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Housing prices and household savings: evidence from urban China

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Abstract Based on precautionary saving motives, this research develops a three-period life-cycle model to manifest the impact of housing price on household savings in urban China. The theoretical model illustrates that the expected appreciation of housing price at a household's middle age leads to the increase of household savings at a household's young age. Second, household savings at a household's young age is positively associated with both expected educational and medical expenditures in a household's middle age and pension expenditures at a household's old age. Third, the expected housing price crowds out educational and medical expenditures at a household's middle age. With the panel data sets of China's 31 provinces during 1996-2016, results suggest that the expected housing prices significantly interact with the current household savings. However, the influence of the expected housing price on the current household savings is greater than that of the current household savings on the expected housing price. Third, the expected expenditures of education, medical care and pension fuel up the current household savings. Meanwhile, the housing prices crowd out the expenditures of education, medical care and pension. Finally, data of the Urban Household Survey (UHS) over the period 2002-2007 show that the household head age has an effect of reverse U-shape on household saving. Accordingly, to prevent a housing bubble and promote household consumption, policy makers should curb housing price inflation by enacting appropriate countercyclical housing policies.

Keywords Housing prices ·Household savings ·Endogeneity

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1. Introduction

1.1 Background

Both housing price and household saving are vital to macro-economy (Case, 2008). Wei and Zhang (2011) find that the size and price of housing tend to be higher in regions with a higher sex ratio, while the sex ratio is significantly associated with the saving ratio. It is well known that China's economy has grown rapidly in recent years. According to the World Bank, the average growth rate of China's GDP was 10.6% in the past decade (2002-2011)①, which far outpaces the average worldwide growth rate of 2.6%. Meanwhile, the disposable income per capita in urban households has increased dramatically, from 7702.8 CNY (Yuan, hereafter) in 2002 to 21809.8 Yuan in 2011, a value that is three times higher than the increase over the previous decade. According to the permanent income hypothesis (Friedman, 1957), the rational consumer is optimistic and reduces saving at the presence of fast income growth. However, the outstanding balance of savings and saving rates of households continue to grow among urban Chinese②. At the end of 2011, the Chinese outstanding urban household saving balance reached 34.4 trillion Yuan, which is 3.9 higher than it was in 2002 and accounts for 42.50% and 72.63% in outstanding bank deposits and GDP, respectively. Fig.1 shows that the amount of household savings per capita increased from 1795.48 Yuan in 1994 to 43230.40 Yuan in 2016, while the urban household savings rate increased from 18.45% in 1994 to 31.35% in 2016. In addition, according to a survey by the People's Bank of China (PBC, hereinafter) in Q1 2013, 44.5%, 37.6% and 17.9% of depositors tended to save, invest and consume, respectively③. In theory, the high savings rate reduces consumption, economic growth and interest rates, resulting in overinvestment and economic overheating. Consequently, the high household saving rate is a stressing issue to China's macro-economy.

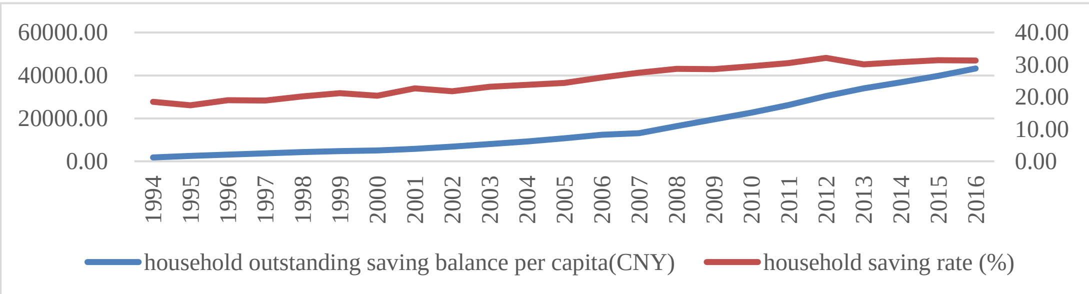

Figure 1 China's urban households' outstanding saving balance per capita (left axis) and saving rate (right axis)

Source: China Statistical Yearbook

Similarly, housing prices experienced a persistent growth between 1996 and 2016 in China. Fig. 2 shows that the national average housing price increased from 1857 Yuan per square meter in the

① http://data.worldbank.org.cn/indicator?display=default
② In this study, household saving propensity is referred as the ratio of current household saving to current household disposable income.
③ http://www.pbc.gov.cn/publish/diaochatongjisi/126/index.html

housing reform year of 1999 to 7203.00 Yuan per square meter in 2016.The average housing prices in large Chinese cities also underwent rapid growth, in which the average housing price in four first-tier cities (i.e. Beijing, Shanghai, Guangzhou and Shenzhen) increased from 4534.56 Yuan per square meter in 1999 to 29060.75 Yuan per square meter in 2016. More importantly, the national average housing price-to-income ratio is 7.68 in 2016, whereas the average housing price-to-income ratios of Beijing, Shanghai, Guangzhou and Shenzhen were 16.11, 8.26, 7.92 and 18.31 in 2016, respectively. In addition, according to a Q1 2013 survey by PBC, 68% of the respondents complained that the current housing price was unacceptably high, whilst only 13.9% of the respondents were willing to buy houses[④]. Accordingly, housing prices are pivotal predeterminants to housing affordability and housing bubble, which affects consumer well-being and financial safety.

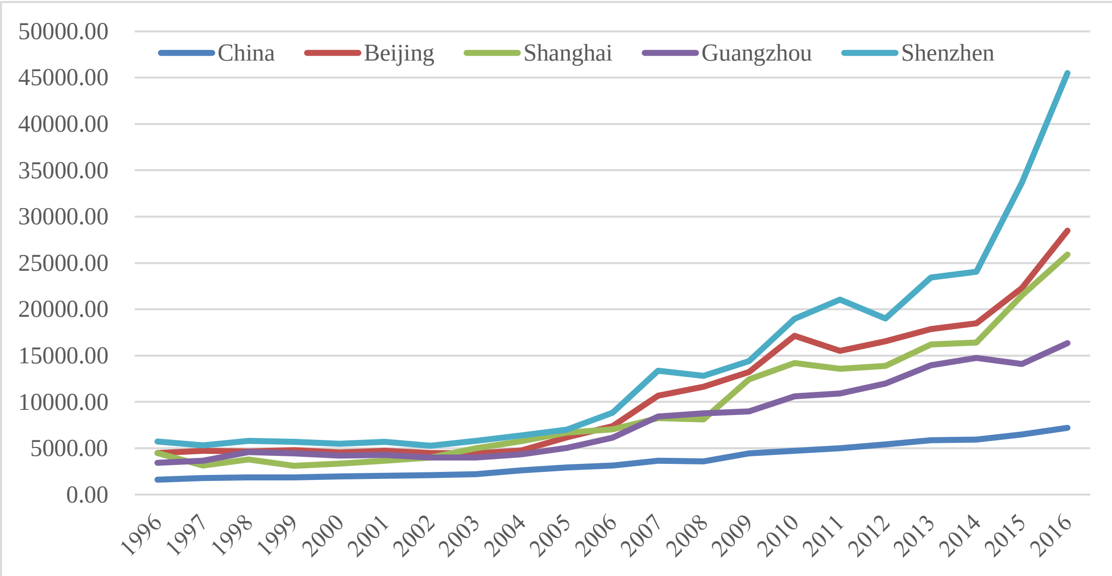

Fig.2 the Average Housing Prices of Four First-Tier Cities in China from 1996 through 2016

Based on Fig.1 to Fig.2, Chinese household saving rate appears to co-move with the housing prices. The correlation coefficient of housing price and household saving rate is around 0.96 over the period 1994-2016. This research attempts to examine the association between household savings and housing prices in urban China because the relationship between housing prices and household saving is pivotal to both consumer welfare and economic growth.

1.2 Literature Review

The extant literature has studied the relationship between housing prices and savings rates from three perspectives. The first strand of literature analyzes savings rates based on the life-cycle model. Skinner (1989) theoretically demonstrates that housing price appreciation reduces consumers' saving rates with rational expectations and perfect foresight. Homeowners with a bequest motive, however, may save more to help their children buy more expensive housing. Employing the household Panel Study of Income Dynamics (PSID) data from the late 1970s, Skinner (1989) finds that housing values have a slight impact on household consumption and

[④] http://www.pbc.gov.cn/publish/diaochatongjisi/126/index.html saving, but have no effects when individual heterogeneity is controlled. Using the household PSID data for homeowners under the age of 65 years over the period 1984-1989, Engelhardt (1996) shows that family saving behavior is unchanged at the presence of housing price appreciation, but is reduced under housing price depreciation. Meng (2003) uses a Chinese survey data of 1999 Urban Household Income, Expenditure and Employment (UHIEE) to find that Chinese urban households are able to smooth most consumption and have a strong motive for precautionary saving. Utilizing the Taiwan micro data from the Survey of Family Income and Expenditure (SFIE) for years 1980, 1990 and 2000, Chen et al. (2007) employ quantile regressions to find that renters show a lower saving rate than homeowners and have lower saving rates at the presence of rapid housing price appreciation. Based on the stylized facts of China's underdeveloped housing finance system and second-hand housing market, Chen et al. (2013) develops a life-cycle model to demonstrate that higher housing prices give rise to more housing investments for wealthier households and further enhance housing prices, which encourages lower-income households and young people to increase their saving rates. Zhou (2014) uses the 2006 China General Social Survey data and finds that an individual has more brothers reduces that individual's household savings rate in urban China in that the brothers share the risks and the cost of supporting the parents. Based on the genetic effects of financial literacy from parents to children, Brown and Taylor (2016) use the panel data from British Household Panel Survey in years 1997-2001 and 2005 to suggest that having saved as a child has relatively large positive effects on both the probability of saving and the amount saved as an adult. Based on the life-cycle model, Curtis et al. (2017) theoretically analyze the demographic effects on the household saving rate with UN data and find that 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. Employing the China Household Finance Survey (CHFS) in 2013, Lugauer et al. (2018) find that the number of dependent children reduces the household saving rate. Combining the data sets of the Urban Household Surveys (UHS) and population censuses in 1990 and 2005, Ge et al. (2018) utilize the provincial fines of unauthorized births under the one-child policy to serve as instruments for demographic structure change and find that older households with fewer adult children, middle-aged households with fewer dependent children and younger households with fewer siblings save more.

The second line of literature explores the impact of precautionary saving upon household savings rates. Employing the 1984 PSID dataset, Sheiner (1995) shows that housing price has a positive impact on the savings of young households and the young households have saved for down payments to buy homes. Using the Japanese data from the Housing Demand Trends survey in January 1993, Moriizumi (2003) finds that the young Japanese renters who plan to purchase homes increase their savings by 30 to 40%. Using the China's National Statistical Bureau data of Urban Household Income and Expenditure Survey (UHIES) from 1986 to 2000, Meng et al. (2005) find that the subsidy reduction and abortion of education, housing and medical care increased saving rate and the resulting poverty of poor households in China 1990s. In terms of survey database of 1305 Polish households at the end of 2004, Roszkiewicz (2006) finds that the lower the young household income, the stronger propensity to accept precautionary saving. Utilizing the micro quarterly panel dataset of consumption, housing wealth and household characteristics over 2000-2002 in Hong Kong, Gan (2007) finds that the housing price has remarkable wealth effects on consumers' consumption, but it comes at the expense of precautionary saving. Using the household dataset from the Urban Household Survey (UHS) in China during 1990-2005, Chamon and Prasad (2010) find that both young households and old households have the higher saving rates, which stems from the increasing expense for housing, education and health. Using eight years data of the China Health and Nutrition Survey (CHNS) over the period 1989-2009, Chamon et al. (2013) ascertain that higher income uncertainty and pension reforms together explain around half of the rise in urban household saving rate in China with an unusual U-shaped age-profile of savings. Merging the geocoded databases of HRS, Zillow, and the FHFA since 1992, Begley (2017) finds that the positive housing price shocks reinforce old homeowners' bequest motives, even though the negative housing price shocks have the negative effects. Aaberge et al. (2017) use the rotational monthly panel data of urban households in Sichuan province for the period 1988-1991 and find that political uncertainty resulted in significant temporary increases in savings.

The third line of literature discusses the role of liquidity constraints on household savings rate. Using the Chicago Title and Trust Company (CT&T) survey datasets for years 1988, 1990 and 1993, Engelhardt and Mayer (1998) find that transfer recipients reduce the time needed to save for a down payment by 9% to 20%. For each dollar of transfer received, the total savings falls by 29 to 40 cents, and the down payment rises by 61 to 71 cents. Using the 1988 PSID data, Hrung (2002) finds that parental house value affects children's consumption and saving. Using the multiple survey datasets from the United Kingdom, the United States and Italy in 1997, Kirsanova and Sefton (2007) find that Italy's household savings rate is the highest primarily due to the liquidity constraints of the homebuyers, particularly for young homebuyers. Chamon and Prasad (2010) argue that households have to increase precautionary saving to satisfy housing demands in undeveloped mortgage markets. Using the Chinese regional and household databases of sex ratios and savings rates from 1980 to 2000, Wei and Zhang (2011) find that housing sizes and prices tend to be higher in regions with higher sex ratios and savings ratios. Wang and Wen (2012) theoretically demonstrate that in a non-stationary economy, the measured aggregate savings rate can become quite sensitive to housing prices under borrowing constraints. Chen et al. (2013) find that the liquidity constraints arising from mortgage payments do not explain China's rising household savings rate. In addition, some researchers show that intergenerational transfer in home purchasing can mitigate liquidity constraints.

In short, the preceding studies analyze household saving behavior from the precautionary saving perspective, but fail to consider the different precautionary saving motives. In addition, the previous studies do not completely resolve the endogeneity between housing prices and household savings. Unlike previous research, based on the life-cycle model, this research contributes to identify different saving motives and resolve the endogeneity problem between housing prices and household savings.

2. The Model

Based on the life-cycle hypothesis, this research incorporates housing price into precautionary saving motives and analyzes the effects of both housing prices and the other precautionary motives on household savings.

2.1 Assumptions

For simplicity, we assume: (1) household disposable income is Y; (2) household consumption includes housing consumption and non-housing consumption; (3) housing consumption refers to dwelling size H, and unit housing price is P; (4) non-housing consumption includes baseline consumption C, education E and medical care M, with their prices standardized into 1; (5) household lifetime is divided into three periods of young age, middle age and old age, with respective wages of Y_1, Y_2 and Y_3; (6) baseline consumption conforms to the permanent income hypothesis (namely, $C_1=C_2=C_3$); (7) dwelling size H is the same throughout the lifetime[⑤]; (8) the rental market and ownership market are perfect substitutes; (9) at young age, d households rent houses with rent R_1 and save for a home purchase and education spending at middle age; (10) at middle age, under liquidity constraints, households use their savings at young age to buy a home of price P_2 with a mortgage, meanwhile, continue to save for pension and medical care spending in old age; (11) at old age, households have no bequest motives, repay their home mortgages and sell their houses with price P_3; (12) deposit rate is r, and mortgage rate is i; (13) time discount rate is η and is equal to capital return rate r (namely, $r=\eta$); (14) utility function is logarithmically additive.

2.2 Model

According to the above assumptions, the optimal utility function of the representative household j can be expressed as:

$$MaxU(C_j,H_j)=Max(\ln C_{j1}+\ln H_j+\frac{\ln C_{j2}}{1+\eta}+\frac{\ln H_j}{1+\eta}+\frac{\ln C_{j3}}{(1+\eta)^2}+\frac{\ln H_j}{(1+\eta)^2})$$

$$s.t.\ Y_{j1}=C_{j1}+UC_{j1}P_{j1}H_j+S_{j1} \quad (1)$$

$$Y_{j2}+(1+r)S_{j1}=C_{j2}+E_j+(1-\lambda_j)P_{j2}H_j+S_{j2} \quad (2)$$

$$Y_{j3}+(1+r)S_{j2}+P_{j3}H_j=C_{j3}+M_j+\lambda_jP_{j2}H_j \quad (3)$$

$$UC_t=i_t+\tau_t+m_t+d_t-g_t^e \quad (4)$$

where P_1, P_2 and P_3 denote the housing prices at a household's young age, middle age and old age, respectively; UC denotes user cost.[⑥] Remind that the budget constraint condition at a household's young age is as follows: $Y_1=C_1+R_1+S_1$, where S_1 denotes precautionary saving for home purchase and education spending at middle age. In terms of tenure choice theory, $R_1=UC_1P_1H$, in which both rental market and homeownership market are cleared simultaneously. Hence, we can rewrite the budget constraint condition at young age as follows: $Y_1=C_1+UC_1P_1H+S_1$. At middle age, households use some of their savings at young age to buy homes with mortgages, for which the loan-to-value (LTV) ratio is λ. In addition, the household income at middle age includes the current wage Y_2 and the precautionary saving S_1 at young age.

⑤Indeed, the dwelling size might be different across household ages. As the purpose of this research is to investigate the relationship between household saving and home purchase, it is easier to handle the theoretical model if the dwelling size is the same throughout the consumer's lifetime.

⑥ UC is normally composed of interest rate i, property tax rate τ, maintenance rate m, housing capital discount rate d and expected housing price growth rate g^e (Hendershott and Slemrod, 1983; Himmelberg et al., 2005).

Meanwhile, the household expenses include the baseline consumption C_2, the education spending E, and the savings for pension and medical care at old age. Hence, the budget constraint condition at middle age is: $Y_2 + (1+r)S_1 = C_2 + E + (1-\lambda)P_2H + S_2$. At old age, the household income arises from the current wage Y_3, the sale of the housing and the precautionary saving S_2 at middle age. However, the households have to pay the baseline consumption C_3, the medical care spending M and the mortgage debt $\lambda P_2 H$. Thus, the budget constraint condition at old age is as follows: $Y_3 + (1+r)S_2 + P_3H = C_3 + M + \lambda P_2 H$.

The first order condition yields: [7]

$$U_H = \frac{(1+\eta)^2+\eta+2}{(1+\eta)^2H} - \frac{UC_1P_1}{Y_1 - UC_1P_1H - S_1} - \frac{(1-\lambda)P_2}{(1+\eta)[Y_2+(1+r)S_1 - E - (1-\lambda)P_2H - S_2]} + \frac{P_3 - \lambda P_2}{(1+\eta)^2[Y_3+(1+r)S_2+(P_3-\lambda P_2)H - M]} \tag{5}$$

2.3 Propositions

From Equation 5, it can derive two propositions as follows (see all the proofs in Appendix 1).

Proposition 1: if $P_3 > \lambda P_2$, and $(1-\lambda)P_2 > UC_1P_1$, then $\frac{\partial S_1}{\partial P_2} > 0$, $\frac{\partial P_2}{\partial S_1} > 0$, $\frac{\partial S_1}{\partial E} > 0$, $\frac{\partial E}{\partial P_2} < 0$, $\frac{\partial P_2}{\partial E} < 0$, $\frac{\partial S_2}{\partial E} < 0$, $\frac{\partial S_2}{\partial M} < 0$

Proposition 1 implies that if housing prices continue to increase, the precautionary saving at young age is positively associated with both the housing prices and the education spending at middle age. In other words, theoretically, the households save for housing costs and education spending at middle age. Moreover, the housing prices at middle age are positively associated with the precautionary saving at young age, which further verifies the households at their young ages save for the housing prices in their middle ages. Second, the housing price crowds out the education expenditures at middle age due to budget constraints. Similarly, the education spending at middle age crowds out precautionary saving at middle age. Third, the precautionary saving at middle age is negatively associated with the medical care spending at old age in that the sale of housing at old age can mitigate the precautionary saving at middle age.

Proposition 2: if $P_3 \le \lambda P_2$ and $(1-\lambda)P_2 > UC_1P_1$, $\frac{\partial S_2}{\partial M} > 0$, $\frac{\partial S_2}{\partial P_3} < 0$, $\frac{\partial M}{\partial P_3} > 0$

Proposition 2 implies that the precautionary saving at middle age is positively associated with the medical expenditure at old age should the housing price at old age is less than that at middle age. Accordingly, the households at middle age save for the medical care spending at old age in the event that the housing price at old age declines. Second, the precautionary saving at middle age is negatively associated with the housing price at old age since the housing price at old age alleviates the precautionary saving at middle age. Third, the medical care spending at old age is positively correlated with the housing price at old age in that the sale of housing has wealth effects on household consumption.

3. Empirical Test

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[7] For simplicity, we depressed subscript j.

3.1 Data

This research utilizes the panel data sets on housing price and household saving in China's 31 provinces during 1996-2016. The provincial-level databases consist of outstanding household savings balance, housing price, household disposable income, pension expenditure, population, CPI, household dwelling size and average family size. They are sourced from the *China Statistical Yearbooks* and the relevant provincial statistical yearbooks. Household education expenditures, medical care spending, baseline consumption spending, and housing expenditures are gathered from *China's Price and Urban Household Life Yearbook*. It is worth noting that baseline consumption refers to expenditures on food, clothes, domestic utility, transportation and communications.

To eliminate inflation, we take the year of 1996 as the base year and translate the normal-term variables into real-term variables via provincial year-on-year CPI.

3.2 Econometric Setup

Based on the theoretical model, household savings and housing price are endogenous over lifetime. In other words, current household saving is endogenous with the expected education spending, medical care spending and pension expenditures. Hence, we employ the system-generalized method-of-moments estimator (SYS-GMM) posed by Arellano and Bond (1995) and Blundell and Bond (1998) to resolve these endogeneity problems[⑧]. First, SYS-GMM estimator solves the unsteady variables by differencing the covariates. Second, SYS-GMM estimator resolves endogeneity problems by introducing lagged level and differentiated instrumental variables. Finally, SYS-GMM estimator solves the serial correlation issue by introducing a lagged dependent variable. As such, to testify the Propositions of 1 and 2, we construct the following household saving model and housing price model, respectively:

$$S_{jt} = \alpha_0 + \alpha_1 S_{jt-1} + \alpha_2 P_{jt+1} + \alpha_3 H_{jt+1} + \alpha_4 INC_{jt} + \alpha_5 C_{jt} + \alpha_6 E_{jt+1} + \alpha_7 M_{jt+1} + \alpha_8 O_{jt+1} + \varepsilon_{jt}$$

$$P_{jt} = \beta_0 + \beta_1 P_{jt-1} + \beta_2 S_{jt-1} + \beta_3 H_{jt} + \beta_4 INC_{jt} + \beta_5 C_{jt} + \beta_6 E_{jt} + \beta_7 M_{jt} + \beta_8 O_{jt} + \mu_{jt}$$

where S_{jt} and P_{jt} denote the household saving balance per capita and the housing price at year t in province j, respectively; H_{jt+1} denotes the household dwelling size per capita at year $t+1$ in province j; INC_{jt} denotes household's disposable income per capita at year t in province j; C_{jt+1}, E_{jt+1}, M_{jt+1} and O_{jt+1} denote the baseline consumption per capita, the education spending per capita, the medical care spending per capita and the pension expenditure per capita at year $t+1$ in province j, respectively. It is noteworthy that for simplicity, this research employs the forward variables at year $t+1$ to capture age effects on household savings at year t.[⑨]

3.3 Descriptive Analysis

[⑧]Although we can apply simultaneous equations to resolve endogeneity problems, it is hard to handle simultaneous equations for more than three endogenous variables.

[⑨]Age effects in household lifetime are investigated in Section 3.6.

Table 1 indicates that the mean outstanding household saving balance per capita is 17540.13 Yuan (approximately 2568 USD), while the household disposable income per capita is 14163.04 Yuan (approximately 2073 USD). Hence, the cumulative household savings is on average greater than the household disposable income in China. In addition, the average housing price is 3461.85 Yuan (approximately 506 USD) per square meter, while the average dwelling size per capita is 24.83 square meters. Thereby, the average housing price is not inflated at China's provincial level. In

Table 1 Summary Statistics of Main Variables

Variables	*S*	*P*	*H*	*INC*	*C*	*E*	*M*	*O*
Mean	17540.13	3461.85	24.83	14163.04	6705.41	1240.31	651.11	905.39
Median	11279.62	2504.78	26.05	11285.50	5657.37	1001.48	516.97	497.80
Max	128909.50	28488.91	44.45	57692.00	18302.30	4533.50	2839.90	10659.92
Min	768.92	63.30	5.51	3353.94	2050.83	211.41	71.94	19.43
S.E.	18469.22	3206.07	8.88	9473.54	3775.28	785.26	472.69	1200.11
Obs.	650	651	650	651	648	649	651	651

Note See the definitions of variables in Section 3.2

terms of household expenditure, the mean baseline consumption per capita is 6705.41 Yuan, while the mean values of education spending, medical care spending and pension expenditure are 1240.31 Yuan, 651.11 Yuan and 651.11 Yuan, respectively. Thus, the baseline consumption accounts for approximately 50% of a household's disposable income, whereas education spending, medical care spending and pension expenditure account for approximately 8% each.

Fig.3 indicates that except for education spending, household saving is positively correlated with housing price, household disposable income, baseline consumption, medical care spending and pension expenditure. Hence, household saving is positively correlated with precautionary savings in China.

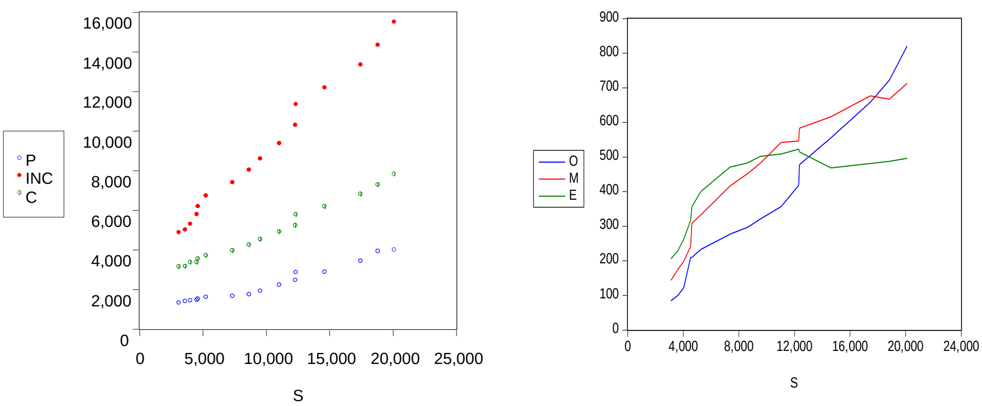

Figure 3 The correlations between household saving and major variables

3.4 Unit Root Test and Cointegration Test

To avoid spurious regression, it is necessary to conduct unit root tests. In general, a panel unit root test consists of homogeneous and heterogeneous panel unit root tests. The former refers to the LLC test (Levin, Lin and Chu, 2002), and the latter includes the IPS test (Im, Pesaran and Shin, 2003), the Fisher-ADF test and the Fisher-PP test (Maddala and Wu, 1999). As China's province-level data are balanced data, we can implement all of the abovementioned panel unit root tests. Table 2 shows that all the variables are $I(1)$. Although our data are not steady, we can still

Table 2 Unit root tests of panel variables

Variables	Level equations				Differenced equations			
	LLC	IPS	Fisher-ADF	Fisher-PP	LLC	IPS	Fisher-ADF	Fisher-PP
S	2.39	3.98	20.05	13.17	-17.14***	3.80	341.85***	318.43***
	(0.99)	(1.00)	(1.00)	(1.00)	(0.00)	(1.00)	(0.00)	(0.00)
P	-12.96	0.32	43.88	48.38	16.01**	-3.03***	154.76***	354.94***
	(0.11)	(0.63)	(0.96)	(0.90)	(0.02)	(0.00)	(0.00)	(0.00)
H	-13.26***	-0.90	61.67	50.52	-17.38***	-13.11***	275.25***	327.46***
	(0.00)	(0.18)	(0.49)	(0.85)	(0.00)	(0.00)	(0.00)	(0.00)
INC	-10.54*	2.40	22.66	43.91	-18.17***	-4.98***	214.18***	455.88***
	(0.10)	(0.99)	(1.00)	(0.96)	(0.00)	(0.00)	(0.00)	(0.00)
C	-10.36	1.90	46.01	39.74	-19.13***	-5.70***	151.10***	226.81***
	(0.72)	(0.97)	(0.94)	(0.99)	(0.00)	(0.00)	(0.00)	(0.00)
E	-9.33	3.09	33.91	60.66	-20.43***	-6.68***	190.85***	539.80***
	(0.38)	(1.00)	(1.00)	(0.52)	(0.00)	(0.00)	(0.00)	(0.00)
M	-10.26	2.224	21.10	35.61	-21.56***	-8.28***	229.62***	491.95***
	(0.75)	(0.99)	(1.00)	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)
O	-1.00	10.62	3.40	4.67	-13.09	-0.06	163.86***	367.11***
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(0.48)	(0.00)	(0.00)

Note The numbers in parentheses are p values. ***, ** and * denote the significant levels of 1%, 5% and 10% respectively (thereinafter). The estimated equation includes the intercept, the lagged variables and the time-trend term

regress the level equations provided that there are cointegrations among the covariates. Thereby, the research employs Pedroni tests to implement the cointegration tests (Pedroni, 1999, 2004). Table 3 indicates that besides the Panel v-statistic, the remaining six statistics verify that there exist cointegration relations among the covariates in both the household savings equation and the housing price equation. For this reason, we could directly regress the level equations for household savings and housing price models.

Table 3 Pedroni cointegration tests of the covariates

Statistics	Household saving equation	Housing price equation

Panel v	-0.3188	-0.7728
Panel rho	3.733 ***	3.516***
Panel t	-2.061***	-5.78***
Panel adf	4.92 ***	3.405 ***
Group rho	5.95 ***	5.636
Group t	-2.322 ***	-6.612***
Group adf	5.305 ***	5.103***

Note The null hypothesis is "no cointegration".

3.5 Results

Table 4 The SYS-GMM estimated results of household saving model and housing price model in China's 31 provinces over 1996-2016

Variables	Household saving model	Housing price model
S_{t-1}	0.87*** (164.16)	0.04*** (27.12)
P_{t+1}	0.45*** (21.27)	
P_{t-1}		0.91*** (108.04)
H_{t+1}	4.51 (0.75)	
H_t		8.87*** (12.86)
C_t	0.001 (0.10)	-0.08*** (-6.82)
E_{t+1}	2.48*** (39.87)	
M_{t+1}	0.33** (2.19)	
O_{t+1}	-0.04 (-0.36)	
E_t		-0.03 (-0.86)
M_t		-0.25*** (-5.23)
O_t		-0.05* (-1.78)
Constant	-1357.99*** (-7.78)	271.72*** (10.22)
$AR(1)$ value	-1.88 （0.06）	-2.25 （0.02）

$AR(2)$ Value	-2.13	-1.56
	（0.03）	（0.12）
Sargan Value	30.33	29.39
	（1.00）	（1.00）
Wald chi-square	717184.86	666781.40
Observations	586	615

Note The numbers in parentheses are z values while p values for AR tests and Sargan test.

To resolve the endogeneity problems, we take P_{it+1}, E_{jt+1}, M_{jt+1} and O_{jt+1} as the endogenous variables of household saving S_{jt}, while take S_{jt-1}, H_{it}, E_{jt}, M_{jt} and O_{jt} as the endogenous variable of housing price P_{it}. It deserves noting that household disposable income is dropped out due to multicolinearity [⑩].

As shown in Table 4, the household saving model suggests a one-Yuan increase in the expected housing price increases the current household saving per capita by 0.45 Yuan. Hence, Chinese households do save for future housing price appreciation, which validates the propositions 1 and 2. Second, a one-Yuan increase in the expected education spending per capita and the expected medical care spending per capita increases the current household savings per capita by 2.48 Yuan and 0.33 Yuan, respectively, whilst the expected pension expenditure per capita has no significant effects. Accordingly, similar to housing prices, Chinese households also have strong precautionary saving motivations for the future education spending and medical care spending. In comparison, however, Chinese households have the strongest precautionary propensity for the future education spending but the weakest precautionary propensity for the future medical expenditure. Third, the baseline consumption has no effect on the household saving, which implies that the baseline consumption does not crowd out household savings.

In terms of the housing price model, a one-Yuan increase in the lagged household saving per capita increases the current housing price by 0.04 Yuan, which corroborates the propositions 1 and 2. In essence, the current household saving enhances the future housing price by virtue of increasing the household's future purchasing power. Nevertheless, the current household savings and the expected housing price have asymmetric impacts for each other. In other words, the impact of current household savings upon the expected housing price is less than that of the expected housing price on the current household saving. Second, a one-Yuan increase in the household dwelling size per capita increases the housing price by 8.87 Yuan. Thus, the housing demand increases the housing price substantially. Third, a one-Yuan increase in the current baseline consumption per capita decreases the current housing price by 0.08 Yuan. Hence, the current baseline consumption crowds out the current housing price, which is consistent with our theoretical model. Finally, besides the educational spending, a one-Yuan increase in the medical care spending per capita decreases the housing price by 0.25 Yuan, while a one-Yuan increase in the pension expenditure per capita increases the housing price by 0.05 Yuan. Hence, the current medical care spending crowds out the current housing price but the current pension expenditure crowds in the current housing price. It is possible that the pension money switches into the housing purchasing power by intergeneration transfer.

[⑩] On the other hand, household disposable income was not the key variable to be detected, we dropped it from both the savings model and the housing price model.

3.6 Robustness Test

In our theoretical model, household age is an important factor in life-cycle saving decisions. The province-level datasets, however, have no household age information, we apply Urban Household Survey (UHS) databases conducted by the National Bureau of Statistics from 2002 to 2007 to examine household age effects. The UHS is based on a probabilistic sample and a stratified design. It provides household-level information on income, consumption expenditures, demography, employment, and similar variables. One-third of households rotate annually, and households remain in the sampling frame for three years, which provides a limited panel of data. The micro databases cover China's six typical provinces of Beijing, Liaoning, Zhejiang, Guangdong, Sichuan, Shanxi and vary across geographic locations and economic development levels.

Table 5 The OLS-estimated results of the household savings model for UHS during 2002-2007

Variables	Model 1	Model 2
Lagged housing price	0.60*	0.79***
	(1.78)	(3.64)
Household head age	14.00*	
	(1.74)	
Household head age squared	-0.004*	
	(-1.76)	
Lagged housing price×Household head age	0.00	
	(0.75)	
Household head aged 18-40 (China's young-age cohort)		—
Household head aged 41-65 (China's middle-age cohort)		-213.33
		(-0.54)
Household head aged 66 and above (China's old-age cohort)		1746.99*
		(1.86)
Lagged housing price×Household head aged 18-40		0.49
		(1.29)
Lagged housing price×Household head aged 41-65		0.56*
		(1.73)
Lagged housing price×Household head aged 66 and above		0.70***
		(2.99)
Household disposable income	0.51***	0.51***
	(24.18)	(24.08)
Household dwelling size	-22.66***	-22.56***
	(-8.89)	(-8.82)

Year-dummy variables	Control	Control
Province-dummy variables	Control	Control
Constant	-1359142***	-9161.253***
	(-1.72)	(-7.84)
R-squared	0.35	0.35
Observations	57195	57195

Note Parentheses are t values. The results of year and province-dummy variables are not reported, but available upon request. "_" denotes dropped because of multicolinearity

First of all, we introduce the age and age squared of household head into the regression models to explore the age effects. In addition, according to China's conventions and criteria, we generate three household head age cohorts of young age (18-40), middle age (41-65) and old age (above 65), respectively. Then, in the manner described by Chamon and Prasad (2010) and Wei and Zhang (2011), we construct interactive dummy variables for housing price and household head age to capture their interaction effects on household savings. Second, as the survey data does not include future information of education expenditure, medical care expenditure and pension expenditure, we do not investigate their effects on household savings. Third, as regional housing price change could capture household expectations for future housing price change, we employ the lagged province housing price to resolve the endogeneity problem between expected housing price and current household saving. It is worth noting that we take household bank deposits as household savings. Fourth, we construct year and province-dummy variables to control for year-fixed effects and geographic-fixed effects. Lastly, taking the year 2000 as the base year, we apply the province-level CPI data to convert the normal-term covariates into the real-term covariates.

As shown in Table 5, Model 1 indicates that the age of the household head has a reverse U-shaped effect on household saving, which coincides with the theoretical propositions. In other words, household saving first increases and then decreases with age in the long-run. The coefficients of age (14.00) and age squared (0.004) indicate that the decrease in household saving will occur when household head reaches age 1750 (14.00/(2×0.004)). Hence, household saving hardly decreases during a household's life in China. In addition, the interaction between housing price and the household head's age is not significant. Model 2 also shows that the old-age households have a higher saving rate than that of the young and middle-age households. In particular, the interaction effects of housing price and household head age increase with the household head age from 0.49 in young age to 0.70 in old age. The results reflect the stylized fact of intergeneration transfer per se in current China. In other words, Chinese young people normally have not enough money to save for a home purchase and have to rely on their parents' financial assistance. Consequently, Chinese old people have a strong bequest motivation to save for their descendants' life happiness. Although the result is converse to the Assumption 11, there exists an age effect in the long run. In other words, the empirical results also support the theoretical propositions in the long run.

4. Conclusions and Policy Implications

The growing household savings ratio is a great puzzle in China. This research attempts to explain the puzzle by examining the relationship between housing prices and precautionary saving. Unlike the existing literature, this research develops a comprehensive theoretical model and uses Chinese province-level datasets and household-level datasets to test the theory.

The theoretical model demonstrates that if housing price keeps growing, household saving at young age is positively associated with housing price and education spending at middle age. In contrast, the housing price at middle age is positively associated with precautionary saving at young age. Hence, housing prices at middle age interplay with precautionary saving at young age. If housing prices at n old age are less than those in middle age, precautionary saving at middle age is positively associated with medical expenditure at old age.

The results show that a household saving is positively associated with housing prices, whereas the impact of housing prices on household saving is greater than that of household saving on the housing prices. Therefore, to increase household consumption (well-being) and advance economic growth, the government should implement effective counter-cyclical housing policies to prevent housing price increases. In addition, current household saving is positively associated with expected education spending, medical care spending and pension costs. Hence, to improve household welfare, the central government should establish effective social institutions to reduce and eliminate the uncertainties of future education spending, medical care spending and pension expenditure. Finally, education spending, medical care spending and pension expenditure crowded out housing prices. Thus, the increases in education spending, medical care spending and pension expenses are conducive to hinder housing price increases.

Appendix 1

From Equation 5, it yields:

$$\frac{\partial U_H}{\partial H} = -\frac{(1+\eta)^2+\eta+2}{(1+\eta)^2 H^2} - \frac{(UC_1P_1)^2}{(Y_1-UC_1P_1H-S_1)^2}$$
$$-\frac{(1-\lambda)^2P_2^2}{(1+\eta)[Y_2+(1+r)S_1-E-(1-\lambda)P_2H-S_2]^2}$$
$$-\frac{(P_3-\lambda P_2)^2}{(1+\eta)^2[Y_3+(1+r)S_2+(P_3-\lambda P_2)H-M]^2}<0$$

$$\frac{\partial U_H}{\partial E} = -\frac{(1-\lambda)P_2}{(1+\eta)[Y_2+(1+r)S_1-E-(1-\lambda)P_2H-S_2]^2}<0$$

$$\frac{\partial E}{\partial P_2} = \frac{\partial U_H}{\partial E}/\partial P_2 = -\frac{(1-\lambda)[C_2+2(1-\lambda)H]}{(1+\eta)C_2^3}<0$$

$$\frac{\partial U_H}{\partial M} = \frac{P_3-\lambda P_2}{(1+\eta)^2[Y_3+(1+r)S_2+(P_3-\lambda P_2)H-M]^2}$$

If $P_3-\lambda P_2>0$, $\frac{\partial U_H}{\partial M}\geq 0$; if $P_3-\lambda P_2\leq 0$, $\frac{\partial U_H}{\partial M}<0$. Thus,

$$\frac{\partial M}{\partial P_3} = \frac{\partial U_H}{\partial M}/\partial P_3 = \frac{C_3-2H(P_3-\lambda P_2)}{(1+\eta)^2C_3^3}$$

If $P_3-\lambda P_2>0$, the sign of $\frac{\partial M}{\partial P_3}$ is not predetermined, if $P_3-\lambda P_2\le 0$, $\frac{\partial M}{\partial P_3}>0$.

$$\frac{\partial U_H}{\partial S_1}=-\frac{UC_1P_1}{[Y_1-UC_1P_1H-S_1]^2}+\frac{(1+r)(1-\lambda)P_2}{(1+\eta)[Y_2+(1+r)S_1-E-(1-\lambda)P_2H-S_2]^2}$$

$$=-\frac{UC_1P_1}{C_1^2}+\frac{(1+r)(1-\lambda)P_2}{(1+\eta)C_2^2} \tag{6}$$

According to the Assumptions 5, 8 and 9, Equation 6 can be rewritten as:

$$\frac{\partial U_H}{\partial S_1}=\frac{(1-\lambda)P_2-UC_1P_1}{C_2^2}$$

Apparently, if $(1-\lambda)P_2>UC_1P_1$, $\frac{\partial U_H}{\partial S_1}>0$; if $(1-\lambda)P_2<UC_1P_1$, $\frac{\partial U_H}{\partial S_1}<0$.

As a Consequence, it derives:

$$\frac{\partial S_1}{\partial Y_1}=\frac{\partial U_H}{\partial S_1}\Big/\partial Y_1=\frac{2UC_1P_1}{[Y_1-UC_1P_1H-S_1]^3}>0$$

$$\frac{\partial S_1}{\partial P_2}=\frac{\partial U_H}{\partial S_1}\Big/\partial P_2=\frac{(1+r)(1-\lambda)[C_2+2(1-\lambda)UC_1P_2H]}{(1+\eta)C_2{}^3}>0$$

$$\frac{\partial S_1}{\partial E}=\frac{\partial U_H}{\partial S_1}/\partial E=\frac{2(1+r)(1-\lambda)P_2}{(1+\eta)C_2{}^3}>0$$

Similarly, we obtain:

$$\frac{\partial U_H}{\partial S_2}=-\frac{(1-\lambda)P_2}{(1+\eta)[Y_2+(1+r)S_1-E-(1-\lambda)P_2H-S_2]^2}$$

$$-\frac{(1+r)[P_3-\lambda P_2]}{(1+\eta)^2[Y_3+(1+r)S_2+(P_3-\lambda P_2)H-M]^2}=-\frac{(1-\lambda)P_2}{(1+\eta)C_2^2}-\frac{(1+r)(P_3-\lambda P_2)}{(1+\eta)^2C_3^2}=-\frac{(1-\lambda)P_2+(P_3-\lambda P_2)}{(1+\eta)C_2^2}$$

Obviously, if $P_3-\lambda P_2>0$, $\frac{\partial U_H}{\partial S_2}<0$; if $P_3-\lambda P_2\le 0$, the sigh of $\frac{\partial U_H}{\partial S_2}$ is not predetermined. As such, we get:

$$\frac{\partial S_2}{\partial Y_2}=\frac{\partial U_H}{\partial S_2}\Big/\partial Y_2=\frac{2(1-\lambda)P_2}{(1+\eta)[Y_2+(1+r)S_1-E-(1-\lambda)P_2H-S_2]^3}>0$$

$$\frac{\partial S_2}{\partial P_3}=\frac{\partial U_H}{\partial S_2}\Big/\partial P_3=-\frac{(1+r)[C_3-2H(P_3-\lambda P_2)]}{(1+\eta)^2C_3^3}$$

If $P_3-\lambda P_2>0$, the sign of $\frac{\partial S_2}{\partial P_3}$ is not predetermined, if $P_3-\lambda P_2\le 0$, $\frac{\partial S_2}{\partial P_3}<0$. Thus,

$$\frac{\partial S_2}{\partial E}=\frac{\partial U_H}{\partial S_2}/\partial E=-\frac{2(1-\lambda)P_2}{(1+\eta)C_2^3}<0$$

$$\frac{\partial S_2}{\partial M}=\frac{\partial U_H}{\partial S_2}/\partial M=-\frac{2(1+r)(P_3-\lambda P_2)}{(1+\eta)^2C_3^3}$$

Hence, if $P_3-\lambda P_2>0$, $\frac{\partial S_2}{\partial M}<0$; if $P_3-\lambda P_2\le 0$, $\frac{\partial S_2}{\partial M}>0$.

$$\frac{\partial U_H}{\partial Y_1}=\frac{UC_1P_1}{(Y_1-UC_1P_1H-S_1)^2}>0$$

$$\frac{\partial U_H}{\partial Y_2}=\frac{(1-\lambda)P_2}{(1+\eta)[Y_2+(1+r)S_1-E-S_2-(1-\lambda)P_2H]^2}>0$$

$$\frac{\partial U_H}{\partial Y_3}=-\frac{P_3-\lambda P_2}{(1+\eta)^2[Y_3+(1+r)S_2+(P_3-\lambda P_2)H-M]^2}$$

Thereby, if $P_3-\lambda P_2>0$, $\frac{\partial U_H}{\partial Y_3}<0$; if $P_3-\lambda P_2\le 0$, $\frac{\partial U_H}{\partial Y_3}>0$.

$$\frac{\partial U_H}{\partial P_1}=-\frac{UC_1(Y_1-S_1)}{[Y_1-UC_1P_1H-S_1]^2}<0$$

$$\frac{\partial U_H}{\partial P_2}=-\frac{(1-\lambda)[Y_2+(1+r)S_1-E-S_2]}{(1+\eta)[Y_2+(1+r)S_1-E-S_2-(1-\lambda)P_2H]^2}-\frac{Y_3+(1+r)S_2-M}{(1+\eta)^2[Y_3+(1+r)S_2+(P_3-\lambda P_2)H-M]^2}$$

$$=-\frac{(1-\lambda)[C_2+(1-\lambda)P_2H]}{(1+\eta)C_2^2}-\frac{C_3-(P_3-\lambda P_2)H}{(1+\eta)^2C_3^2}$$

Similarly, if $P_3-\lambda P_2>0$, the sign of $\frac{\partial U_H}{\partial P_2}$ is not predetermined; if $P_3-\lambda P_2\le 0$, $\frac{\partial U_H}{\partial P_2}<0$. Thus,

$$\frac{\partial P_2}{\partial S_1}=\frac{\partial U_H}{\partial P_2}/\partial S_1=\frac{(1+r)(1-\lambda)[C_2+2(1-\lambda)P_2H]}{(1+\eta)C_2^{\ 3}}>0$$

$$\frac{\partial P_2}{\partial E}=\frac{\partial U_H}{\partial P_2}/\partial E=-\frac{(1-\lambda)[Y_2+(1+r)S_1-E-S_2+(1-\lambda)P_2H]}{(1+\eta)[Y_2+(1+r)S_1-E-S_2-(1-\lambda)P_2H]^3}$$

$$=-\frac{(1-\lambda)[C_2+2(1-\lambda)P_2H]}{(1+\eta)C_2^{\ 3}}<0$$

$$\frac{\partial U_H}{\partial P_3}=\frac{Y_3+(1+r)S_2-M}{(1+\eta)^2[Y_3+(1+r)S_2+(P_3-\lambda P_2)H-M]^2}=\frac{C_3-H(P_3-\lambda P_2)}{(1+\eta)^2C_3^2}>0$$

$$\frac{\partial P_3}{\partial S_2}=\frac{\partial U_H}{\partial P_3}/\partial S_2=-\frac{(1+r)[C_3-2(P_3-\lambda P_2)H]}{(1+\eta)^2C_3^2}$$

If $P_3-\lambda P_2>0$, the sign of $\frac{\partial P_3}{\partial S_2}$ is not predetermined; if $P_3-\lambda P_2\le 0$, $\frac{\partial P_3}{\partial S_2}<0$.

$$\frac{\partial P_3}{\partial M}=\frac{\partial U_H}{\partial P_3}/\partial M=\frac{C_3-2(P_3-\lambda P_2)H}{(1+\eta)^2C_3^2}$$

If $P_3-\lambda P_2>0$, the sign of $\frac{\partial P_3}{\partial M}$ is not predetermined; if $P_3-\lambda P_2\le 0$, $\frac{\partial P_3}{\partial M}>0$.

(Q.E.D.)

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