributes to a growing literature on household saving in China. The topic has been increasingly popular for two reasons. First, the growth of China's foreign reserves is astonishing, flying from 21 billion USD in 1992 (5% of its annual GDP) to 2,130 billion USD in June 2009 (46% of its GDP), and contributes significantly to the global imbalance. Understanding the increase of saving rates in China, therefore, may help to shed some lights on the cause and even the future of global imbalance. Perhaps more importantly, Chinese household saving behavior has its unique features and some of them are hard to explain by the existing theory (see, e.g., Chamon and Prasad, 2009; Yang, Zhang and Zhao, 2009; Yang and Zhang, 2009). To address the puzzle, the literature often resorts to factors which are also unique for China, including dramatic demographic structure changes (Modigliani and Cao, 2004; Horioka and Wan, 2007), sharp increases of health and education expenditure and strong motives for owning a home (Chamon and Prasad, 2009), and even sex ratio imbalance (Wei and Zhang, 2009). Although some factors may turn statistically significant in regressions, it is far from reaching any concensus. Our work is distinguished from the existing literature by methodology. Our strategy is to isolate the effect of flattening earnings profiles in an oth-

[3]See, for example, Auerbach and Koltikoff (1987). Idiosyncratic earnings shocks are introduced in later studies (e.g., Imrohoroglu et al., 1995; Storesletten et al., 2004). But the average age earnings remain to be stationary across cohorts.

erwise stanard OLG model. This approach can generate predictions along different aspects and, therefore, allows us to check whether the theory is in accordance with various features of Chinese household saving behaviors. In other words, our paper has an attempt in providing an internally consistent view on household saving in China.

The rest of the paper is organized as follows. Section 2 presents facts on Chinese household saving, including the sharp increase of aggregate saving rates, the U-shaped saving rates over the life cycle and the unusually high saving rates of the young and college educated. Section 3 presents facts on earnings and pensions. In particular, both cross-sectional evidence and cohort-based analysis reveal a substantially flattening of life-cycle earnings profiles. We provide a simple four-period OLG model in Section 4 to investigate how the flattening of earings profiles affects aggregate saving rates as well as saving rates over the life-cycle. More serious quantitative exercises are conducted in Section 5, in which we show that our model can replicate quantitatively reasonably well a number of puzzling facts. Section 6 concludes.

2 The Chinese Household Saving Puzzle

2.1 The Data

The data we use in this paper come from 16 consecutive years of the Urban Household Surveys (UHS) conducted by China's National Bureau of Statistics (NBS). The starting year is 1992, when NBS began the use of standardized questionnaires. The latest data are from 2007 due to the NBS one-year-lag policy for releasing household data. The UHS data record basic conditions of urban households and detailed information on employment, wages, and demographic characteristics of all household members in each calendar year. We use the full sample covering all provinces except Tibet because of missing surveys in certain years and the lack of representation from this autonomous region.[4]

The choice of households in UHS is based on the principle of random and representative sampling, and the sampling method is consistent over all years. However, we discover that the response rates for workers of state-owned and collective firms are systematically higher than workers of other firms. Therefore, we deploy a resampling scheme which adjusts the sample distribution of workers by ownership type to the national distribution figures (see Data Appendix for details on resampling). After resampling, our sample covers 13145 households in 1992 and the number increases to 30493 in 2007.

Throughout the paper we focus on savings of households with household head age between

[4]NBS adopts a sampling scheme such that in every 5 years they have a complete rotation of the urban household samples. Some changes to the questionnaires are also made along with the reshuffling of the samples.

25 and 55 (for female) or 60 (for male), the official retirement age in China. Various saving definitions may yield very different saving rates after retirement (see appendix for details). Moreover, excluding savings of retirees leaves no major change to the facts we will present below. Summary statistics are provided in Table A-1.

2.2 Facts

Our UHS data begin from 1992, the year when China launched a new stage of reforms toward a full-fledged market economy. The aggregate household saving rates have increased remarkably since then (see Figure 1), rising from 16.5% in 1992 to 25.5% in 2007. Appendix **??** shows that using alternative household saving definitions reveals equally striking upward trends since 2002, from which the relevant data for computing saving rates become available.[5] The pattern is also robust to alternative data sources. A similar increasing trend also holds true for the aggregate saving rates computed by data from the Flow of Funds Accounts in China Statistical Yearbooks, though the Flows of Funds data report higher aggregate saving rates than the survey data as in many other countries (Chamon and Prasad, 2009). The rising aggregate saving rates in a fast-growing economy are at odd with the standard life-cycle/permanent-income models, in which high income growth would naturally result in lower saving rates for reasons discussed in the introduction.

[Insert Figure 1]

We then present saving rate patterns over the life cycle. The dotted line in Panel A of Figure 2 presents the average cross-sectional life-cycle saving rate profile over the period 1992 to 1994. The saving rates are relatively flat before 45 and then increase towards the retirement age. The solid line in the panel presents the profile over 2005 to 2007, from which one can see a dramatic change: The saving rate profile turns to a U-shape over the life cycle.[6] To eliminate fixed life-cycle effects, we take difference of the two profiles.[7] This yields the increase of saving rates over the life cycle from 1992-1994 to 2005-2007, as depicted in Panel B of Figure 2. The U-shape pattern turns more pronounced: The average increase of saving rates for those aged below 40 and above 50 is equal to 10.3 and 8.1 percent, respectively, while that for those middle-aged is only 5.5 percent. The rise of saving rate of the young sharply contrasts the

[5] We also show in the appendix that truncating the UHS data at age 80 would give essentially the same result. Quantitative, it would lower the aggregate saving rates by less than one percentage point.

[6] Using alternative saving definitions result in qualitatively similar U-shape profiles (see Appendix **??** for details), though the uprise of the saving rate for age 50-60 may be less remarkable under certain definition.

[7] Life-cycle effects may be time-varing (for instance, the changing demographic effects on saving rate and the changing family structures). See below for an investigation of these time-varing life-cycle effects.

typical hamp-shamped or relatively flat life-cycle saving rate profiles in mature economies. This is particularly hard to reconcile with the mainstream thinking that productivity growth leads to earnings growth for everyone. In that circumstance, the youngest households would have the lowest saving rate since they face the steepest life-cycle earnings profile.

[Insert Figure 2]

It has been well-know in the literature that household saving rates are increasing in household income (e.g., Yang, Zhang and Zhou, 2009), as confirmed by our regression results reported in Table A-1 in the appendix. To shed light on this fact, we investigate two subsamples classified by household head education: Subsample 1 and 2 include households with high/technical-school and college-and-above educated household head, respectively. Column (1) of Table 1 shows that the average saving rate of college-and-above educated increased by 8.50 percentage points, significantly larger than 6.66 percentage-point-increase of the average saving rate of high/technical-school educated. Enhanced by increasing shares of college-and-above educated and the widening income gap across different education groups, the increase of saving rates of college-and-above educated alone can explain more than 40 percent of the increase in aggregate household saving rates. Column (2) to (4) show that each education group features a qualitatively similar U-shaped increase of saving rates over the life cycle.[8] The increase of saving rates of the young and middle-aged (household head age between 25 and 50) with college-and-above education is particularly worth being noticed. It alone yields a three-percentage-point increase in aggregate saving rate, about one third of the rise of aggregate saving rate over the sample period. If the young and middle-aged benefit more from economic growth, their earnings profiles would be steeper and their saving rates would be lower accordingly. Therefore, this observation adds extra burden for theory to match the data.

[Insert Table 1]

3 Facts on Life-Cycle Earnings Profiles

3.1 The Data

We focus on annual wages for adult workers engaged in wage employment. Wage income consists of basic wage, bonus, subsidies and other labor-related income from regular job. We deflate annual wages to 2006 yuan by province-specific urban consumption price indices.[9]

[8] Since each subsample contains much fewer observations, we choose to report average saving rates of three age groups, rather than the entire age profiles.

[9] See Data Appendix for detailed descriptions of data sources, variable definitions and data adjustments.

Our sample for analysis include all workers who are aged 25-55 for females and 25-60 for males, excluding employers, self-employed individuals, farm workers, retirees, students, those re-employed after retirement, and those workers whose real annual wages were below one half of the real minimum wage.[10] We also deploy the same resampling scheme as for households to correct the sample distribution. The resampled dataset cover 26963 individuals in 1992 and the number increases to 66516 in 2007. Summary statistics are provided by Table A-2.

3.2 Cross-Sectional Evidence

We first take a preliminary look at the data by presenting cross-sectional results. The dotted line in Figure 3 presents the cross-sectional earnings profile in 1992. The profile features the standard pattern: Earnings increase in age, reach a peak at 56 and then decline before retirement. China started its transition towards a full-fledged market economy in the early 1990s. Since then, the earnings profile has changed dramatically. The solid line in the figure presents the cross-sectional profile in 2007. For visual convenience, we adjust the scale of the solid line such that the mean of age earnings is equalized across 1992 and 2007. The flattening of the earnings profiles is evident: Individuals at age of 50 earn essentially the same as those at age of 30. Although earnings remain to be increasing for age below 30, the slope of the profile has also flattened out: The log difference of earnings between age of 30 and 25 decreases from 0.217 in 1992 to 0.084 in 2007.

[Insert Figure 3]

We then examine the data statistically. It has been long documented that education is a key factor affecting earnings profiles. In particular, the flatterning cross-sectional earnings profiles might simply reflect the fact that the later generations are better educated and, therefore, earn more than the earlier generations. To control for such an effect, we run the following standard Mincer's regression repeatedly for each cross-section:

$$\log y(i,t) = \alpha_0(t) + \alpha_1(t)\, e(i,t) + \alpha_2(t)\, e(i,t)^2 + \alpha_3(t)\, h(i,t) + \varepsilon(i,t), \tag{1}$$

where $y(i,t)$ denotes the log annual earnings for an individual i at period t, $e(i,t)$ and $e(i,t)^2$ stand for years of experience and its square, respectively, $h(i,t)$ is years of schooling. Panel A of Figure 4 depicts the estimated coefficients, $\alpha_1(t)$. The downward trend is obvious: The

[10] Provincial-level minimum wages are available only in 2006 from Ministry of Human Resources and Social Security. To impute minimum wages for the previous years, we calculate the ratios of the minimum wages to the mean wages for each province in 2006. We use the product of these ratios and annual mean wages in each province as our estimates for province-specific minimum wages in 1992-2005.

estimate drops from 0.036 in 1992 to 0.020 in 2007. This, together with the fact that the estimated coefficients on the quadratic experience term are rather stable over time, provides statistical evidence on the flattening of the life-cycle earnings profile. Interestingly, the return to education has been increasing over time (see Panel B of Figure 4), rising from 0.059 in 1992 to 0.114 in 2007. We will discuss in Section **??** the underlying driving forces for the flattening earnings profiles and for the increasing rates of return to education.

[Insert Figure 4]

3.3 Cohort-Based Profiles

One caveat is that repeated cross-sectional profiles do not necessarily reveal how the actual life-cycle earnings change over time. In particular, the difference between any two cross-sectional profiles across periods entails both cohort and year effects, while the difference of earnings between any two ages within a cross-sectional profile results from a combination of age and cohort effects.[11] We then take an alternative approach: tracing the earnings of a given cohort of persons by constructing synthetic cohorts. A cohort is denoted by the year in which individuals turn 25 and enter into our sample. Therefore, individuals with the same entry year in repeated surveys across periods are treated as being in the same cohorts. For instance, the 2004 cohort consists of individuals of 25 in 2004. Figure 5 plots earnings profiles for cohorts with different entry years. An immediate observation is that for any given age, the later cohorts earn substantially more than the older cohorts. For instance, the 2004 cohort at age 25 earn 47% more than the 2000 cohort at the same age. The strict order of earnings across cohorts is clearly an important reason for the flattening of the cross-sectional profiles in Figure 5. These findings actually provide support for Modigliani's argument on the change of life-cycle earnings profile in a growing economy (e.g. Modigliani, 1986), i.e., aggregate growth manifests itself in a rapid shift upward of the level of the earnings profiles from cohort to cohort. However, in Modigliani's analysis, the slope of the earnings profiles remain stable. We shall show below that the profiles actually become flatter from the later cohorts.

[Insert Figure 5]

To see more accurately changes in the cohort-based earnings profile, we use the following regression specification used by Beaudry and Green (2000) and Kambourov and Manovskii

[11] See our technical appendix for detailed discussion.

(2005).

$$\log y(i,t) = \alpha_0 + \kappa_1 z(i) + \kappa_2 z(i)^2 + \kappa_3 z(i) x(i,t) + \alpha_1 x(i,t) + \alpha_2 x(i,t)^2 + \alpha_3 x(i,t)^3 + \alpha_4 \log \hat{Y}(t) + \varepsilon(i,t). \quad (2)$$

Here, the dependent variable, $y(i,t)$, is the log annual earnings for a given cohort i in a given year t. The regressors include the cohort entry year, $z(i)$, and its square, an interaction of age, $x(i,t)$, and the cohort entry year, plus a polynomial of age.[12] To control for earnings variations over the business cycle, we introduce log detrended aggregate earnings, $\log \hat{Y}(t)$, as an additional regressor.[13] The estimated results are reported in column (1). The solid lines in Figure 5 plot the predicted cohort-based earnings profiles according to the regression results in Column (1). One can see that the predicted profiles replicate the actual profiles reasonably well, suggesting a good fitness of the regression specification with the data (see also the high R^2).

Consistent with the visual inspection of Figure 5, the positive coefficient on the linear cohort term, κ_1, shows higher earnings for later cohorts. The negative coefficient on the quadratic cohort term, κ_2, on the other hand, suggests that the earnings gap across cohorts is narrowing down. The estimates imply an annual growth rate of 8.55% for starting earnings at age 25, even higher than the growth rate of 7.48% for aggregate earnings. Moreover, the coefficient on the age-cohort interaction, κ_3, another key variable of interest, is negative and marginally significant at 1% level. That is to say, the later cohorts face flatter earnings profiles and, thus, lower earnings growth as they age than the earlier cohorts. Such an effect is quantitatively large. For the 2007 cohort, their earnings grow at an annual rate of 5.74% over the life cycle according to the estimates in column (1), substantially lower than the rate of 7.53% for the 1992 cohort.[14] The cohort-based analysis, therefore, reinforces the finding from repeated cross-sectional evidence. Finally, it is worth mentioning that the estimates in Column (1) imply a moderated earnings growth in the future. The negative κ_2 weakens the cohort effect on starting earnings. The flattening earnings profiles by the negative κ_3 pull down further aggregate earnings growth by lowering individuals' earnings growth over their life cycle. A simulation of future earnings growth is presented in Section 5.

[12] Following Beaudry and Green (2000), the first cohort with entry year of 1957 in our sample is indexed by cohort 1. The following successive cohorts are counted up incrementally.

[13] $\hat{Y}(t) = Y(t) / (1+g)^t$, where $g = 7.48\%$ is the average annual earnings growth rate in our sample. Beaudry and Green (2000) use unemployment rates, which are actually flat and not informative in China.

[14] China started reforming the central-planned economy in the late 1970s. Cohorts entering into the labor market after the reform might natually have different earnings profiles from earlier cohorts. To isolate the life-cycle earnings profiles of the "lucky generations," we run the same regression for cohorts with entry years later than 1992 only. The results are available upon request. The estimate of κ_3 is still negative and significant, though the absoluate value drops to 0.0006.

[Insert Table 2]

We then run a similar regression for each of the three subsamples classified by education levels.

$$\log y(i,j,t) = \alpha_0(j) + \kappa_1(j) z(i) + \kappa_2(j) z(i)^2 + \kappa_3(j) z(i) x(i,t) \quad (3)$$
$$+\alpha_1(j) x(i,t) + \alpha_2(j) x(i,t)^2 + \alpha_3(j) x(i,t)^3 + \alpha_4(j) \log \hat{Y}(t) + \varepsilon(i,j,t),$$

where $y(i,j,t)$ denotes the earnings of individuals with age i and education j at period t. Column (2), (4) and (5) report results for middle-school-and-below, high/technical-school and college-and-above educated, respectively. The estimates change considerably across three groups. Cohorts effects are significant for the high/technical-school educated and become much stronger for the college-and-above educated. However, little statistical evidence can be found in column (2) and the negative κ_1 is particularly puzzling. To avoid the potential misspecification problems, Column (3) adopts a simpler approach for the middle-school-and-below educated by restricting $\kappa_2 = \kappa_3 = 0$. Now κ_1 turns positive and highly significant. We will use estimates in Column (3) in the following analysis.

Figure 6 provides a depiction of the flattening of life-cycle earnings profiles for the high/technical-school and college-and-above educated according to the estimates in column (3) and (4) of Table 2.[15] One can see that though later cohorts start with much higher earnings, they experience slower earnings growth than earlier cohorts. The flattening of earnings profiles is particularly remarkable for the college-and-above educated. For the 2007 cohort, their annual earnings growth rate is merely 4.66% over the life cycle, less than 60% of the rate of 8.05% for the 1992 cohort. $\alpha_4(j)$ also features substantial heterogeneity across education groups, varying from 0.93 for the least educated to 1.09 for the most educated. The increase of $\alpha_4(j)$ along education levels suggests that high-income households tend to have more volatile earnings over the business cycle and, therefore, would save more for precautionary motives. This might provide an explanation for the positive correlation between earnings and saving rates, complementary to our explanation provided below. We will leave it as an interesting extension for future research.

[Insert Figure 6]

Beaudry and Green (2000) and Kambourov and Manovskii (2005) find similar patterns of the flatterning life-cycle earnings profiles in Canada and U.S. Nevetheless, the flattening of

[15] The out-of-sample detrended aggregate earnings are set equal to the sample mean.

the profiles in China is, on average, more prominent. For instance, Kambourov and Manovskii (2005) report an estimated κ_3 of -0.004 in the PSID data, with a magnitude much smaller than the one in column (1) of Table 2. Beaudry and Green (2000) document a strong flatterning of the earnings profiles for high-school educated men in Canada. However, the overall piciture is less clear as κ_3 becomes statistically insignificant for university educated men and high-school educated women and even turn positive for university educated woman.

4 A Four-Period OLG Model

We have shown the dramatic change of the life-cycle earnings profile in China over the period associated with fast economic growth. The cohort effects on starting earnings and the flattening of the earnings profile are particularly remarkable. We now formulate a life cycle model in order to ask how these changes affect the aggregate saving rate as well as the life-cycle saving pattern. We shall first use a four-period OLG model with simple analytical results, to make the underlying mechanism highly transparent. A full-fledged Auerbach-Kotlikoff OLG model will be presented in the next section, in which the observed life-cycle earnings profiles are imposed to deliver quantitative results.

The economy is populated by four overlapping generations with equal mass, referred to as the young, middle-aged, old and retired. In each period, individuals, except for the retired, supply one unit of labor inelastically. The after-tax earnings of the young, middle-aged and old at period t are denoted by w_t^1, w_t^2 and w_t^3, respectively. The retirees at period t receive pensions of p_t, which is equal to $\psi \bar{w}_t$, where ψ and $\bar{w}_t$ represent the replacement rate and average earnings, respectively. We abstract away taxes and, thus, how pensions are financed. Alternatively, we may Introduce a balancing government budget, allowing the tax rate to be endogenously determined by pensions. Such an extension would lead to no major change to our main results.

Preferences for a young individual born at period t are represented by

$$\sum_{i=1}^{4} \beta^{i-1} u\left(c_{t+i-1}^{i}\right), \tag{4}$$

where $u(\cdot)$ is a standard twice differentiable and strictly concave utility function, β denotes the discount factor, and c_t^i stands for consumption of an individual of age i at period t. The young individual chooses the optimal saving decision by maximizing (4) subject to her intertemporal budget constraint:

$$\sum_{i=1}^{4} \frac{c_{t+i-1}^{i}}{(1+r)^{i-1}} = \sum_{i=1}^{3} \frac{w_{t+i-1}^{i}}{(1+r)^{i-1}} + \frac{p_{t+3}}{(1+r)^{3}},$$

where r is the interest rate.

For expositional ease, we restrict our attention to the case with $\beta = 1 + r = 1$, in which the Euler equation implies equalized consumption flow over the life time. In the technical appendix, which is available from our website, we relax the assumption and show that our main results are robust to a large set of parameter values.

Lemma 1 *Assume that $\beta = 1 + r = 1$. Then, the life-cycle saving rate profiles follow*

$$s_t^1 = \frac{3}{4} - \frac{1}{4}\left(\frac{w_{t+1}^2 + w_{t+2}^3 + p_{t+3}}{w_t^1}\right), \tag{5}$$

$$s_t^2 = \frac{3}{4} - \frac{1}{4}\left(\frac{w_t^1 + w_{t+2}^3 + p_{t+2}}{w_{t+1}^2}\right), \tag{6}$$

$$s_t^3 = \frac{3}{4} - \frac{1}{4}\left(\frac{w_{t-2}^1 + w_{t-1}^2 + p_{t+1}}{w_t^3}\right), \tag{7}$$

where $p_t = \psi \sum_i w_t^i/3$, and s_t^i denotes the saving rate of individuals of age i at period t.

The results of Lemma 1 are standard and the proof is straightforward. In particular, (5), (6) and (7) indicate that saving rates increase in the current earnings and decrease in the past and future earnings. In other words, the life-cycle saving rate profile appears to "track" the earnings profile for consumption smoothing.

To reveal how earnings profiles affect saving decision, we assume

$$w_t^i = \begin{cases} \alpha \cdot f(i) & \text{if } t = T \text{ and } i = 1 \\ f(i) & \text{otherwise} \end{cases}, \tag{8}$$

where $\alpha > 1$ and $f(\cdot)$ is monotonically increasing. Three remarks on (8) are in order. First, (8) implies cross-sectional earnings profiles of $\{f(1), f(2), f(3)\}$ and $\{\alpha f(1), f(2), f(3)\}$ before and at period T, respectively. The rise of starting earnings of the T cohort flattens the cross-sectional earnings profile, consistent with the pattern depicted in Figure 3. Moreover, we have cohort-based life-cycle earnings profiles of $\{f(1), f(2), f(3)\}$ and $\{\alpha f(1), f(2), f(3)\}$ for cohorts born before and at period T, respectively. The flattening of cohort-based life-cycle earnings profiles is also in line with estimated results in Table 2. Finally, (8) implies an aggregate earnings growth at period T and a setback of aggregate earnings at period $T+1$. This can be considered a reflection of the moderation of future earnings growth implied by the negative κ_2 and κ_3 in (2) as discussed in the previous section. To conclude, despite highly hypothetical, (8) captures, in a broad sense, the stylized features of earnings profiles we observe from the fast-growing economy of China described in the previous section.

Substituting (8) back into (5) to (7) in Lemma 1 proves the following proposition.

Proposition 1 *Assume that $\beta = 1 + r = 1$ and earnings follow (8). Then,*

(i) $\Delta s_T^1 > 0$, $\Delta s_T^3 = 0$ and $\Delta s_T^3 > 0$, where $\Delta s_T^i \equiv s_T^i - s_{T-1}^i$;

(ii) the aggregate saving rate increases at period T.

The first part of the proposition suggests that saving rates feature a U-shaped increase over the life cycle. The young at period T increase their saving rate because of the rise of starting earnings; i.e., $w_T^1 = \alpha f(1) > f(1)$. Although earnings of the old at period T remain unchanged, their pensions at period $T+1$ are less than pensions at period T for the previous cohort. The reason is simple. Pensions are determined by average earnings, which grow at period T but fall at period $T+1$. This leads to a higher saving rate of the old at period T.

The increase of the aggregate saving rate in the second part of the proposition is an immediate implication of the first part. Note that we exclude pensions and dissavings of retirees from the definition of aggregate saving rate. Nevertheless, since $\Delta s_T^4 > 0$, the aggregate saving rate increases even if pensions and dissavings of retirees are included. Retirees at period T dissave less primarily because they receive more pensions than retirees in previous periods.

The above analysis can easily be extended to incorporate within-generation heterogeneity. Denote w_t^{ij} the wage of an individual of age i with education level j. For simplicity, we assume that pensions are equally distributed among the retirees; i.e., $p_t^j = \psi \bar{w}_t$. The superscript j for pensions will be dropped when there is no source of confusion. In this case, life-cycle saving rates still follow (5), (6) and (7) in Lemma 1, where w_t^i is replaced with w_t^{ij}.

We then assume the following earnings profiles in a way similar to (8).

$$w_t^{ij} = \begin{cases} \alpha(j) \cdot f(i) \cdot g(j) & \text{if } t = T \text{ and } i = 1 \\ f(i) \cdot g(j) & \text{otherwise} \end{cases}, \tag{9}$$

where $\alpha(j) > 1 \; \forall j$, $\alpha(\cdot)$, $f(\cdot)$ and $g(\cdot)$ are monotonically increasing. The monotonicity of $g(\cdot)$ captures the effect of education on earnings. By the properties of $\alpha(\cdot)$, (9) implies that more educated individuals feature a more pronouced flatterning of life-cycle earnings profile, echoing, again, the empirical observation in Section 3 (see Table 2). The rest of the specifications in (9) is identical to that in (8). Now we can easily prove the following proposition:

Proposition 2 *Assume that $\beta = 1 + r = 1$ and earnings follow (9). Then, $\Delta s_T^{1j} > 0 \; \forall j$ and Δs_T^{1j} is decreasing in j.*

The key finding is that the young who experience a more pronouced flattening of earnings profile would increase their saving rate more dramatically. This is in line with the observation reported in Table 1: The increase of saving rate of young households is significantly increasing in the education level of household head.

We have shown that in a highly stylized life cycle framework, more starting earnings, together with a flattening of the earnings profile, can not only increase the aggregate saving rate, but result in a U-shape increase of saving rate over the life cycle. Moreover, the increase of saving rate is larger for individuals experiencing a more pronouced flattening of the earnings profile. In the next section, we shall turn to a more sophisticated model, to assess quantitatively how observed changes to earnings profiles in China would affect household savings at the aggregate level and over the life cycle.

5 A Full-Fledged OLG Model

In this section, we incorporate changes in earnings profiles observed from China to an otherwise standard life-cycle model. Our aim is to provide a quantitative assessment on to what extent the observed changes in earnings profiles can explain the Chinese household saving puzzle (including the surge of aggregate household saving rate as well as the U-shaped increase in saving rates over the life cycle) over the period 1992 to 2007. Given such a goal, the above four-period OLG model, in which one period corresponds to twenty years, would be inadequate. Therefore, we extend the model to a full-fledged OLG model, in which one period corresponds to one calendar year and individuals live up to 75 periods.

Individuals start working at age 1 and retire at age Tr. Each Individual receives an endowment of human capital at born, and supplies one unit of labor inelastically in each period. We use w_t^{ij} to denote the after-tax earnings of an individual of age i with endowment j at period t. Similarly, p_t^{ij} stands for the pensions of a retiree of age i with endowment j at period t. Lifetimes are uncertain. Let δ_i denote the unconditional survival rate up to age i, with $\delta_1 = 1$. The survival rate conditional on being alive at age $i-1$ is thus equal to δ_i/δ_{i-1}.

5.1 Perfect Foresight

To compute inidividuals' optimal saving rates, we need to specify how expectations on future earnings are formed. There are two alternative approaches in the literature of life cycle analysis: adopting either myopic expectation (e.g. Davies and Whalley, 1991) or perfect foresight (e.g. Auerbach and Kotlikoff, 1987). In this subsection, we assume that, as in the four-period model, individuals hold perfect foresight on their earnings, which are drawn from the estimated ohort-based earnings profiles by (3). Individuals can also foresee perfectly the evolution of demographic structures and macro aggregates. We will turn to an alternative myopic expectation approach below as a robustness check.

Preferences for an individual of age $i = n$ with endowment j are represented by

$$\sum_{i=n}^{T} \beta^{(i-n)} \frac{\delta_i}{\delta_n} u\left(c_{t+i-n}^{ij}\right), \tag{10}$$

which is analogous to (4). She chooses the optimal saving decision by maximizing (10) subject to the following budget constraint:

$$\begin{aligned} \sum_{i=n}^{T} \frac{c_{t+i-n}^{ij}}{(1+r)^{i-n}} &= I\left(\sum_{i=n}^{Tr} \frac{w_{t+i-n}^{ij}}{(1+r)^{i-n}} + \sum_{i=Tr+1}^{T} \frac{p_{t+i-n}^{ij}}{(1+r)^{i-n}}\right) \\ &\quad + (1-I) \sum_{i=n}^{T} \frac{p_{t+i-n}^{ij}}{(1+r)^{i-n}} + (1+r)\, a_t^{ij}, \end{aligned} \tag{11}$$

where I is an indicator function with $I = 1$ for $n \leq Tr$ and $I = 0$ otherwise, and a_t^{ij} denotes asset position of an individual with age i and endowment j at period t. We add a borrowing constraint:

$$a_t^{ij} \geq 0.$$

As in many other countries, the public pension system in China entails both inter- and intra-generational components (see the appendix for detailed discussion). To capture within-cohort redistributive features of the system, we assume that pension is equal to a weighted average of aggregate earnings and the average earnings of education group j multiplied by the replacement rate:

$$p_{t+i-n}^{ij} = \psi_{t+i-n} \cdot \left(\begin{array}{c} \omega \sum_i \sum_j \phi\left(i, j, t+i-n\right) w_{t+i-n}^{ij} \\ + (1-\omega) \sum_i \frac{\phi(i,j,t+i-n)}{\sum_i \phi(i,j,t+i-n)} w_{t+i-n}^{ij} \end{array} \right). \tag{12}$$

A larger ω implies more within-cohort redistribution.

Denote sr_t^{ij} the saving rate of individuals with age i and type j at period t. The aggregate saving rate can be computed by aggregating individual saving rates over i and j:

$$sr_t = \sum_{i}^{Tr} \sum_{j} \phi\left(i, j, t\right) sr_t^{ij}. \tag{13}$$

To be consistent with the data, we exclude saving rates of the retirees. The cross-sectional life-cycle saving rate profile at period t consists of the average saving rates of individuals of age $i \in [1, Tr]$:

$$sr_t^i = \sum_j \frac{\phi\left(i, j, t\right)}{\sum_j \phi\left(i, j, t\right)} sr_t^{ij}. \tag{14}$$

5.1.1 Benchmark Parameterization

Agents enter the economy at age 25 and live until 100 ($N = 76$). Let $Tr = 36$ as the retirement age for male in China is 60. The annual interest rate is set to 3%, which is slightly higher than government bond returns in the period 1992-2007 but much lower than stock market returns over the period. We assume log preference so that the intertemporal elasticity of substitution is equal to one. The survival rates are obtained by the actual age-conditional survival rates from the 2005 population consensus (China Statistical Yearbook, 2006). β is set equal to 1. The population density, $\phi(i, j, t)$, follows the actual density in the UHS data. $\phi(i, j, t) = \phi(i, j, 2007)$ for $t > 2007$. In the appendix, we show that the replacement rate has been declining dramatically from above 80% in 1992 to about 50% in 2007. To downplay the role of pensions in the benchmark analysis, we simply set the replacement rate equal to 0.4. A rich dynamics of replacement rates will be introduced in Section 5.2. Finally, we let $\omega = 0.5$.

We formalize within-cohort heterogeneity by different education endowments at birth. Let $j \in \{M, H, C\}$, representing individuals with education of middle school and below, high/technical school, and college-and-above, respectively. Their earnings profiles follow (3), with coefficients being equal to estimates in column (3) to (5) of Table 2. Moreover, we use the estimated earnings profiles, based on individual data, to generate aggregate earnings in the future. To this end, we first use estimates in column (3) to (5) of Table 2 to compute $y(i, j, t)$ according to (3). Then, earnings are aggregated through

$$Y(t) = \sum_{i=25}^{Tr} \sum_{j} \phi(i, j, t)\, y(i, j, t), \tag{15}$$

where Tr stands for retirement age (55 for females and 60 for males) and $\phi(i, j, t)$ is the density of age i and education j at period t in the sample. For $t > 2007$, we simply let $\phi(i, j, t)$ equal $\phi(i, j, 2007)$. Panel A of Figure 7 plots aggregate earnings observed in the sample (dashed line) and those predicted by (15). Solid and dotted lines are used to distinguish within-sample and out-of-sample predictions. The predicted aggregate earnings fit the data very well in the first four years and last three years over the sample period. Aggregate earnings in between, however, are considerably overestimated.[16] Panel B plots aggregate earnings growth rates. Although predicted earnings based on individual data fail to replicate much of the cyclical component of aggregate earnings growth (especially the trough in the mid 1990s), they can match the growth trend. The predicted aggregate earnings grow at an average annual rate of 7.51%, very close to the rate of 7.48% in the data.

[16] More sophisticated specifications are perhaps needed to capture the nonlinear dynamics of aggregate earnings from 1996 to 2004.

[Insert Figure 7]

Perhaps the most striking finding comes from out-of-sample prediction. The estimates in Table 2 imply a substantial decline in aggregate earnings growth over the next 25 years: The aggregate earnings growth rate would drop from 7.7% in 2005 to 3.5% in 2030. The reason for the moderation is two-fold. The negative κ_2 weakens the cohort effect on starting earnings. The flattening earnings profiles (due to the negative κ_3) pull down further aggregate earnings growth by lowering individuals' earnings growth over their life cycle. Although our paper is not aimed for forecasting, the estimated earnings profiles may shed som light on the future of China's economic growth, which has been increasingly hot recently. Indeed, it would be unsurprising to see China' economy gradually converge to a balanced growth path with growth rates similar to developed countries, after growing at an rate of at least 5% for more than 40 years (since 1978 until 2020).[17]

The initial asset distribution is such that $a_t^{ij} = 0$.[18]

5.1.2 Results

The increase of aggregate saving rate, $sr_t - sr_{1992}$, is plotted in Panel A of Figure 8. Solid and dotted lines represent the simulated results and actual data, respectively. The model predicts a take-off of aggregate saving rate since 2000, a year around which the increase of aggregate saving rate also features an acceleration in the data. Moreover, the effect of observed changes in earnings profiles is quantitatively large. It increases aggregate saving rate by 9.03 percentage points, even larger than the increase of 8.95 percentage points in the data. Panel B displays the increase of saving rate over the life cycle, $sr^i_{2007} - sr^i_{1992}$. Again, the model prediction (solid line) matches the data (dotted line) reasonably well: The simulated $sr^i_{2007} - sr^i_{1992}$ track closely the U-shaped pattern in the data. Young individuals increase their saving rate more than the middle-aged precisely because of the flattening of their life-cycle earnigs profile, as illustrated analytically in the fourth-period model. The rise of saving rate of the old is driven by relatively less pension benefits, due to the slow-down of economic growth depicted in Panel B of Figure 7.

[Insert Figure 8]

[17] Nevertheless, out-of-sample predictions are often sensitive to data samples and regression specifications. We will adopt alternative approaches for computing future aggregate earnings in Section 5.3 as a robustness check.

[18] Anticipating high earnings growth afterwards, individuals of all ages at the initial period would optimally postpone savings and let their next-period assets equal zero, unless their initial asset positions are sufficiently large.

Now, we check the parameter sensitivity of the above findings. Specifically, we analyze sensitivity to two key model parameters: the inverse of the intertemporal elasticity of substitution, σ, and the replacement rate, ψ. Panel A of Figure 9 shows that an increase in σ has a non-monotonic effect on the increase of aggregate saving rate. Nevertheless, the effect is quantitatively sizable over a large internal of σ. Once incorporating the observed changes in earnings profiles, the model has the ability of generating large increase of aggregate saving rate over a period of 16 years. The sensitivity to ψ is illustrated in Panel B. A larger ψ leads to a smaller increase of aggregate saving rate. Still, aggregate saving rate would increase by at least 2 percentage points with $\psi < 0.6$. Panel C and D report the sensitivity of the increase of saving rate by age groups to σ and ψ, respectively. In particular, Panel C and D show that with a sufficiently large σ or ψ, the increase of saving rate would feature a U-shape over the life cycle (the increases of saving rates of age 25-30 and 55-60 are above those of age 45-50). These results suggest that our findings on the rise of aggregate saving rate and the U-shaped increase of saving rate over the life cycle are robust to a large set of parameter values.

[Insert Figure 9]

Our quantitative analysis shows that, once incorporating the observed changes in earnings profiles, an otherwise standard life-cycle model can account well for the recent surge in household saving as well as the U-shaped increase in saving rates over the life cycle. However, it is also worth pointing out that the model is less successful in matching the level of saving rates. In particular, anticipating high earnings growth, individuals at the initial period would like to postpone their savings and, therefore, face a binding borrowing constraint. This implies a zero initial aggregate saving rate, which is inconsistent with the sizable aggregate saving rate of 15% in the data. One natural way of increasing the level of saving rates is to add precautionary savings by introducing earnings risks. We leave this as an important extension for future research. The next subsection adopts a different approach. We shall see that by assuming myopic expectation, the level of saving rates can be calibrated to match the data. More importantly, similar to the results under perfect foresight, changes in earnings profiles under myopic expectation can generate a quantatively large increase of saving rate at the aggregate level and a U-shaped increase of saving rate over the life cycle.

5.2 Myopic Expectation

This subsection adopts myopic expectation as an alternative approach. Although myopic expectation is theoretically less appealing, it might be a snapshot of the way individuals form their expectations in a rapidly-changing economy like China. With a former central-planned economy transformed into a rather sophisticated market economy in less than two decades, information about future earnings must be limited, while past information quickly becomes obsolete. Individuals, therefore, may naturally rely more on current information to form expectations. In fact, a number of studies have even found empirical evidence supporting myopic behavior in developed economies. Reimers and Honig (1996) provides an example. They show that male workers in the U.S. respond only to current pension benefits and do not take into account changes in future benefits.

In the context of the present paper, myopic expectation is referred to as the case in which individuals use the current cross-sectional life-cycle earnings profile to forecast their future earnings; i.e.,

$$E_t\left[w_{t+i-n}^{ij}\right] = \alpha_0(t) + \alpha_1(t)\,e(i) + \alpha_2(t)\,e(i)^2 + \alpha_3(t)\,h(j)\,, \tag{16}$$

where $E_t\left[w_{t+i-n}^{ij}\right]$ denotes the expectation on w_{t+i-n}^{ij} at period t, and the RHS of (16) represents earnings of individuals with age i and education j, with coefficients, $\alpha_0(t)$ to $\alpha_3(t)$, being equal to the estimates from repearted cross-sectional regressions (1). In other words, everyone expects that the current cross-sectional life-cycle earnings profile will remain unchanged indefinitely. Consequently, any change to the profile in the future will be perceived as a unanticipated permanent change.

We further assume that indviduals hold myopic expectation on the replacement rate; i.e., they expect future replacement rates to be the same as the current rate. Individuals can in principle form forward-looking expectations on their pensions by perceiving the rules of the system. However, as discussed in the appendix, the Chinese pension system has undergone a series of reforms, transiting from a original work-unit-based system to the current PAYGO mixed with individual accounts. During the transition, the replacement rate of the average wage has dropped by more than twenty percentage points from 1992 to 2005. It is thus hard for individuals to make sensible forecast on their future pensions.[19]

Under these assumptions, the expectation on pension benefits follows

$$E_t\left[p_{t+i-n}^{ij}\right] = E_t\left[\psi_{t+i-n}\right]\cdot\left(\begin{array}{c}\omega\sum_i\sum_j\phi(i,j,t+i-n)\,E_t\left[w_{t+i-n}^{ij}\right]\\ +(1-\omega)\sum_i\frac{\phi(i,j,t+i-n)}{\sum_i\phi(i,j,t+i-n)}E_t\left[w_{t+i-n}^{ij}\right]\end{array}\right). \tag{17}$$

By assumption, $E_t\left[\psi_{t+i-n}\right] = \psi_t$. Here, individuals hold perfect foresight on future distributions over age and education.

[19] Michaud and van Soest (2006) show that even in the U.S., workers tend to misperceive the complicated rules of the social security system.

5.2.1 Parameterization

The myopic expectation on earnings follow (16), with coefficients being equal to the estimates from repearted cross-sectional regressions (1). $\{\psi_t\}_{t=1992}^{2007}$ is set equal to the sequence of observed replacement rates in the data (see the appendix for details). Different from the initial distribution of $a_t^{ij} = 0$ under perfect foresight, we let the initial asset distribution be identical to that in a steady state where the earnings profile is stationary and equal to the estimated profile using the cross-sectional UHS data in 1992. Moreover, β can be calibrated to match the initial aggregate saving rate in 1992. This results in $\beta = 0.996$. Note that under perfect foresight, such a calibration is not feasible since the initial aggregate saving is always equal to zero except for β substantially above one. All the other parameter values are identical to those in Section 5.1.1 under perfect foresight.

5.2.2 Results

The aggregate saving rates of the benchmark economy are plotted in Panel A of Figure 10. Panel B displays the increase of saving rates over the life cycle from 1992 to 2007. Solid and dotted lines represent the simulated and actual data, respectively. First of all, the benchmark economy generates a sharp increase of aggregate saving rate, with a trend as well as a magnitude comparable to its empirical counterpart. Recall that the economy is calibrated to match the initial aggregate saving rate, but not its time path. Still, the model economy can replicate the fact that the increase of aggregate saving rate was relatively modest in the 1990s and then it started to accelerate after 2000. Quantitatively, the simulated aggregate saving rate increases by 11 percentage points over the 16 years, slightly higher than 9 percentage points in the data. Second, the increase of saving rates over the life cycle (Panel B) replicates reasonably well the U-shaped pattern in the data. Young individuals increase their saving rate due to the same reason as in the case of perfect foresight. The rise of the saving rate of the old is essentially driven by the declining replacement rates, which is somewhat different from the mechanism in the case of perfect foresight. The latter result is particularly related to the literature on savings and social security, an important issue pioneered by Feldstein (1974).[20] Although our work has a focus on changes in life-cycle earings profiles, the observations on the declining replacement rates and the rise of saving rates of household head close to retirement age in

[20] Using models calibrated to the U.S. economy, the literature has repeatedly illustrated a quantitatively large effect of social security on household savings and, hence, interest rates in general equilibrium (e.g., among many others, Imrohoroglu et al., 1995; Conesa and Krueger, 1999). Empirical evidence is, however, limited and sometimes mixed. For instance, the evidence is mixed for cross-country data (Samwick, 2000). Using Italian household data, Attanasio and Brugiavini (2003) find that a reduction of pension wealth increases saving rates significantly.

China are in accordance with the standard theoretical prediction with myopic expectations. Echoing the existing work, our quantitative exercise confirms a large effect of replacement rate on saving rate. The declining replacement rates alone can increase aggregate saving rate and saving rate of the old (with age 50-60) by about 9 and 15 percentage points.

[Insert Figure 10]

5.3 Robustness Check

Demographics of family structure are potentially important for household saving decision. Due to the one-child policy, China is undergoing a demographic transition. The average young dependency ratio declined from 0.39 in 1992 to 0.24 in 2007, while the average old dependency ratio rised from 0.07 to 0.10 (see Table A-1). Therefore, it is natural to check whether the following two features are primarily driven by demographic factors: (i) the increase of the Chinese household saving rate at the aggregate level and (ii) the U-shaped increase of the saving rate over the life cycle. Let the saving rate for a household be the dependent variable, and let young and old dependency ratios of the household be the regressors. Household income, household head age and its square are also included as additional controls. We then run the regression repeatedly for data in each UHS. The results are presented in Table A-3. The coefficients of interests on the young and old dependency ratios are statistically significant and have the expected signs in most years: A family with fewer children or more retired tends to save more. Qualitatively, these results suggest that the declining young dependency ratios and the rising old dependency ratios contribute to the increase of the aggregate household saving rate. Such effects, however, are quantitatively not important. For instance, the average estimated coefficient on the young dependency ratio is about -4. Multiplied by the drop of the young dependency ratio of 0.15 from 1992 to 2007, the estimate implies only 0.6 percentage-point increase of the aggregate saving rate over this period. To see this more explicitly, the dotted line in Panel A of Figure 11 plots the dependency-ratio adjusted saving rates feature essentially the same upward trend at the aggregate level. The difference between adjusted and unadjusted aggregate saving rates is less than one percentage point in most years. These results are in line with Chamon and Prasad (2009), who also find a limited role of demographics in the rise of the aggregate household saving rates in China.

[Insert Figure 11]

Next, we check the demographic effect on life-cycle saving profiles. The estimated effects of the old dependency ratio on household saving rate change significantly, rising from about 2 in the 1990s to above 4 since 2002 (see, again, Table A-1). Moreover, households with household head age above 50 have a much higher old dependency ratio (with an average of 0.18) than the other households (with an average of 0.09). A combination of these two findings can potentially explain the recent rise of the old household saving rate. The dotted line in Panel B of Figure 11 plots the dependency-ratio adjusted life-cycle saving profile over the period 2005-2007. As expected, the demographic effects turn significant for age above 50. Despite this, the demographic effect per se is not strong enough for explainning a significant part of the increase of the old household saving rate. The difference between adjusted and unadjusted saving rates never exceeds two percentage points.[21]

6 Concluding Remarks

The life cycle and permanent income hypotheses represent a simple and elegant paradigm that can be used to understand the determinants of consumption and saving decisions. While the theory has succeeded in unifying a wide range of diverse phenomena, it is difficult to reconcile with the positive relationship between saving and income growth found in fast growing economies or cross-country regression analysis. The puzzle is that forward-looking consumers with standard utility should save less, not more, in anticipation of higher future income, holding the shape of age-earnings profiles fixed.

This puzzle is resolved in the context of the fast growing economy of China. Using a unique national household survey covering the period 1992-2007, instead of observing stable age-earnings profiles as assumed either explicitly or implicitly in past studies, we found that rapid income growth in China has dramatically raised the earnings of successive cohorts of young workers relative to older workers. We also found that the cohort-specific age-earnings profiles have become flattened over time. Our quantitative analysis showed that an otherwise standard life-cycle model can account well for the recent surge in household saving as well as the U-shaped increase in saving rates over the life cycle, once we incorporated the changes in earnings profiles and a social security scheme of transferring pension incomes from rich and well-educated households to poor and less-educated households during China's transition. Our analysis showed how income growth manifests itself in the changes in earnings profiles over the life cycle, suggesting a new channel for growth to affect saving.

Rising saving rate is a widely observed phenomenon in fast growing economies, including the

[21] Alternatively, we may regress saving rate on dummies reflecting family structure. Specifically, we may include three dummies, for households with children only, with retirees only, with both children and retirees, respectively. This approach gives quantitatively similar results (details are available upon request).

newly industrialized countries in Eat Asia and more recently the BRICs. It remains a challenge to validate whether the life-cycle mechanisms proposed in this paper could well explain the rise in saving in other rapidly growing economies.

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7 Appendix

7.1 Pension

We now turn to the Chinese pension system, which is relevant for the following two reasons. First, pensions are particularly important for saving decision over the life cycle (e.g. Attanasio and Brugiavini, 2003). Moreover, we shall use a combination of the earnings profile and the replacement rate, a key variable measuring the generosity of a pension system, to provide a full characterization of individuals' non-asset income over their life time.

The Chinese pension system, which has undergone a series of reforms since the early 1990s. The original system was primarily based on state and urban collective enterprises in the central-planned economy. All pension beneficiaries received pension benefits directly from their employers. The work-unit-based system was under severe financial distress in the late 1980s and early 1990s, mainly due to a growing disproportion between the numbers of contributors and beneficiaries (see, e.g., Zhao and Xu, 2002). To deal with the issue, the government has initiated a transition from the traditional Pay-As-You-Go system (PAYGO henceforth) to a partially-funded one since the early 1990s. A new system was implemented after the State Council issued "A Decision on Establishing a Unified Basic Pension System for Enterprise Workers" in 1997. The new system consists of three pillars. The first pillar, funded by payroll taxes, guarantees a replacement rate of 20 percent of the local average wages for retirees with a minimum of 15 years of contribution. The second (third) pillar provides pensions from individual accounts financed by mandatory (voluntary) contribution. In particular, the new system targets a replacement rate of 58.5 percent for an individual who has a life expectancy of 70 years and contributes to her account for 35 years. Nevertheless, the actual replacement rates turn out to be substantially higher (except for high-income group). For instance, Lin and Ding (2007) show an average replacement rate of 72.4%.

More recently, a new reform was implemented after the State Council issued "A Decision on Improving the Basic Pension System for Enterprise Workers" in 2005. The reform adjusted the proportion of taxes paid by enterprises and individuals and the proportion of contribution for individual accounts. Moreover, the reform changed the first pillar dramatically. Now, the replacement rate of an individual is entirely determined by years of contribution: One year contribution increases the replacement rate of the average wages and the individual wages by one percentage point. The new reform announced a targeted replacement rate of 59.2%. Although the rate is 0.7 percentage points higher than the target of 1997, the actual replacement rates decline dramatically. According to Lin and Ding (2007), the average actual replacement rate drops to 60.3%, more than 12 percentage points lower than that in the old system.

We next present a quantitative assessment on the evolution of the Chinese pension system. Due to the lack of data on historic earnings, replacement rates of individual earnings are hard to obtain. Instead, we compute the replacement rate as a percentage of average pensions per retiree over average wages per worker, which has been widely adopted in the literature (see, e.g., Imrohoroglu et al., 1995; Conesa and Krueger, 1999).[22] Chinese Statistical Yearbook

[22] Some studies have already pointed out that wages outgrow pensions considerably since the mid 1990s, making the system less favorable to the retirees (e.g. Dunaway and Arora, 2007, Yang et al., 2009).

reports “Pensions for Retired and Resigned Persons per capita” up to 2005. We then divide this variable by “Average Wage of Staff and Workers” to generate a proxy for the replacement rate. The solid line in Figure 6 plots the results from 1992 through 2005. Although there is little direct evidence on the generosity of the Chinese pension system before and after the 1997 reform, the impressionistic view is that the original work-unit-based pension system entails larger inter-generational redistribution. This is consistent with the dramatically declining replacement rates after 1997 as shown by the figure: The rate dropped from an average above 80% in the mid 1990s to 58% in 2005. Dunaway and Arora (2007) report a similar but less dramatic pattern. They show that the replacement rate of the average manufacturing wages declined from 82% in 2000 to 68% in 2005.

[Insert Figure A-1]

Alternatively, we may use pensions data in UHS. One caveat is that since 2002, UHS has adopted a new definition of pension that covers a lot more items other than the narrowly-defined pension, such as the reimbursement of medical expenditure from enterprises and the public health care system. To maintain the data consistency, we only compute the ratio of average pensions per pension beneficiary over average earnings per worker for the period 2002 to 2007. The results are plotted by the dotted line in Figure 6. Again, the replacement rate features a downward trend, declining from 61.8% in 2002 to 52.4% in 2007. Note that a significant part of the decline occurred after 2005, which is in line with the finding that the 2005 reform implies lower actual replacement rates than the 1997 reform.

Table 1 The Increase of the Average Saving Rates from 1992-1994 to 2006-2008

	(1) All ages	(2) 25-40	(3) 41-50	(4) 51-60
High/technical school	6.66	8.42	3.78	8.83
College and above	8.50	10.50	6.98	9.07

Column (1) gives the increase of the average saving rates in three education groups from 1992-1994 to 2005-2007. Column (2) to (4) give the increase of the average saving rates of households with household head age of 25-40, 41-50 and 51-60, respectively.

Table 2 Beaudry and Green's Regressions

Dep. Variable	Log of real annual earnings				
	(1) Full sample	(2) Middle school	(3) Middle school	(4) High school	(5) College
Constant	-9.6584***	0.1186	-4.3893***	-7.7232***	-12.6889***
	(-5.47)	(0.04)	(-7.11)	(-3.09)	(-4.58)
Cohort	0.1299***	-0.0320	0.0533***	0.1412***	0.2252***
	(4.19)	(-0.6371)	(76.93)	(3.22)	(4.62)
Cohort Sq.	-0.0002	0.0008**	-	-0.0006*	-0.0010***
	(-1.01)	(2.08)		(-1.78)	(-2.73)
Cohort*Age	**-0.0011****	**0.0011**	-	**-0.0012***	**-0.0021*****
	(-2.46)	**(1.46)**		**(-1.84)**	**(-2.99)**
Age	0.3178***	0.0817	0.1362***	0.2251***	0.3439***
	(9.55)	(1.5167)	(7.08)	(4.78)	(6.58)
Age square	-0.0042***	-0.0012**	-0.0015***	-0.0022***	-0.0033***
	(-11.70)	(-2.01)	(-3.17)	(-4.28)	(-5.80)
Age cube	0.0000***	0.0000***	0.0000***	0.0000	0.0000***
	(12.25)	(2.87)	(2.75)	(3.77)	(4.50)
Aggregate Detrended Earnings	1.0304*** (12.15)	0.6806*** (4.95)	0.9373*** (14.75)	0.9743*** (8.11)	1.0922*** (8.20)
Obs.	576	576	576	576	576
Ad. R^2	0.9831	0.9391	0.9336	0.9601	0.9709

Column (1), (2)-(3), (4) and (5) are regressions for the full sample (all workers included), middle-school-and-below, high/technical-school and college-and-above educated, respectively. *t* statistics are in parentheses. ***, ** and * stand for significance at 1%, 5% and 10%, respectively.

Figure 1 The Aggregate Household Saving Rates

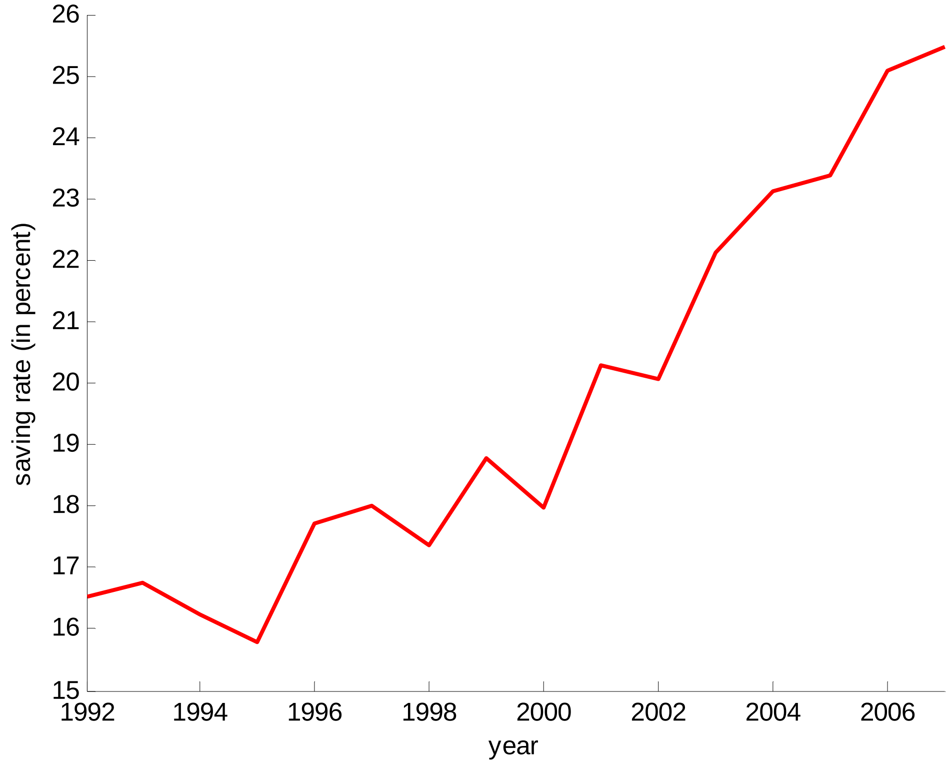
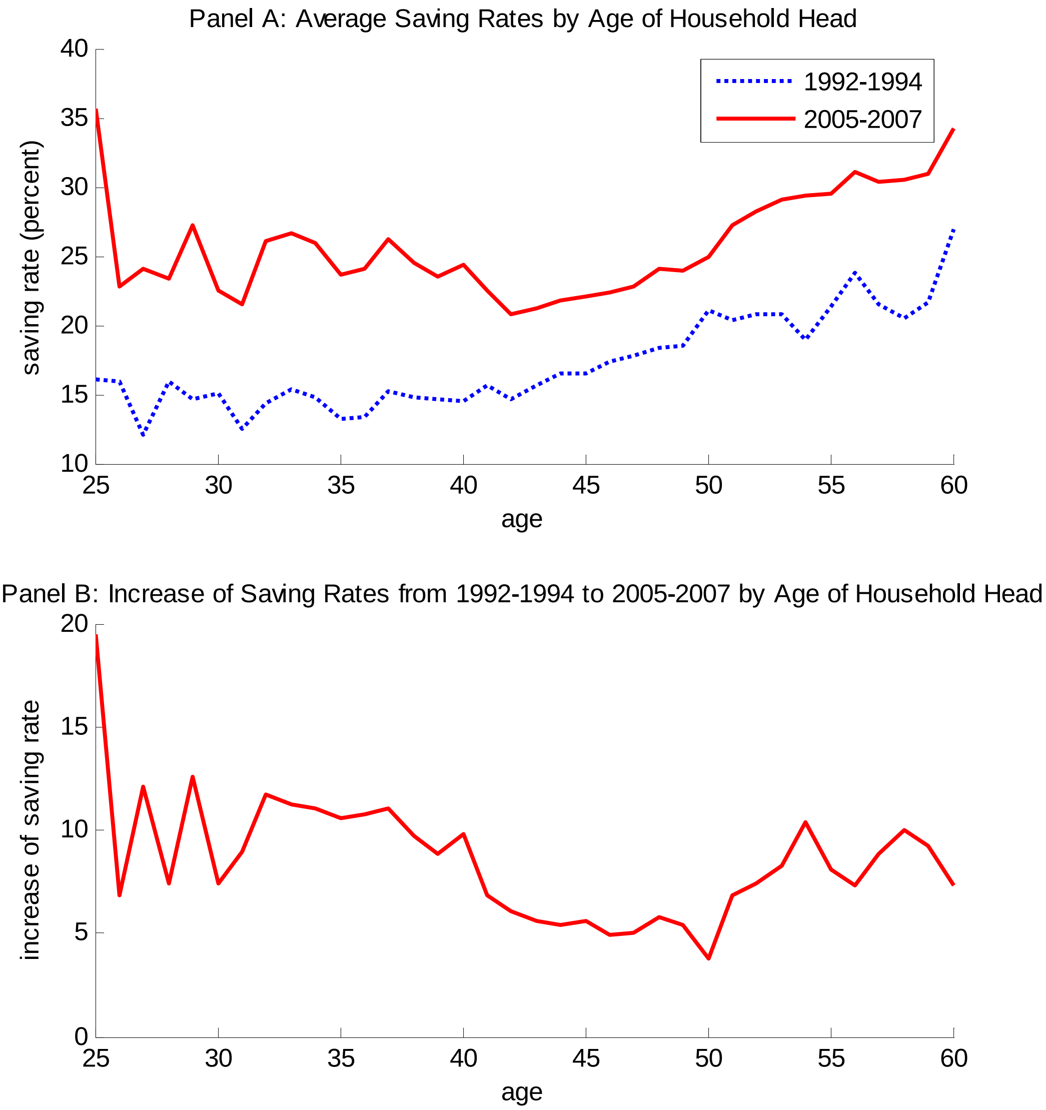
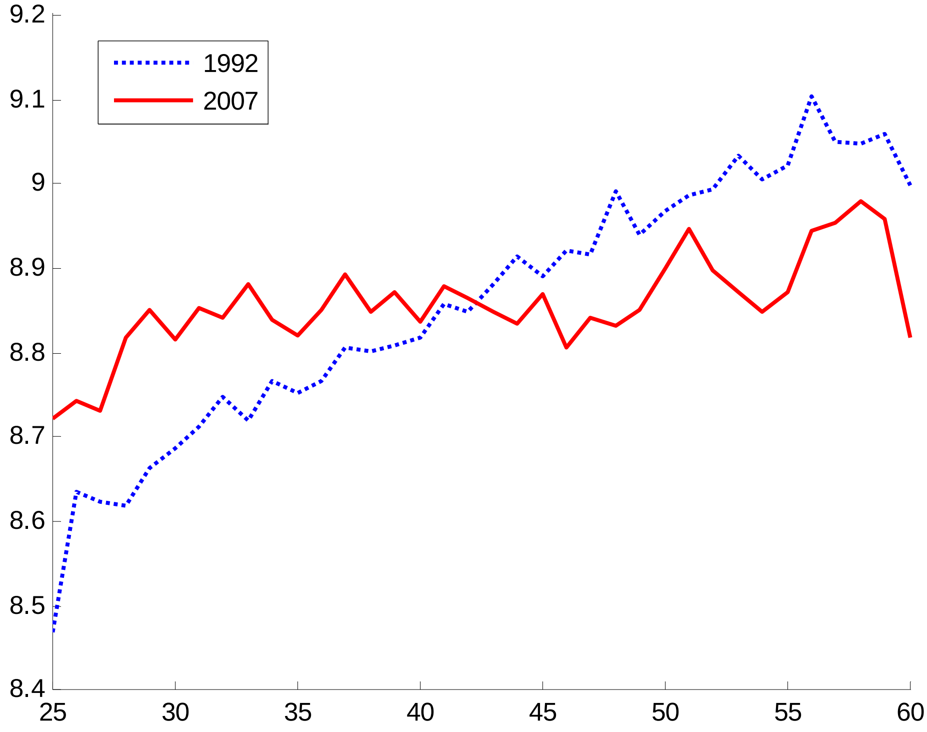


Figure 2 Cross-Sectional Life-Cycle Saving Rate Profiles



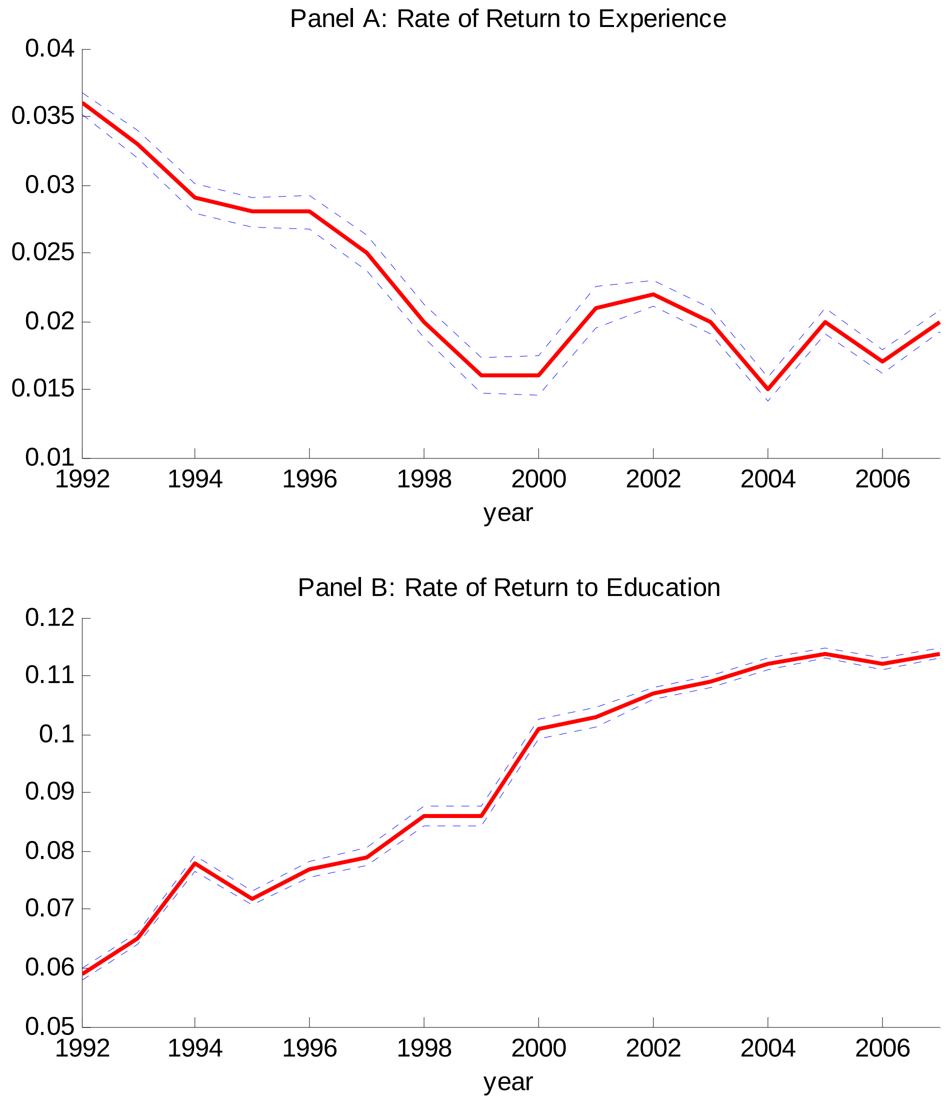
The dotted and solid lines in Panel A refer to the cross-sectional age saving rates profiles averaged over 1992-1994 and 2006-2008 (weighted by the number of observations in each age cell), respectively. The line in Panel B plots the increase of average saving rates from 1992-1994 to 2006-2008 (namely, the difference between the two profiles in Panel A).

Figure 3 Cross-Sectional Life-Cycle Earnings Profiles



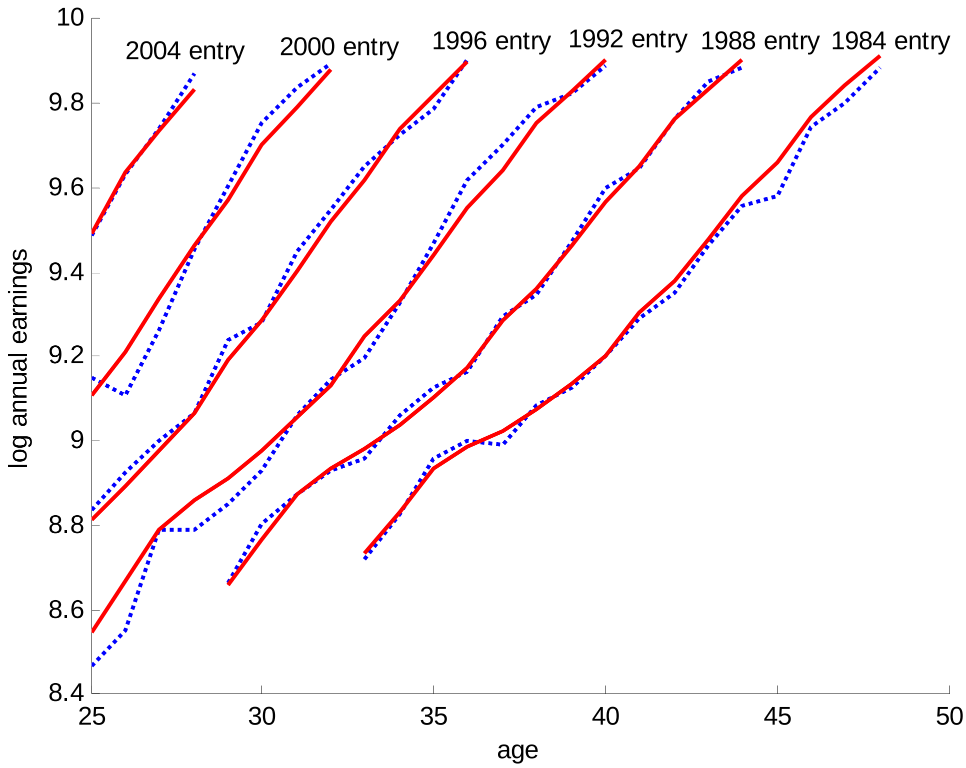
The dotted and solid lines refer to the cross-sectional age earning profiles in 1992 and 2007, respectively. The scale of the profile for 2007 is adjusted such that the mean of age earnings is equalized across 1992 and 2007.

Figure 4 Mincer's Regressions



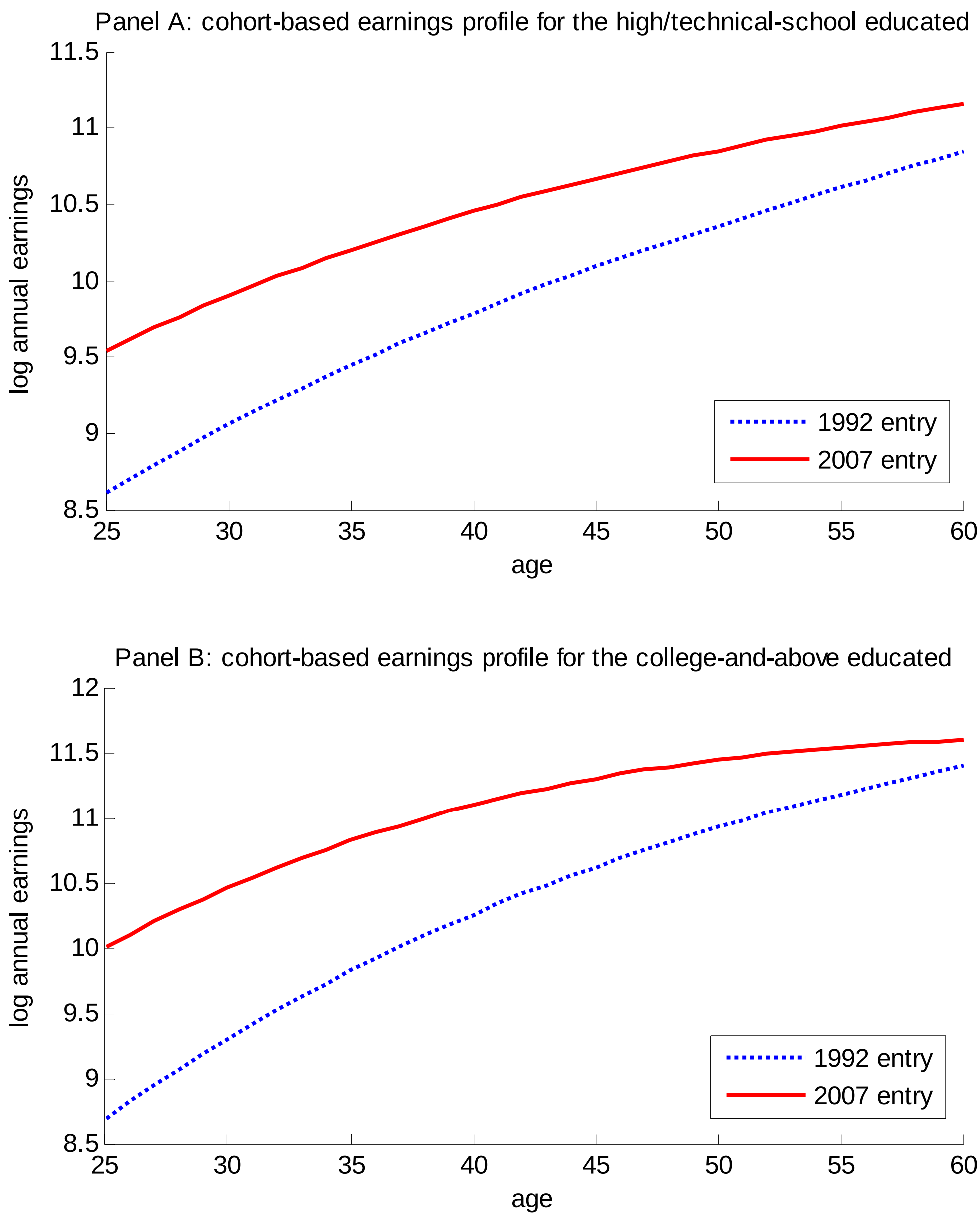
Panel A and B plot the estimated coefficient on years of experience and years of schooling in the Mincer's regression, respectively. Dotted lines present 95% confidence limits.

Figure 5 Life-Cycle Earnings Profiles by Cohorts



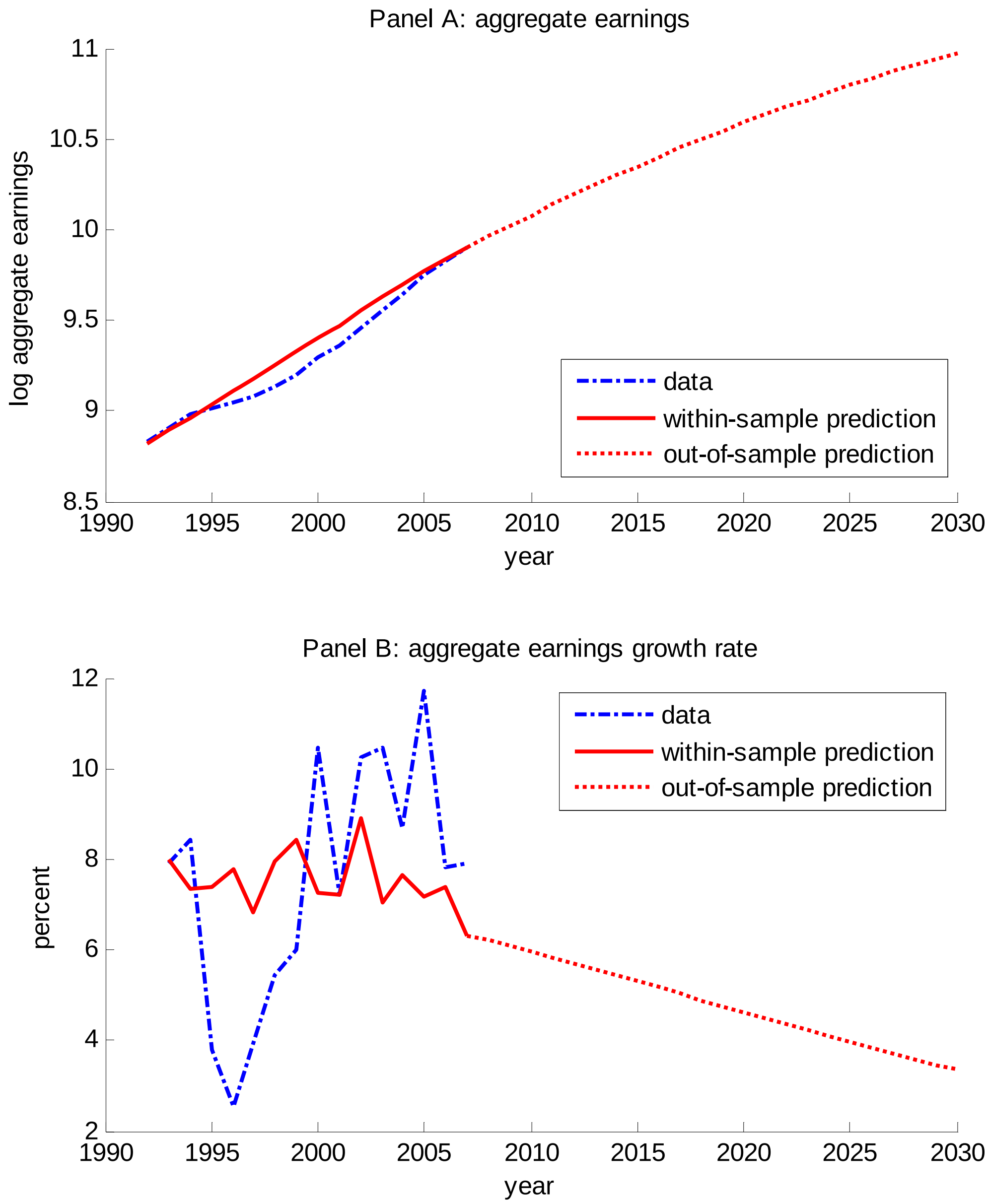
The dotted lines are log annual earnings by cohorts. The solid lines are predicted earnings according to the regression results in column (1) of Table 2.

Figure 6 Estimated Life-Cycle Earnings Profiles



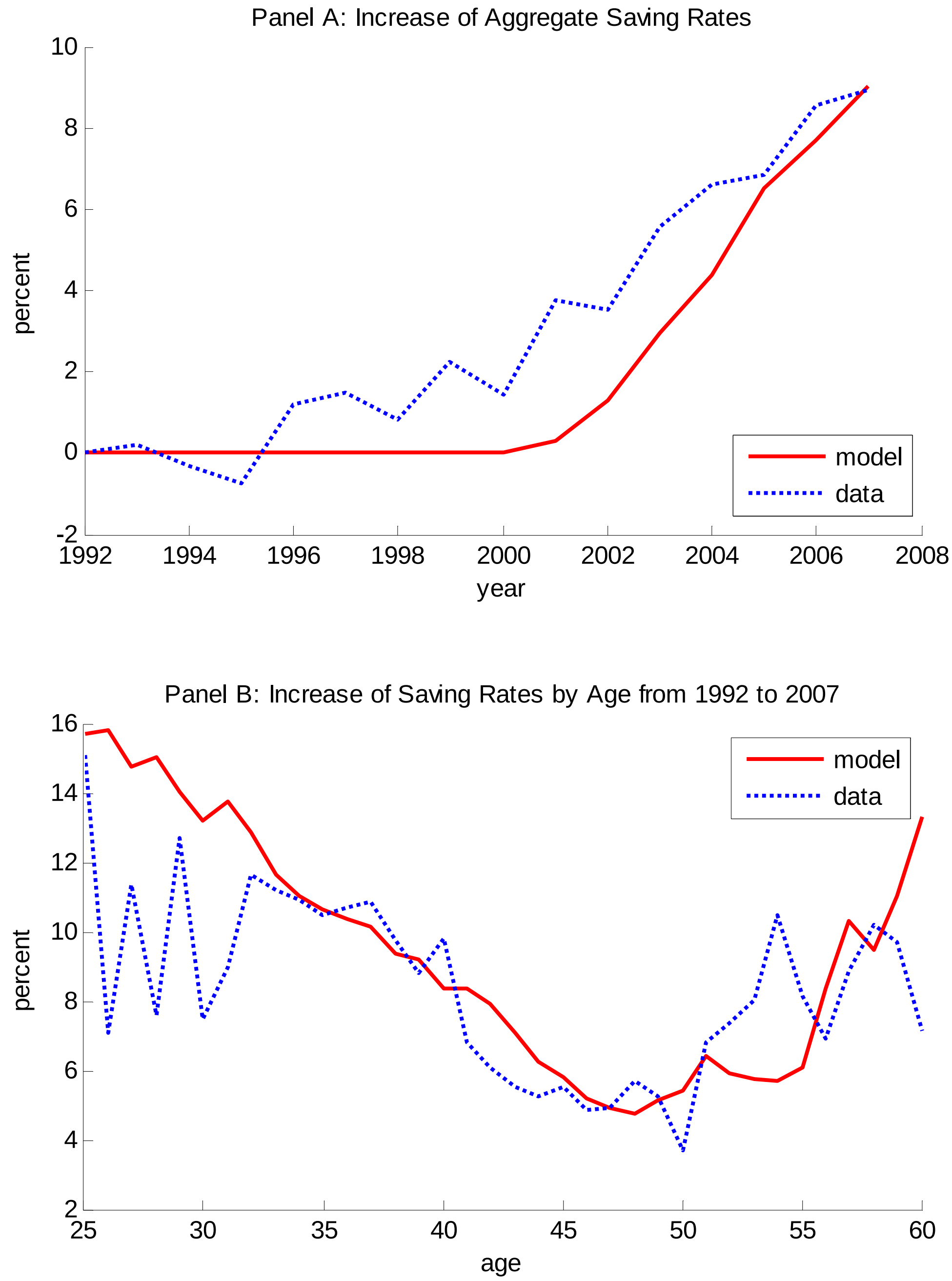
Panel A and B plot the predicted life-cycle earnings profiles for the high/technical-school and college-and-above educated, respectively, according to the estimates in column (4) and (5) of Table 2. The out-of-sample detrended aggregate earnings are set equal to the sample average.

Figure 7 Aggregate Earnings Growth



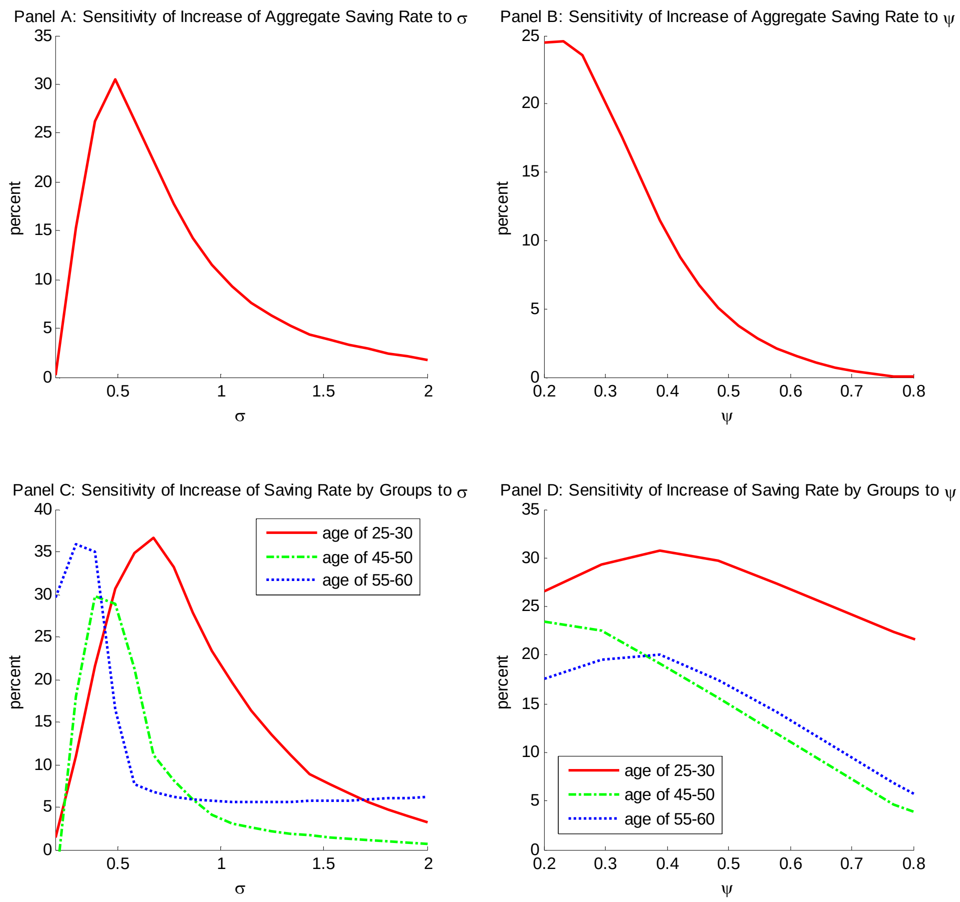
Panel A plots observed log aggregate earnings (dashed line) and the predicted log earnings (solid and dotted lines, representing within-sample and out-of-sample prediction, respectively) by estimates in column (3) to (5) of Table 2. Aggregation is based on observed distributions over age and education for years in the sample period and the 2007 distribution for years afterwards. Panel B plots aggregate earnings growth rates. The out-of-sample detrended aggregate earnings are set equal to the sample mean.

Figure 8 Simulation Results under Perfect Foresight



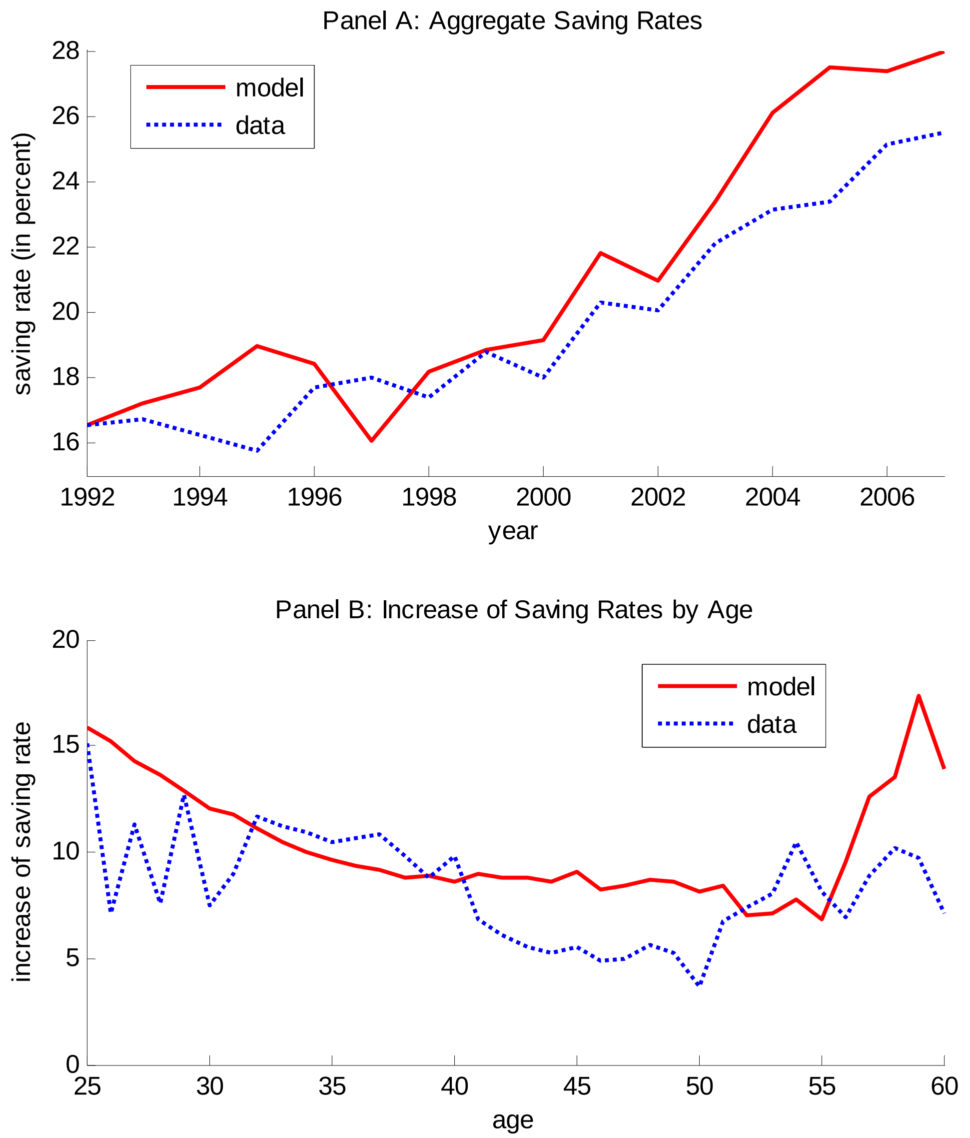
Solid lines in Panel A and B plot the simulated increase of saving rate at the aggregate level and over the life cycle, respectively, under the benchmark parameterization (see the text for details). Dotted lines plot the increases in the data.

Figure 9 Increase of Saving Rate from 1992 to 2007 (Simulation Results)



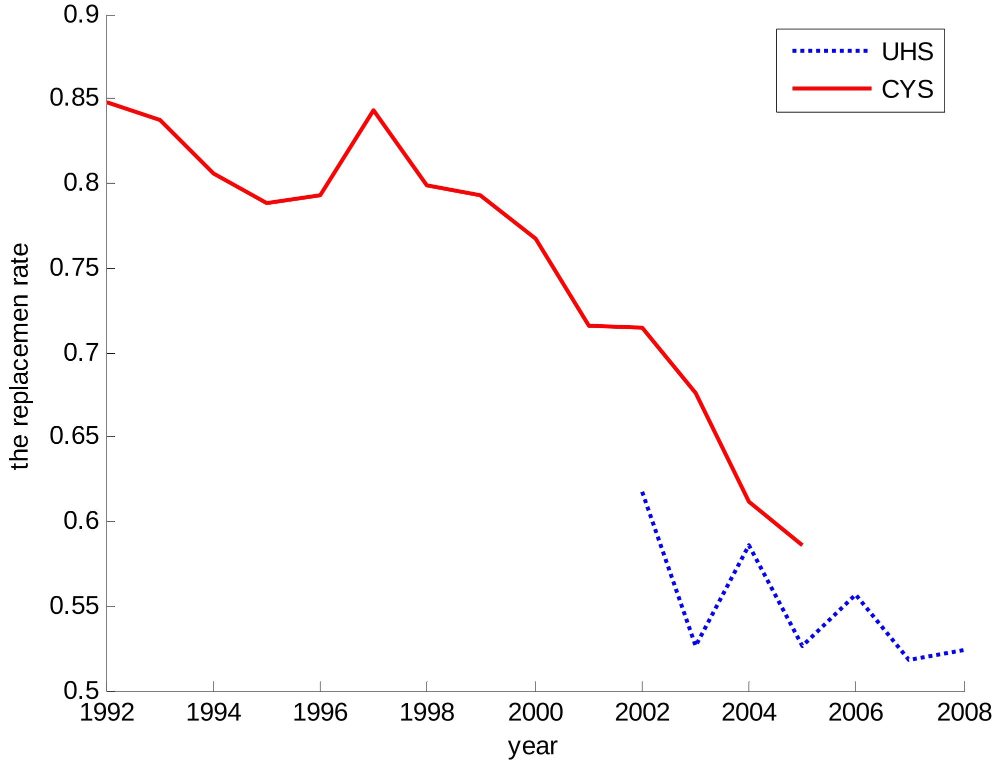
This figure plots the sensitivity of the increase of saving rate at the aggregate level (Panel A and B) and by age groups (Panel C and D) to the inverse of intertemporal elasticity of substitution (Panel A and C) and the replace rate (Panel B and D).

Figure 10 Simulated Results under Myopic Expectation



Solid lines in Panel A and B plot the simulated increase of saving rate at the aggregate level and over the life cycle, respectively, under myopic expectation. Dotted lines plot the increases in the data.

Figure A-1 Replacement Rates



The solid line is the ratio of pensions for retired and resigned persons per capita over average wage of staff and workers. Data source: China Statistical Yearbook (2006). The dotted line is the ratio of average pensions per pension beneficiary over average earnings per worker. Data source: UHS.