



Demographics and aggregate household saving in Japan, China, and India



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ABSTRACT

We use a model of household life-cycle saving decisions 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 a decline in 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, and increased longevity have combined to profoundly change the population age distribution in many countries. These demographic shifts are causing changes in the ratio of savers to non-savers and changes in household size, both of which affect the aggregate saving rate, capital formation, the viability of pension schemes, labor supply. The demographic transition may also 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.

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Each of these countries has embarked on a demographic transition whereby their populations have gone from relatively young to relatively old. However, their transitions started at different times and evolved 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 is set to age considerably in the near future. India, on the other hand, has a younger population, with an elderly 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 from [Curtis et al. \(2015a\)](#) 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 support dependent children, and make saving and consumption decisions. Working age agents 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 through 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 the household's 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, having relatively more people in their prime-earning years increases aggregate saving, while having relatively more retirees decreases aggregate saving (all else constant), due to a demographic 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 because 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.

We conduct two exercises to disentangle these 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, by holding age-specific saving rates fixed in the model, while allowing the age distribution to change as in the data, we get 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 in our baseline model.

This paper makes three main contributions. First, we show that a unified framework can account for very disparate saving behaviors across time and for countries at different points in their demographic transition. These results represent a powerful confirmation of the life-cycle theory of household saving. The ability of the model to capture the broad features of the data for populations with varied experiences and institutions gives us confidence in the transferability of the basic mechanisms to other countries. Our cross-country analysis is related to [Chen et al. \(2007\)](#) and [Braun et al. \(2009\)](#), who study Japanese saving. While these two papers focus on years prior to 2000, each considers a period during which the Japanese fertility rate declined, the working age population began to shrink, and the elderly fraction of the population grew. Our paper also makes contact with recent papers on saving in China, including [Banerjee et al. \(2014\)](#), [Chamon and Prasad \(2010\)](#), [Chao et al. \(2011\)](#), [Zhou \(2014\)](#), [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 \(2011\)](#).

Second, to the best of our knowledge, the application of quantitative life-cycle saving models of this sort to India is new. Modern literature on aggregate saving in India includes [Athukorala and Sen \(2004\)](#) and [Mehta \(2013\)](#), but they focus on empirically documenting the increase in household saving. We find that demographics, primarily the decline in family size, are a critical factor governing the trends in Indian household saving rates. As the world's third largest economy by PPP and poised to be the most populous country by 2022, understanding India's saving behavior and how it relates to its growing influence in international capital markets is a worthwhile undertaking.

Our third contribution is to forecast how the demographic changes will impact household saving rates through 2050. In Japan, the working-age to elderly ratio will fall to 1.25 by 2050, and the model predicts that household saving rates will continue to decline as the country ages. In China, the ratio of working-age to elderly is also projected to fall, from 6 to 2 by 2050. As the current large working age population moves into retirement, the model predicts a 14 percentage point decline between now and 2050. India's high household saving rate, on the other hand, is projected to persist. India is the youngest

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

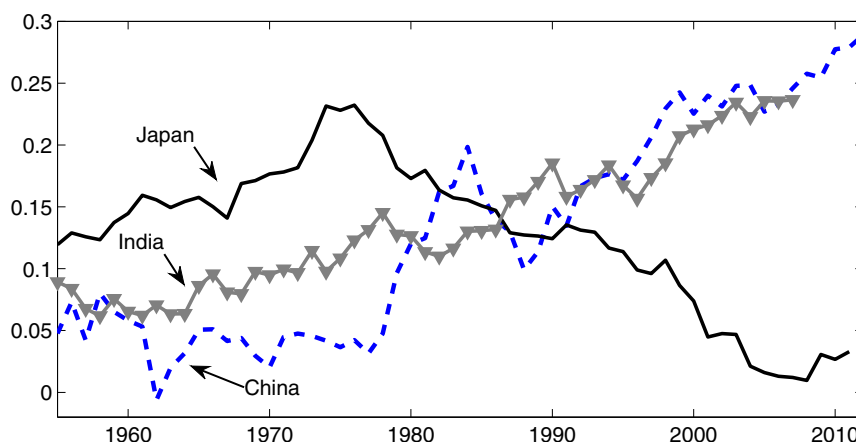


Fig. 1. Household saving rates in Japan, China, and India.

of the three countries; a growing working age population with smaller family sizes will maintain India's high household saving rates.

The main results of the paper are generated by the baseline model, which isolates the effects of demographics by imposing uniformity in other dimensions across the countries. However, we also show that the generosity of the government-run pension system does impact the *level* of household saving. A more generous pension reduces the saving rate as retirees need to rely less on saving. Conversely, a less generous pension induces retirees to save more for their mainly self-funded retirement. We find that variations in country-specific pension features have a strong level effect on the saving rate, but the *dynamics* of the saving rate are mostly driven by demographic variations.

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

Fig. 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. From that point, the saving rate declines, coinciding with a rapid aging of the population, especially since 2000. By 2012 Japanese households saved less than 5 percent of their income.

In contrast, the saving rate of Chinese households were quite low before economic reforms of 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. Currently, China's saving rate is nearly 40 percent. 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.

Fig. 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 2015 Revision. The bottom area corresponds to the share of the population below the age of 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, the lowest share under 20, and the largest share in retirement. 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 share of the young. 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 is

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.

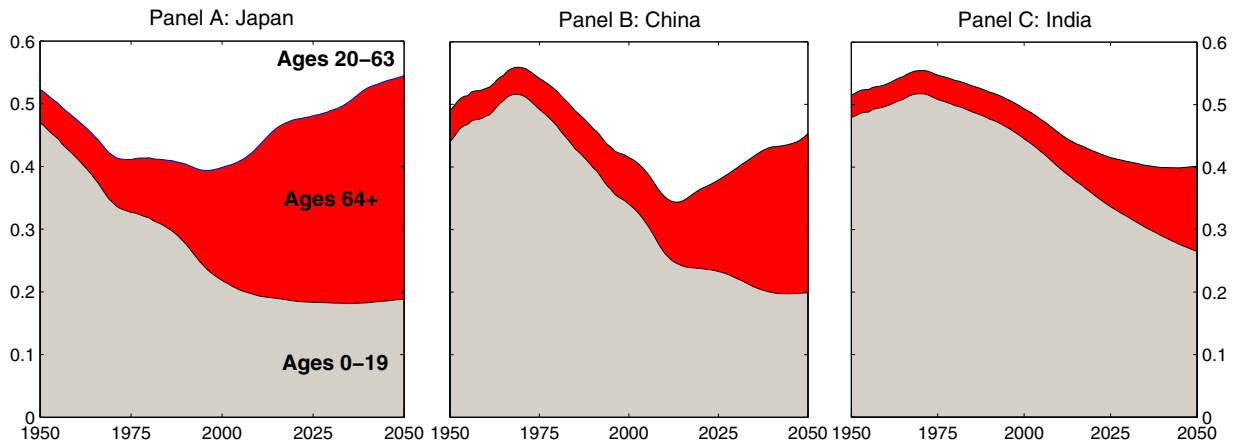


Fig. 2. Demographics in Japan, China, and India. *Notes:* The three groups sum to 1, but the figure is truncated above at 0.6. The data comes from the *United Nations Population Prospects 2015 Revision medium variant*.

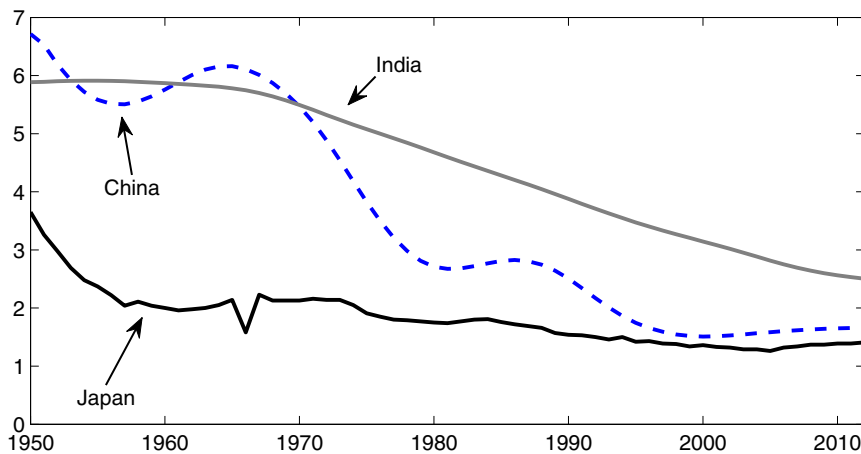


Fig. 3. Total fertility rates. *Notes:* China and India data are from the *United Nations Population Prospects 2015 Revision medium variant*. Japanese data comes from the *Japan Statistical Yearbook 2015*, Statistics Bureau, Ministry of Internal Affairs and Communications.

poised to undergo a 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 its demographic transition began later and has evolved more gradually. 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.

The declining birth rate has been a key determinant behind these demographic shifts. Fig. 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 it is projected to fall to 107 million by 2050. 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 The most obvious reason for the decline might be the fact that per-capita income grew substantially after World War II. In addition, abortion has been legal in Japan since 1949 and was a widely used method of birth control in the 1950s and 1960s.⁶ The continuing decline in births may be due to a cultural bias

⁴ The sharp dip in fertility during 1966 occurred because it was the year of the Fire Horse (Hinoeuma) 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 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

against married women in the labor force and the general unavailability of child care. Recent low wage growth may have contributed to fewer marriages and smaller family sizes, too. Also, compromised quality of family life due to the grueling ‘salary-man’ culture tied to corporate employment might inhibit family size.

The current fertility rate in China is low, due in large part to the well-known and coercive one-child policy. In the beginning of our sample, however, Chinese fertility rates were high. During the 1950s and 60s, Communist Party Chairman Mao Zedong viewed a large population (and therefore a large labor force), to translate into economic might and encouraged people to have many children. Population policy reversed in 1972 when a voluntary campaign, known as ‘Later, Longer and Fewer,’ was launched to encourage couples to delay marriage, increase the spacing between children, and limit the number of children to two. In 1980, the effort to reduce fertility was intensified through implementation of the One-Child policy. 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 (Fig. 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, saving rates are low in Japan and very high in China and India. The age distributions depicted in Fig. 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. Looking forward, Chinese and Indian households anticipate fewer working age children from which to draw retirement support, so these households will engage in higher rates of asset accumulation. In the next section, 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

We use the life-cycle model from Curtis et al. (2015a), which builds on the framework presented in Auerbach and Kotlikoff (1987). In each period, the economy is populated by 95 generations. Only agents aged 20–95 make consumption/saving decisions as those under 20 are dependents who rely on their parents for consumption. Within age groups, all agents are identical. The model focuses on how changes in the age distribution impact household saving. As such, we follow a long line of literature by having the model agents take the current and future age distribution as exogenous.⁸

We call people aged 0–19 children. They live as dependents and consume what their parents give them. People aged 20–63 are prime-working age. These people supply labor inelastically and receive a wage.⁹ From age 20 to 50, these people are also responsible for dependent children living in the household. Both their children’s and their own consumption enter into household utility as in Barro and Becker (1989). People aged 64–95 are retired. These people have no children to support and live off of saved assets, family transfers from their now working age children, and a formal pension. The pension is a pay-as-you-go (PAYGO) scheme. Agents face an age and cohort specific probability of death until age 95 when all agents die with certainty.¹⁰

⁷ See Diamond-Smith and Potts (2010).

⁸ Related papers featuring exogenous fertility include Auerbach and Kotlikoff (1987) on the US social security system and Krueger and Ludwig (2007) on capital flows across OECD countries, among many others.

⁹ Many closely related papers (e.g. İmrohoroğlu and Zhao, 2016; Choukhmane et al., 2013; Curtis et al., 2015a, and Chen et al., 2007) also abstract from a labor/leisure choice. A few other related papers (notably Braun et al., 2009 and Braun and Joines, 2014) endogenize labor supply, although these papers do not stress the labor margin as having a large effect on saving. After presenting the model, we further discuss how labor supply decisions might affect our results.

¹⁰ We experimented with an explicit bequest motive 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). For simplicity, we do not include bequests in the model.

2.1. Preferences

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 worker with age j , $n_{t,j}$ denotes the number of dependent children in the household.¹¹ Each child consumes $c_{t,j}^c$, and preferences for households with dependent children have consumption by parents and children entering separately into household utility as in Barro and Becker (1989).¹² The per-period utility function for a household head of decision-making age j in year t is

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

When individuals no longer support children, $n_{t,j} = 0$. 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.

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. Preferences for a 20 year old in year t are

$$U_t = \sum_{j=0}^{43} \beta^j \left(\mu(n_{t+j,j})^\eta \left(\frac{(c_{t+j,j}^c)^{1-\sigma}}{1-\sigma} \right) + \left(\frac{c_{t+j,j}^{1-\sigma}}{1-\sigma} \right) \right) + \sum_{j=44}^{75} \delta_{t+j,j} \beta^j \left(\frac{c_{t+j,j}^{1-\sigma}}{1-\sigma} \right). \quad (1)$$

Family size affects consumption/saving decisions 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 usual case without children in the utility function. In the model, $n_{t,j} = 0$ when $j \geq 30$. 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 (see Curtis et al., 2015a for more on this). 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.

2.2. Budget constraints

During the parenting years, agents choose their own consumption $c_{t,j}$, their dependent children's consumption $c_{t,j}^c$, and (non-negative) assets $a_{t+1,j+1}$ to take into the next period. Working age people take the return on savings r_t and labor income (age-dependent wage) $w_{t,j}$ as given. They pay a fraction τ_t^g of their wages into the formal pension system and transfer fraction τ^f of their wages to retirees through an informal family support network.¹³ The flow (period-by-period) budget constraints for working-age households are

$$c_{t,j} = (1 - \tau_t^g - \tau^f)w_{t,j} + (1 + r_t)a_{t,j} - a_{t+1,j+1} - n_{t,j}c_{t,j}^c, \quad j \in [0, 43]. \quad (2)$$

The model agents continue working 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 remaining assets and die with certainty at age 95 ($j = 75$). If an agent dies early, any remaining assets are simply lost; adult children do not receive bequests.¹⁴ The budget constraints for retirees are

$$c_{t,j} = p_{t,j} + (1 + r_t)a_{t,j} - a_{t+1,j+1}, \quad j \in [44, 75]. \quad (3)$$

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 government funded pension is a constant replacement rate retirement plan where a retiree earns a fixed percent ρ of their final working year's wage as a pension during each year of retirement.¹⁵ Thus, g is calculated as

$$g_{t,j} = \rho w_{t+43-j,43}, \quad j \in [44, 75].$$

The tax rate on the workers τ_t^g adjusts each period to fund the formal pension. On the other hand, the rate τ^f for the informal family transfer remains fixed. The size of the family transfer received by retirees $f_{t,j}$ depends on the number of

¹¹ In the simulations, we set n to zero for all t once the parent reaches age 50, making for 'empty-nester' households. Alternatively, we reran the model letting n go to zero only at retirement, but this alteration does not matter quantitatively for the evolution of the saving rates.

¹² 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.

¹³ 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.

¹⁴ We think this modeling choice is reasonable given that no evidence points towards large average bequests impacting saving decisions in any of the three countries, at least not historically. Also, any unused assets would be quantitatively small.

¹⁵ Basing pension payments on the agent's last year of wages is a simplification; however, since the baseline model simulations do not feature income growth, it is an innocuous assumption. For example, using the average lifetime wage would be identical.

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^f	0.040
Replacement rate	ρ	0.250
Interest rate	r	0.040

working children for a given cohort of retired parents. Cohorts of retirees with more children thus receive a higher family transfer because they have more children providing support.¹⁶

Demographics work through the budget constraints to impact saving decisions through several channels. First, (see Eq. (2)) a decline in the number of dependents ($n_{t,j}$) frees up resources for asset accumulation ($a_{t+1,j+1}$). 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 because more people are saving from labor income. 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 Eq. (3), the declining support ratios in China and India mean there will be relatively small future family transfers f , making total old-age support smaller 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.

In our model, aggregate labor supply depends only on the demographics, even though the marginal utility from household consumption is higher (which depresses savings) when the family has more children. By making labor supply exogenous, we rule out the possibility that households with larger families could accumulate assets by working more, potentially mitigating the decline in saving. The size of this effect on total saving and saving rates would of course depend on the structure and parametrization of the utility function. Changes to wages (which we also abstract from) would matter, too. For example, an increasing labor supply might decrease wages in a general equilibrium setting.¹⁷ The labor supply of mothers might also change. We take these important considerations as being beyond the scope of our analysis and keep labor supply as exogenously determined. Thus, the household's problem is to choose sequences of consumption, consumption for children, and asset holdings to maximize (1) subject to budget constraints (2) and (3). 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 time-paths of 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; that 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 the demographic mechanism affecting 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 inter-generational transfers affect saving. 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. (2015a). This value may seem high, but it is partially offset because individuals effectively further discount the future by incorporating 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 $j \in [0, 29]$, as calculated from the UN data.

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. (2015a) 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.

¹⁶ Appendix A.3.2 provides the details, and we employ two different ways of calculating family transfers below.

¹⁷ As mentioned above, Braun et al. (2009) does include a labor/leisure choice in a full general equilibrium setting and still finds a sizable role for demographics in determining the saving rate for Japan.

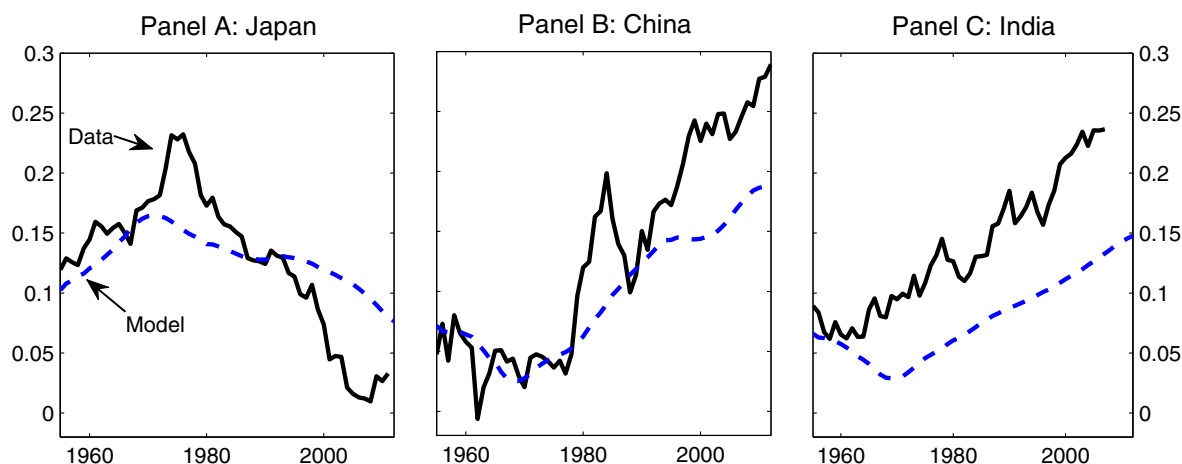


Fig. 4. Household saving rates in the baseline model and the data.

The baseline simulations use identical configurations for the intergenerational transfers in 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^f to 0.04.¹⁸ We set the government pension payments $g_{t,j}$ so that each retiree receives a 25 percent replacement rate in every year.¹⁹ Funding the model's pay-as-you-go constant replacement rate pension system requires the tax rate τ^g on labor income to vary. Intergenerational transfers affect saving rates, so later we implement different pension and family support levels across countries and over time. In the baseline, though, we keep these values fixed.

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.²⁰ Initial assets equal zero for each 20 year old (decision-age $j = 0$).²¹ 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

Fig. 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 generally 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. See Curtis et al. (2015a) for a number of robustness checks on these results in addition to the simulations reported on below.

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

¹⁸ This choice comes from an estimate by Choukhmane et al. (2013) based on a survey covering intergenerational transfers in China.

¹⁹ This choice comes from Curtis et al. (2015a) for China.

²⁰ Aggregate wage growth, in particular, affects both the level and (to a lesser extent) the dynamics of aggregate household saving. For example, if Indian and Chinese households expect much higher wages in the future, they will save less today. In the working paper, Curtis et al. (2015b), we introduce country-specific wage growth and show that our results stay largely unchanged as long as country-specific interest rates and pension support levels are also included in the analysis.

²¹ 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.

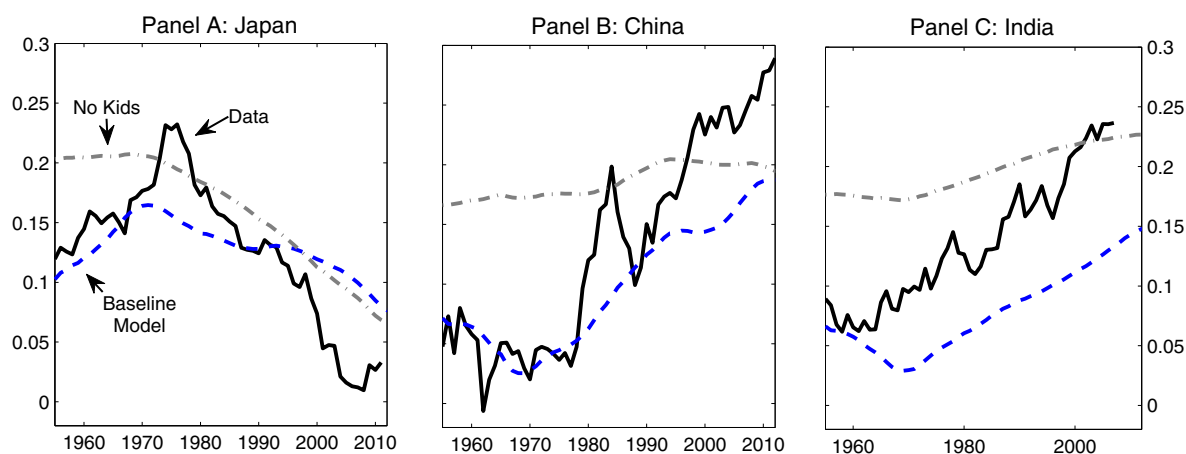


Fig. 5. Household saving rates in the baseline model, the data, and the model without dependent children ($\mu = 0$).

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

Comparing just the simulated household saving rates in Fig. 4, note the sharp contrast between Japan 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 generally replicates the dynamics of the saving patterns, demographic changes do not account for everything. Thus, we also have incorporated many country-specific details into the model, such as differences in interest rates, wages, and inter-generational transfers, as well as cross-sectional fertility. The full results are not reported here, but can be found in the working paper version (Curtis et al., 2015b). While each of these additional factors also impacts saving behavior, demographic change remains the primary force behind the evolution of the saving rates within the model.

Additional institutional and societal factors (beyond demographics) have affected saving rates, too. We have intentionally abstracted from other potential explanations, as they take us too far afield from demographics.²² One key difference among the countries is the level of old-age support provided or expected. We further study how inter-generational transfers influence saving below. However, before introducing country-specific levels of pension support, we next disentangle how the separate demographic channels impact each country.

3.2.1. Decomposing the demographic channels

We run two exercises to separate the demographic channels. In the relatively younger populations of China and India, the rapid decline 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, and parents have additional incentives to save because they foresee fewer children to from which to draw support in 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. Fig. 5 contains the resulting simulated saving rates when $\mu = 0$. For China (panel B), 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 C) 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.

²² 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. Also see Chamon et al. (2013) for more on income uncertainty and saving.

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 ^a	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

^a The household saving rate series for India extends only to 2007.

For Japan (panel A), the story is different. Japanese fertility rates (see Fig. 3) have been low for decades and exhibits little variation over the sample. As a result, the family size channel cannot contribute much to variations in Japan's saving rate.²³ Even without children in the utility function, the model generates steadily declining savings after 1970. We show below, that it is the composition effect, or growing number of retirees, has the largest impact for Japan.

The composition effect. To study the composition effect, we examine the change in aggregate saving rates due solely to variation in the proportion of households at different points in their life-cycle. The experiment here 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.

To measure the composition effect, we decompose the model's implied saving rate in 1970 into contributions by age group, 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

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

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.²⁴

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

$$\widehat{SR}_t = \sum_{j=0}^{75} N_{t,j}(\varphi_{1970,j})(sr_{1970,j}), \quad (5)$$

for any year t . The composition effect measure includes only changes in household saving induced by changes in the number of 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 fall continuously 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

²³ 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 for China and India.

²⁴ The saving rate at any time t can be decomposed as

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

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

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

total decline in the Japanese saving rate in 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 its 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 most of the variation in aggregate saving rates over time. Thus, the composition effect has less of an influence on saving rates in China and India than for Japan.

The degree to which households need to save for the end of life depends, at least partly, on the generosity of the public pension system. Until now, the analysis has abstracted from differences in expected old-age support across the three countries, but we turn to this topic next.

3.2.2. Role of the formal pension system

In our baseline simulations, formal pensions are identical across countries to isolate the role of demographic change on household saving rates. However, the national pension systems vary greatly across the three countries. Japan's formal pension system is highly developed and features a high replacement rate, while India's is near zero. Here, we give a brief overview of each system, and incorporate these country-specific pensions into the model.

Japan. As Japan is an industrialized and developed economy, its social-security system is by far the most advanced. Retirement begins 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, but they have been reformed frequently since then. 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 has, and will continue to gradually reduce the replacement rate to 50 percent by 2023.

We incorporate these frequent reforms of the Japanese social security system into the model.²⁵ 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 1999 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 of 50.2 by 2023 through 2050.

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.

Under China's commune system, production teams were the units that calculated and divided income among its members, and approximately 80 percent of the population were members of the teams in 1978 (O'Leary and Watson, 1982). The economic reforms that dismantled the communes left rural people to rely largely on saving and inter-generational family transfers for old-age support.²⁶ 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. During the period of SOE reforms (in the 1990s), many people lost their pensions due to SOE downsizing in which 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. In our baseline simulations, we use an unvarying replacement rate of 25 percent based on Curtis et al.'s (2015a) replacement rate estimates for China. Below, we also consider an unexpected decrease in pension benefits in 1979 when economic reforms began in earnest.

²⁵ Braun and Joines (2014) consider future reforms to the Japanese social security system.

²⁶ Feng et al. (2011) show that pension levels affect saving in China. He et al. (2014) and Song et al. (2015) also study past and future pension reforms.

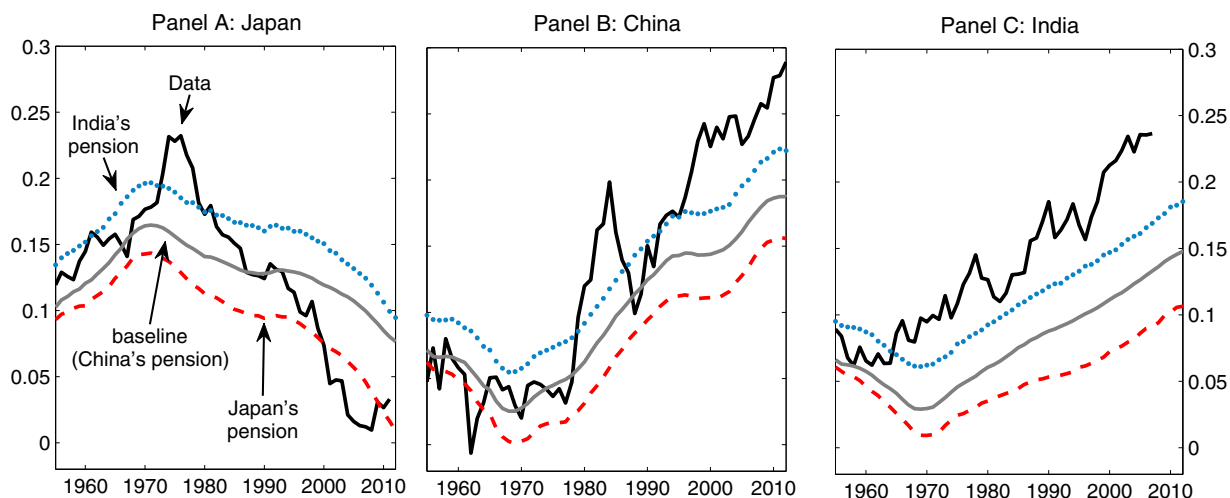


Fig. 6. Household saving rates in the data and under alternative pension plans. *Notes:* Table 3 lists the different pension replacement rates. All other aspects of the model are as in the baseline version.

Table 3

Country-specific pension replacement rates and transfers.

	Replacement rate	
Japan	0.17	–1973
	0.35	1974–1979
	0.40	1980–1998
	0.50	1999–
China	0.25	
India	0.05	

India. India's pension system is complex, fragmented, and covers only a small fraction of the population. In 2007, coverage was 10.2 percent (Stelten, 2011). Historically, India 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.

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 use a replacement rate of 5 percent.

Fig. 6 plots the simulations incorporating the country-specific pensions. Holding all else constant in the baseline model, we use the pensions of Japan, China, and India applied separately to each country. Recall the original baseline simulations used the time-invariant pension system from China for all three countries. The pension replacement rates are given in Table 3 as described above.

The distinguishing feature of the different pension schemes is a level effect of household saving rates; a higher (lower) pension induces households to save less (more) for retirement. For each country, moving from the most generous pension (Japan's) to the least generous (India's) increases the saving rate by an average of 7 percentage points. For Japan (panel A), simulations using its own pension system better fits the data in the latter half of the sample. For India (panel C), simulations using its pension system get the level of saving closer to the data throughout. The dynamics across all the simulations, however, are largely unchanged. We conclude that applying alternative pension plans to the model primarily changes the level of saving, but does not substantially alter the evolution of the household saving rates.

In these simulations, China's formal pension system remains fixed throughout. However, China's retirement system has perhaps experienced the largest changes of the 3 countries as it has moved from a highly centralized economy to one embracing market-based reforms. As discussed, the shift from the era of the 'Iron Rice Bowl' to its current economy led to a pension system that was basically universally guaranteed to one with a lower level of participation. To capture this change, we model the one-time dismantling of the Iron Rice Bowl. Fig. 7 simulates the model with a one-time unexpected decrease in the replacement rate from 80 to 25 percent in 1979, marking the initiation of economic reforms and the dismantling

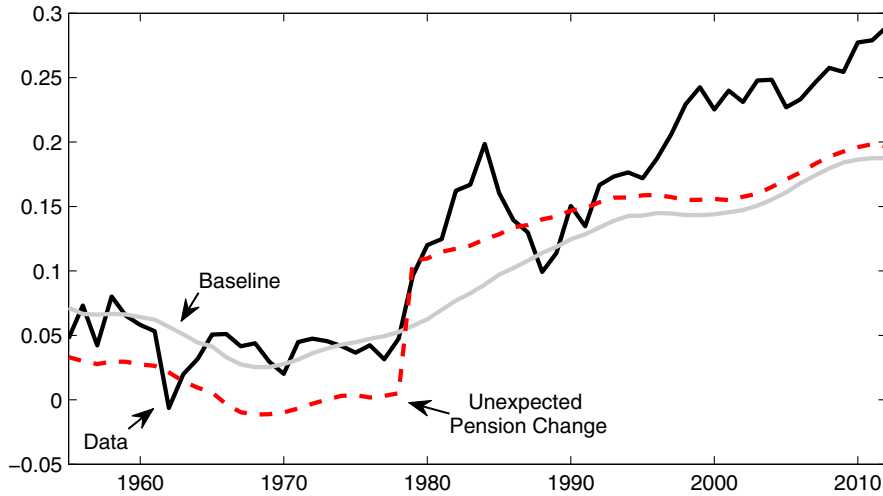


Fig. 7. Household saving rate in China when the pension replacement unexpectedly changes from 0.80 to 0.25 in 1979.

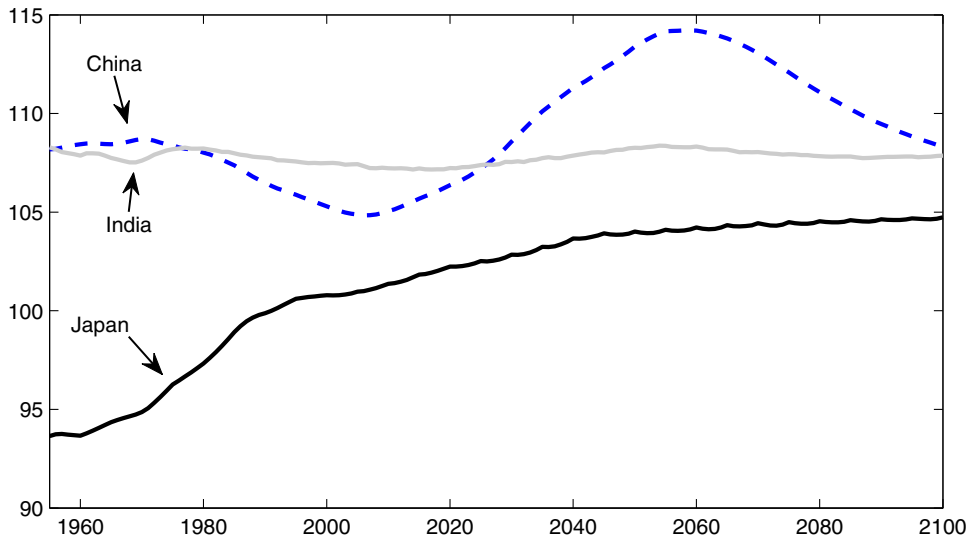


Fig. 8. Sex ratio (males per 100 females) of ages 20–63 from 1955 projected to 2100. Notes: The sex ratio estimates are from the United Nations Population Prospects 2015 Revision.

of the commune system. In the simulations, saving rates were very low prior to 1979 before sharply increasing at the unexpected pension change. After the replacement rate reduction, the model households rely more on personal saving than the formal pension system. The one-time change in the pension replacement rate improves the fit of the model with the data, particularly in the 1980s.

3.2.3. Role of family transfers and gender

In the past, parents in each country has had a preference for boys. The tradition has been for (mostly) male offspring to offer monetary (and/or housing) support for their elderly parents. This practice has been cited as one of the reasons for the rise of sex ratio imbalances, especially in China.

To understand how gender might affect saving through transfers, we have simulated the model assuming only male offspring provide the informal transfer (with τ^f still set to 0.04). For each cohort, we use the estimated sex ratio by year to calculate the share of each cohort that contributes to the informal pension. Estimates and projections on sex ratios by country from 1950 through 2100 are taken from the World Population Prospects 2015 Revision. We fix the ratios before and after this time frame at the 1950 and 2100 values, respectively. We do not alter how the pensions are distributed from the baseline simulation.

Fig. 8 shows the evolution of the sex ratio of ages 20–63 by country from 1955 and projected until 2100 for each country (number of males per 100 females). The projected sex ratio changes for this age group in China are large. China’s sex ratio

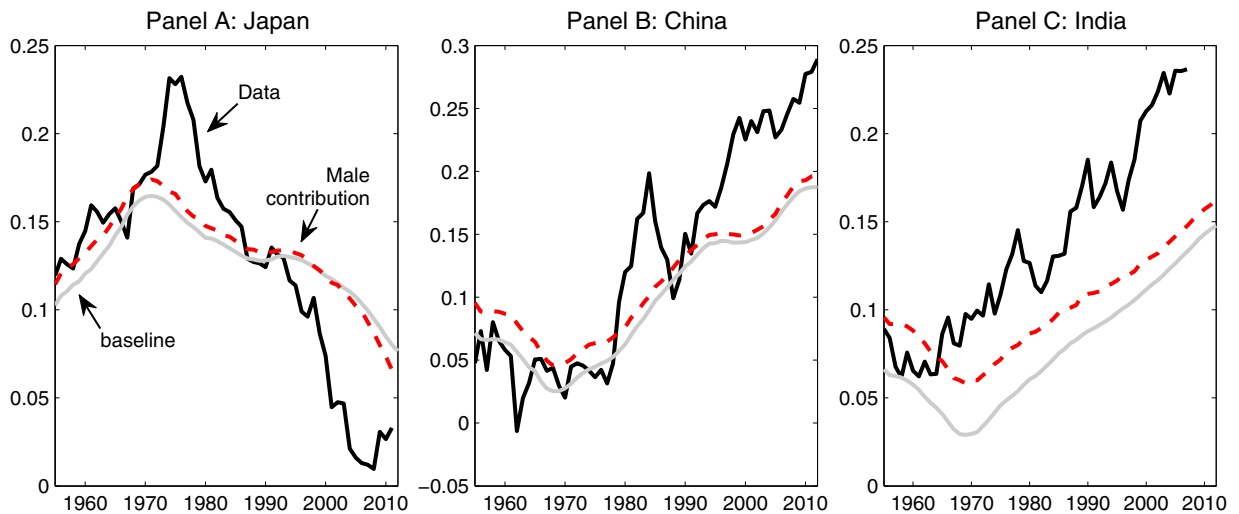


Fig. 9. Household saving rates in the data, the baseline, and when only male children contribute to family transfers.

at birth increased from 107 in 1975–1980 to 117 in 2005–2010.²⁷ As these cohorts age, the sex ratio of the 20–63 age group is expected to increase to over 114 by 2060. In India, the sex ratio has, and is projected to, remain stable around 108. As a comparison, in the US the sex ratio of the 20–63 age group is estimated at 101 in 2015. In Japan, the sex ratio was low through the 1970s, reflecting the loss of predominately males in WWII, and is expected to level off at around 105 by the end of the century.

Fig. 9 plots the new simulation results in which only males contribute to informal family transfers. For Japan and China, the level of saving changes slightly, but the dynamic pattern over time stays mostly the same as in the baseline. Informal transfers are not as important for Japan, and China's sex imbalance overcomes part of the level effect on saving. For India, the level effect is more pronounced, but again the evolution of the household saving rates remains similar to the baseline.²⁸

We also examined an alternative family support system pattern for multiple siblings (results not shown). In this exercise, each worker's contribution to their elderly parents depends on the number of siblings they have. The per-person contribution to family transfers are decreasing in their number of siblings, but total contributions by all members is increasing in the number of siblings (at a decreasing rate). The resulting simulated saving rates are very close to the baseline. Overall, variations in family transfer schemes do not alter the dynamics of household saving rates. We conclude that, within our model, family transfers do not play a substantial role in accounting for the evolution of saving rates.

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 pensions described in Section 3.2.2 (see Table 3), but they are otherwise the same as the baseline version of the model where only the age distributions differ across countries. 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. Thus, we keep the pension support levels fixed at their 2012 values. Fig. 10 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 14 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

²⁷ source: World Population Prospects 2015 Revision

²⁸ Wei and Zhang (2011) find that families with only male children increase their saving rates to bolster their son's attractiveness for marriage.

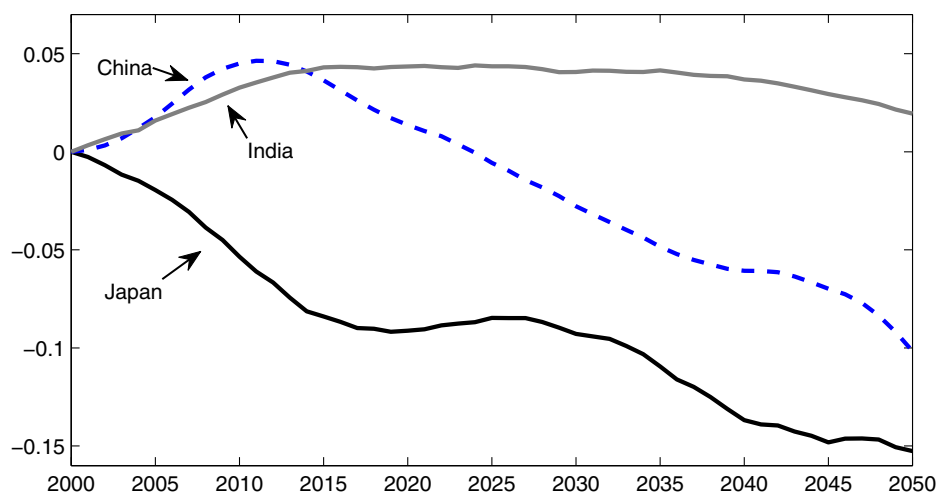


Fig. 10. Change in household saving rates relative to 2000 in the baseline model.

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.

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 household saving rates across countries and through time. Household saving decisions are modeled within a fairly standard life-cycle framework, embedding the observed and projected demographic profiles from 1955 on. A distinguishing feature of this framework is the incorporation of Barro and Becker (1989) style preferences with children in the utility function. We show that 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 partially 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.

Acknowledgments

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Appendix A. Appendix

A1. 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.

A2. 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 2015 Revision (<http://esa.un.org/wpp/>) and 2.) Angus Maddison Historical Data (<http://www.gdpc.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).

A3. Further details on the simulations

A3.1. Initial asset holdings

We begin the simulations in 1870, so that by 1955 the 20 year-olds from 1870 have already died. The initial model agents begin with no assets (no matter their age in 1870), but they still make transfers to (non-existent) elderly parents. We base the tax rates faced by these initial cohorts on an estimate of the number of retirees. Note, however, our results are not sensitive to the initial asset distribution in 1870 because each subsequent cohort begins life with zero assets (regardless of their parents saving behavior), and the model is partial equilibrium. That is, no price movements relate saving behavior by one cohort to the next. Thus, the main findings are highly robust to the initial conditions for the distribution of assets, and by 1955 the model emits a full asset distribution and saving rates by age (both of which exhibit something roughly hump-shaped, as is typical in life-cycle models).

A3.2. Number of children supporting the retired

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 inter-generational 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. The family transfer received per retiree in cohort j is then calculated as

$$f_{t,j} = \tau^j \theta_{t,j} \frac{\sum_{i=0}^{43} N_{t,i} w_t}{\sum_{i=44}^{75} N_{t,i}}, \quad j \in [44, 75]$$

where $\theta_{t,j}$ is the average number of children for a retired cohort divided by the average number of children across all retirees.

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