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ABSTRACT

We present a model of household life-cycle saving decisions in order to quantify the impact of demographic changes on aggregate household saving rates in Japan, China, and India. The observed age distributions help explain the contrasting saving patterns over time across the three countries. In the model simulations, the growing number of retirees suppresses Japanese saving rates, while decreasing family size increases saving for both China and India. Projecting forward, the model predicts lower household saving rates in Japan and China.

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Introduction

Momentous demographic transitions have been occurring throughout the world since the mid-20th century. Declining fertility and mortality have combined to profoundly change the population age distribution in many countries. These demographic shifts have serious long-term macroeconomic implications. Variations in the age distribution alter the ratio of savers to non-savers and changes the size of households, both of which affect the aggregate saving rate, capital formation, the viability of pension schemes, labor supply, and may ultimately affect the long-run economic growth rate.

This paper studies one aspect of the age distribution's effect: the impact on the aggregate household saving rate. We show that a life-cycle model of saving behavior coupled with the observed demographic changes accounts for a substantial share of the time-variation in aggregate household saving rates from 1955 through recent years in Japan, China, and India. We focus on these countries for two reasons. First, they are large. China and India together are home to over a third of humanity. By GDP (PPP basis), Japan, China, and India are 3 of the 4 largest economies in the world. Second, all three countries have experienced substantial variation in their demographics and household saving rates.

Each of these countries has embarked on the demographic transition from a relatively young to an aging population. However, their transitions have occurred at different times and on different scales. Consequently, Japan, China, and India currently have distinctly contrasting demographics. Japan is the oldest country in the world with an elderly population (over 63) share of 28 percent. Japan's total population peaked in 2009 at 127 million and is projected to continue falling for the foreseeable future. In China, the majority of the population is in its prime working years (ages 20-63), but its population will also age considerably in the near future. India, on the other hand, is a relatively young country, with an elderly population share of just 6 percent.

The household saving rates in these countries also show substantial variation over time. Japanese households had high saving rates in the 1970s and 1980s. As their population has aged, however, Japan's saving rate has fallen. In China, the saving rate was low under the central planning regime. Since the onset of economic reforms in 1978, Chinese saving has soared to the point where, at nearly 30 percent, the Chinese household saving rate now ranks among the highest in the world. Saving in India follows a pattern similar to China in that it generally has increased over time, approaching 25 percent by 2007. The large variation in saving rates and demographic profiles make Japan, China, and India an attractive set of countries to study the life-cycle hypothesis of household saving.

Our model is adapted from Curtis et al. (2015) and features Barro and Becker (1989) style preferences with children in the utility function. The agents live up to 95 years. From birth to age 19, individuals make no decisions and are part of their parent's household. Beginning at age 20, individuals form their own household, work, and make saving and consumption decisions. From age 20 until retirement, agents support children. Working age parents decide how much to consume and how much to save for retirement, and they transfer, as a tax, a portion of their wages to current retirees both through a formal national pension system and as an informal intergenerational transfer. Retirees live off of accumulated assets, their pension, and family transfers.

Agents take wages, interest rates, and the demographic structure (including the number of dependent children) as exogenously given. Dependent children's and parent's consumption both enter into parent's (household) utility. Having household saving and consumption decisions explicitly depend on the number of children in the household is a natural way to consider the impact of declining family size on saving rates.

In addition to family size, the model features three other channels through which demographics affect saving. First, a large cohort of households in their prime-earning years increases aggregate saving, while relatively more retirees decreases aggregate saving (all else constant), due to a simple composition effect. Second, as life spans increase, model agents save more for their longer expected retirement.[1] Third, as fertility decreases, forward looking prime-age agents save more as they expect less retirement support from the smaller cohorts that follow.

Applied separately to each country and considering only differences in demographics, the model can qualitatively replicate the core aspects of the saving patterns in Japan, China, and India. Quantitatively, the simulations do not account for all the observed changes; factors other than demographics affect saving. However, since the large demographic changes occurred at different times and under different circumstances, we think our results represent a powerful confirmation of the life-cycle theory of household saving.

We conduct two exercises to disentangle the demographic channels. First, by removing children's consumption from the parent's utility function, we show that the reduction in family size is an important factor for explaining the increased saving rates in China and India. Second, we hold age-specific saving rates fixed in the model, while allowing the age distribution to change as in the data. This computation gives us a measure of the composition effect, which has the largest impact on Japan. The growing retired population is the most important factor for explaining the decline in Japan's household saving rate within our baseline model.

The main results of the paper are generated by this baseline model, which isolates the effects of demographics by imposing uniformity in other dimensions across the countries. However, we also run model simulations with country specific differences in the government-run pension systems, informal intra-family intergenerational support, returns to saving, wage growth rates, and age-wage and age-family size profiles. The impact from the changing demographics on household saving remains large even when incorporating all of these other factors.

Finally, we use the model to project the changes in household saving rates generated by future demographic changes for each country through 2050. Japan will age further and is projected to have a working-age to elderly ratio below 1.25 by 2050. Accordingly, our model predicts that Japanese household saving rates will continue to fall as the country ages further. Demographic factors also will cut China's saving rate. The ratio of working aged Chinese to elderly is projected to fall from 6 in 2014 to around 2 in 2050. As the currently large working age population moves into retirement, our model predicts a 12 percentage point decline between now and 2050. India, on the other hand, is projected to maintain a high household saving rate. India is the youngest of the three countries; falling family sizes and a growing share of the working aged will continue to boost aggregate household saving rates.

[1]See Bloom et al. (2007) for a more complete analysis of lifespan, retirement age, and saving.

Our paper employs a common framework to understand how saving rates have responded to demographic transitions in the three largest Asian economies. The ability of the model to capture the broad features of the data for populations with varied experiences gives us confidence in the transferability of the basic mechanisms to other countries. To our knowledge, the application of quantitative life-cycle saving models of this sort to India is new. Contributions to the modern literature on saving in India include Athukorala and Sen (2004) and Mehta (2013), but they focus on empirically documenting the increase in household saving. Related work on Japan includes Chen et al. (2007) and Braun et al. (2009). These papers cover an earlier period and stop before the population began to decline. Notable recent papers on saving in China include Banerjee et al. (2014), Chamon and Prasad (2010), Chao et al. (2011), Choukhmane et al. (2013), Horioka and Wan (2007), Modigliani and Cao (2004), Rosenzweig and Zhang (2014), Song et al. (2015), Song and Yang (2010), and Wei and Zhang (2011).

The remainder of the paper is organized as follows. Section 1 discusses the aggregate data on household saving and demographics and emphasizes the contrasting patterns over time across the three countries. Section 2 presents the model used to link demographics to household saving decisions. Section 3 details the parameterization of the model and presents simulation results demonstrating the importance of demographics for explaining saving rates. Section 4 concludes.

1 Household Saving and Demographic Patterns

Figure 1 shows aggregate household savings as a percent of household income in Japan, China, and India over time.[2] Saving in each country has displayed substantial variation. Japan's saving rate increased from an already high 12 percent in 1955 to a peak of over 23 percent in the mid 1970s. Then, the saving rate began to fall, while, especially since 2000, the population quickly aged. By 2012 Japanese households saved less than 5 percent of their income.

In stark contrast, Chinese households currently save nearly 30 percent of their income, but their saving rates were quite low before economic reforms began in 1978. China's saving rate began to climb around 1980, increasing from 12 percent to 16 percent by 1986, dropping back to 11 percent by 1989, and then increasing more or less steadily thereafter. India's saving rate also has risen steadily over time. Indian households saved less than 10 percent of their income before 1970, but they have saved nearly 25 percent in recent years.[3]

While each country experienced large swings in their household saving rate, the patterns differ. Japan had high saving rates in the 1970s, while Chinese and Indians saved little. Now, Japan has low saving rates, while China and India enjoy high levels of saving. Our hypothesis is that these divergent saving patterns are explained, at least in part, by differential demographic patterns across the countries.

Figure 2 graphs the share of the population in three broad age groups for each country from 1950 through to 2050. The historical and projected data comes from the United Nations (UN) Population Prospects 2012 Revision. The bottom area corresponds to the share of the population below the age of

[2]The Appendix lists the sources for the aggregate household saving rates and the demographic information used throughout the paper.

[3]Our data ends in 2007; however, the available evidence suggests that household saving in India has remained high.

20 (a rough measure of dependent children), the middle group is the share older than 64 (the retired), with the remainder being the working age population.

Looking across the three panels, Japan (Panel A) has the oldest population with the lowest share under 20 and by far the most in retirement. Japan faces a major demographic challenge. While Japan's youth share has stabilized near 20 percent, the share of its population in retirement age exceeds 25 percent and is still growing. Japan is now considered the oldest country in the world.

China (Panel B) has experienced the most dramatic decline in the youngest share. Fifty percent of the Chinese population was under 20 in the 1970s, compared to less than 25 percent today. China remains much younger than Japan, but will experience dramatic aging. The proportion of the working aged population began to fall in 2012 and will continue to decline through the foreseeable future. At the same time, the relative size of the retired population will expand.

India's demographics (Panel C) follow a pattern similar to Japan and China, but the onset of demographic change was later and more gradual. The share of the population under 20 has been declining since 1970. However, compared to Japan and China, India has, and is expected to maintain, a higher share under 20 and a lower share over 63. The working aged share of the population in India is still increasing and will continue to do so through 2050.

Declining birth rates have been a key determinant behind these demographic shifts. Figure 3 shows total fertility rates in each country from 1950-2012. Following a temporary increase after WWII, Japanese fertility rates declined to 2 in 1960, increased to 2.16 in 1971, then gradually declined to the current rate of 1.4.[4] After peaking at 127 million in 2009, the total population began to decline and is projected to fall to 87 million by 2060. As documented in Ogawa et al. (2010), Japan was the first country in the post-war period to experience fertility decline.

Reasons suggested for Japan's low fertility are varied.[5] Abortion has been legal in Japan since 1949 and was a widely used method of birth control in the 1950s and 1960s.[6] A cultural bias against married women in the labor force, the general unavailability of child care, and low wage growth may have contributed to fewer marriages and smaller family sizes. Also, compromised quality of family life due to the grueling 'salary-man' culture tied to corporate employment might inhibit family size.

China also currently has a low fertility rate. In the beginning of our sample, however, Chinese fertility rates were high. During the 1950s and 60s, Communist Party Chairman Mao Zedong's view was that a large population, and therefore a large labor force, translated into economic might. As a result, no efforts to reduce fertility were undertaken until 1972. Then, a voluntary campaign, known as 'Later, Longer and Fewer,' was launched to encourage couples to delay marriage, increase the spacing

[4]The sharp dip in fertility during 1966 occurred because it was the year of the Fire Horse (Hineouma) according to the Japanese Zodiac calendar. Many families avoided having children due to the superstition that children, especially girls, born during the Fire Horse are bad luck.

[5]Japanese people have had a long history of voluntary limitations on family size and self-imposed population control. The imposition of a caste system in the 1700s eliminated social mobility and rendered economic advance to inherited capital, which by convention was available only to the first son. This led to delays in the age of marriage, and abortion and infanticide in the case of multiple pregnancies (Flath, 2000).

[6]Kato, Mariko. "Abortion Still Key Birth Control." The Japan Times 20 Oct. 2009. Accessed Japan Times Web. 6 Feb. 2015. http://www.japantimes.co.jp/news/2009/10/20/reference/abortion-still-key-birth-control/#.VPPOA_nF98E

between children, and limit the number of children to two. Although Later, Longer and Fewer was successful, the Communist Party intensified efforts to reduce fertility by formally adopting the One-Child policy in 1980. The first five years of the policy were characterized by compulsory insertion of intra-uterine devices for women with one child and sterilization for couples with two children (Naughton, 2007). Hefty financial penalties are still sometimes imposed on those with more than one child and termination of employment is also a possibility. The fertility rate has plummeted in response to the family-planning policies.

In 2013, India, the world's second most populous country, had 1.25 billion people. While China's harsh one-child policy is well known, perhaps less known is that India also has a history of fertility reduction policies. In 1952, India implemented family planning policies using voluntary sterilization as the primary method. In the 1970s, under the Indira Gandhi government, the National Population Policy was launched, which allowed individual states to enforce compulsory sterilization. While the forced sterilization policy was never officially discharged (only one state passed such a law but did not enforce it), the government's role in reducing fertility has been viewed as coercive.[7] As a result, the Indian fertility rate (Figure 3) has dramatically declined from above 5 to the current rate of 2.4, and it is projected to fall below the replacement rate by 2030.

To summarize, the saving rates and demographic profiles display substantial variation across the three countries and over time. Each country experienced large swings in their household saving rate, but the patterns differ. Japan had high saving rates in the 1970s, while Chinese and Indians saved little. Presently, Japanese saving rates are very low, and very high in China and India. The age distributions depicted in Figure 2 suggest several ways through which demographics may affect saving. The preponderance of older people in Japan almost certainly reduces its aggregate saving rate because retirees live off of their accumulated assets rather than accumulating new savings. While in China and India, the current, relatively large, working age populations are saving in anticipation of their retirement years. These large cohorts in China and India also have (relatively) few dependent children to support, as fertility rates have declined. Thus, households in China and India have more resources available to save than they would with larger families. Plus, looking forward, Chinese and Indian households will have few working age children to provide support upon retiring, so these households are accumulating assets now. Next, we build these linkages between demographics and saving into a life-cycle model of saving decisions.

2 A Life-cycle Model Relating Demographics to Saving

The model is adapted from Curtis et al. (2015) which builds on the framework presented in Auerbach and Kotlikoff (1987). The economy is populated by 95 generations. People live up to 95 periods or years, but only agents aged 20 to 95 make decisions. All agents of the same age are identical, and they take the current and future age distribution as given.

We classify the population into three groups: children (age 0 to 19), working age parents (age 20 to

[7] See Diamond-Smith and Potts (2010).

63), and retirees (age 64+). For the first 19 years, people live as children dependent on their parents, consuming what their parents choose for them. Parental and dependent children's consumption both enter separately into household utility as in Barro and Becker (1989). People support children, supply labor inelastically, and receive labor income from age 20 until retirement. Children who leave the household after age 19 no longer receive consumption from their parents, and upon retiring, parents no longer support children. Retired people live off of their accumulated assets, any family transfers from their working age children, and their pension (which we model as a pay-as-you-go scheme). Agents die with an age and cohort specific probability prior to age 95 and with certainty at age 95. In the last year of life, utility depends only on consumption.[8]

2.1 Budget Constraints

Let $c_{t,j}$ be the year t consumption of an individual with decision-making age $j \in [0, 75]$, where $j = 0$ corresponds to real-life age 20. We suppress the notation indicating country. For a parent with age $j \in [0, 43]$, $n_{t,j}$ denotes the number of dependent children in the household, each of whom consumes $c^c_{t,j}$.[9] During the parenting years, agents choose their own consumption $c_{t,j}$, their dependent children's consumption $c^c_{t,j}$, and (non-negative) assets $a_{t+1,j+1}$ to take into the next period. Working age people take the gross return on savings $1 + r_t$ and labor income (age-dependent wage) $w_{t,j}$ as given and pay fraction τ_t of their wages into the formal pension system, while also transferring fraction τ^c of their wages to retirees through an informal family support network.[10] The flow (period-by-period) budget constraints for households with children are

$$c_{t,j} = (1 - \tau_t - \tau^c)\, w_{t,j} + (1 + r_t)\, a_{t,j} - a_{t+1,j+1} - n_{t,j} c^c_{t,j}, \qquad j \in [0, 43]. \tag{1}$$

The model agents continue working and supporting children until age 64 ($j = 44$). Retirees consume out of accumulated assets and (family and pension) transfers $p_{t,j}$ received from the current working generations. Retirees consume all remaining assets and die with certainty at age 95 ($j = 75$). The budget constraints for retirees are

$$c_{t,j} = p_{t,j} + (1 + r_t)\, a_{t,j} - a_{t+1,j+1}, \qquad j \in [44, 75], \tag{2}$$

with $a_{t+1,76} = 0$.

Old-age support $p_{t,j} = g_{t,j} + f_{t,j}$ has two components to allow the system of government pension transfers g to differ from informal family transfers f. The tax rate τ_t adjusts every period to fund

[8] We experimented with variations of the model including either an explicit bequest motive or accidental bequests due to early death in the case of China. The simulation results were similar to the model without bequests. For Japan, earlier research has found that bequests are not an important determinant of saving (Hayashi, 1995). To maintain simplicity in the model, we proceed without bequests.

[9] Consumption by children should be interpreted broadly to include things like spending on education and housing. Saving for future education or housing expenditures could be another mechanism relating family size to household saving, but our model does not explicitly include these considerations. See Wang and Wen (2011) for more on the topic.

[10] The informal family transfer should be interpreted broadly to include non-financial transfers. See Pal (2007) and Rosenzweig and Zhang (2014) for more on the decision to co-reside, for example.

constant replacement rate government pension payments to retirees, where the replacement rate equals the percent of final working year ($j = 43$) wages received as a pension (i.e. $\frac{g_{t,j}}{w_{t+43-j,43}}$, $j \in [44, 75]$). In contrast, the rate τ^c for the informal family transfer remains fixed. Thus, the size of the family transfer $f_{t,j}$ received depends on the number of working adults paying support to each specific cohort of retirees. Cohorts of retirees with more children receive a higher family transfer, all else constant, because they have more children providing support.

Demographics work through the budget constraints to affect saving decisions in a few ways. First, in Equation (1) a decline in the number of dependents ($n_{t,j}$) frees up resources for asset purchases ($a_{t+1,j+1}$). China and India have had large decreases in family size in recent years, reducing $n_{t,j}$. Second, a large population with ages $j \in [0, 43]$ increases the saving rate through increased numbers of people who are saving from labor income. Or conversely, as in Japan, large retired cohorts with ages $j \in [44, 75]$ reduce aggregate savings as these households consume their accumulated assets. Finally, looking at Equation (2), the declining support ratios in China and India mean there will be relatively small future family transfers f, making total old-age support p small for the current working age cohort upon retiring. Chinese and Indian households can overcome this shortfall by aggressively accumulating assets during their working years, i.e. now.

2.2 Preferences

Preferences for households with dependent children take the functional form of Barro and Becker (1989), in which consumption by parents and children enter separately into household utility. The per-period utility function for a household head of decision-making age $j \in [0, 43]$ in year t is

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

The parameter σ is the inverse of the elasticity of inter-temporal substitution, and $\mu \in [0, 1]$ and $\eta \in [0, 1]$ characterize the weight parents put on utility from children's consumption. The number of children $n_{t,j}$ is expressed on a per-person basis as households are single-parent families. Beginning at age 64, individuals stop supporting children and have the flow utility function

$$u_{t,j} = \frac{c_{t,j}^{1-\sigma}}{1-\sigma}, \quad j \in [44, 75].$$

Let $\beta \in [0, 1]$ be the subjective discount factor, and $\delta_{t,j} \in [0, 1]$ be the cohort (and country) specific probability of living to age $j \in [44, 75]$. All agents in the model live to at least age 63. A 20 year old in year t chooses a sequence of consumption, consumption for children, and asset holdings in order to maximize lifetime utility,

$$\begin{aligned} U_t = &\sum_{j=0}^{43} \beta^j \left(\mu \left(n_{t+j,j}\right)^{\eta} \left(\frac{\left(c^c_{t+j,j}\right)^{1-\sigma}}{1-\sigma} \right) + \left(\frac{c_{t+j,j}^{1-\sigma}}{1-\sigma} \right) \right) \\ &+ \sum_{j=44}^{75} \delta_{t+j,j} \beta^j \left(\frac{c_{t+j,j}^{1-\sigma}}{1-\sigma} \right), \end{aligned} \tag{3}$$

subject to the budget constraints in Equations (1) and (2). Agents make decisions taking the current and future demographic structure and family size ($n_{t,j}$) as exogenous and known.

Family size affects saving through preferences because the effective weight on utility during parental years depends on the number of dependent children in the household, n. If $n_{t,j} = 0$ or $\mu = 0$, then the household problem collapses to the case without children in the utility function. When the effective weight on parental utility increases with family size, as it does in all our simulations, the household with more children acts as if it is less patient. Thus, family size affects saving by altering the household's effective weight on utility for the parental years. This channel is key for the model's ability to explain the evolution of saving rates in China and India. Next, we discuss the selection of parameter values and use the model to quantify the size of the demographic effect in each country.

3 Quantifying the Effect of Demographics on Saving

This section reports the simulated saving rates generated by embedding the demographic data presented in Section 1 into the model developed in Section 2. We begin by discussing the selection of parameter values. Then, we study the model's properties using only the differences in country-specific, time-varying, age distributions, while keeping the other parameters fixed. This baseline version of the model focuses on the demographic-based mechanism at the heart of our story; demographics explain a sizable portion of the variation in the aggregate household saving rates in Japan, China, and India. We present additional experiments to further illustrate how demographics affect saving in each country. The key factors generating the saving rate dynamics are the falling number of children in China and India and the growing share of retirees in Japan. We then consider how altering the country-specific pension levels, informal intergenerational transfers, interest rates, wages, and cross-sectional fertility and wage profiles affect saving rates. Lastly, we examine the model's implications for future household saving rates.

3.1 Parameter Values

Table 1 reports the parameter values used in the baseline model simulations. The inter-temporal elasticity of substitution ($1/\sigma$) is set to 0.67. We set the time discount factor β to 0.997, as in Song et al. (2011) and Curtis et al. (2015). This value may seem high, but individuals effectively further discount the future due to the incorporation of survival probabilities δ. We calculate these age and cohort specific survival probabilities along with the age distribution from the UN population estimates for each country. All parents support the same number of children within a given year (and country), $n_{t,j} = n_t$ for all $j \in [0, 43]$, as calculated from the UN data. We relax this simplification below.

In specifying parent's attitudes toward children, we choose the same values, $\mu = 0.65$ and $\eta = 0.76$, as estimated in Manuelli and Seshadri (2009) for a model featuring the Barro-Becker children in utility function and fertility choice. Curtis et al. (2015) select slightly different values based on a calibration to China's pre-reform saving rate. Since the focus is on demographics rather than preferences, we will proceed with the Manuelli and Seshadri (2009) values.

The baseline simulations use the identical configurations for intergenerational transfers for each country so that we can isolate pure age distribution effects. We set the value for the share of labor income given to retired parents through the informal family transfer τ^c to 0.04.[11] We set the government pension payments $g_{t,j}$ so that each retiree receives a 25 percent replacement rate in every year.[12] Funding the model's pay-as-you-go constant replacement rate pension system requires the tax rate τ_t on labor income to vary. Intergenerational transfers affect saving rates, so later we implement different support levels across countries.

We separately simulate the saving decisions for households in Japan, China, and India beginning from 1955, with no aggregate wage growth and no cross-sectional wage dispersion ($w_{t,j} = w$, for all t) and a constant interest rate of 4 percent. Again, our goal is to isolate the demographic effects. Initial assets equal zero for each 20 year old (decision-age $j = 0$).[13] To solve the utility maximization problem, a 20 year old takes the next 75 years of demographic observations into account. Agents' projections for family size come from the UN data, which in the model is perfect foresight. The UN age distribution information consists of annual observations by single year age groups.

3.2 Simulated Saving Rates

Figure 4 compares the data to the baseline model economy's aggregate household saving rates when only the demographic composition and family size varies. The simulated saving rates for Japan (panel A) increase from 1955 until the early 1970s. Then, as the population ages, saving rates decrease. The decrease generated by the model leads the data slightly, and the simulated saving rate does not go as low as in the data. The model's saving rate falls below 10 percent in 2010, while the actual saving rate lies below 5 percent. Overall, however, the model generates the hump-shaped pattern seen in the Japanese time series.

For China (panel B), the baseline model generates low saving rates prior to 1980 and an upward trend thereafter. Between 1970 and 2010, the simulated saving rate increases by over 15 percentage points (compared to 24 percentage points in the data). By 2010, the implied saving rate is over 17 percent, about two-thirds the size of the actual rate. The timing for the increase in the saving rate corresponds well with the data; however, the model misses the decline in household saving in the early 1960s and the big increase and decrease during the 1980s. The age distribution evolves too slowly to explain these shorter run fluctuations.

For India (panel C), the model generates a sizable portion of the observed increase in the household saving rate. The simulated saving rate increases by almost 10 percentage points from 1970 to 2007 (compared to 15 percentage points in the data). The level lies about 5 percentage points below the actual rate over much of the sample. As we discuss in Section 3.2.2, the 25 percent pension replacement rate is much larger than the reality in India. The generosity of the pension system affects the level of

[11] This choice comes from an estimate by Choukhmane et al. (2013) based on a survey covering intergenerational transfers in China.

[12] This choice comes from Curtis et al. (2015) for China.

[13] To generate initial asset holdings for agents older than 20 in 1955, we begin the simulations in 1870 and base the pre-1950 demographic structure on Maddison Historical Data. The Appendix provides the details.

saving, but, as we show below, smaller pensions do not greatly alter the upward trend in the saving rate generated by the model.

Figure 5 plots only the countries' simulated saving rates for easy comparison. Note how the household saving rates generated for Japan contrast sharply with China and India. During the early 1970s, the model reproduces the high saving rates in Japan and low saving in China and India. By the end of the sample, though, saving in Japan has become comparatively low. In these simulations, the countries only differ in their age distributions and nothing else. Without the changes in demographics over time, the simulated household saving rates would be straight lines. Comparing the model simulations to the data, the model generates about 14 of the observed 24 percentage point increase in the Chinese saving rate since 1978, 10 of the 15 percentage point increase in India since 1970, and over 7 of the observed 20 percentage point decline in Japanese saving since its peak in 1976.

While the model successfully replicates the general dynamics of the saving patterns, demographic changes do not account for everything. Institutional and societal factors beyond demographics have affected saving rates. We have intentionally abstracted from other potential explanations, as they take us too far afield from demographics.[14] Next, we identify how the separate demographic channels impact each country.

3.2.1 Decomposing the Demographic Channels

We run two exercises in order to separate the demographic channels. In the relatively younger populations of China and India, the rapid fall in the number of children has the most influence on the rising saving rates. As fertility rates decline, and families get smaller, households have additional resources to consume *and* to save. Parents have additional incentives to save because they foresee fewer children from which they can draw support in their retirement. In Japan, on the other hand, the composition effect, stemming from the large and growing retiree share, is quantitatively the most influential demographic factor for generating the saving rate decline; retirees consume their accumulated assets.

The Impact of Dependent Children First, we examine the importance of the reduction in family size by setting parental valuation of children's utility from consumption to zero. In these simulations, the model's other characteristics (utility functions, parameter values, demographic data, transfers, etc.) remain unchanged from the baseline. Figure 6 contains the resulting simulated saving rates when $\mu = 0$. For China (panel A), removing dependent children from utility causes the saving rate implied by the model to overstate saving (sometimes considerably) before 1996. The implied saving rate becomes much less variable, and the model can no longer generate as substantial a portion of the observed increase in saving. The simulation for India (panel B) reacts similarly. For both China and India, the reduction in family size, working through the parents' explicit desire to give their offspring consumption, is the key factor increasing household saving rates.

For Japan (panel C), the story is different. Even without children in the utility function, the model

[14] Choi et al. (2014) discuss other important determinants of household saving for China, in particular wage growth and uncertainty in an environment with a precautionary saving motive.

generates steadily declining savings after 1970. Japanese fertility rates (see Figure 3) have been low for decades. Thus, the decline in family size has been smaller, with little effect on recent saving behavior.[15] Instead for Japan, the composition effect, or growing number of retirees, has the largest impact. Relative to China and India, Japanese family size has experienced substantially less variation. From 1960 to 2013, total fertility rates fell from 5.8 to 1.7 in China, 5.9 to 2.5 in India, and 2 to 1.4 in Japan. Hence, we conclude that changes in family size are not as an important factor for explaining the recent Japanese saving rate dynamics.

The Composition Effect The composition effect is the change in aggregate saving rates due solely to variation in the proportion of households at different points in their life-cycle. The idea is to mimic the situation in which agents of the same age face the same economic state (e.g. family size) throughout time and therefore make the same saving decisions. Thus, a forty year-old, for example, would save the same way in 2010 as a forty year-old in 1970, only the number of forty year-olds changes. All else equal, an increase in the share of households in their working, prime saving years should increase the aggregate saving rate, and a growing retired population should reduce the aggregate saving rate.

We measure the composition effect by decomposing the model's implied saving rate in 1970 into contributions by age group. We then generate counterfactual aggregate saving rates by holding age-specific saving rates constant and varying the age distribution according to the data. We use 1970 as the base year because large variation in both saving and demographics have occurred since that time in all three countries. The decomposition of the aggregate saving rate for each country in 1970 is

$$SR_{1970} = \sum_{j=0}^{75} N_{1970,j} \left(\varphi_{1970,j}\right) \left(sr_{1970,j}\right), \tag{4}$$

where the model's aggregate saving rate in 1970 is SR_{1970}, $\varphi_{1970,j}$ is age group j's per person income share from the model in 1970, and $sr_{1970,j}$ is the age specific saving rate from the model.[16]

The 'composition effect' holds the age-specific income share and age-specific saving rates constant but allows the age distribution, embodied in $N_{t,j}$, to vary with t as in the data. This is given as

$$\widehat{SR}_t = \sum_{j=0}^{75} N_{t,j} \left(\varphi_{1970,j}\right) \left(sr_{1970,j}\right), \tag{7}$$

[15] The Japanese saving rates in the early part of the sample are higher than for the case with children in the utility function. This change occurs for the same reasons as outlined for China and India.

[16] The saving rate at any time t can be decomposed as

$$SR_t = \sum_{j=0}^{75} sr_{t,j} \Phi_{t,j} \tag{5}$$

where $\Phi_{t,j}$ is cohort j's share of total income in year t. This share can be written as the number of people with age j times the per person share of total income for that age group

$$\Phi_{t,j} = N_{j,t} \varphi_{t,j}. \tag{6}$$

for any year t. The composition effect measure includes only changes in household saving induced by changes in life-cycle savers and not changes in age-specific saving rates.

Table 2 reports the changes in aggregate household saving rates since 1970 for the data, the baseline model, and from the composition effect. In Japan, the data and baseline model saving rates continuously fall through each decade. Changes in saving rates due to the composition effect are relatively small through 1990 but account for 5.7 of the 7.9 percentage point decrease in the model's saving rate by 2010. Overall, the composition effect accounts for a substantial share of the total decline in the Japanese saving rate within the model simulations. As the country has aged, the growing number of retirees has placed downward pressure on aggregate saving.

In China and India, saving rates in the data and model increase each decade. The composition effect is positive in China until the late 1990s before turning negative due to the aging population. In India, the composition effect is positive through each decade and by 2010 accounts for one-third of the increase in the saving rate generated by the model. For both countries, the large difference between changes in the baseline model's saving rate and changes from the composition effect means that increases in the age-specific saving rates, sr, (caused by falling family size) accounts for the bulk of the variation in aggregate saving rates over time. Thus, while not trivial, the composition effect influences the saving rates in China and India less than in Japan.

In the cross section (results not shown), the saving profiles by age have a standard hump shape. In China and India, declining family size alters the saving rate by age but does not change the general shape of the cross-sectional saving rate profile; the relatively small composition effect indicates that the increase in aggregate saving comes from the increasing saving rates for each age group. In Japan, however, the large composition effect comes from the growing share of households at the far end of the hump-shaped life-cycle saving profile.

3.2.2 Introducing Country-Specific Characteristics

The baseline model imposes wide-ranging homogeneity across the countries. In this section, we relax these restrictions by tailoring the model to each country. We let the formal pension support levels and the intergenerational transfers reflect country-specific characteristics. Table 3 lists the choices. We also allow additional heterogeneity by introducing country-specific age-fertility and age-wage profiles. The United Nations demographic data does not allow us to link generations to uncover the number of children per parent by parent's age, $n_{t,j}$. Thus, to construct the cohort-specific number of children $n_{t,j}$, we turn to alternative data sources to estimate the cross-sectional fertility profiles (number of children per parent). We also consult micro-data to construct the wage profiles in the cross section. Finally, we input country specific values for average aggregate wage growth and the return to saving r. The other parameters and features of the model remain unchanged from the baseline simulations. The Appendix details the construction of the data used in this section. We discuss each country in turn.

Japan As Japan is an industrialized and developed economy, its social-security system is by far the most advanced. Mandatory retirement occurs at the relatively low age of 60, even though Japan has the world's highest longevity (Ogawa et al., 2010). Universal pension and medical care plans were established in 1961. From 1980 to 2004, the system was reformed every 5 years. Currently, Japan has a two-tiered benefit system. All qualified Japanese people receive the first-tier flat-rate basic benefit. This tier includes the self-employed, students, and all registered residents. The second-tier (earnings-related benefit), available to employees in the private sector and the government, pays a generous 60 percent replacement rate. A 2004 reform will gradually reduce the replacement rate.

We incorporate the frequent reforms of the Japanese social security system into the model.[17] We implement the pension replacement rates from Chen et al. (2007) based on data reported in Oshio and Yashiro (1999) through 1999. From 1955 through 1973 retirees receive a 17 percent replacement rate. From 1974 through 1979 the replacement rate equals 35 percent before increasing to 40 percent in 1980. The replacement rate increases to 50 percent in 2000 where it remains. The OECD (2005) calculates that the average male earner had a gross replacement rate of 50.3 in 2005 and Ogawa et al. (2010) reports that the 2004 pension reform targets a leveling off of the public pension replacement rate to 50.2 by 2023 and through 2050.

Informal intergenerational transfers from working children to retired parents have been falling in Japan. Ogawa et al. (2010) show that in 1984 net family transfers from the young to the old were positive for those aged 65 and older. By 2004, net transfers to the elderly were negative until age 77. Also, the percentage of people over 65 living with their children fell from 70 percent in 1980 to 50 percent in 2005. Accordingly, we decrease τ^c over time. We set τ^c to 5 percent from 1955 through 1973, 3 percent from 1974 through 1998, and 1 percent thereafter.

We use data from the Historical Statistics of Japan compiled by the Statistics Bureau of the Ministry of Internal Affairs and Communications in Japan to calculate the number of dependent children per parent by age in the cross section. Household size by age displays a hump shape with the average 40 year old having more children living at home than the average 20 or 60 year old. We estimate this relative number of children per parent from the one cross section. Thus, we keep the relative support ratio across groups constant, even as the absolute number of children per parent varies with demographic change. We use the same procedure for China and India, as described below and in the Appendix.

We construct cross-sectional income profiles based on the method of Braun et al. (2009) using data from the 2012 *Basic Survey in Wage Structure* by the Ministry of Health, Labor, and Welfare. These numbers give us an estimate for the relative wages by age, or efficiency wages, in the cross section. For example, we find that household heads in their prime working years receive more labor income than younger workers on average. We keep the cross-sectional wage profile fixed throughout time even as the aggregate wage level grows.

Finally, aggregate wage growth and interest rates are taken from Hayashi and Prescott (2002), which report the series from 1960-2000. We use the average annual interest rate before 1991, the year the real estate bubble burst and the start of Japan's "Lost Decade", for years prior to 1991.[18] From 1991 on, we use the average interest rate from 1991-2000. We calculate the average wage growth in the same

[17] Braun and Joines (2014) consider future reforms to the Japanese social security system.

[18] We assume no wage growth prior to 1947. The results are not sensitive to this assumption.

sub-sample periods.

Table 4 reports the saving rates generated by the full model (i.e. including the Japan specific details) and baseline model alongside the actual data every 10 years from 1960 to 2010. The broad trends in the simulated saving rates remain unchanged. After 1973, households in the full model receive a higher replacement rate than in the baseline model, reducing their incentive to save. Conversely, the decline in the informal transfer encourages saving for retirement, especially after 1999. However, the rapid aging of the population overcomes this effect, and the simulated saving rate declines after 1980. By 2012, the saving rate in the full model falls below 5 percent, as it does in the data.

China China's old-age security system is in flux. During the central planning era, communes provided old-age support for rural people and state owned enterprises (SOEs) provided cradle-to-grave protections to urban workers. The benefits to urban people working at SOEs were extensive. Referred to as the 'Iron Rice Bowl,' it included lifetime employment, health care, children's education and housing in addition to the old-age pension. While provided by the work unit, the plan was backed by the state, which subsidized the SOEs and effectively guaranteed the pensions.

The economic reforms that dismantled the communes left rural people to rely largely on saving and intergenerational family transfers for old-age support. Although there exists a voluntary public pension for rural people, the participation rate in 2007 was only 11 percent (Jackson et al., 2009). In urban areas, individual SOEs assumed financial responsibility for pension obligations. Unprofitable enterprises simply canceled pension payments. In the early 1990s, a scheme to pool SOE pension contributions formed the basis of the current basic pension system. This two-tiered system consists of a pay-as-you-go (PAYGO) benefit and what is supposed to be a funded personal retirement account. The basic pension system has struggled with ongoing structural issues, such as the un-funding of personal accounts through diversion of contributions to the PAYGO system and evasion. The structural issues contribute to incomplete participation and coverage. In 2007, 20 percent of urban workers were covered in the basic system and an additional 5 percent of urban people were covered by a separate civil service system. For the country as a whole, Sin (2005) estimates that less than 25 percent of the working population participated in the formal pension system; Jackson et al. (2009) put the figure at 30 percent.

For China, we select country specific details by following Curtis et al. (2015). Pension support (25 percent replacement rate) and informal support (4 percent transfer taken from wages of current workers) remain the same as in the baseline simulations.[19] To construct the cohort-specific number of children $n_{t,j}$ for China, we turn to the 2007 Rural-urban Migration in China (RUMiC) micro-level survey. Similarly, we use the RUMiC data to calculate the average household labor income, or efficiency wage, by age of the household head.

The aggregate wage growth and interest rate data come from Curtis et al. (2015). We use the average interest rate before and after 1979 to capture the economy-wide changes from economic reforms. Similarly, we calculate the average wage growth in each sub-period to construct the average wage series.

[19] Curtis et al. (2015) provide a justification for these choices and also consider alternative values. Feng et al. (2011) show that pension levels affect saving in China. He et al. (2014) and Song et al. (2015) study past and future pension reforms acting to reduce support levels. There also has been evidence of declining informal support for the elderly.

Table 4 reports the results. The full model uses the wage and interest rate data, and the baseline model allows only the demographics to vary (keeping aggregate wages and interest rates fixed). The full model can account for most of the observed increase in the aggregate household saving rate since the 1970s, more than the baseline. The wage and interest rate series alter the dynamics slightly, but the demographic channel still drives the upward trend.

India India's pension system is complex, fragmented, and covers only a small fraction of the population. In 2007 this figure was 10.2 percent (Stelten, 2011). There exists a variety of civil service plans (Civil Service Pension (1972), Civil Service Provident Fund (1981), New Pension System (2004)), and plans for workers in firms with more than 20 employees (Employees' Provident Fund Organization (1952)). However, with approximately 80 percent of employment in the informal sector, the vast majority of Indian people rely on self-funding and familial transfers for old-age support.

For India, we reduce the replacement rate to 5 percent. Historically, India has had no formal pension for most of its population. Civil servants receive a combination of a lump-sum pay out and an annuity based on salary and years of service. Nation-wide pension programs have been recently enacted (e.g. allowing all workers to contribute to the National Pension System and raising support for impoverished elderly through the Indira Gandhi National Old Age Pension Scheme). Using data from the National Transfer Account Program, Lee and Mason (2012) show public transfers play almost no role in funding consumption net of labor income for the elderly. To this point, Ladusingh and Narayana (2011) find that inter- and intra- household transfers are negative for the elderly through their 70s. They state "This finding is contrary to the widespread belief that in the absence of a viable public social security system net Indian elders depend on their kin...(p. 470)" We thus keep the transfer τ^c constant at 0.04 as in the baseline simulation.

We calculate cross-sectional profiles for fertility and wages using the 2004 India Socio-Economic Survey data. The Indian Socio-Economic Survey reports wages in 1983, 1987, 1999, and 2004. We use the implied average annual wage growth through these periods for 1950 on.

Finally, for the average interest rate series we first calculate the share of saving in bank deposits versus other assets. We allow the deposits to earn the real deposit rate, while the remaining assets earn the marginal product of capital. Curtis et al. (2015) use a similar procedure to calculate the return on savings for China. The Reserve Bank of India reports the share of household saving in deposits from 1973-2012, and the real deposit interest rate is calculated as the nominal deposit rate less the previous year's inflation. The marginal product of capital is estimated from a Cobb-Douglas production function with capital share $\alpha = 0.34$ using data from the Penn World Tables 8.0 database. The overall interest rate is the share weighted average of the real deposit rate and the marginal product of capital.

Table 4 reports the simulations with the Indian specific details. The interest rate and wage series from the data create a level shift downward in the saving rate time series. Since 1970, the full model accounts for a 13 percentage point increase in the aggregate household saving rate compared to 11.3 percentage points in the baseline model. Adding wage and interest rate variation leaves the saving rate dynamics largely unchanged; demographics still push the saving rate higher in India.

Overall, incorporating country-specific details does not alter our main findings. The baseline simulations generate a substantial portion of the observed changes in each country's aggregate household saving rates using only demographics. These results are robust to the inclusion of country-specific pension levels, intergenerational transfers, cross-sectional age profiles for wages and fertility, aggregate wage growth, and interest rates. While each of these factors also impacts saving behavior, demographic change remains the primary force behind the evolution of the saving rates within the model.

3.3 Projected Saving Rates

We next consider the model's implications for future saving rates given the projected age distributions from the UN. These simulations use the baseline version of the model where the only difference between countries is their age distributions. Our purpose is to quantify the impact from continued demographic change and not to take a stance on the direction of pension reforms, future growth rates, etc. Figure 7 plots the change in household saving rates relative to 2000 each year from 2000 to 2050.

The changes in Japan's simulated household saving rate level off between 2015 and 2030. The decline in the saving rate prior to 2015 is largely attributed to the retirees of the post-WWII baby boom generation (i.e. the composition effect). By 2015, most of this cohort has already entered retirement; however, after 2030 their children begin to enter retirement, pushing saving rates down even further. The working age population share and retirement support ratio in Japan will remain substantially lower than in China and India, and the prevalence of Japanese working aged households will continue to decline.

The model indicates that demographic factors will now begin to depress aggregate household saving in China as well. The demographic channels act to lower the simulated saving rates by 12 percentage points between 2015 and 2050. The Chinese population is set to age rapidly as the current large working cohort enters retirement, and this large elderly population decreases saving in the model.

For India, the demographic effect on saving is roughly neutral over the next 25 years. In contrast to China and Japan, India will stay young with the share of working aged households slowly growing in the near term. Despite an increasing number of retirees, the growing share of working aged households coupled with declining family sizes act to keep Indian saving rates high in the model. Only after about 2040 does the population aging in India become severe enough to start reducing the aggregate household saving rate within the model.

The demographic implications for future saving rates are important for several reasons. The model suggests that the demographic contributions to saving rates may be transitory. The rise and predicted fall in China's working-aged share of the population mirrors that of Japan's historical experience. Thus, China's future trends in household saving rates might resemble those in present day Japan. Population aging has greatly reduced saving in Japan and will do the same in China. To the extent household saving contributes to national saving, these patterns may be an indication of the future external imbalances across the world (see Backus et al. (2014) for more on this topic). The on-going changes in household saving rates also partially determine future investment-based economic growth. As Japan's national saving rate declined, its growth slowed. The same outcome could occur in China. Meanwhile, in the near term, India has a more favorable demographic outlook. Finally, all three countries (and much of the world) must deal with a growing elderly population, and accumulated household savings will, of course, be central to this issue.

4 Conclusion

In this paper, we explore how the different demographic profiles across Japan, China, and India have affected the evolution of each country's household saving rate. Our main finding is that the changing age distributions can account for a large portion of the differences in the aggregate household saving rates over time. We model household saving decisions within a fairly standard life-cycle model, embedding the observed and projected demographic profiles from 1955 on. A distinguishing feature of our framework is the incorporation of Barro and Becker (1989) style preferences with children in the utility function. Within our framework, the rapid decline in the share of dependent children accounts for the majority of the increased saving rates in China and India. On the other hand, the decrease in Japan's saving rate since the mid 1970s is driven by the large and growing retirement-aged population. The model's success in explaining the observed saving patterns across three countries with very different demographics is a powerful confirmation of the life-cycle hypothesis of household saving.

References

Athukorala, P.-C. and K. Sen (2004): "The Determinants of Private Saving in India," *World Development*, 32, 491–503.

Auerbach, A. J. and L. J. Kotlikoff (1987): "Evaluating Fiscal Policy with a Dynamic Simulation Model," *The American Economic Review*, 49–55.

Backus, D., T. Cooley, and E. Henriksen (2014): "Demography and Low-Frequency Capital Flows," *Journal of International Economics*, 92.

Banerjee, A., X. Meng, T. Porzio, and N. Qian (2014): "Aggregate Fertility and Household Savings: A General Equilibrium Analysis using Micro Data," *National Bureau of Economic Research Working Paper 20050.*

Barro, R. J. and G. S. Becker (1989): "Fertility Choice in a Model of Economic Growth," *Econometrica*, 57, 481–501.

Bloom, D. E., D. Canning, R. K. Mansfield, and M. Moore (2007): "Demographic Change, Social Security Systems, and Savings," *Journal of Monetary Economics*, 54, 92–114.

Braun, R. A., D. Ikeda, and D. H. Joines (2009): "The Saving Rate in Japan: Why it has Fallen and Why it will Remain Low," *International Economic Review*, 50, 291–321.

Braun, R. A. and D. H. Joines (2014): "The Implications of a Graying Japan for Government Policy," *Federal Reserve Bank of Atlanta Working Paper 2014-18.*

Chamon, M. and E. Prasad (2010): "Why Are Saving Rates of Urban Households in China Rising?" *American Economic Journal: Macroeconomics*, 2, 93–130.

Chao, C.-C., J.-P. Laffargue, and E. Yu (2011): "The Chinese Saving Puzzle and the Life-Cycle Hypothesis: A Revaluation," *China Economic Review*, 22, 108–120.

Chen, K., A. İmrohoroğlu, and S. İmrohoroğlu (2007): "The Japanese Saving Rate Between 1960 and 2000: Productivity, Policy Changes, and Demographics," *Economic Theory*, 32, 87–104.

Choi, H., S. Lugauer, and N. C. Mark (2014): "Precautionary Saving of Chinese and US Households," *NBER Working Paper*, 20527.

Choukhmane, T., N. Coeurdacier, and K. Jin (2013): "The One-Child Policy and Household Savings," *SciencesPo Paris working paper.*

Curtis, C. C., S. Lugauer, and N. C. Mark (2015): "Demographic Patterns and Household Saving in China," *American Economic Journal: Macroeconomics*, 7, 58–94.

Diamond-Smith, N. and M. Potts (2010): "Are the population policies of India and China responsible for the fertility decline?" *International Journal of Environmental Studies*, 67, 291–301.

FENG, J., L. HE, AND H. SATO (2011): "Public pension and household saving: Evidence from urban China," *Journal of Comparative Economics*, 39, 470–485.

FLATH, D. (2000): *The Japanese Economy*, Oxford University Press.

HAYASHI, F. (1995): "Is the Japanese Extended Family Alturistically Linked? A Test Based on Engel Curves," *Journal of Political Economy*, 103, 661–674.

HAYASHI, F. AND E. C. PRESCOTT (2002): "The 1990s in Japan: A lost decade," *Review of Economic Dynamics*, 5, 206–235.

HE, H., F. HUANG, Z. LIU, AND D. ZHU (2014): "Breaking the "Iron Rice Bowl" and Precautionary Savings: Evidence from Chinese State-Owned Enterprises Reform," *Working Paper, Federal Reserve Bank of San Francisco*.

HORIOKA, C. Y. AND J. WAN (2007): "The Determinants of Household Saving in China: A Dynamic Panel Analysis of Provincial Data," *Journal of Money, Credit, and Banking*, 39, 2077–2096.

JACKSON, R., K. NAKASHIMA, N. HOWE, AND J. ZHOU (2009): "China's Long March to Retirement Reform," *Washington DC: Centre for Strategic and International Studies Hallym International Journal of Aging*.

LADUSINGH, L. AND M. NARAYANA (2011): "The Role of Familial Transfers in Supporting the Lifecycle Deficit in India," in *Population Aging and the Generational Economy: A Global Perspective*, Ronald Lee and Andrew Mason, eds. Edward Elgar Publishing: Massachusetts.

LEE, R. AND A. MASON (2012): "Population Aging, Intergenerational Transfers, and Economic Growth: Asia in a Global Context," in *Aging in Asia: Findings From New and Emerging Data Initiatives*, James P. Smith and Malay Mayjmundar, Eds. The National Academies Press: Washington, D.C.

MANUELLI, R. AND A. SESHADRI (2009): "Explaining International Fertility Differences," *Quarterly Journal of Economics*, 124, 771–807.

MEHTA, R. (2013): "Trends and Patterns of Household Saving in India (Pre and Post Economic Reforms)," *The Global eLearning Journal*, 2, 1–19.

MODIGLIANI, F. AND S. L. CAO (2004): "The Chinese Saving Puzzle and the Life-Cycle Hypothesis," *Journal of Economic Literature*, 42, 145–170.

NAUGHTON, B. (2007): *The Chinese Economy: Transitions and Growth*, Cambridge, MA: MIT Press.

OECD (2005): "OECD Pensions at a Glance 2005: Public Policies across OECD Countries," Paris.

OGAWA, N., A. MASON, A. CHAWLA, AND R. MATSUKURA (2010): "Japan's Unprecedented Aging and Changing Intergenerational Transfers," in *The Economic Consequences of Demographic Change in East Asia, NBER-EASE Volume 19*, University of Chicago Press, 131–160.

Oshio, T. and N. Yashiro (1999): "Social Security and Retirement in Japan," in *Social Security and Retirement around the World. Jonathan Gruber and David A. Wise, eds.*, University of Chicago Press.

Pal, S. (2007): "Effects of Intergenerational Transfers on Elderly Coresidence with Adult Children: Evidence from Rural India," *IZA Discussion Paper*, 2847, 1–34.

Rosenzweig, M. R. and J. Zhang (2014): "Co-residence, Life-Cycle Savings and Inter-generational Support in Urban China," *National Bureau of Economic Research Working Paper 20057.*

Sin, Y. (2005): "Pension Liabilities and Reform Options for Old Age Insurance," *World Bank Working Paper No. 2005-01.*

Song, Z., K. Storesletten, Y. Wang, and F. Zilibotti (2015): "Sharing High Growth Across Generations: Pensions and Demographic Transition in China," *American Economic Journal: Macroeconomics*, 7, 1–39.

Song, Z., K. Storesletten, and F. Zilibotti (2011): "Growing Like China," *American Economic Review*, 101, 196–233.

Song, Z. and D. T. Yang (2010): "Life Cycle Earnings and Saving in a Fast-Growing Economy," Chinese University of Hong Kong working paper.

Stelten, S. (2011): "Extending Coverage of the New Pension Scheme in India: Analysis of Market Forces and Policy Options," *Hertie School of Governance Working Paper.*

Wang, X. and Y. Wen (2011): "Can Rising Housing Prices Explain China's High Household Saving Rate?" *Federal Reserve Bank of St. Louis Review*, 93, 67–87.

Wei, S.-J. and X. Zhang (2011): "The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings Rates in China," *Journal of Political Economy*, 119, 511–564.

5 Data Sources

5.1 Aggregate Saving Rate Data

Japan: The Japanese data comes from Japan's *Statistics Bureau*. Disposable income and expenditure data are used to construct the household saving series. The data comes from three releases: 1.) Data compiled using the 1968 System of National Accounts (SNA) standards (1955-1998). 2.) Data compiled using the 2005 release which follows 1993 SNA standards (1980-2003). 3.) Data compiled using the 2013 release following the 1993 SNA standards (1994-2012). For the overlapping years of the series, we average the saving rates together to form a single household saving rate series.

China: The Chinese data comes from various issues of *China Statistical Yearbook* compiled by the *National Bureau of Statistics*. From 1955-1979, the saving rate is computed using the methodology in Modigliani and Cao (2004). After 1979 the saving rate is disposable income less consumption as a share of disposable income.

India: The Indian data comes from the Indian *Ministry of Statistics and Programme Implementation*. Household saving in India is defined as financial and physical asset saving as a share of disposable income.

5.2 Demographics Data

We use two data sources in conjunction for the year-by-year, age-by-age, age distribution from 1870-2139: 1.) United Nations Population Prospects 2012 Revision (http://esa.un.org/wpp/) and 2.) Angus Maddison Historical Data (http://www.ggdc.net/maddison/oriindex.htm).

The UN data includes the number of people by single age group for ages 0-100 for every year beginning in 1990 and projected through 2100. Beyond 2100, we assume the number of births remains constant at the 2100 UN value and set the survival probabilities (from age a to $a+1$) to their 2100 values.

The UN data also provides historical estimates from 1950-1990, but only for ages 1-79. To complete the age distribution (i.e. ages 80-95), we do the following.

1. For ages 80-85, we set the survival probabilities equal to the survival probability projected (by the UN) for individuals aged 90-95 but 100 years in the future (e.g. we assume the survival probability for an 80 year-old in 1989 is the same as a 90 year-old in 2089). This is approximately what is observed in the UN projections for later years.

2. For ages 86 and above, we set the remaining population by age according to the share of the population in each age group in 1990. For example, if 25% of those over 85 are age 86 in 1990, then we always have 25% of those over 85 be age 86.

Prior to 1950, we use the Maddison data to backcast the total population. To do this, we calculate the implied population growth rates from 1870-1950 from the Maddison data (note: for India, we assumed flat population growth over the period 1947-1948 due to missing observations). We use those rates to calculate the total population going back in time. The resulting time series of total population is very close to the Maddison estimates. It is not exact because the UN estimates and Maddison estimates do not exactly agree for 1950.

Finally, we break the total population from 1870-1950 down into an age-distribution. We assume that each age group's share of the population remained constant at its 1950 share (for ages 1-79). For ages 80+, we used the same method described above for 1950-1990.

The results for Japan are in line with (but do not exactly match) the estimates given by the 5-year Japanese census. The UN 1955 and Japanese census age distributions (and total population estimates) do not exactly coincide; therefore our backcasts are slightly off from the Japanese census (but still fairly close, e.g. the share of the population aged 1 in 1884 in our projections is similar to the Japanese census data).

5.3 Dependent Children in the Cross Section

5.3.1 Number of dependent children per household

In the full model, the number of children in the household varies with the age of the household, producing a hump shaped age-to-family size profile (i.e. the average 20 year old and 59 year old have fewer children to support than the average 40 year old in a given year). Below details the construction of these profiles by country.

China: We use the 2007 Urban Household Survey of China, which is part of the Rural-Urban Migration in China and Indonesia survey (RUMiC).[20] This gives the number of children per parent (by age of parent) in the cross section for one year. We use a centered three year average of the number of children per parent to smooth out the profile. We then calculate the implied number of children per parent (by age) for the rest of the time series by assuming the relative number of children across cohorts stays the same (although the total number of children changes), as follows

$$n_{t,j} = \frac{n_{2007,j}}{\sum\limits_{j=0}^{43} n_{2007,j} N_{t,j}} N_t^c, \tag{8}$$

where $n_{2007,j}$ is the average number of dependent children per parent that cohort j had in 2007 (from the RUMiC data), $N_{t,j}$ is the total number of parents with age j in year t (from the United Nations data), and N_t^c is the aggregate number of children in year t. This calculation ensures that the number of children used in the simulations agrees with the United Nations data in every year.

Japan: We use data from the Historical Statistics of Japan compiled by the Statistics Bureau (accessed at http://www.stat.go.jp/english/data/chouki/index.htm). We use annual data on the average number

[20]The Longitudinal Survey on Rural Urban Migration in China (RUMiC) consists of three parts: the Urban Household Survey, the Rural Household Survey and the Migrant Household Survey. It was initiated by a group of researchers at the Australian National University, the University of Queensland and the Beijing Normal University and was supported by the Institute for the Study of Labor (IZA), which provides the Scientific Use Files. The financial support for RUMiC was obtained from the Australian Research Council, the Australian Agency for International Development, the Ford Foundation, IZA and the Chinese Foundation of Social Sciences.

of live births for mothers in 5 year age groups from 1947-2004. We assume that the number of births is uniform across mothers within a 5 year age group to get the number of births in single year age groups. Let the number of births at year t for mother's age group j be $b_{j,t}$. As in the model, we assume that there are no births before age 20 and children remain at home until age 20. We find the number of children per woman (by age) in the cross section for one year, 1990. We calculate the total number of children per age group j in 1990, W_j, as the sum of total children born in the past 20 years for that age group

$$W_j = \sum_{i=0}^{19} b_{j-i,1990-i}.$$

Since our model is described as single parent households, we assume that the father and mother's age is the same and estimate the number of children per household in 1990, $\widehat{n}_j$, by dividing the number of children by mother's age by the total number of people in that age group. We use the predicted number of children by age of the household head, n_j, for the rest of the series by assuming the relative number of children across cohorts stays the same (although the total number of children changes), using (8) for the Japanese data. We experimented with using different years for the cross section, but this choice had little effect on the quantitative results.

India: We use the 2004 Socio-Economic Survey (obtained through IPUMS (Ruggles et al. 2012)), which samples the non-foreign, non-institutionalized, civilian population. Sample weights are provided by the National Sample Survey Organization to form a representative sample. This gives the number of children per parent (by age of parent) in the cross section for one year. We use a centered three year average of the number of children per parent to smooth out the profile. We then calculate the implied number of children per parent (by age) for the rest of the time series by assuming the relative number of children across cohorts stays the same (although the total number of children changes), using (8) for the Indian data.

5.3.2 Number of Children Supporting the Retired

Finally, for all three countries, we estimate the number of working age children supporting each retiree (separately for each cohort) using the model in conjunction with the United Nations data. Specifically, we set the number of working children for a given cohort of retired parents equal to the maximum number of children that the specific cohort ever supported in their household at one time (in the model). The intergenerational family transfers from working children to retired parents are distributed accordingly. For example, an 85 year-old in 2009 receives transfers from more workers than a 65 year-old in 2009 because the 85 year-old cohort had more children on average than the 65 year-olds.

5.4 Age Specific Wages

In the full model, the wage varies by the age of the worker, producing a hump shaped profile of wages by age (i.e. the average 20 year old earns less than a 50 year old). Below details the construction of this profile by country.

Japan: We use the Year Book of Labour Statistics 2012 compiled by the Ministry of Health, Labour, and Welfare (accessed at: http://www.mhlw.go.jp/english/database/db-yl/2012/03.html) to calculate wages by age. This data allows us to estimate average hourly earnings. We follow the methodology of Braun et al. (2009) by defining the following for each age group:

Full time and salary workers:

$$\begin{aligned} weft &= \text{Average Weekly Earnings} \\ &= \frac{\text{Monthly Earnings}}{4} + \frac{\text{Annual Special Earnings}}{48} \end{aligned}$$

$$\begin{aligned} AHFT &= \text{Average Weekly Hours} \\ &= \frac{\text{Monthly Scheduled Hours} + \text{Monthly Overtime Hours}}{4} \end{aligned}$$

$$NFT = \text{Number of Workers}$$

Part time workers:

$$\begin{aligned} wept &= \text{Average Weekly Earnings} \\ &= \frac{\text{Hourly Earnings} \cdot \text{Daily Hours} \cdot \text{Monthly Days Worked}}{4} + \frac{\text{Annual Special Earnings}}{48} \end{aligned}$$

$$\begin{aligned} AHPT &= \text{Average Weekly Hours} \\ &= \frac{\text{Daily Hours} \cdot \text{Monthly Days Worked}}{4} \end{aligned}$$

$$NPT = \text{Number of Workers}$$

For each age group j, we construct the average hourly earnings w_j as

$$w_j = \frac{weft_j \cdot NFT_j + wept_j \cdot NPT_j}{AHFT_j \cdot NFT_j + AHPT_j \cdot NPT_j}$$

and overall average hourly earnings are calculated as

$$w = \frac{\sum_j weft_j \cdot NFT_j + wept_j \cdot NPT_j}{\sum_j AHFT_j \cdot NFT_j + AHPT_j \cdot NPT_j}$$

The data only reports wages by 5 year age groups. To estimate the individual wage by age, we estimate (9) using the 5 year age groups. Using the coefficients, we predict the wages by age, $\widehat{w}_j$. We use these to construct the age-profile weights as $\widehat{w}_j/w$.

China: We use the 2007 RUMiC survey to calculate the average wage by worker's age. The series is hump shaped with some high frequency variation. To smooth the series, we estimate the average wage by age j, called $\widehat{w}_j$, with the following regression

$$\widehat{w}_j = \alpha + \beta_1 age_j + \beta_2 age_j^2 + \beta_3 age_j^3 + \beta_4 age_j^4 + \epsilon_j. \tag{9}$$

We use the predicted wages as the average wage by age and construct the age-profile weights as $\widehat{w}_j/w$ where w is the average wage across all age groups.

India: We use the 2004 wave of the Socio-Economic Survey to calculate wages by age. The series is hump shaped with some high frequency variation. To smooth the series, we estimate the average wage by age j, called $\widehat{w_j}$, with (9) using this data. We use the predicted wages as the average wage by age and construct the age-profile weights as $\widehat{w}_j/w$.

5.5 Wage Growth and Interest Rates

We use various data sources to construct the wage growth and interest rate series for the full model. Since we are interested in capturing the trend in saving rates, we average wage and interest rate series over intervals to capture the salient economic conditions in those periods. When simulating the model, we use the Hodrick-Prescott filtered trend (smoothing parameter $\lambda = 100$) to smooth the transition of the series between the intervals.

Japan: We use the wage growth and interest rate series from Hayashi and Prescott (2002) who report estimated wages and after tax marginal product of capital from 1947-2001. We use their average wage growth and marginal product of capital as our interest rate from 1947-1991. The wage growth and interest rates from 1992-2100 are the averages from Hayashi and Prescott (2002) from 1992 to 2001. We chose 1991 as the break point as this year marks the beginning of Japan's "Lost Decade", which has persisted through to today. Prior to 1947, we assume wage growth is 0 and interest rates are the same as they were from 1947-2001. The results in the 1955-2012 interval are not sensitive to the initial wage growth and interest rates.

China: The wage and interest rate series come from Curtis et al. (2015). We use their average wage growth and interest rate series from 1851-1978, 1979-2015, and 2015-2100. We chose 1979 as a break point in the series to capture the changes in factor prices following the major economic reforms.

India: We use the 2004 wave of the Indian Socio-Economic Survey to calculate wage growth. The data is available in 1983, 1987, 1993, 1999, and 2004. We estimate the annual real wage growth from 1983-2004. Since a consistent data source is not available throughout the timeline of our study, we use this wage growth from 1950 to 2100. Prior to 1950, we set the annual wage growth to 0. The results are not sensitive to this assumption. To find the interest rate series, we first calculate the share of saving in bank deposits and other assets. We allow the deposits to earn the real deposit rate and the remaining assets earn the marginal product of capital. The Reserve Bank of India reports the share of household saving in deposits from 1973-2012. The real deposit interest rate is calculated as the nominal deposit rate less the previous year's inflation (the deposit rate data is available from 1993-2012). The marginal product of capital is estimated from a Cobb-Douglas production function with capital share $\alpha = 0.34$ using data from the Penn World Tables 8.0 database (Data accessed at http://www.rug.nl/research/ggdc/data/pwt/.) The overall interest rate is the share weighted average of the real deposit rate and the marginal product of capital.

Table 1: Parameter Values

Parameter	Symbol	Value
Coef. of relative risk aversion	σ	1.500
Discount factor	β	0.997
Weight on children	μ	0.650
Concavity for children	η	0.760
Transfer share	τ^c	0.040
Replacement rate	-	0.250
Interest rate	r	0.040

Table 2: Change in the Aggregate Saving Rates since 1970

		1970-1980	1970-1990	1970-2000	1970-2010
Japan	Data	-0.004	-0.052	-0.103	-0.165
	Baseline Model	-0.023	-0.036	-0.045	-0.079
	Composition Effect	0.002	-0.004	-0.013	-0.057
China	Data	0.100	0.130	0.205	0.257
	Baseline Model	0.035	0.097	0.116	0.159
	Composition Effect	0.014	0.033	-0.009	-0.015
India	Data[#]	0.032	0.090	0.118	0.142
	Baseline Model	0.031	0.058	0.082	0.113
	Composition Effect	0.018	0.034	0.027	0.038

[#] The household saving rate series for India extends only to 2007.

Table 3: Country-Specific Details

	Replacement Rate		Transfers τ^c	
China	0.25		0.04	
India	0.05		0.04	
Japan	0.17	–1973	0.05	–1973
	0.35	1974-1979	0.03	1974-1998
	0.40	1980-1998	0.01	1999-
	0.50	1999-		

Table 4: Saving Rates in the Data, Baseline Model, and Full Model

		1960	1970	1980	1990	2000	2010
Japan	Data	0.145	0.177	0.173	0.124	0.074	0.027
	Baseline Model	0.121	0.164	0.141	0.128	0.119	0.085
	Full Model	0.046	0.090	0.095	0.093	0.062	0.058
China	Data	0.058	0.020	0.120	0.150	0.225	0.277
	Baseline Model	0.064	0.028	0.063	0.125	0.144	0.186
	Full Model	0.058	-0.006	0.041	0.112	0.154	0.223
India	Data[#]	0.065	0.095	0.127	0.185	0.213	0.237
	Baseline Model	0.058	0.030	0.060	0.088	0.111	0.143
	Full Model	-0.018	-0.028	0.011	0.028	0.057	0.107

[#] The household saving rate series for India extends only to 2007.

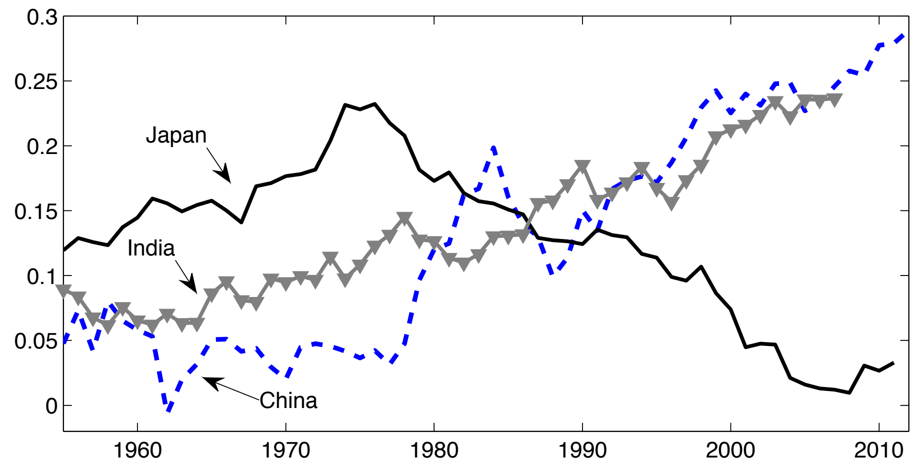

Figure 1: *Household Saving Rates in Japan, China, and India*

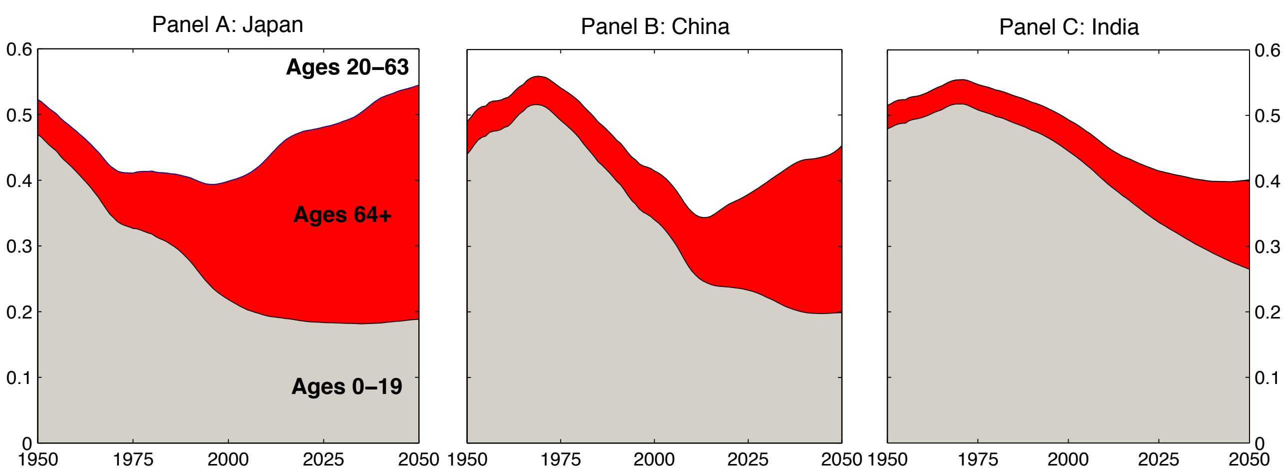

Figure 2: *Demographics in Japan, China, and India*

Notes: The three groups sum to 1, but the figure is truncated above at 0.6. The data comes from the United Nations Population Prospects 2012 Revision medium variant.

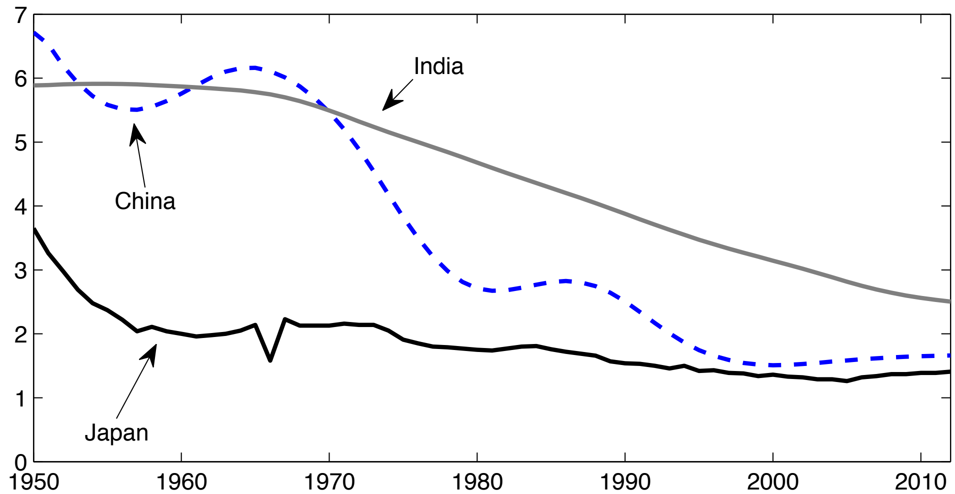

Figure 3: *Total Fertility Rates*

Notes: China and India data are from the United Nations Population Prospects 2012 Revision medium variant. Japanese data comes from the Japan Statistical Yearbook 2015, Statistics Bureau, Ministry of Internal Affairs and Communications.

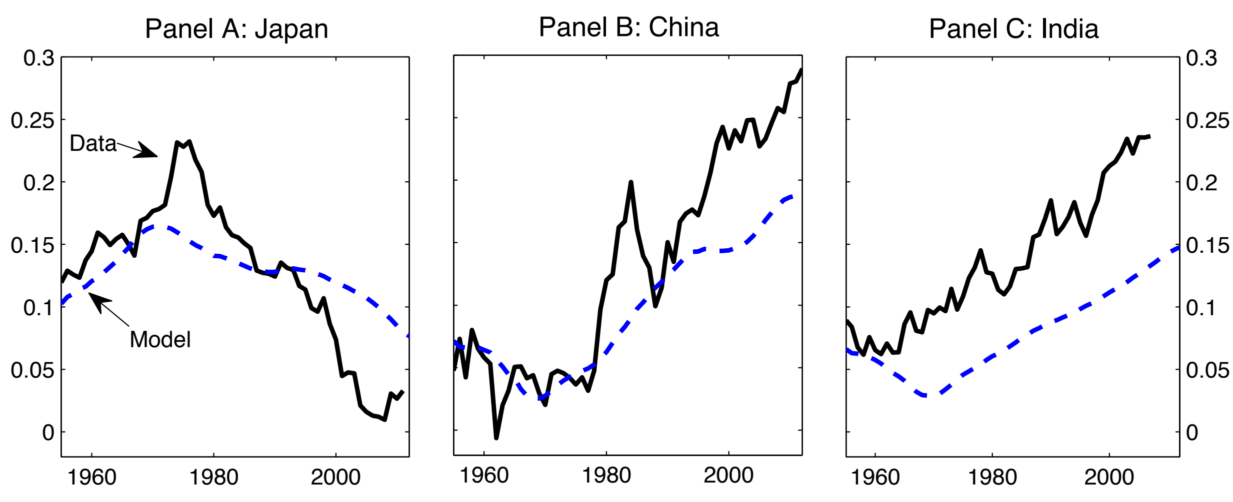

Figure 4: *Household Saving Rates in the Baseline Model and the Data*

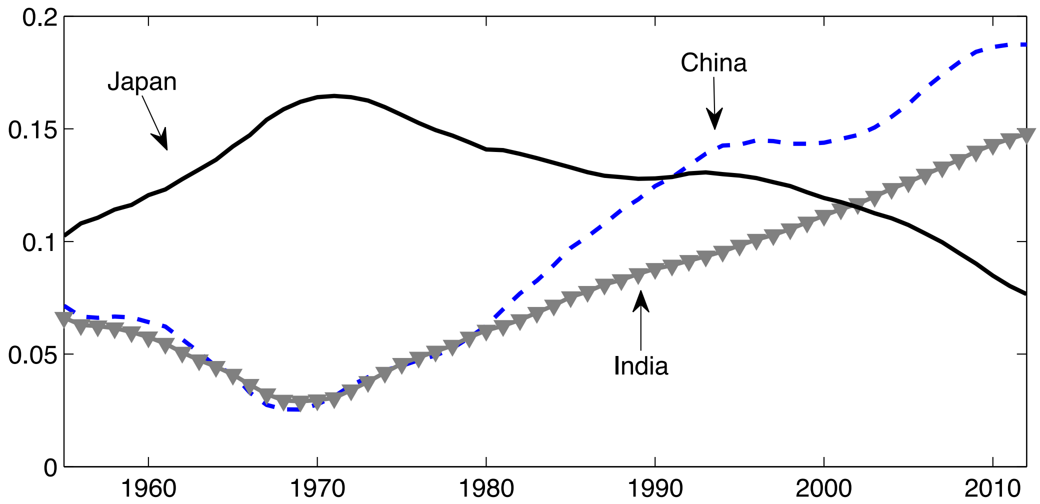

Figure 5: *Household Saving Rates in the Baseline Model*

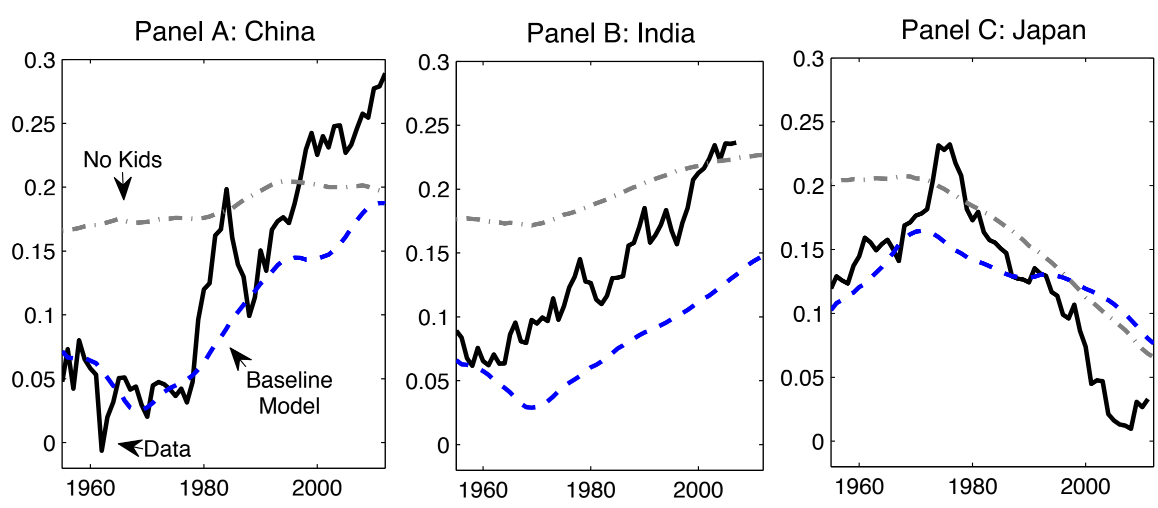

Figure 6: *Household Saving Rates in the Baseline Model, the Data, and the Model Without Dependent Children ($\mu = 0$)*

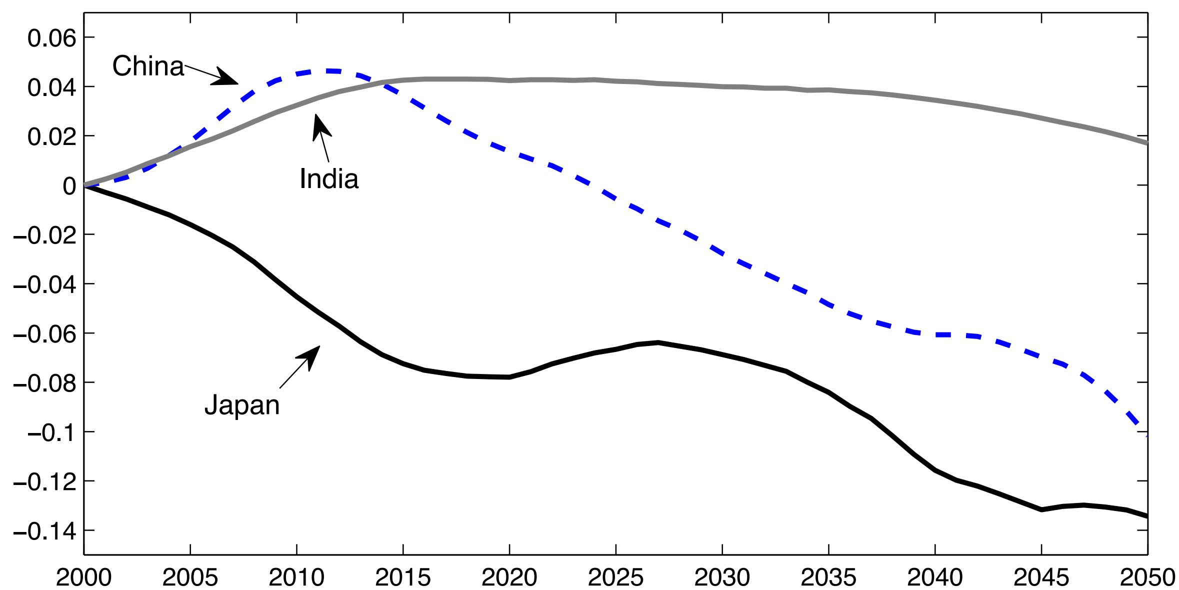

Figure 7: *Change in Household Saving Rates relative to 2000 in the Baseline Model.*