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Housing and Saving with Finance Imperfection

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In this paper, we construct a life cycle model with housing demand and incomplete market to explore the relationship between housing demand, accompanied with underdeveloped housing finance, and the household saving rate in China. We investigate two types of finance imperfection: a) the high down payment ratio required by central bank, and b) the unsmooth home equity withdrawal due to the prohibitive nature of refinancing. Without access to home equity withdrawal, households have to hold a considerable amount of non-housing asset such as deposit, cash, and bond as it is difficult for them to insure against negative income shocks and retirement via housing asset. This helps to account for the rising household saving rate during the past 10 years in China where commercialized housing market had been emerging. Yet interestingly on another note, we find higher down payment ratio leads to a substitution between housing and non-housing assets, leaving the aggregate household saving rate almost unchanged.

Key Words: Housing; Saving; Down payment; Home equity withdrawal.
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1. INTRODUCTION

During recent years, the household saving rate in China rise dramatically with the release of housing demand, triggered by central government, after 1998. In this transition from an old welfare housing system to the new market-oriented one, state-allocated or state-subsidized housing has gradually been replaced by self-owned commercialized houses[1]; and at the same time, households begun to substantially save for home purchase. Viewed from aggregate statistics, the sharp rise in housing expenditure can be the main contributor to the rise of the household saving rate: from 1998 to 2007, the aggregate value of Commercialized Residential Housing[2] sales has grown from 4.8% to 19.9% in proportion of household disposable income, and the household saving rate[3] has grown from 29.9% to 37.9%. While after considerable spending on housing, Chinese residents did not accumulate a large amount of liabilities despite their easy access to mortgage loans. The residential mortgage-to-GDP ratio, known as the rate of residential mortgage permeability, is as low as 11%, far below the typical level of financially developed economies such as the U.S. and the U.K. This misalignment between large home purchase expenditure and low residential mortgage accumulation indicates the rising household saving rate, which is our focus in this paper, can find its explanation in the release of housing demand with finance imperfection[4].

Assume housing asset can be fully collateralized, households then have the option to hold liabilities as much as the market value of their collateralized housing assets, thus no need to save for home purchase. However, the holding of residential mortgage loans in China is restricted in two ways.

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[1]In July 1994, the State Council of China outlined procedures for state employers to sell public housing units to sitting tenants in urban areas throughout the country (See Wang 2010 for details). According to Macros, Liu, and Prasad (2010), anecdotal evidence suggests that much of the privatized housing stock is unappealing, and many households may be saving to purchase new dwellings. Our observations on a nationwide household survey (Aordo 2009) also indicates that as housing demand is increasing along with the rapid growth of per capita income, households move up to a better house by purchasing commercialized residential housing and this type of house has gradually become the most popular type of self-owned house since 1998.

[2]Secondhand homes are not included.

[3]Household saving rate is defined as the ratio of saving expenditure to disposable income, in which housing expenditure is counted as one part of saving expenditure.

[4]Other explanations include the demographic dividend (Modigliani and Cao, 2004), the rapid economic growth along with borrowing constraints (Wen, 2009), the increasing income volatility (Macros, Liu, and Prasad, 2010), the transition of life cycle earning profile (Song and Yang, 2010), and the disproportionate gender ratio (Wei and Zhang, 2011).

Firstly, down payment requires the loan-to-value ratio to be smaller than one. Homeowners are hence forced to hold a positive net asset position no less than a certain proportion of their housing values, leading to an increase on their net wealth lower bound for housing investors. Secondly, with limited access to home equity withdrawal, homeowners have to pay monthly installments on time in order to avoid foreclosure. Given home equity withdrawal can arise as the result of housing transaction, additional borrowing (refinancing hereafter), or a combination of the two, we show that refinancing is essential in explaining the relationship between housing demand and high household saving rate later.[5] Namely, besides down payment, the refinancing is mainly shed lights on, though we will still discuss the role of transaction.

In this paper we construct a life cycle model with housing demand and incomplete market to explore whether the down payment and refinancing difficulty are quantitatively important in the relationship between housing demand and household saving rate. We model the finance imperfections mentioned above by imposing a down payment constraint and a repayment constraint: the specification of down payment constraint is to set an upper bound for loan-to-value ratio, while that of repayment constraint sets a lower bound for debt repayment in each period. We in further generate the low market share of secondhand homes in model by imposing a high transaction cost. Individual heterogeneity along dimensions of income, net wealth, and housing asset positions is also introduced into model in order to capture the individual decision aggregation, to mimic wealth accumulation life cycle profile, as well as to take households that switch from renting a house to owning a house into consideration[6].

We use data sets from National Bureau of Statistics (NBS), the People's Bank of China (PBC), China Health and Nutrition Survey (CHNS), and the Aordo Investor Center (Aordo)[7] to calibrate our baseline. We then in further undertake quantitative experiments to cross compare household saving behaviors and aggregate saving rates in the baseline model, model without demand for a self-owned house, model without residential mort-

[5]According to Klyuev and Mills (2007), home equity withdrawal rises when homeowners a) Increase their mortgage indebtedness when moving into a new house of similar value; b) Trade down to a lower value house when they have no mortgage or while maintaining their level of secured debt; c) Sell a house, repaying any remaining mortgage, to move into rental accommodation or to realize a bequest; d) Remortgage or refinance their existing mortgage with a higher principal; or e) Take out a second mortgage or home equity loan. It is costly or even prohibitive to take any of these five options in contemporary China's housing market.

[6]We do not explore the aggregate effects of heterogeneity on household savings. As is examined by Li and Zou (2004), the relationship between savings and income distribution is theoretically ambiguous.

[7]See appendix for detailed data set description.

gage loans, model without repayment constraints, and model with a lower housing transaction cost.

After taking the household saving rate, share of housing asset in net wealth, homeownership rate of nearly retired households, market share of secondhand houses, and ratio of residential mortgage permeability as target moments for calibration, our baseline model matches the real economy well along several other dimensions. On one hand, the model replicates the distribution of home purchase age, the cross-sectional wealth Lorenz Curve, and roughly the life cycle wealth profile; on the other hand, it is able to capture the "threshold effect" of down payment before home purchase, the debt repayment in advance after home purchase, the wealth accumulation before retirement, and the "buffer stock savings"[8] with illiquid housing asset.

We find refinancing difficulty is crucial in explaining the relationship between housing demand and household saving rate. Given the considerable cost of transaction in secondhand housing market, refinancing restriction will make it quite difficult to withdraw home equity[9]. Thus, households are not able to completely buffer against earning shocks or retirements via housing asset and therefore tend to repay their debt in advance and hold a considerable amount of non-housing asset such as deposit, cash, and bond. As a consequence, the release of housing demand will not completely crowd out the non-housing asset holdings and inevitably leads to a rise of household saving rate in aggregate.

We also find that changes in down payment ratio have limited impact on aggregate household saving rate. With a lower down payment ratio, original homeowners will borrow more and reduce savings, namely the "intensive margin", while certain original tenants begin to save for home purchase, namely the "extensive margin". These two margins offset and present a substitution between the housing asset and non-housing asset. In further, the refinancing limitation weakens the "intensive margin" by requiring households to repay their debt, thus households would not reduce their savings too much on average even if they can borrow more in the beginning of home purchase. Consequently, household saving rate can possibly remain or be even higher with a lower down payment ratio.

As far as we know, our work is the first attempt to lay out a complete explanation on the relationship between housing demand and household saving rate, as well as the first one to propose that refinancing difficulty works more significantly than down payment in shaping Chinese household saving rate.

[8]See Carroll (1997, 2009b) for details about the theory of "Buffer Stock Savings".

[9]Nakajima and Telyukova (2011) find households tend to withdraw home equity by selling their homes when refinancing is costly. In our model, selling homes is costly and therefore home equity withdrawal becomes costly.

Still is this work related to, and also contributes to, several strands of literature. After Artless and Varaiya (1978) introduced home purchase into life cycle model, Hayashi, Ito, and Slemrod (1989), Krumm and Kelly (1989), Engelhardt (1994), and Sheiner (1995) initially explored the relationship between home purchase and household saving rate. Limited by techniques, those works mainly focused on the "threshold effect" from down payment and concluded that housing market frictions would not have a significant impact on household saving rate in aggregate, though there can be a change on saving behaviors of the young. Following this tradition, Fernández-Villaverde and Krueger (2011) and Yang (2009) adopted state-of-art and full-fledged life cycle model with household level heterogeneity to analyze the effect of housing market frictions on life cycle consumption and saving patterns. However, they didn't pay attention to aggregate savings. When Klyuev and Mills (2007) shed lights on the role of increasing personal wealth accompanied with home equity withdrawal during the personal saving rate decline in US, they did not achieve a quantitatively important result since their focus is "Wealth Effect" rather than the access to home equity withdrawal. Nakejima and Telyukova (2011) studied the patterns of home equity withdrawal among retirees, and found that the cost of home equity borrowing did not affect total asset holding when households have easy access to selling their dwellings. Our work captures household housing decision and saving behavior, as well as explores the aggregate effects of housing demand release in a full-fledged life cycle framework where both housing transaction and refinancing are costly. We improve the literature above mentioned by exploring a) the relationship between home equity withdrawal and savings against negative income shocks and retirement, b) the substitution between housing and non-housing savings while adjusting down payment ratio, and c) the quantitative link between savings and saving rate.

Our work also extends the "Buffer Stock" theory developed in Carroll (1997), by introducing an additional dimension of attribute to the self-insurance assets. Since households are unable to withdraw home equity after the housing asset appreciation, our model is in accord with the fact that there is no significant "Wealth Effect"[10] in China. Meanwhile, our work is consistent with Carroll (2009a) and Kaplan and Violante (2011), which found the marginal propensity of consumption to transitory income shock is far larger than 0 when the wealth for buffering against earning risks is much less than aggregate wealth. In addition, our work can be combined with the idea of Krueger and Perri (2010) which focuses on the dynamics along all three dimensions of consumption, income and wealth on household

[10]See Case, Quigley, and Shiller (2005), Campbell and Cocco (2005) and Carroll, Otsuka, and Slacalek (2006) for details.

level. We find that with unsmooth home equity withdrawal, housing assets cannot be used to insure against income risks and retirement. Therefore, households tend to repay their debt in advance and hold a considerable amount of non-housing assets even with very low down payment ratio. And this, on one hand, helps to explain the misalignment between housing expenditure and the rate of residential mortgage permeability and, on the other hand, eventually leads to a conclusion different from Wang and Wen (2011).

In addition, we make a first attempt to build a structural model to account for the rise of household saving rate in China from the view of housing demand[11]. According to Macros and Prasad (2010), the unique empirical work on Chinese household saving rate under micro panels, housing reform accounts for approximately half of the rise on household saving rate in urban areas during 1995-2005 regardless of controversies on its sample selection and understatement in actual income and asset as mentioned in Kraay (2000). Interestingly is, those first get deeper studied are the parallel findings in that work. That framework outlined that the increasing burden of education and medical expenditure along with the transition of income structure are also important to explain the rising household saving rate. Following these findings, Yang and Chen (2009) maps the problem of education expenditure to a precautionary saving model. Although there is no model on Chinese residents' medical expenditure, the problem in China is not very different from that in the U.S. analyzed in De Nardi, French and Jones (2010). Song and Yang (2010) and Macros, Liu and Prasad (2010) also built models to explore the aggregate effects of the transition of the life cycle earning profile and the rise of income uncertainty. Therefore, housing demand turns out to be the only blind spot in understanding the household saving rate in China. This paper attempts to fill in that gap.

This paper is organized as follows. In Section 2, we discuss two key assumptions in our model by presenting related empirical findings. Section 3 introduces our baseline model. We develop intuitions on the main mechanisms in model in Section 4 and undertake quantitative works in Section 5. Section 6 concludes.

[11]Wang and Wen (2011) also build a structural model to explore the relationship between housing price and household saving rate in China, but the housing demand in their model is exogenous and will not respond to housing price, which makes their quantitative work irrelevant to the real economy.

2. STYLIZED FACTS

Unsmooth home equity withdrawal in terms of high transaction cost and refinancing difficulty is an assumption in need of more validation[12]. In this section, we list stylized facts in Chinese housing market besides validating this assumption. First, we present that the share of housing expenditure in household disposable income and the household saving rate are moving on the same direction, this indicates the rise of housing expenditure did not crowd out non-housing savings completely. Second, we compare housing assets and risk-free assets' real returns and their shares in portfolio between China and the U.S., and argue that the difference in portfolios within these two economies can possibly be explained by the different development level of housing finance. Third, we develop a simple regression model on consumption volatility of Chinese urban residents and find there is no significant "Wealth Effect". This regression model additionally illustrates that households do save to buffer against earning shocks, yet housing assets are not good buffer stocks. Last, we show our assumptions on transaction cost and refinancing difficulty are consistent with the fact that both the market share of secondhand housing and the rate of residential mortgage permeability are very low. On another note, it is not necessary to model the microfoundation of these two ad hoc assumptions, a short cut is sufficient.

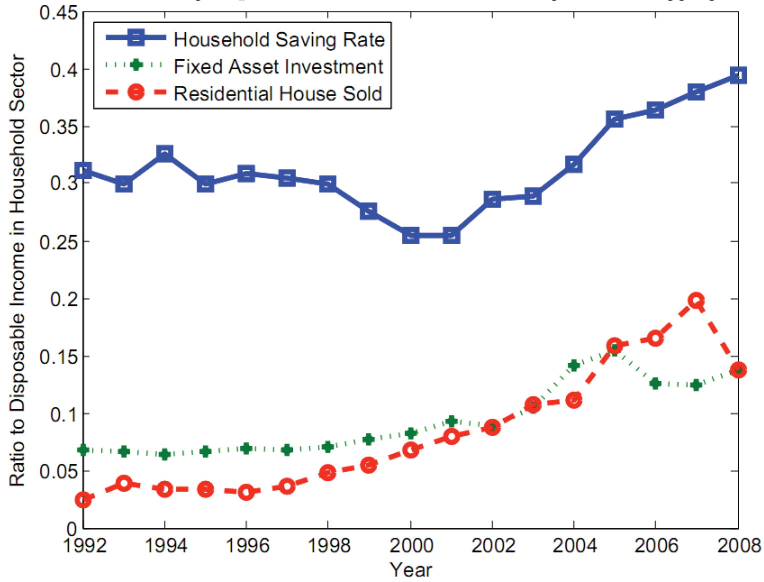
2.1. Housing and Saving in Aggregate

During 1998-2007, the share of housing expenditure in household disposable income is growing faster than household saving rate. Figure 1 gives the time series of household saving rate and household fixed asset investment rate from the "Flow of Funds Accounts". It also presents the ratio of aggregate commercialized residential housing (on trade) in household disposable income based on "China Statistical Year Book 2010". We hold that "Fixed Asset Investment" and "Commercialized Residential House (on trade)", in other words, "Residential House Sold", can be interpreted as housing demand. We observe that their time series are roughly consistent yet the trend of "Fixed Asset Investment" is slightly flatter than that of "Residential House Sold". This is because "Fixed Asset Investment" takes non-commercialized housing into account and potentially underestimates the value of commercialized housing. Hence we adopt the increase in "Residential House Sold" as upper bound for housing demand release later, which guarantees no over-estimation on the effect of housing demand upon saving rate.

[12]Down payment is a given fact in current China and is another type of finance imperfection as previously discussed. We hold that it is self-evident thus producing no need to qualify its feature.

According to our back-of-the-envelope calculation, the rise of housing-demand-to-disposable-income ratio is 15.1%. This is much larger than that of household saving rate, merely being 8.0%[13]. We truncate data at 2008 when there was a recession in housing market. However, some anecdotal evidence suggests that housing demand is to bounce back in 2009, and consequently the housing-demand-to-disposable-income ratio can be even higher than that in 2007.

FIG. 1. Housing Expenditure and Household Saving Rate in Aggregate



2.2. Portfolio and Real Return Rate

Table 1 displays a comparison on household portfolio and real return rate of each main asset category in China and the U.S. We obtain the U.S. data from previous literature (see in table), and calculate that of China from several data sets. To be specific, we summarize the portfolio of Chinese urban households from Aordo (2009) (a nationwide cross-sectional household survey), the risk-free rate from PBC, and the housing price as well as CPI from NBS respectively. We can find the real return rates of both housing asset and risk-free asset are similar; while the portfolios distinguish much from each other: there is almost no risky asset other than housing in China, yet households almost hold no risk-free assets in U.S.

[13]The rise of housing demand calculated from UHS by Macros and Prasad (2010) is less than that developed from aggregate statistics of NBS.

TABLE 1.

Comparison on Portfolios and Real Return Rates of Assets in China and U.S.

Nation	Item	Housing	Stock	Business	Cars	Safe N.W.	Source
China	Share	76.72	2.72	1.84	< 4.23	> 14.49	Aordo (2009)
	Return Rate	2.50				about 0.00	NBS, PBC
U.S.	Share	50.79	30.28	12.87	3.45	2.60	Glover et al. (2011)
	Return Rate	2.52	6.94			0.75	Piazzesi et al. (2007)

The differences in Chinese and American's household portfolios arise from different development stages of their financial markets. Since investment neither on stock market nor on productive capital in China is as accessible as it is in U.S., Chinese households hold far less stock and business capital than what household do in U.S. When home equity withdrawal is not easily accessible, households have to allocate much of their net wealth into risk-free assets in order to insure against negative income shocks and retirements. Therefore, we can infer that the release of housing demand in China will not crowd out as much non-housing asset as it will do in the U.S and thus leads to a rise on household saving rate in aggregate.

2.3. Wealth Effect and Partial Insurance

To further explore the consequence of underdeveloped housing finance, we run a simple regression on individual level consumption volatility with Aordo (2008) and Aordo (2009), the unique nationwide household panel in China reporting income, consumption and wealth composition. We test in model whether Chinese households will increase their consumption after housing asset appreciation and whether they mainly rely on non-housing assets for self-insurance. Our parsimonious regression model is similar to that in Campbell and Cocco (2005):

$$\Delta c_{i,t+1}^{j} = \beta_0 + \beta_1 \cdot \Delta y_{i,t+1}^{j} + \beta_2 \cdot \Delta p_{i,t+1}^{j} + \beta_3 \cdot \text{age}_{i,t+1}^{j} + \beta_4 \cdot {\text{age}_{i,t+1}^{j}}^{2} + \varepsilon_{i,t+1}^{j}, \quad (1)$$

where the dependent variable is log-difference in consumption and the independent variables are log-difference in income, housing price, along with the age characteristics of the head of a family. Denote the wealth-to-income ratio as wi, and the share of housing assets in the portfolio as hw. And we divide the whole sample into four groups marked with $j = 1, 2, 3, 4,$, subject to $wi < 10$, $hw < 75\%$, $wi < 10$, $hw \geq 75\%$, $wi \geq 10$, $hw < 75\%$, and $wi \geq 10, hw \geq 75\%$, respectively. With households having no easy access to home equity withdrawal presumed, we expect the coefficients of housing price are not significantly positive and households with a higher share of housing asset in net wealth would experience larger consumption volatility.

We report the estimation in Table 2. Compared with results in Campbell and Cocco (2005), our coefficients of income are similarly significant yet those to housing price are not. We find consumption elasticity to income decreases along the wealth-to-income ratio dimension, consistent with the "Bended Consumption Function" finding in Zeldes (1989) and Carroll (1997, 2001), when observing Group 1 against Group 3 and Group 2 against Group 4 with portfolios controlled. Yet on another side, an increase on consumption elasticity to income emerges along the housing share dimension when comparing Group 1 to Group 2 and Group 3 to Group 4 with wealth-to-income ratio controlled. This indicates housing assets are not good buffer stocks. We can conclude that the estimation results accord with our previous expectation and further support our model built on the framework of "Buffer Stock Saving" Theory[14].

TABLE 2.

Testing the "Wealth Effect" and "Partial Insurance" of Urban Chinese Households

Independent Variable	$j=1$	$j=2$	$j=3$	$j=4$	Campbell et al.
Δy	0.201^{***}	0.301^{***}	0.136^{***}	0.239^{***}	0.406^{***}
	(0.031)	(0.031)	(0.036)	(0.048)	(0.035)
Δp	−0.004	−0.027	0.011	−0.046	1.222^{***}
	(0.028)	(0.023)	(0.035)	(0.152)	(0.164)
Age	-0.007^{*}	0.001	0.015^{***}	−0.004	−0.070
	(0.004)	(0.004)	(0.005)	(0.007)	$(0.043)^{*}$
Age squared	0.000^{*}	0.000	0.000^{***}	0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Obs	1010	947	678	285	
Adjusted R-square	0.039	0.089	0.029	0.078	
F-statistics	11.25	24.14	6.07	6.93	

Note: The numbers in parentheses are the deviation of coefficients with ***, **, and * denoting the 1%, 5%, and 10% level of significance.

2.4. Refinancing and Lemon's Market

In this subsection, we show the assumptions in terms of high transaction cost and refinancing difficulty are reasonable to be imposed on our baseline model by three steps. Firstly, international comparison on housing finance indicates economies where households have easy access to mortgage equity withdrawal tend to display higher mortgage-debt-to-GDP ratios, yet on this ratio Chinese presents clearly that there exists a refinancing difficulty. Secondly, after a short period of transition, both the market share of secondhand housing and the average loan-to-value ratio of newly purchased homes have stabilized at around 20%, and it confirms both the

[14]See details of "Buffer Stock Saving Theory" in Carroll (1997, 2009b).

secondhand housing market and the housing finance system are still underdeveloped. And thirdly, these two aforesaid ad hoc assumptions are sufficient to capture not only the market underdevelopment but also the imperfect substitution between housing and non-housing assets, which is crucial in explaining the rise of the household saving rate.

Based on European Central Bank (2003), IMF (2008) and annual statistics of the People's Bank of China, we display the mortgage equity withdrawal arrangement, typical loan-to-value ratio, the average typical terms, and the mortgage-debt-to-GDP ratio (rate of residential mortgage permeability) of both China and the Group of Seven (G7 hereafter) in Table 3. Data for G7 are the average for 2001-2006, while that of China is in 2007. We can find the rate of residential mortgage permeability in China is significantly lower than that of most members of G7.

As Table 3 indicates, the rates of residential mortgage permeability in economies without access to mortgage equity withdrawal are significantly lower than those with it, although Germany behaves as an exception. And most of these economies have similar typical loan-to-value ratios as well as average typical terms. This implies that the differences in typical loan-to-value ratio and average typical term are not as important as that in mortgage equity withdrawal. Therefore, we can infer that refinancing is crucial in determining the aggregate value of residential mortgage loan.

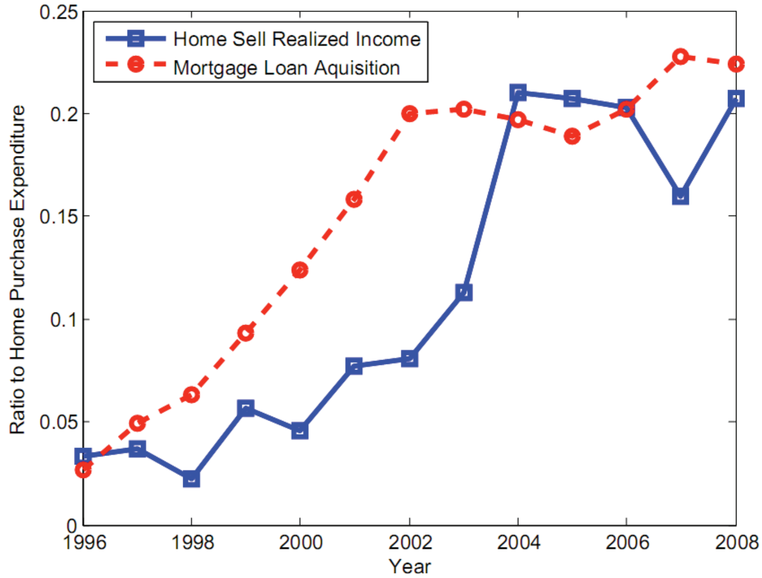
TABLE 3.

Institutional Differences in Housing Market and the Permeability of Mortgage Loans

	Mortgage Equity Withdrawal	Typical Loan-to-Value Ratio (percent)	Average Typical Term (Years)	Mortgage-Debt-to-GDP Ratio
China	No	70	15	0.11
Canada	Yes	75	25	0.43
France	No	75	15	0.26
Germany	No	70	25	0.52
Italy	No	50	15	0.14
Japan	No	80	25	0.37
U.K.	Yes	75	25	0.71
U.S.	Yes	80	30	0.65

Figure 2 depicts the per capita income realized through residential house selling against the per capita mortgage loans used for home purchase, both divided by per capita housing expenditure. These two ratios become stationary after a short period of transition. It should be noted here the dwellings sold by households in China are all secondhand houses, while the housing expenditure contains expenditures on both new and secondhand homes. Thus we can calculate the market share of secondhand housing through them. We find that the share of secondhand housing in China is approximately 20%, which is much lower than that in developed economies where the number is generally 80%. On another note, this average loan-to-value ratio of a newly purchased house calculated from the ratio of loans used for home purchase in housing expenditure is possibly biased, since the numerator and denominator are possibly suffering from a different range of bias. Still is the trend plausible as long as the bias is relatively constant over time. In sum, we can conclude that both the secondhand housing market and the housing finance system are still underdeveloped in China.

FIG. 2. Transition of Market Share of Secondhand Housing and Average Loan-to-Value Ratio of Newly Purchased Houses



A convenient way to replicate the stylized facts mentioned above is to impose high transaction cost and refinancing restriction. With a high transaction cost, households would not trade housing assets frequently, and new housing will dominate secondhand housing when housing demand is increasing along with per capita income. And with restrictions on refinancing, households will not hold mortgage loans as mush as they otherwise would, thus they do not accumulate a large amount of liability.

Though a short-cut alike, these two ad hoc assumptions are already sufficient to capture both the market underdevelopment and the imperfect substitution between housing assets and non-housing assets. And with these assumptions settled, the limited home equity withdrawal will invariably affect the relationship between housing demand and household saving rate no matter why households do not refinance or sell their dwellings.

For instance, if households are able to refinance, yet choose not to after considering the high transaction cost of remortgage or high interest rate of home equity loans, they will still hold a considerable amount of non-housing savings against negative income shocks and retirement. In this situation, households actually save the first-order transaction cost by bearing much more second-order intertemporal consumption distortion. In another example, if infrequent trade on second homes is not a consequence of high transaction cost, but rather the result of subjective utility discount on second homes or inefficiency arising from moral hazard, adverse selection, or searching frictions, households will still tend not to withdraw home equity by selling their dwellings. In this case, housing transactions cannot be an alternative option of home equity withdrawal for refinancing, either.

3. BASELINE MODEL

In this section, we construct a life cycle model with housing demand and incomplete market to explore the relationship between housing demand and household saving rate in China, where housing finance is underdeveloped. Our model is built on the framework of Yang (2009), Iacoviello and Pavan (2009), Chen (2010), Díaz and Luengo-Prado (2010) and Bajari, Chan, Krueger and Miller (2010). And in this model, housing transaction cost is non-convex and refinancing difficulty is captured by a repayment constraint.

3.1. Preference

We model a typical household's consumption and housing choice as a partial equilibrium decision problem with a finite lifetime horizon. In each period t, households either rent housing service d_t or own a house h_{t+1}, then choose expenditures on nondurable consumption c_t, and the amount of risk-free non-housing assets a_{t+1} to bring into the next period. Households value nondurable consumption and housing services according to a standard utility function[15]:

$$U(\{c_i, d_i, h_{i+1}\}_{i=t}^{T}) = E_i \sum_{i=t}^{T} \beta^{i-1} u(c_i, d_i, h_{i+1}), \tag{2}$$

where β is the standard time discount factor and expectation operator E_t is taken with respect to the stochastic processes driving labor income.

We assume that the intratemporal elasticity of substitution between nondurable consumption and housing service is 1. And households prefer self-

[15] "Housing in utility" is similar to the "Spirit of Capitalism", which can also be used to explain certain puzzles in consumption theory such as the "Excess Smoothness" (See Luo, Smith, and Zou, 2009).

owned houses to rented ones: one unit of rented house is equivalent to only $(1-\Psi)$ unite of self-owned one in utility, where $\Psi \in [0,1]$[16]. Thus we have instantaneous utility function as:

$$u(c,d,h) = \frac{(c^{\alpha}((1-\Psi)d+h)^{1-\alpha})^{1-\sigma}}{1-\sigma}. \tag{3}$$

3.2. Endowment

Agents are endowed with one unit of time each period, with which they supply inelastically in the labor market to earn labor income y_t. The earning process y_t consists of three components: a) a deterministic growing trend $(1+g_y)^t$ as result of technological progress, b) a fixed effect η_{j_t} to capture the life cycle earning profile, and c) a stochastic shock s_t drawn from finite state space S, following a first order Markov process with conditional transitional probability $p(s_{t+1}|s_t)$. Denote j_t as the individual's age at period t, we have

$$y_t = (1+g_y)^t \eta_{j_t} s_t. \tag{4}$$

3.3. Market Frictions

We model four frictions in our baseline model: tenure choice, down payment, transaction cost, and repayment constraint. The first three frictions are standard in literature, while the last one is distinctive compared with literature that focus on housing market in the U.S.

First, households have tenure choice at each period, but homeowners are not allowed to lease their houses out, either to occupy more than two houses. Once they improve the sizes or quality of their homes, they have to sell the old house before purchasing the new one. Therefore, the value of the house being invested in by individuals is equal to that being consumed for homeowners and zero for the renters. Thus we have

$$d_t \cdot h_{t+1} = 0. \tag{5}$$

[16]This specification is standard. Traditionally, there are two approaches to generate the tenure choice and it is easy to prove their mathematical equivalence. To be specific, one method is to consider the moral hazard problem that drives up the user's rented costs in rental market, as in Yang (2009), Chambers, Garriga, and Schlagenhauf (2009a, 2009b, 2009c) and Chen (2010). While the other is to assume that people prefer self-owned houses to rented ones, as in Iacoviello and Pavan (2009), Kiyotaki, Michaelides, and Nikolov (2011) and Díaz and Luengo-Prado (2010). Micro-level evidence in Dotsey, Li, and Yang (2010) further suggests that $\Psi \approx 0.1$ in the U.S. Since here we do not intend to model a general equilibrium, we take the rent rate as an exogenous variable; however, we still have to calibrate the homeownership preference parameter Ψ in order to match the homeownership rate on aggregate.

In addition, the physical stock of the house depreciates at a constant rate δ each period, while the relative price of one unit of housing asset p_t, in terms of the numeraire non-durable good, appreciates at a constant rate g_p annually. The rent-to-price ratio of housing is r_{rent}.

Second, the upper bound of loan-to-value ratio in model is less than one; thus, households on one hand, have to pay the down payment, and on the other hand, are only able to borrow up to a fixed fraction of the house value when purchasing a house. In other words, we have

$$a_{t+1} \geq -(1-\lambda_t)p_t h_{t+1}. \tag{6}$$

We do not impose a minimum house size $h_{\min}$ as Chambers, Garriga, and Schlagenhauf (2009a, 2009b, 2009c) and Iacoviello and Pavan (2009) do. And the thresholds of home purchase in model are actually heterogeneous and endogenous, which reflects the tradeoff between the utility discount from renting a house and the intertemporal consumption distortion from purchasing a house.

Third, in order to model the underdeveloped second hand housing market, we assume that households are subject to non-convex adjustment cost Ω, which is a certain proportion τ to the value of the house sold when moving up or down. Homeowners and renters do not have to pay transaction costs if and only if they retain their original houses and keep on renting respectively. Hence the transaction cost can be expressed as

$$\Omega(p_t, h_t, h_{t+1}) = 1_{\{h_{t+1} \neq (1-\delta)h_t\}} \cdot \tau p_t h_t. \tag{7}$$

Forth, we assume that households have no access to refinance, and have to repay at least a proportion λ_3 of their debt each period in order to mimic the mortgage maturity in China without increasing computational complexity. Denote λ_2 as the indicator of the enforcement of repayment constraint. Hence,

$$1_{\{h_{t+1}=(1-\delta)h_t\}} \cdot \lambda_2(a_{t+1} + \min\{(1-\lambda_3)|a_t|, 0\}) \geq 0 \tag{8}$$

Although Chambers, Garriga, and Schlagenhauf (2009a, 2009b, 2009c) have modeled the residential mortgage loan term structure by imposing a fixed repayment schedule, it is more plausible and convenient to simply require households who stay in original dwellings to reduce their indebtedness each period at a certain rate. Households then are subject to either (7) or (8). And via them, we capture the current state of home equity withdrawal in China.

The key frictions can be summarized by rent option d_t, down payment ratio λ_1, transaction cost ratio τ, and the indicator of repayment constraint λ_2, with $d_t = \lambda_1 = \tau = \lambda_2 = 0$ denoting a frictionless economy. (The term, "frictionless economy", hereafter all refers to the economy with $\lambda_1 = \tau = \lambda_2 = 0$ for convenience.)

3.4. Household's Problem

Denoting $V(a_t, h_t, s_t, j_t) = \max U(\{c_i, d_i, h_{i+1}\}_{i=j_t}^{T})$ as the value function, we then rewrite the household's utility maximization problem in recursive formulation:

$$V(a_t, h_t, s_t, j_t) = \max_{\{c_t, d_t, h_{t+1}, a_{t+1}\}} \{u(c_t, d_t, h_{t+1}) + \beta E_t V(a_{t+1}, h_{t+1}, s_{t+1}, j_{t+1})\}. \tag{9}$$

In each period t, the household's disposable wealth consists of their depreciated house value $(1-\delta)p_t h_t$, non-housing asset with interest income $(1+r)a_t$, and labor income y_t. With these resources, households make their choices. The intertemporal budget constraints can be written as

$$c_t + r_{rent} p_t d_t + a_{t+1} + p_t h_{t+1} + \Omega(p_t, h_t, h_{t+1}) \leq (1+r)a_t + y_t + (1-\delta)p_t h_t. \tag{10}$$

Definition 3.1. Denote $X = A \times H \times S \times J \subset R^4$ as the state space and $M = C \times D \times A \times H \subset R^4$ as the control space. The value function $V : X \to R$ and policy function $P : X \to R$ solve the households' problem, in which $P = P^c \times P^d \times P^a \times P^h$ denotes the policy function in each dimension of control space.

3.5. Aggregate Saving Rate

Housing asset in our model also generates capital income. With a self-owned house, household does not have to pay for housing service and thus we regard this imputed rent as one part of capital income from housing assets. Moreover, household's net wealth increases when the housing asset appreciates, serving as another part of capital income from house. With no housing transaction, the imputed rent is to be consumed while the increment in house value (or home equity) is to be saved.

We then clarify three types of household saving rates, conditioning on how to deal with the imputed rent and housing asset appreciation. The first type of saving rate takes both of them into consideration, through which saving rate can be directly mapped into net wealth increment. While the second type follows the tradition of national accounting caliber, it only considers realized capital income. Namely households receive their capital income from housing asset appreciation exclusively when they sell their houses. And the third one aims to reflect a fact that the imputed rent from house in China's nation accounts is seriously underestimated. Thus we have

DEFINITION 3.2.

$$
\begin{aligned}
SR1_t^h &= \frac{\int_{A\times H\times S\times J}[p_t P^h(a_t,h_t,s_t,j_t) - p_{t-1}h_t]dF(a_t,h_t,s_t,j_t)}{\int_{A\times H\times S\times J}[y_t(s_t,j_t) + ra_t + (r_{rent}-\delta)p_t h_t + (p_t - p_{t-1})h_t]dF(a_t,h_t,s_t,j_t)},\\
SR1_t^a &= \frac{\int_{A\times H\times S\times J}[P^a(a_t,h_t,s_t,j_t) - a_t]dF(a_t,h_t,s_t,j_t)}{\int_{A\times H\times S\times J}[y_t(s_t,j_t) + ra_t + (r_{rent}-\delta)p_t h_t + (p_t - p_{t-1})h_t]dF(a_t,h_t,s_t,j_t)},\\
SR2_t^h &= \frac{\int_{A\times H\times S\times J}p_t[P^h(a_t,h_t,s_t,j_t) - (1-\delta)h_t]dF(a_t,h_t,s_t,j_t)}{\int_{A\times H\times S\times J}[y_t(s_t,j_t) + ra_t + (r_{rent}-\delta)p_t h_t]dF(a_t,h_t,s_t,j_t)},\\
SR2_t^a &= \frac{\int_{A\times H\times S\times J}[P^a(a_t,h_t,s_t,j_t) - a_t]dF(a_t,h_t,s_t,j_t)}{\int_{A\times H\times S\times J}[y_t(s_t,j_t) + ra_t + (r_{rent}-\delta)p_t h_t]dF(a_t,h_t,s_t,j_t)},\\
SR3_t^h &= \frac{\int_{A\times H\times S\times J}p_t[P^h(a_t,h_t,s_t,j_t) - (1-\delta)h_t]dF(a_t,h_t,s_t,j_t)}{\int_{A\times H\times S\times J}[y_t(s_t,j_t) + ra_t]dF(a_t,h_t,s_t,j_t)},\\
SR3_t^a &= \frac{\int_{A\times H\times S\times J}[P^a(a_t,h_t,s_t,j_t) - a_t]dF(a_t,h_t,s_t,j_t)}{\int_{A\times H\times S\times J}[y_t(s_t,j_t) + ra_t]dF(a_t,h_t,s_t,j_t)},
\end{aligned}
\tag{11}
$$

$$
\begin{aligned}
SR1_t &= SR1_t^h + SR1_t^a,\\
SR2_t &= SR2_t^h + SR2_t^a,\\
SR3_t &= SR3_t^h + SR3_t^a,
\end{aligned}
\tag{12}
$$

where F is the accumulated distribution function of heterogeneity defined as $A \times H \times S \times J \to [0, 1]$, SR, SR^h, SR^a denote the household saving rate on aggregate, on housing assets, and on non-housing asset, and $SR1$, $SR2$, $SR3$ denote the saving rates under the three definitions mentioned above, respectively.

Given non-negative aggregate housing asset, if the asset price growth rate g_p is larger than its depreciation rate δ, then accounting home equity increment would lead to a higher household saving rate, while accounting imputed rent would lead to a lower household saving rate through the saving expenditures on housing asset. On another note, the left saving channel, on non-housing assets, is determined by changes in household disposable income upon which both accounting home equity and imputed rent throw negative impacts. Therefore, the second saving channel is arithmetically dominated by the first one and here we have Proposition 1

Proposition 1. *When $g_p > \frac{\delta}{1-\delta} > 0$, we have*

$$\begin{aligned} SR1_t^h \geq SR2_t^h, SR3_t^h \geq SR2_t^h, \\ SR1_t^a \leq SR2_t^a, SR3_t^a \geq SR2_t^a, \\ SR1_t \geq SR2_t, SR3_t \geq SR2_t. \end{aligned} \tag{13}$$

4. DEVELOPING INTUITION

We will illustrate the mechanism lying in our baseline model by steps in this section. First, we map a frictionless economy with housing demand and tenure choice into one with no houses, and further demonstrate housing choice has no effect on saving in this specific case. Second, we investigate the intertemporal effects from housing demand suppression in a two-period OLG model. We find both the down payment and the limitation on withdrawing home equity tend to drive up savings for homeowners, while the limitation on withdrawing weakens the role of down payment in affecting savings. Thirdly, we explore the aggregate effects from down payment via a continuous-time OLG model with "once for all" housing investment and heterogeneous life expectancy in order to show how the intensive margin and extensive margin are offsetting. And lastly, we develop a simplified buffer stock saving model to illustrate that the substitution between housing and non-housing assets is further weakened when considering precautionary saving motives with refinancing difficulties.

4.1. A Frictionless Economy

Accompanied with no transaction cost, no repayment constraint, either any down payment requirement, housing decision will produce no intertemporal effect on saving behaviors. Since it is costless to transfer asset type in this situation, the net wealth dimension becomes a sufficient state. It is noted that under this circumstance benefit from holding housing asset is housing asset appreciation and imputed rent, and opportunity cost is real returns of non-housing assets. Consequently, the gap between benefit and opportunity cost from holding housing assets is equivalent to the price of housing service flow, following which we can map our baseline model into one with both non-durable and housing service consumption yet only has one type of asset.

Lemma 1. *When $\lambda_2 = \tau = 0$, the baseline model can be mapped into one with single risk-free asset, two types of consumption goods, and occasionally binding intra-temporal constraint.*

Proof. Denote $r_h = 1-(1-\delta)(1+g_p)/(1+r)$ and $w_{t+1} = a_{t+1} + (1-r_h)p_t h_{t+1}$; we can transform (10) and (6) into

$$c_t + r_{rent}p_t d_t + r_h p_t h_{t+1} + w_{t+1} \leq y_t + (1+r)w_t, \tag{14}$$

$$(\lambda_1 - r_h)p_t h_{t+1} \leq w_{t+1}, \tag{15}$$

where $(y_t, c_t, d_t, h_t, w_t) \geq 0$. ∎

Lemma 1 simplifies the household's problem. We further abandon the constraints on w_{t+1}, and have the following proposition:

PROPOSITION 2. *When $\lambda_1 = \lambda_2 = \tau = 0$, housing choice is irrelevant to saving.*

Proof. With $\lambda_1 = \lambda_2 = \tau = 0$, we consolidate the housing and non-housing consumption into the composite consumption as $\mathbf{c}_t = \kappa_t(c_t + r_{rent}p_t d_t + r_h p_t h_{t+1})$, with the composite price $\mathbf{p}_t = \kappa_t^{-1}$, where $\kappa_t = (1-\alpha)^{1-\alpha}\alpha^{\alpha} \cdot \min\{p_t r_{rent}, p_t r_h\}^{-\alpha}$; thus we have

$$u(\mathbf{c}_t) = \frac{\mathbf{c}_t^{1-\sigma}}{1-\sigma}, \tag{16}$$

$$\mathbf{p}_t \cdot \mathbf{c}_t + w_{t+1} \leq y_t + (1+r)w_t, \tag{17}$$

$$U = \kappa_1^{1-\sigma} \max_{\{w_{t+1}\}} E_0 \sum_{t=1}^{T} \left[\frac{\beta}{(1+g_p)^{\alpha}}\right]^{t-1} \frac{[y_t + (1+r)w_t - w_{t+1}]^{1-\sigma}}{1-\sigma}, \tag{18}$$

where housing choice has no intertemporal effects. ∎

This simplified version serves as the benchmark when we analyze market frictions.

We further set $r_{rent} = r_h$ to equalize the real return rate of housing asset and that of non-housing asset, and consolidate housing and non-housing asset into net wealth. Then increment on saving at each period is the amount required to keep aggregate net wealth-to-income ratio constant over time in the balanced growth path. Thus we have

PROPOSITION 3. *With $\lambda_1 = \lambda_2 = \tau = 0$ and $r_{rent} = r_h = r$, housing demand has no influence on $SR1$, but has a negative impact on $SR2$.*

Proof. Denote W as the net wealth to labor income ratio on the balanced growth path, then

$$SR1 \approx \frac{g_y W}{1 + rW}. \tag{19}$$

Definition 2 notes that $SR2$ accounts neither the unrealized capital income nor the corresponding savings from housing asset appreciation, thus $SR2$ should be arithmetically decreasing with housing demand when $SR1 < 1$. ∎

4.2. Housing Demand Suppression

In this subsection, we present how the down payment requirement as well as the home equity withdrawal affects household saving in a two-period life cycle model; and for simplicity, home equity withdrawal is modeled as the option to sell dwellings and rent houses[17]. Comparison is conducted between the case where households can sell their houses and the one where they cannot in order to observe the impact from down payment. Our discussion also covers the case in which all households can only rent.

According to proposition 2, the case with no down payment requirement or transaction cost is equivalent to that granted with no self-owned house. Although two periods are not adequate to capture either the mortgage term structure or the repayment constraint, we reconcile it by requiring households to repay their debt before the end of life.

ASSUMPTION 1. *(i)* $w_1 = h_1 = 0$; *(ii)* $T = 2$; *(iii)* $(y_1, y_2) = (\overline{y}, 0)$; *(iv)* $w_3 - h_3 \geq 0$.

Households enter the economy with no net wealth under Assumption 1. They live for two periods and only receive labor income in the first period. All debt must have been repaid by the end of the second period. $\sigma = 1$ is set in order to obtain a closed-form solution. We discuss four cases conditioning on whether there is down payment requirement and whether households can withdraw home equity, as is depicted in Table 4. And we analyze the housing demand and saving in Period 1.

[17] In this paper we focus on access to refinancing options. However, modeling the option of house transaction is much simpler in this version of model. What is more, transaction cost and refinancing difficulty have similar effects on savings for retirement, which here is the main incentive for saving other than home purchase.

TABLE 4.

Four Cases under Assumption 1

Case	Period 1	Period 2	Down payment	House	Saving
1	Purchase	Sell	No	H^1	W^1
2	Purchase	Sell	Yes	H^2	W^2
3	Purchase	Stay	No	H^3	W^3
4	Purchase	Stay	Yes	H^4	W^4

PROPOSITION 4. *With sufficiently tight down payment constraint* $\lambda_1 > (1 + \beta/\alpha)r_h$*, we have*

$$\begin{aligned} &H^1 > H^2 > H^3 = H^4, \\ &W^1 < W^2 < W^3 = W^4. \end{aligned} \tag{20}$$

Proof. Solve the two period model, we have

$$\begin{pmatrix} H^1 & H^2 & H^3 & H^4 \\ W^1 & W^2 & W^3 & W^4 \end{pmatrix} = \begin{pmatrix} \frac{\alpha}{1+\beta}\frac{\overline{y}}{r_h} & \frac{\alpha+\beta}{1-\beta}\frac{\overline{y}}{\lambda_1} & \alpha\overline{y} & \alpha\overline{y} \\ \frac{\beta}{1+\beta}\overline{y} & (1 - r_h/\lambda_1)\frac{\alpha+\beta}{1+\beta}\overline{y} & \frac{\alpha+\beta}{1+\beta}\overline{y} & \frac{\alpha+\beta}{1+\beta}\overline{y} \end{pmatrix} \tag{21}$$

■

We can find that households save more when housing demand is suppressed. With a sufficiently high down payment ratio, there emerges intratemporal distortion on the allocation of non-durable consumption and housing service, which yet can be alleviated by intertemporal wedge of over saving. It also should be noted here that without home equity withdrawal, households have to save for retirement yet reduce their housing demand. As a consequence, the down payment constraint is loosened in this case and thus has no effects on savings.

4.3. Intensive versus Extensive Margin

In this subsection, we discuss the role of down payment requirement on aggregate savings in an economy with both original homeowners and households switching from renters to owners. We endogenize house size, home purchase age, as well as heterogeneity along individual level asset holdings into a multi-period life cycle model. To keep simplicity, we assume households present a homogeneous retirement age yet have heterogeneous life expectancy. Consequently, those who live longer will save more for retirement and are better able to purchase their homes. With lower down payment ratio, renters with longer life expectancy will choose to become owners earlier. We deduce a continuous function mapping the down payment ratio to aggregate household savings next.

ASSUMPTION 2. *(i)* $Y = \{\overline{y}, 0\}$*; (ii)* $p(\overline{y})|_{0\leq t\leq Tr<T} = p(0)|_{0<Tr<t\leq T} = 1$*; (iii)* $\tau = 0, \lambda_2 = 0$*; (iv)* $h_t = 1_{\{t_1\leq t\leq T\}}\cdot h_{t_1}$*; (v)* $T < \infty$*, (vi)* $\rho = r = r_{rent}$*, (vii)* $\delta = g_y = g_p = 0$*, (viii)* $p_t = p$*.*

The household's optimal control problem is

$$\begin{aligned} U = \max_{\{c_1,d_1,t_1,h_1\}} & \int_0^{t_1} e^{-\rho t}\frac{(c_t^{1-\alpha}((1-\Psi)d_t)^{\alpha})^{1-\sigma}}{1-\sigma}dt + \int_{t_1}^{T} e^{-\rho t}\frac{(c_t^{1-\alpha}h_t^{\alpha})^{1-\sigma}}{1-\sigma}dt, \\ s.t. \quad & \dot{w}_t = r(w_t - ph_t) + y_t - c_t - r_{rent}pdt, \\ & w_0 = w_T - h_T = 0, \\ & w_t \geq \lambda_1 ph_t, \\ & h_t = 1_{\{t_1\leq t\leq T\}}\cdot h_1 \\ & t_1 \geq [0, T]. \end{aligned} \tag{22}$$

In this continuous time and simplified version of baseline model, households live for T period, and work for Tr period. They receive constant labor income from working per period and none after retirement. Households enter the economy with no house, and can only purchase their homes once for all. And once becoming homeowners, they are not allowed to move up or down. The home purchase time t_1 and home size h_1 are both endogenously determined. For simplicity, we do not consider physical depreciation, asset appreciation, economic growth, and assume that both the interest rate and rent rate are equal to the subjective discount rate.

LEMMA 2. *The homeowner's optimal decision on* (t_1, h_1) *satisfies the following condition:*

$$w_{t_1} = \lambda_1 ph_{t_1}, \tag{23}$$

$$\frac{1}{r}\ln(1 + \lambda_1 rph_1/\overline{y}) < t_1 < \frac{1}{r}\ln(1 - (1-\lambda_1)rph_1/\overline{y}) + Tr, \tag{24}$$

$$(1-\Psi)\frac{1-e^{-rTr}}{1-e^{-rT}}\frac{\alpha\overline{y}}{rp} < h_1 < \frac{1-e^{-rTr}}{1-e^{rT}}\frac{\alpha\overline{y}}{rp}. \tag{25}$$

This lemma gives the feasible interval of housing decision. Its implication is straightforward. Firstly, (23) should be binding, otherwise, household can either purchase a larger house or purchase one with same size, but earlier, which could result in higher level of lifetime welfare. Secondly, there should be enough time for potential home buyers to accumulate assets for the down payment, while this preparation period, at the same time, should not last too long in case households are not able to repay their debt with their remaining lifetime labor income; thus we have (24). Thirdly, the optimal size of self-owned house should be smaller than that of a rented house, however, the generated housing service should be larger than that of a rented one (after it is discounted by the factor of $(1-\Psi)$); namely, we have (25). When home equity withdrawal is not feasible, the real cost of self-owned housing service is higher than that of a rented one; thus, the optimal self-owned house size is smaller than that of rented one. However, the utility derived from self-owned housing service should be higher than that from a rented one, since only in this case are households willing to own their homes.

PROPOSITION 5. *After optimizing (c_t, d_t) given (t_1, h_1), we have*

$$\begin{aligned} U^o &= \max_{\{t_1,h_1\}} \frac{\left\{(1-\alpha)^{1-\alpha}\left[\frac{(1-\Psi)\alpha}{rp}\right]^{\alpha}\left[\overline{y}-\frac{\lambda_1 rph_1}{e^{rt_1}-1}\right]\right\}^{1-\sigma}}{1-\sigma}\cdot\frac{1-e^{-rt_1}}{r} \qquad (26)\\ &+ \frac{\left\{\left[\overline{y}\cdot\frac{1-e^{-r(Tr-t_1)}}{1-e^{-r(T-t_1)}}-\frac{(1-\lambda_1)rph_1}{1-e^{-r(T-t_1)}}\right]^{1-\alpha}(h_1)^{\alpha}\right\}^{1-\sigma}}{1-\sigma}\cdot\frac{e^{-rt_1}-e^{-rT}}{r},\\ U^r &= \frac{\left\{(1-\alpha)^{1-\alpha}\left[\frac{(1-\Psi)\alpha}{rp}\right]^{\alpha}\overline{y}\cdot\frac{1-e^{-rTr}}{1-e^{-rT}}\right\}^{1-\sigma}}{1-\sigma}\cdot\frac{1-e^{-rT}}{r}, \qquad (27)\\ U &= \max\{U^o, U^r\} \qquad (28)\end{aligned}$$

Proposition 5 prepares for numerical solution as this multi-period model has no closed form solution[18]. We set $(\rho, \alpha, \Psi, \sigma, \overline{y}, Tr) = (0.04, 0.35, 0.50, 1.50, 1.00, 35)$, and assume households enter the economy at the age of 25.

We illustrate the relationship between home purchase age and the corresponding optimal home size through a numerical example. Given $(T, \lambda_1) = (60, 0.30)$, the indifference curve is depicted in Figure 3.

With labor income normalized to 1, the optimal choice is $(t_1, h_1) = (29.3, 5.6)$, and suitable age for home purchase age is between 27 and 34. Besides, we plot the optimal (t_1, h_1) conditioning on (T, λ_1) in Figure 4, and find that the optimal age of home purchase is only sensitive to down payment ratio, while the optimal house size is also sensitive to life expectancy aside down payment ratio.

With $T = 60$, we further plot the saving life cycle profile before retirement against different down payment ratios in Figure 5. Positive effects from down payment ratio on household saving are observed in almost all age cohorts. It takes more time for potential home buyers to afford the

[18]The proof for Proposition 5 is simple yet tedious. We do not present it here.

FIG. 3. Indifference Curve on Purchase Time and House Size

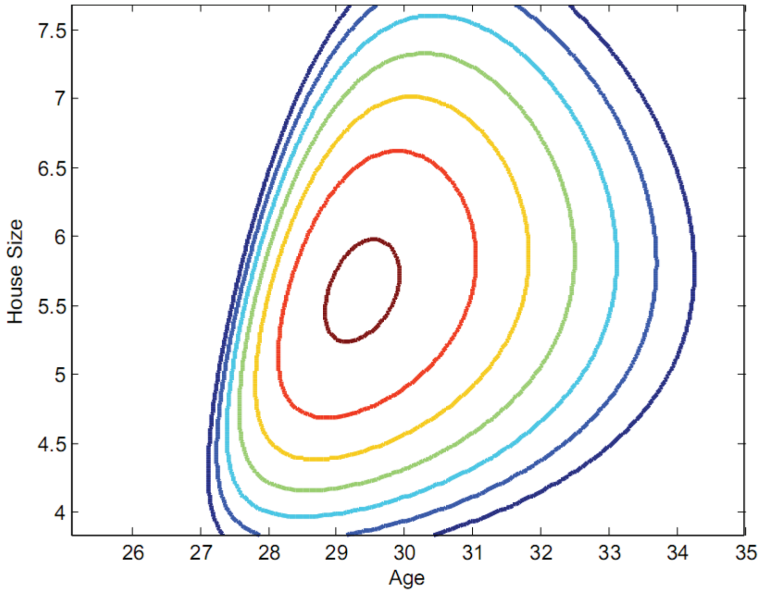
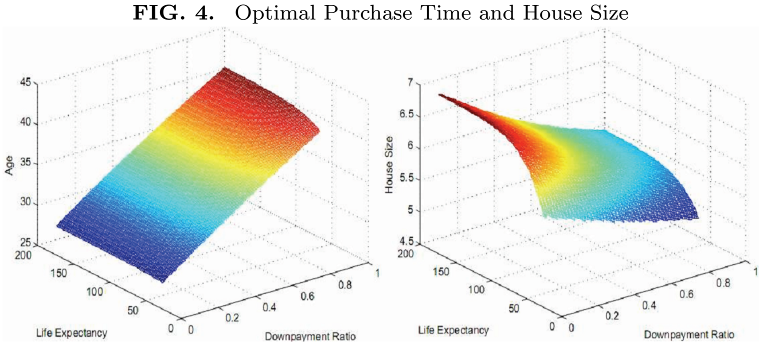


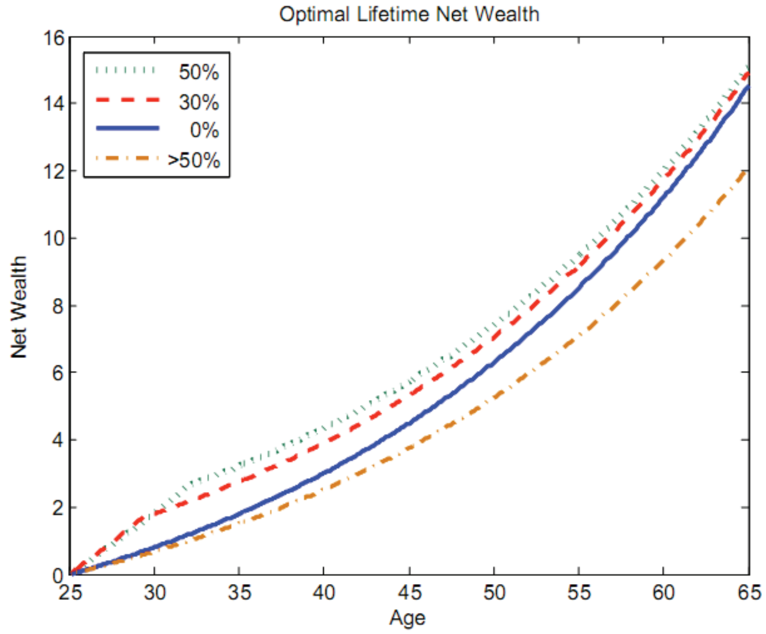
FIG. 4. Optimal Purchase Time and House Size



down payment when this ratio is higher, yet the degree of intertemporal distortion during this preparation time is generally constant. And when the down payment ratio is higher than 50%, households would choose to rent houses for the whole of lifetime, thus dramatically reduces lifetime savings. To flip it around, lowering the down payment ratio will not necessarily reduce savings.

Two channels should be considered in order to discuss the aggregate saving's marginal change when slightly raising down payment ratio. The first is marginal saving decrement from original homeowners, named as "intensive margin"; and the other is marginal saving increment in households

FIG. 5. Life Cycle Profile of Net Wealth with Different Down payment Ratio



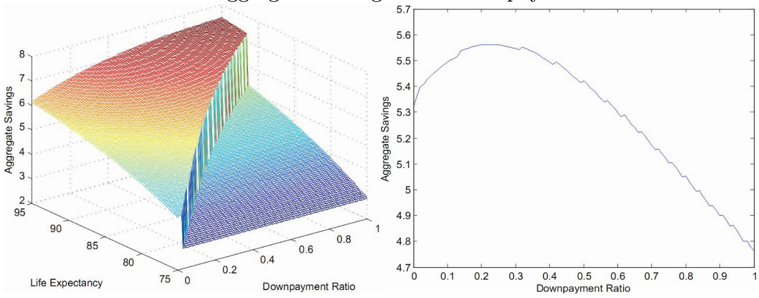
switching from renters to owners, named as "extensive margin". Intensive margin becomes weaker with higher down payment ratio because the homeownership rate is already low, while the extensive margin is more obvious with higher down payment ratio because homeowners save even more than renters.

Combination of these two channels generates an "Inverse U-Shaped" household saving, shown in Figure 6, with increasing down payments. In Figure 6, we first aggregate household savings along the dimension of life cycle (left), and then along the dimension of down payment (right). The numerical result is in accord with our prior analysis. With proper definition such as $SR1$, the household saving rate is also "Inverse U-Shaped", which means that high down payment ratio might not be the cause for high household saving rate.

4.4. Refinancing Difficulty and Precautionary Savings

The influence from refinancing difficulty on precautionary saving, instead of on saving for retirement, is studied in this subsection. Based on Flavin and Nakagawa (2008), we built a continuous time buffer stock model with infinitely lived agents, with non-tradable house, yet with no down payment requirement. Households are subject to irreversible disability or unem-

FIG. 6. Aggregate Savings and Down payment Ratio



ployment shock, following a Poisson Process, and have no access to rental market.

In case of unbounded savings, we assume that the subjective discount rate ρ is higher than interest rate. Thus we have

ASSUMPTION 3. *(i)* $Y = \{y^g, y^b\} = \{\overline{y}, 0\}$*; (ii)* $p(0|0) = 1$*; (iii)* $p(y_{t+\Delta t}|y_t = \overline{y})|_{\Delta t=0} = \lambda^{y_{t+\Delta t}}$*; (vi)* $\tau = +\infty, d_t = 0$*; (v)* $T = \infty$*, (vi)* $\rho > r$*, (vii)* $\delta = g_y = g_p = 0$*, (viii)* $p_t = p$*, where* $\sum_{y \in Y} \lambda^y = 0$.

The household's problem is

$$\max_{\{c_t, h_t\}} U = E_0 \int_0^{+\infty} e^{-\rho t} u(c_t, h_t) dt, \tag{29}$$

$$\dot{w}_t = r(w_t - p h_t) + y_t - c_t \tag{30}$$

Denote $V(w, h, y)$ as the supremum of a household's expected lifetime utility conditioned on (w, h, y), then the bellman equation is

$$V(w_t, h_t, y_t) = \tag{31}$$

$$\sup_{\{c_t\}} \left\{ \int_t^{t+\Delta t} u(c_t, h_t) dt + e^{-\rho \Delta t} \sum_{y \in Y} V(w_{t+\Delta t}, h_{t+\Delta t}, y_{t+\Delta t}) p(y_{t+\Delta t}|y_t) \right\}.$$

According the Carroll (2009b), we define the "target saving":

DEFINITION 4.1. Target saving $\breve{w}(y, h)$ is defined as:

$$\breve{w}(y, h) = \lim_{t \to +\infty} w(y_t, h_t, w_0, t)|_{\{y_t, h_t\} = \{y, h\}}. \tag{32}$$

Target saving is the limit of net wealth held by a household when both time goes to infinity and no shocks are realized, regardless of the initial level of wealth w_0. According to (30), we have target level consumption:

$$\breve{c}(y,h) = r(\breve{w}(y,h) - ph) + y. \tag{33}$$

LEMMA 3. *The target saving $\breve{w}$ is determined by the following equation:*

$$(\rho - r)u_c(c(\breve{w}, h_t, y_t), h_t) = \sum_{y \in Y} \lambda^y u_c(c(\breve{w}, h_t, y_t), h_t). \tag{34}$$

Proof. Subtract both sides of equation (31) by $V(w_t, h_t, y_t)$, and take $\Delta t \to 0$, then we have the Hamilton-Jacobi-Bellman equation:

$$0 = \sup_{\{c_t\}} \left\{ u(c_t, h_t) - \rho V(w_t, h_t, y_t) + \sum_{y \in Y} \lambda^y V(w_t, h_t, y_t) + V_w \dot{w}_t + V_h \dot{h}_t \right\}, \tag{35}$$

and the first order condition $u_c = V_w$ on the right-hand side. Take derivatives with respect to w, and use the Envelop Theorem, we have the Benveniste-Scheinkman formula:

$$0 = (r - \rho)V_w(w_t, h_t, y_t) + \sum_{y \in Y} \lambda^y V_w(w_t, h_t, y_t) + V_{ww}\dot{w}_t + V_{wh}\dot{h}t. \tag{36}$$

In the state where w is the target level, we have $\dot{w} = \dot{h} = 0$, thus we have (34). ∎

LEMMA 4. *Under Assumption 3, we have*

$$c(w, h, y^b) = \begin{cases} ((\rho - r)/\sigma + r)w, & \lambda_2 = 0 \\ ((\rho - r)/\sigma + r)(w - ph), & \lambda_2 = 1 \end{cases} \tag{37}$$

Proof. When $\lambda_2 = 0$, there is no repayment constraint, and the disposable wealth is w; thus we have $c(w, h, y^b) = c(w, 0, y^b)$. Together with the F.O.C. $\dot{c} = -\frac{\rho - r}{\sigma} c$ and resource constraints $\int_t^{+\infty} e^{-rt} c_t dt = w$, we have $\int_t^{+\infty} c_0 e^{-(\frac{\rho - r}{\sigma} + r)t} dt = w$, hence $c_0 = (\frac{\rho - r}{\sigma} + r)w$. When $\lambda_2 = 1$, then the disposable wealth is $w - ph$. Analogously, $c_0 = (\frac{\rho - r}{\sigma} + r)(w - ph)$. Since the problem is stationary, we can eliminate the time subscripts and have (37). ∎

PROPOSITION 6. *Under Assumption 3, there exists a constant κ, s.t.*

$$\breve{w}(\overline{y}, h) = \begin{cases} (\overline{y} - rph)/\kappa, & \lambda_2 = 0 \\ \overline{y}/\kappa + ph, & \lambda_2 = 1 \end{cases} \tag{38}$$

Proof. Since $\lambda^g + \lambda^b = 0$, equation (34) can be reformulated as

$$\left(1 + \frac{\rho - r}{\lambda^b}\right)^{\frac{1}{1+(1-\alpha)(\sigma-1)}} = \frac{c(\breve{w}, h, y^g)}{c(\breve{w}, h, y^b)}, \tag{39}$$

where $c(\breve{w}, h, y^g) = r(\breve{w} - ph) + \bar{y}$, and $c(\breve{w}, h, y^b)$ is subject to (37). Denote

$$\kappa = \left(r + \frac{\rho - r}{\sigma}\right)\left(1 + \frac{\rho - r}{\lambda^b}\right)^{\frac{1}{1+(1-\alpha)(\sigma-1)}} - r > 0, \tag{40}$$

then (38) solves (39). ▮

Proposition 6 implies refinancing difficulty has significant effects on precautionary savings. When households are not able to refinance, they have to solely rely on non-housing assets to buffer against negative shocks. And once households are allowed to use housing assets as buffer stock, decrease in their target savings will be no less than the value of housing assets.

5. QUANTITATIVE WORK

In the interest of further demonstrating how the housing demand with two kinds of finance imperfections influences households saving behaviors, we take our model against data and present quantitative work in this section. We first calibrate our model and find it matches considerable first-order and second-order moments well. Then we undertake quantitative experiments to present the role of housing demand with finance imperfections. At last, we outline the mechanisms in our results.

5.1. Calibration

Parameters in Table 5 are determined via aggregate statistics, institutional arrangements, and audit conventions. Households are assumed to enter the economy at the age of 25, retire at 60, and die at 72 according to the age structure and life expectancy of Chinese population. The per capita disposable income, the trading volume of commercialized residential building and CPI are taken from the "China Statistic Year Book 2010", based on which we obtain the growth rates of both per capita disposable income and housing price. We set the depreciation rate to be 0.03 as the Ministry of Construction of China announced the service life of residential buildings is about 30 years on average. The deposit rate is taken from Song and Yang (2010), which also covers real returns from other non-housing savings; and the mortgage rate is slightly higher than deposit rate. In accord with the housing price in urban areas of China, we set the rent-to-price ratio to 1:400.

The down payment ratio is taken from commercial bank requirements. We have $\lambda_2 = 1$ to implement the repayment constraint and take $\sigma = 3$ to generate sufficiently high precautionary saving motives. The intertemporal bias from non-separable relative risk aversion and intertemporal elasticity of substitution[19] is offset by adjusting discount factor later on.

TABLE 5.

Predetermined Parameters

Parameters	Value	Sources
Tr	36	Retired at 60
T	48	Died at 72
g_y	0.092	NBS 2010
g_p	0.055	NBS 2010
δ	0.030	Average Service Life is 30
r_d	0.030	Song and Yang (2010)
r_m	0.050	Slightly higher than r_d
r_{rent}	0.030	Rent to Price Ratio 1:400
λ_1	0.300	Commercial bank requirements
λ_2	1.000	No access to refinancing
σ	3.000	Chosen arbitrarily

We then estimate the earning process. Since our focus is aggregate saving rate, life cycle is assumed to be a step function with flat earning profile before, and after retirement respectively[20]. Thus we have

$$\eta_{j_t} = \begin{cases} 1, & 0 \leq j_t \leq Tr \\ b, & Tr < j_t \leq T \end{cases} \tag{41}$$

According to Song and Yang (2010), $b \approx 0.50$ in 2007. We estimate the transition matrix as well as the stationary distribution of first order Markov earning process through Aordo (2008) and Aordo (2009) with repeatedly

[19]Etner (2006) underlines the relation between risk aversion, intertemporal substitution, and preference for the timing of resolution of uncertainty.

[20]The age profile of earnings estimated from UHS and CHNS are generally flat despite difference exists on the location of their humps. While In China, the pension system is run by the local government or state-owned enterprises; therefore, households are still subject to income dispersion and risks.

surveyed samples.

$$S = (2.0150\ 1.1490\ 0.8420\ 0.6200\ 0.3740) \tag{42}$$

$$p(s_j|s_i) = \begin{bmatrix} 0.7810 & 0.1747 & 0.0300 & 0.0117 & 0.0026 \\ 0.1589 & 0.5664 & 0.2161 & 0.0456 & 0.0130 \\ 0.0391 & 0.1969 & 0.5163 & 0.2151 & 0.0326 \\ 0.0156 & 0.0495 & 0.1979 & 0.5651 & 0.1719 \\ 0.0052 & 0.0130 & 0.0391 & 0.1628 & 0.7799 \end{bmatrix} \tag{43}$$

Parameters capturing households' preference and the availability state of home equity withdrawal can be calibrated to match corresponding key moments in data. We adjust the subjective discount factor β to fit the household saving rate, the share of housing service in utility α to fit the housing share in portfolio, and the homeownership preference rate Ψ to fit the homeownership rate of just retired households. We then set the transaction cost rate τ to match the average market share of secondhand house during the 2006-2008, and the repayment rate λ_3 to match the debt-to-income ratio, respectively. It should be noted here the slightly higher debt-to-income ratio in model can be interpreted by the fact that not all residents have access to residential mortgages in current Chinese economy.

TABLE 6.

Parameters Chosen to Match the Target First-Order Moments

Parameters	Value	Target moments	Model	Data	Data Source
β	1.180	Saving rate of workers	38.2%	37.9%	NBS 2010
α	0.200	Housing share in portfolio	76.6%	76.7%	Aordo 2009
Ψ	0.200	Homeownership rate at Tr	87.7%	86.9%	CHNS 2006
τ	0.500	Share of Secondhand homes	17.3%	19.0%	NBS 2010
λ_3	0.100	Debt to income ratio	25.2%	19.6%	PBC 2007

Note: Since the elasticity of intertemporal substitution is low, we are in need of a sufficiently high subjective discount factor to generate the proper level of household saving rate.

5.2. Matching Second-Order Moments

Validation and fitness of our model also depends on whether it can match several second-order moments such as the distribution of home purchase age and the net wealth holdings. Significance of them comes from that, earlier home purchase age implies heavier burdens on saving for the young and more dispersed wealth results in less population on the margin of tenure choice.

Figure 7 compares the distribution of home purchase age between model and data (namely the Aordo (2009) survey). The average home purchase age in the model is 41.4, only slightly larger than that in data, which is 39.8 (second home also included). However, the home purchase age in data is more dispersed than that in model, possibly due to that the non-comprehensive heterogeneity captured by model is only along the dimensions of wealth and income. Since we mainly focus on the household savings after aggregation, our goodness of fit on average home purchase age is sufficient.

FIG. 7. Distribution of Home Purchase Age

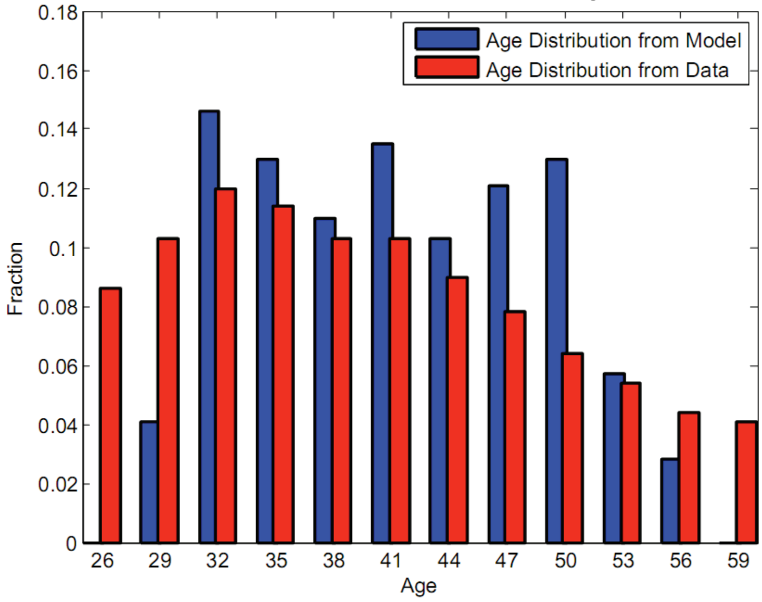


Figure 8 portrays the Wealth Lorenz Curve of model against that of data. The wealth dispersion generated by the model is slightly larger than that in the data, with more households at the bottom. This can be explained by the underestimation of the young's wealth in data, as depicted in Figure 9.

Compared to Figure 5, Figure 9 shares some properties with lifetime target savings as in Carroll (1997). It indicates that households will stop accumulating wealth before retirement when they have accumulated sufficient savings to insure against negative income shocks and retirements. The life cycle wealth profile even shows an earlier age at which target saving is achieved. Thus our model will not overestimate the precautionary saving motive.

FIG. 8. Distribution of Net Wealth

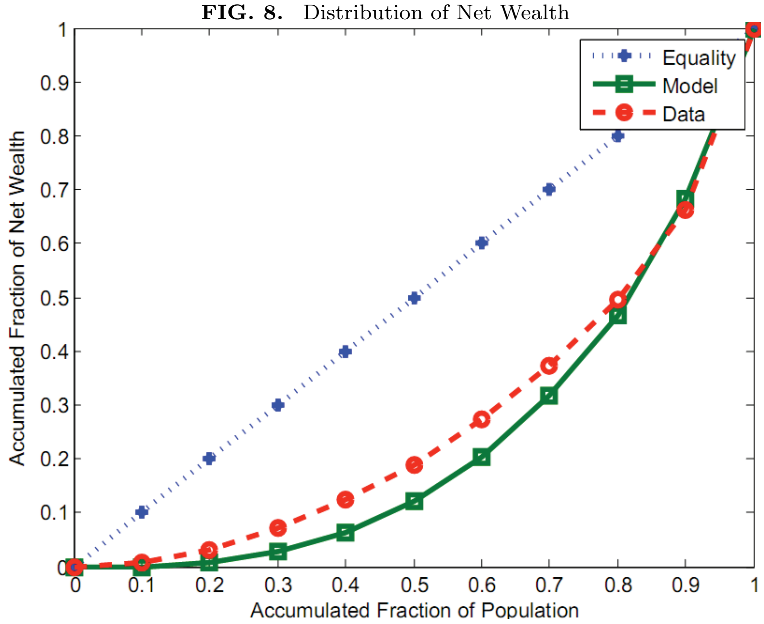
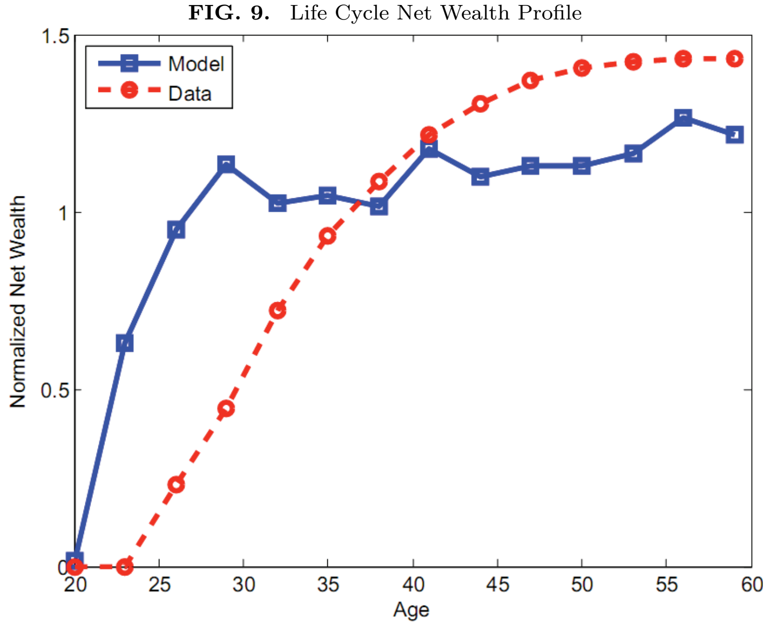


FIG. 9. Life Cycle Net Wealth Profile



5.3. Aggregate Results

We display the quantitative results (or statistic summary) of a) data in 1998, b) model without self-owned house, c) data in 2007, d) baseline model, e) model with no mortgage, f) model with no repayment constraints, and g) model with low transaction cost in Table 7 and Table 8, marked with Scenario 1-7, respectively. Here we mainly shed lights on the household saving rates in those scenarios. We also investigate their saving rate structures, the crowding out ratio from SR^h on SR^a (Check1), the market shares of secondhand houses (Check2) and the mortgage debt-to-GDP ratios (Check3).

Results from Scenario 1-4 in Table 7, especially the comparison between Scenario 1 and Scenario 2 and that between Scenario 3 and Scenario 4, claim that our baseline model is not only well consistent with all data dimensions, but also be able to capture the household saving rate's rising and its structure change during 1998-2007. This qualifies our model to further reveal the relationship between housing demand, accompanied with housing finance imperfections, and household saving rate in China.

To observe the scenario variations when changing parameters helps to understand how these factors influence households saving behaviors and which of them plays more in driving up the household saving rate during 1998-2007. Compared with Scenario 5, Scenario 4 indicates mortgage loans lubricate the substitution between housing asset and non-housing asset yet does not necessarily lead to a lower saving rate. This is consistent with the predictions from our previous developed "extensive margin" rule. And Scenario 6 illustrates, without repayment constraints, saving in housing asset crowds out that in non-housing asset to a large extent. However, despite there is an rise on housing saving, households save much less in the form of non-housing assets since the refinancing constraints first affects non-housing savings straightly and then affects housing expenditure indirectly, which finally provides a lower household saving rate. To flip it around, the existence of refinancing difficulty would lead to a rise on household saving rate.

On another note, as in Scenario 7, lower transaction cost first stimulates housing demand directly, which presents more savings in housing asset, and then reduces the demand of non-housing saving indirectly. And with lower transaction cost, households are more willing to trade on secondhand homes as well as adopt residential mortgages. The crowding out effect is also stronger, yet the household saving rate might be higher since the increment in housing is greater than the decrement in non-housing savings. Hence by this far we can conclude that refinancing difficulty is the main reason why household saving rate is rising along with housing demand after the housing reform.

Table 8 presents the other two types of household saving rates. We find $SR1$ is generally consistent with $SR3$, while $SR2$ is on a lower level. This means the increment on $SR2$ is smaller than that on $SR1$ and $SR3$ during the release of housing demand after 1998. However, we observe the quantitative relationships revealed upon $SR3$ still holds upon $SR2$. When refinancing is costless, the saving rate of $SR2$ is considerably low, actually even lower than the case with no self-owned house. In addition, Scenario 4 and Scenario 5 show that mortgage might also lower the household saving rate, although the decrement is not very significant.

Therefore, despite our numerical results are slightly influenced by the specification of household saving rate concerning their absolute values, our main findings in this paper, that refinancing difficulty is essential in driving up Chinese household saving rate and that down payment requirement is not, keeps robust.

TABLE 7.

Household Saving Rate and Some Facts

Scenario	Model	$SR3^h$	$SR3^a$	$SR3$	Check1	Check2	Check3
1	Data1998	4.8%	25.1%	29.9%			
2	$\alpha = 0$	0.0%	26.8%	26.8%			
3	Data2007	19.9%	18.0%	37.9%	44.2%	19.0%	11.3%
4	Baseline	22.1%	16.1%	38.2%	47.0%	17.3%	14.5%
5	$\lambda_1 = 1$	15.0%	22.4%	37.4%	29.3%	26.5%	
6	$\lambda_2 = 0$	48.5%	−13.9%	34.6%	83.9%	12.2%	107.2%
7	$\tau = 0.10$	37.8%	2.1%	39.9%	65.3%	39.8%	38.3%

TABLE 8.

Saving Rates in Alternative Specifications of Household Saving

Scenario	Model	$SR1^h$	$SR1^a$	$SR1$	$SR2^h$	$SR2^a$	$SR2$
1	Data1998						
2	$\alpha = 0$	0.0%	26.8%	26.8%	0.0%	26.8%	26.8%
3	Data2007						
4	Baseline	24.0%	14.4%	38.4%	15.2%	16.0%	31.2%
5	$\lambda_1 = 1$	16.7%	20.8%	37.5%	10.8%	22.3%	33.1%
6	$\lambda_2 = 0$	44.6%	−11.0%	33.6%	33.3%	−13.8%	19.5%
7	$\tau = 0.10$	38.1%	1.8%	39.9%	26.0%	2.1%	28.1%

5.4. Quantitative Mechanisms

Quantitative mechanisms are developed in this subsection. Firstly, we plot the life cycle wealth profile to have an overview of wealth accumulation. Secondly, we compare the life cycle wealth profiles among the model with no repayment constraint, the model with lower transaction cost, and the baseline model to check the effects the refinancing constraint impose on household liabilities. Thirdly, we explore the role of down payment requirement in life cycle wealth accumulation.

Figure 10 indicates that home purchase, housing asset investment in other words, has significant effect on wealth accumulation. Young households accumulate non-housing assets to afford the down payment. Households between the ages of 36 and 50 will improve their dwellings by purchasing new homes, resulting in a constant aggregate housing-asset-to-income ratio. And after the age of 50, households begin to accumulate a considerable amount of non-housing assets to insure against retirements.

FIG. 10. Wealth Accumulation along the Life Cycle

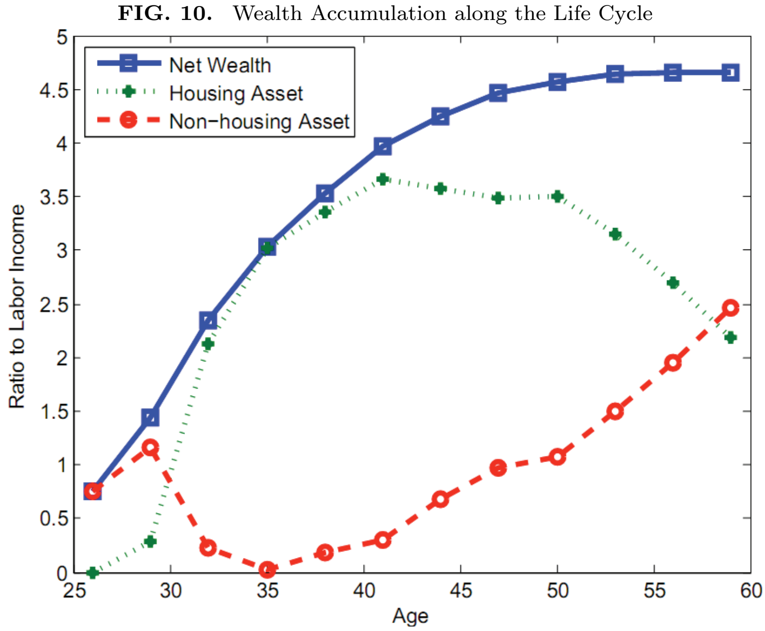
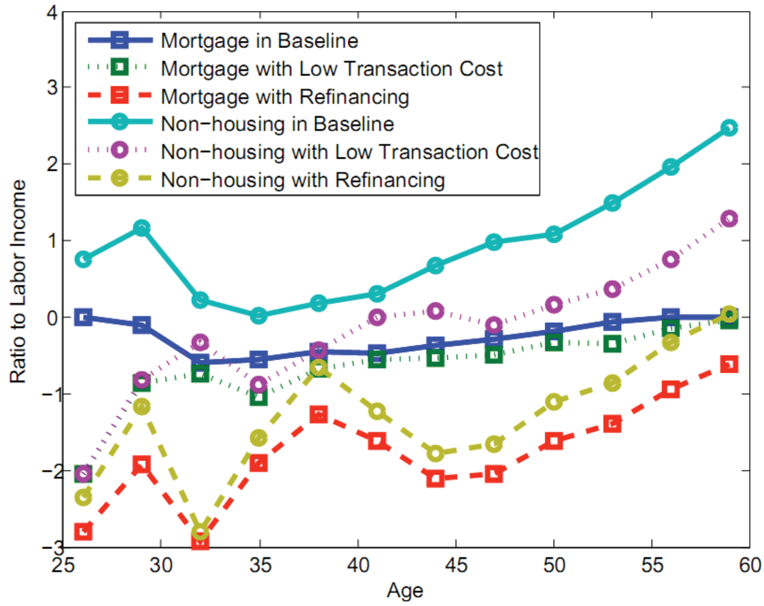


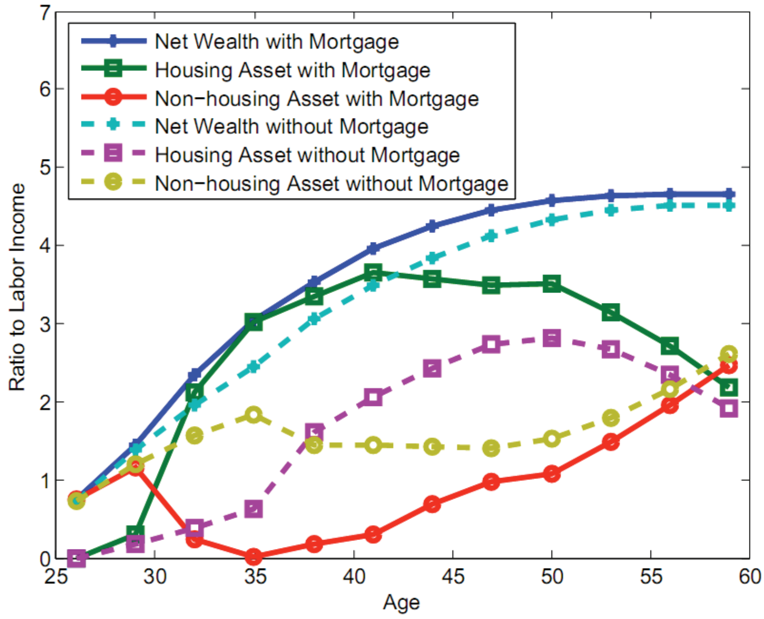
Figure 11 shows that refinancing constraints not only make mortgage loans less preferable, but also stimulate savings through the channel of buffer stock savings and retirement insurance. For the convenience to observe this channel, we plot the life cycle profiles of both aggregate mortgage loans and the non-housing wealth. We find in baseline model, households only hold a small amount of liabilities and repay all debts before retirements; and the gap between mortgage loans and non-housing positions is the aggregate wealth held by households with positive non-housing asset positions. Yet in the scenarios with no refinancing constraints, households dramatically increase their indebtedness, and part of households even holds negative non-housing positions after retirement, which means they decrease their savings by a large extent. In this situation, the life cycle profile of mortgage loans is close to that of non-housing wealth, which indicates that only a small fraction of households are positive in non-housing asset positions. In the scenario of low transaction cost, households also tend to borrow more, and can partially rely on housing asset to smooth their consumption before retirement. Yet as still is there transaction cost, households insist to save non-housing assets as a complement to housing asset before retirement.

FIG. 11. Mortgage and Non-housing Asset along the Life Cycle



We compare the paths of housing assets, non-housing wealth, and net wealth between the model with mortgage loans and that without in Figure 12, and find the main influence from down payment requirement is the substitution between housing saving and non-housing saving. However, the response of aggregate saving to down payment ratio change is not significant. In the model without mortgage loans, it takes much longer time for households to accumulate more non-housing assets for the down payment (down payment ratio is equal to 1) when they are young. And the gaps in housing asset and non-housing savings vanish over time. And due to the substitution between housing and non-housing wealth, changes in down payment ratio have almost no effect on aggregate household savings.

FIG. 12. Down payment and Wealth Accumulation along the Life Cycle



6. CONCLUSION AND FUTURE WORK

In this paper, we construct a life cycle model with housing demand and incomplete markets to explore the relationship between housing demand, accompanied with underdeveloped housing finance, and household saving rate in China. We consider two types of finance imperfection: a) the high down payment ratio required by central bank, and b) the unsmooth home equity withdrawal due to the prohibitive nature of refinancing. We find without access to home equity withdrawal, it is difficult for households to insure against negative income shocks and retirement through housing asset. Therefore they have to hold a considerable amount of non-housing asset such as deposit, cash, and bond. This helps to account for the rising household saving rate during the past 10 years in China where commercialized housing market had been emerging. Yet interestingly on another note, we find higher down payment ratio leads to a substitution between housing and non-housing assets, leaving the aggregate household saving rate almost unchanged.

The assumption of limited home equity withdraw in terms of high transaction cost and refinancing difficulty is crucial in our model, which reflects the fact that both the secondhand housing market and the housing financial market are underdeveloped. These two constraints are in accord with the facts that both the secondhand house market share and the Mortgage debt-to-GDP ratio are very small in China. When two constraints are enforced, home equity withdrawal becomes difficult. This is also consistent with our observation from data that Chinese residents rely on savings to insure against negative income shocks and retirement, and housing assets are not good buffer stocks.

We also discuss the relationship between household savings and household saving rate, and test whether our results are sensitive to saving rate specifications. We find different ways of dealing the housing asset appreciation increment as well as the imputed rent have an obvious impact on the absolute value of saving rate. But, our main finding, that refinancing difficulty is much more quantitatively important in accounting for the household saving rate in China, still holds.

Admittedly, there could be a lot of extensions to this work. Theoretically, we could endogenize the housing price and consider the non-balanced growth of housing and non-housing consumption. Empirically, we could estimate the preference parameters of housing demand for Chinese residents via the BBL approach. (See Bajari, Benkard, and Levin (2007), Patrick, Chan, Krueger, and Miller (2011) for details). In addition, we could also model the relationship between housing and saving with consideration of "Urbanization", "Demographic Transition" and "Intergenerational Transfer" process.

APPENDIX A

Data Set Description

National Bureau of Statistics (NBS)

This is the main source for aggregate statistics in this paper. We take the aggregate output, household disposable income, consumption, saving, housing investment, CPI, and housing price from the "China Statistics of Year Book 2010" there. UHS, surveyed by NBS, is a largely sampled panel which contains the information on household income, consumption and saving specifics. Despite having no access to the raw data, we fetch some summary statistics from publications by NBS, and get the household earning age profile from Chamon and Prasad (2010).

People's Bank of China (PBC)

We acquire the aggregate value of mortgage loans from the annual statistics of the People's Bank of China.

China Health and Nutrition Survey (CHNS)

The China Health and Nutrition Survey (CHNS) is an ongoing open cohort, as well as an international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention. The survey took place over a 3-day period using a multistage, random cluster process to draw a sample of about 4400 households with a total of 26,000 individuals in nine provinces that vary substantially in geography, economic development, public resources, and health indicators. We mainly take the homeownership rate from CHN-S.

Aordo Investor Center (Aordo)

Aordo (2009), commissioned by Aordo Investor Center and conducted by NBS, is cross-sectional nationwide household survey containing specific information on households' wealth and portfolios. Aordo (2008), ahead of Aordo (2009), covers more information in terms of variables concerning income, consumption, and saving specifics. Aordo (2008) and Aordo (2009) are the main data support for us to study risk-sharing, cross-sectional, and life cycle wealth accumulation in urban China.

APPENDIX B

Computational Strategies: Transition Node Allocation

As far as we know, the most efficient method to compute incomplete market model with depreciating house values is to impose maintenance cost, use fewer nodes in the smooth value function, and then interpolate the next period state space when searching for the optimal value during each iteration on the value function. This method takes around 10 minutes to compute a full-fledged lifecycle incomplete market model with illiquid house and general equilibrium in FORTRAN (Yang, 2009).

However, the method of maintenance cost is not feasible here for two reasons. On one hand, the maintenance cost should be very large if we intend to circumvent the interpolation in the case of inaction (stay in the original house) in balanced growth path, yet this may bring about considerable bias in saving rate accounting; on the other hand, without the maintenance cost, we are forced to do interpolation on the optimal problem of each node, especially when the optimal choice is not to move. In this no move case, we have to interpolate near the previous period node and compare the value function of each discrete tenure choice, which makes the computation procedure less robust. (We have tried that method, and it seems that the policy function is only not abnormal in some particular intervals of parameters.)

In order to deal with this problem, we develop a method of "Transition Node Allocation". Specifically, when the detrended housing state depreciates at the rate of g each period, we have an exponential node allocation along the housing asset dimension, where the $i+1$'s node value is $1+g$ times as large as that of i. Thus we circumvent the interpolation in the case of inaction. This method is feasible when the trend growth of illiquid state is large enough, which is the case in China.

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