Discontinuous Evolution of Housing Shares in Households' Portfolios

Yubing Cui

International Business School
Brandeis University

Jan 5th, 2018

Outline

Introduction

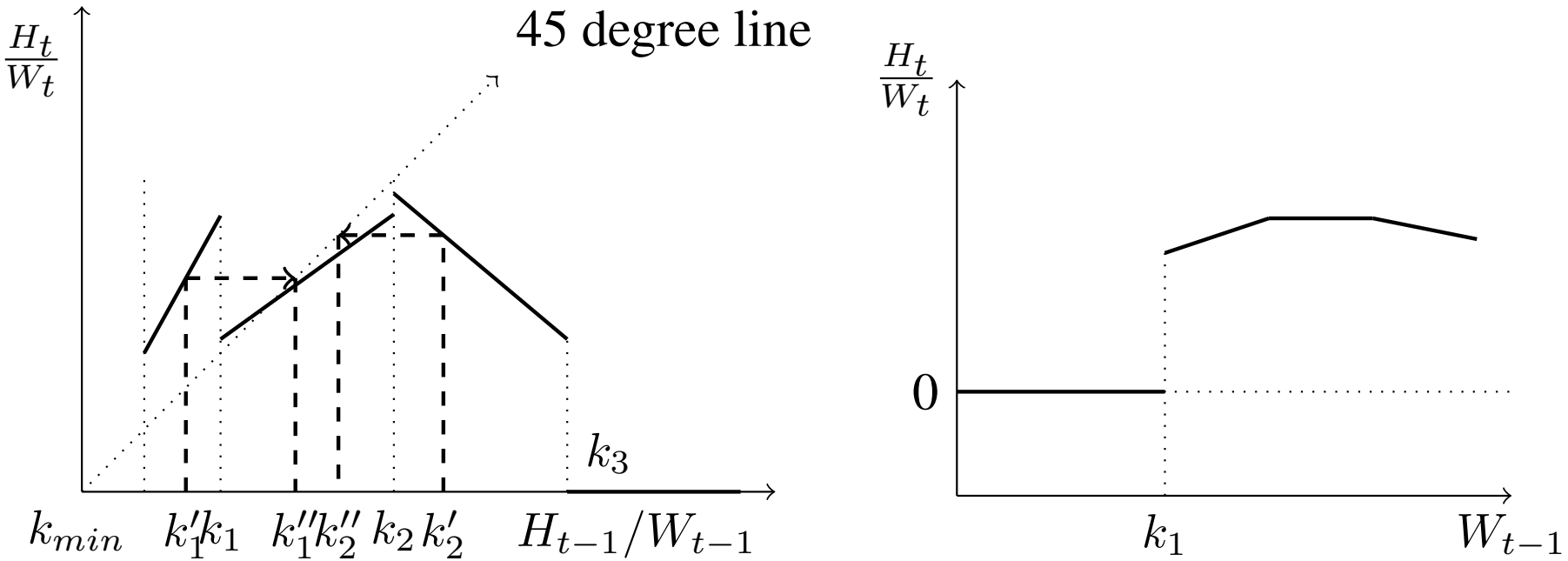
- Housing assets: earn higher returns, expand borrowing limits, save rental expenditures, costly to trade, require downpayments
- Optimal housing allocations depend on: current total savings, value-weighted portfolio returns
  - Higher housing shares, higher portfolio returns, saving more in liquid wealth to reduce the housing shares. If reaching a higher threshold, probabilities of downsizing increase.
  - Lower housing shares, lower portfolio returns, saving less in liquid wealth to raise the housing shares. If reaching a lower threshold, probabilities of upsizing increase.
  - With lower savings in both assets, probabilities of selling increase.
  - Renters save more to raise the housing shares. If reaching a threshold in liquid wealth, probabilities of home purchases increase.
- Evolution of housing shares has discontinuities and kinks once the endogenous thresholds of an optimal region are crossed.
- Thresholds are determined by households' state variables and aggregate market conditions.

Literature Review

- Housing demand and consumption of housing services
  - Hanushek & Quigley (1982), Venti & Wise (2001)
  - Charlier, Melenberg & van Soest (2001)
- Optimal portfolio choices with illiquid objects
  - Faig & Shum (2002), Cocco (2005)
- Durable consumption with optimal stopping behaviors
  - Bar-Ilan & Blinder (1988), Grossman & Laroque (1990)
  - Attanasio (2000), Caballero & Engel (1991)
- Methods in semiparametric estimations
  - Hahn, Todd & Van der Klaauw (2001), Porter (2003), Card, Lee, Pei & Weber (2012), Imbens & Kalyanaraman (2012), Calonico, Cattaneo & Titiunik (2014)
  - Card, Mas & Rothstein (2008), Angrist & Lavy (1999), Jacob & Lefgren (2002), Matsudaira (2007)

Optimal Policy Function

Figure 1: Plot of H_t/W_t as a function of H_{t-1}/W_{t-1} or W_{t-1}



- The kinked function: housing allocations averaged across homeowners with varying total wealth, age, marriage status, housing shocks, income shocks, rental price shocks, etc., conditional on making different transactions.
- The hump-shaped function: average housing ratios for renters with different other state variables given home purchases.

Optimal Policy Function

- When housing assets earn higher returns than liquid assets, and given unexpected income shocks and home value growth:
  - Between K_1 and K_2: optimal allocations without jumps in probabilities of making costly transactions; distances to K_1 or K_2: imply future probabilities of housing transactions.
  - Conditional on all other state variables, probabilities to trade jump up if beyond the thresholds due to the fixed costs; but probabilities not equal to one because of the unobserved rental income shocks.
  - Lower housing shares, lower future consumption, to raise the ratios: those with higher total wealth save less; those with lower total wealth increase housing assets.
  - Higher housing shares, lower current period's consumption, to reduce the ratios: those with higher total wealth save more; those with lower total wealth decrease housing assets.
  - When housing shares are beyond K_3, households are liquidity constrained and very likely to sell homes.

Optimal Policy Function

- Renters have no housing assets, lowest housing shares at zero before home purchases:
  - Home purchases expand the borrowing limits and save rental expenditures: consumption is higher after buying homes.
  - Renters save a little more for future home purchases until the buying threshold is reached.
  - Those with higher liquid wealth buy larger houses: housing shares first increase with liquid wealth.
  - After the highest share is reached, the housing shares decline with liquid wealth: buying even larger houses increases future probabilities of downsizing and selling given the permanent income.
  - Probabilities of home purchases also experience jumps at the threshold and increase with liquid wealth.

Determinants of the Thresholds

- Thresholds are determined as follows, given the same total wealth and other demographic variables such as age and marriage status:

$$H/W^*(H/W^*_{up}, H/W^*_{down}, H/W^*_{sell}) = f(Y^p, r, r_H, \theta, \delta, P^{rental}) \quad (1)$$

  - permanent income Y^p: total savings and consumption
  - average assets' returns r, r_H: relative prices between housing and liquid assets
  - credit constraint θ: precautionary savings
  - fixed costs δ: locations of the thresholds
  - mean rental prices P^{rental}: relative costs of homeownership

- Factors impact both the optimal amount of total savings and the housing allocations.
- Variations affect the actual housing shares and the thresholds.

Data Description

- Data: Panel Study of Income Dynamics, 1999-2009

Table 1: Shares of population with each type of transitions (%)

# of adj	0	1	2	3	4	5
% of HH	64.29	24.78	8.13	2.41	0.38	0.01

Year	Pre-Sample	Owner-Buyer	Owner-Seller	Renter-Seller	Renter-Buyer	Renter-Renter	Owner-Owner	Adj-All
2001	0.5	3.8	2.1	0.3	4.8	26.1	62.5	11.0
2003	0.5	4.2	2.9	0.2	5.3	24.5	62.4	12.5
2005	0.3	4.4	3.2	0.2	5.3	24.8	61.8	13.1
2007	0.4	4.3	2.9	0.2	4.8	26.1	61.3	12.2
2009	0.2	2.2	3.2	0.1	3.9	28.1	62.4	9.3

Notes: Transitions are identified from each survey by comparing current homeownership status to that in the previous survey year. P-S: households make transactions before entering the sample; O-B: homeowners move to different houses; O-S: homeowners move to renting; R-S: renters buy and sell houses within two years; R-B: renters buy houses; R-R: renters keep renting; O-O: homeowners stay in the same houses; Adj-All: the total fraction of population making different housing transactions every two years.

Data Description

Table 2: Comparisons of home price return and housing wealth growth (%)

Year	Home price return			Housing wealth growth		Value-weighted return	Market return
	O-B	O-S	O-O	O-B	O-O	O-O	R-S
2001	−0.63	−2.63	17.34	63.94	17.34	15.28	21.59
2003	−5.45	12.90	17.05	57.04	17.05	14.86	21.55
2005	5.72	4.89	24.71	66.65	24.71	22.41	33.56
2007	4.06	5.16	16.77	51.18	16.77	13.30	3.75
2009	−7.52	−18.10	−4.00	21.87	−4.00	−8.23	−26.89

Notes: The estimates are average two-year housing returns of the same houses in columns 3, 5 and 6; actual realized capital gains from sales of the old houses in columns 1 and 2; actual growth in housing wealth including quantity changes in column 4; and average two-year returns on monthly Case-Shiller 20-City HPI in column 7. O-B: homeowners move to different houses; O-S: homeowners move to renting; O-O: homeowners stay in the same houses; R-S: repeated sales.

Discrete Choice Regressions

- From the optimal policy functions:
  - Lagged housing shares are positively correlated with probabilities of downsizing and selling, but negatively correlated with probabilities of upsizing.
  - Total amounts of savings affect the housing choices given the same lagged housing shares.
  - Lagged income increases the upsizing probabilities, but decreases the downsizing and selling probabilities.
  - Younger households are more likely to buy or upsize homes, but less likely to downsize or sell homes.
  - Other demographics such as marriage also affect the different probabilities.
  - Unobserved variables such as the implicit rental income shocks influence housing choices when households are close to the thresholds.

Table 3: Estimations of homeowners' housing choices

	Model 1			Model 2		
	Upsize	Downsize	Sell	Upsize	Downsize	Sell
$\ln Y_{t-1}$	0.298***	0.138	−0.118**	0.294***	0.115	−0.069
	(0.066)	(0.085)	(0.050)	(0.067)	(0.084)	(0.052)
$\ln(H_{t-1}/W_{t-1})$	−0.071**	0.132***	0.160***	−0.075*	0.175***	0.106*
	(0.034)	(0.049)	(0.043)	(0.039)	(0.057)	(0.056)
45<Age<65	−1.062***	−0.242	−0.849***	−1.064***	−0.256	−0.814***
	(0.106)	(0.156)	(0.129)	(0.107)	(0.156)	(0.130)
Age>=65	−1.178***	−0.126	−1.699***	−1.187***	−0.156	−1.580***
	(0.218)	(0.268)	(0.288)	(0.218)	(0.271)	(0.280)
Married	1.265***	0.325	−0.866***	1.264***	0.256	−0.784***
	(−0.405)	(−0.371)	(−0.232)	(−0.407)	(−0.370)	(−0.235)
Male	−0.827**	−0.161	0.543***	−0.828**	−0.148	0.523***
	(−0.332)	(−0.312)	(−0.188)	(−0.333)	(−0.312)	(−0.190)
$LowW_{t-1}$				−0.353	−4.314**	1.676***
				(−0.575)	(−2.080)	(−0.333)
$LowW_{t-1}*$				0.120	1.159*	−0.389***
$\ln(H_{t-1}/W_{t-1})$				(−0.188)	(−0.627)	(−0.124)
Constant	−6.116***	−5.649***	−1.574***	−6.065***	−5.288***	−2.279***
	(−0.747)	(−1.027)	(−0.595)	(−0.762)	(−1.028)	(−0.622)
Observations	15,230	15,230	15,230	15,230	15,230	15,230
Pseudo R2	6.06%	6.06%	6.06%	6.47%	6.47%	6.47%

Notes: Multinomial logit regressions for homeowners. Clustered standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1

Table 4: Estimations of renters' housing choices

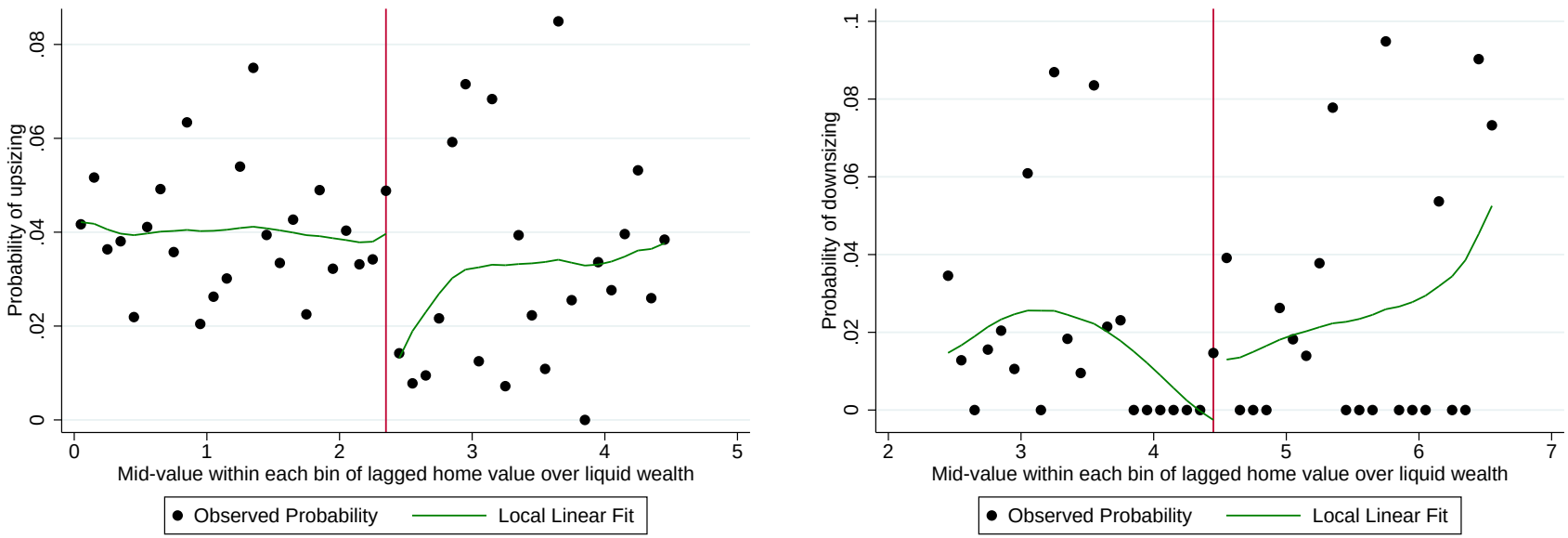
	Model 1	Model 2	Model 3	Model 4
$\ln Y_{t-1}$	0.229^{***}	0.195^{*}	0.462^{***}	0.447^{***}
	(0.080)	(0.100)	(0.069)	(0.092)
$45 \leq$Age<65	-0.518^{***}	-0.510^{***}	-0.349^{***}	-0.344^{***}
	(0.106)	(0.105)	(0.101)	(0.100)
Age≥ 65	-1.246^{***}	-1.303^{***}	-0.579	-0.636^{*}
	(0.433)	(0.435)	(0.354)	(0.355)
Married	0.682^{***}	0.665^{***}	0.926^{***}	0.916^{***}
	(0.201)	(0.201)	(0.175)	(0.175)
Male	-0.158	-0.155	-0.163	-0.171
	(0.176)	(0.176)	(0.157)	(0.157)
$\ln(W_{t-1})$	0.257^{***}	0.229^{***}	0.248^{***}	0.218^{***}
	(0.033)	(0.035)	(0.029)	(0.032)
$LowY_{t-1}$		-1.394^{**}		-1.359^{**}
		(0.683)		(0.592)
$LowY_{t-1}*$		0.133^{*}		0.143^{**}
$\ln(W_{t-1})$		(0.074)		(0.067)
Constant	-5.872^{***}	-5.190^{***}	-8.766^{***}	-8.288^{***}
	(0.739)	(0.984)	(0.736)	(0.957)
Observations	5,011	5,011	5,088	5,088
R2/Wald Chi2	0.116	0.118	283.5	284.7
Random Effects	No	No	Yes	Yes

Notes: Logit regressions for renters with the baseline choice as to keep renting. The last two columns report logit regressions with i.i.d. random effects. Clustered standard errors in parentheses for the logit regressions. ***p<0.01, **p<0.05, *p<0.1

Identifying Endogenous Thresholds (I)

- Procedure: use random subsamples, fit local polynomial regressions at any possible change point and find the maximum jump, test for the local Wald estimator, filter out insignificant values, and repeat the process.

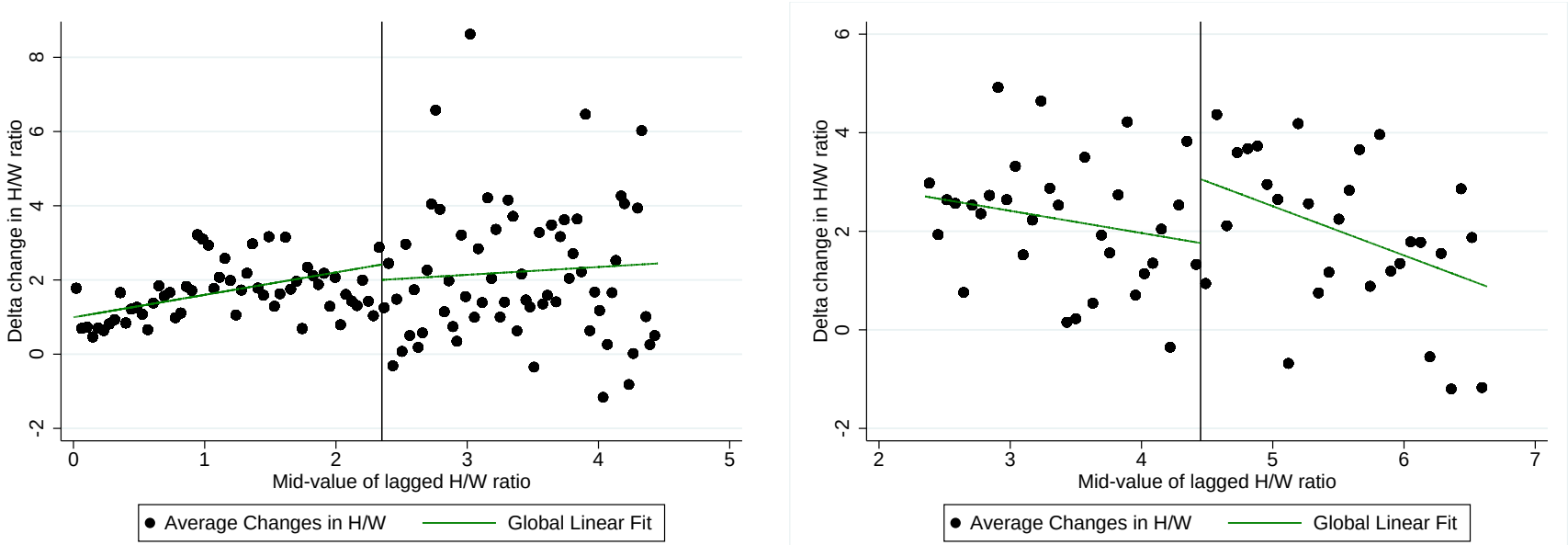
Figure 2: Probabilities of upsizing and downsizing within each bin of H_{t-1}/W_{t-1}



Notes: The left figure plots the observed probabilities of upsizing within each bin of H_{t-1}/W_{t-1} between 0 and K_2 in the upsizing random subsample with local linear fits. The optimal bandwidth is 1.089. The right figure plots the observed probabilities of downsizing within each bin of H_{t-1}/W_{t-1} between K_1 and K_3 in the downsizing random subsample with local linear fits. The optimal bandwidth is 1.335.

- In the other random subsamples, test for the slope differences in the function of housing shares around K_1 and K_2 following Calonico, Cattaneo & Titiunik (2014). The estimates show a significant upward kink of 0.51(0.14) at K_1 and a downward kink of -0.61(0.16) at K_2.

Figure 3: Regression discontinuity plots of average $\Delta H_t/W_t$ within each bin of H_{t-1}/W_{t-1}

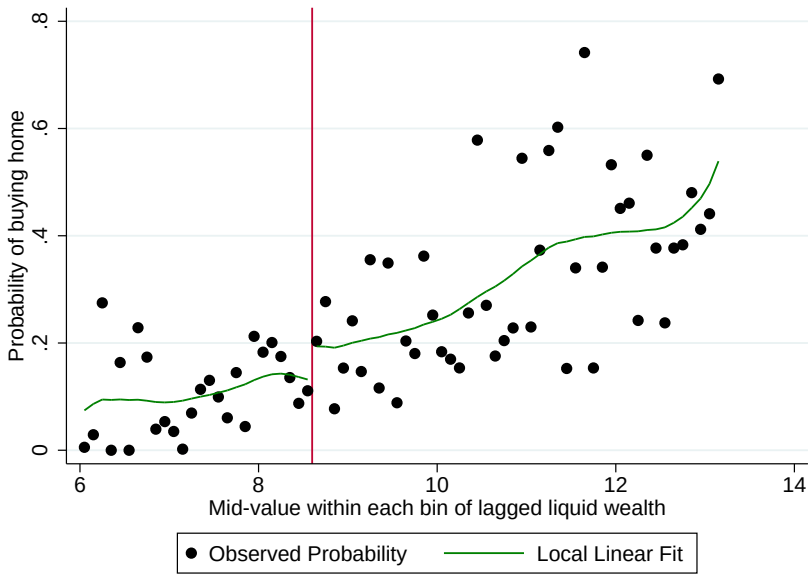


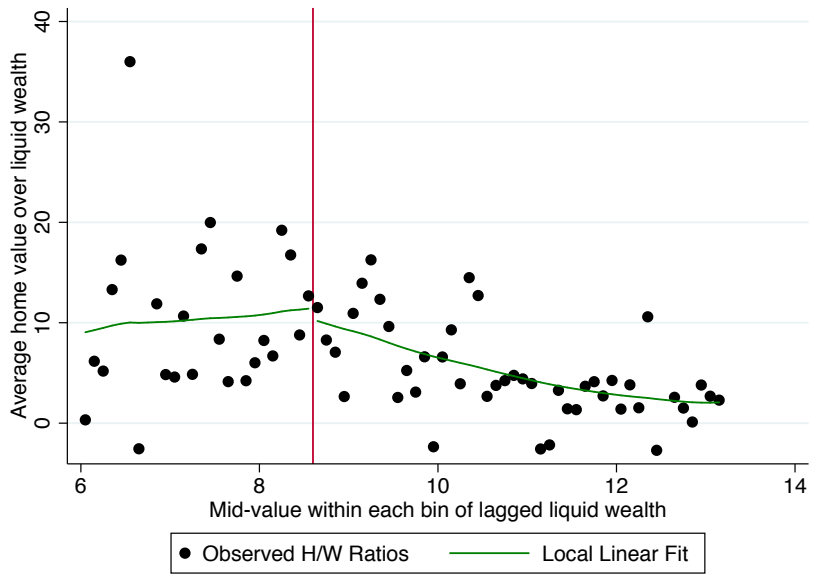
Notes: The left figure uses the second subsample generated using the criteria of observing at least one upsizing transaction, and it plots the mean values of $\Delta H_t/W_t$ within each bin of H_{t-1}/W_{t-1} from 0 to 4.45 and a linear fit on either side of the threshold K_1=2.35; the right figure uses the second subsample generated using the criteria of observing at least one downsizing transaction, and it plots the mean values of $\Delta H_t/W_t$ within each bin of H_{t-1}/W_{t-1} from 2.35 to 6.65 and a linear fit on either side of the threshold K_2=4.45.

Identifying Endogenous Thresholds (II)

- Renters' estimates of jumps in the purchase probabilities and conditional average housing shares

Figure 4: Renters' purchase probabilities and conditional average H_t/W_t within each bin of $\ln(W_{t-1})$





Notes: The left figure plots the observed probabilities of buying homes within each bin of $\ln(W_{t-1})$ in the renters' subsample with local linear fits. The optimal bandwidth is 1.189. The right figure uses the second random subsample for renters and plots the average ratios of H_t/W_t conditional on buying homes within each bin of $\ln(W_{t-1})$ and a local linear fit on either side of the threshold. The local Wald estimator is statistically insignificant at -1.140 with an optimal bandwidth 3.042. The bin width for lagged liquid wealth is set at 0.1.

Fuzzy Regression Kink Model

- Conditional on the jumps and kinks in the average probabilities of making transactions, the average housing shares also exhibit discontinuities and kinks at the thresholds.
- Fuzzy regression kink model: estimate causal effects of housing transactions on shifting the slope of the optimal policy function

$$\begin{cases} \Delta \frac{H_t}{W_t} &= \alpha + \beta_{j1} \sum_{j=1}^{p} (\frac{H_{t-1}}{W_{t-1}})^j + \beta_2 \hat{T}_t + \beta_{j3} D_t \sum_{j=2}^{p} (\frac{H_{t-1}}{W_{t-1}})^j + \tau_t \\ T_t &= \pi_0 + \pi_{j1} \sum_{j=1}^{p} (\frac{H_{t-1}}{W_{t-1}})^j + \pi_{j2} D_t \sum_{j=1}^{p} (\frac{H_{t-1}}{W_{t-1}})^j + \xi_t \end{cases} \tag{2}$$

- Estimator of β_2: slope difference of the policy function around the threshold conditional on the kink in the probabilities of making transactions
- Thresholds are endogenous: other households' variables and market variables are excluded
- Specification limited in estimating the discontinuities, only estimates the size of the kinks

Table 5: 2SLS estimations of the changes in optimal housing shares

	RKD of upsizing on [0,K2]		RKD of downsizing on (K1,K3]	
1st Stage Estimation:	Local Linear	Local Polynomial	Local Linear	Local Polynomial
H_{t-1}/W_{t-1}	−0.006	−0.027	−0.025	−0.345*
	(0.007)	(0.031)	(0.020)	(0.200)
$H_{t-1}/W_{t-1} * D_t$	0.003	−0.031	0.011	0.144
	(0.013)	(0.054)	(0.009)	(0.095)
$(H_{t-1}/W_{t-1})^2$		0.004		0.048*
		(0.008)		(0.029)
$(H_{t-1}/W_{t-1})^2 * D_t$		0.020		−0.031
		(0.026)		(0.021)
Constant	0.116***	0.137***	0.122*	0.637*
	(0.017)	(0.029)	(0.066)	(0.341)
$\hat{T}_t$	137.014	−85.723	−9.786	11.179
	(696.104)	(154.812)	(26.155)	(22.370)
H_{t-1}/W_{t-1}	1.010	−2.474	0.068	3.324
	(4.340)	(4.936)	(0.266)	(2.808)
$(H_{t-1}/W_{t-1})^2$		0.546		−0.352
		(1.045)		(0.378)
$(H_{t-1}/W_{t-1})^2 * D_t$		0.654		−0.015
		(1.166)		(0.093)
Constant	−15.064	11.993	2.333	−5.328
	(82.686)	(19.456)	(1.839)	(5.943)
Observations	1,798	1,798	719	719
Wald Chi2	0.08	0.46	0.32	1.90

Notes: 2SLS regressions of changes in optimal housing shares in the samples of lagged ratios within [0, K2] and (K1, K3]. Observed values T_t are instrumented using the interaction terms of the indicator variables for the thresholds and lagged housing ratios. Clustered standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1

Sample Selection Model

- Renters' liquid savings affect both the homeownership decisions and conditional housing allocations.
- Sample selection model: estimate the probabilities of home purchases and then average housing shares given that they buy houses

$$\begin{cases} \ln(\frac{H_t}{W_t}) & = \pi_0 + \pi_1 z_t + \psi_t, \text{ if } y_t^* > 0 \\ y_t^* & = \beta_0 + \beta_1 w_{t-1} + \beta_2 D_t(w_{t-1} > K) + \omega_t \end{cases} \tag{3}$$

- Purchase probabilities increase with liquid wealth and have discontinuous jumps at the threshold.
- Other covariates affect the location of the threshold and are excluded from the selection equation.
- Conditional on buying houses, average housing shares first increase with liquid wealth and then decline as liquid wealth rises, indicating lower future probabilities of downsizing and selling.

Table 6: Estimations of $\ln(H_t/W_t)$ in the sample selection model

	(1) Full Sample Selection		(2) Local Sample Selection	
Dep:	$\ln(H_t/W_t)$	$Buy_t = 1$	$\ln(H_t/W_t)$	$Buy_t = 1$
$\ln W_{t-1}$	0.620	0.126***	0.240	0.161***
	(0.480)	(0.026)	(0.988)	(0.049)
$(\ln W_{t-1})^2$	−0.050**		−0.046	
	(0.019)		(0.045)	
45 ≤Age< 65	−0.092		−0.013	
	(0.113)		(0.134)	
Age≥ 65	1.195**		1.112**	
	(0.577)		(0.566)	
$D_t(\ln W_{t-1} > K)$		0.239***		0.178
		(0.090)		(0.113)
lambda	−0.545		−2.035	
	(1.101)		(2.034)	
Constant	1.099	−2.254***	6.588	−2.524***
	(4.307)	(0.202)	(8.189)	(0.381)
Observations	530	3,035	401	2,494
Chi2	43.72		12.08	

Notes: Sample selection models use Heckman's two-step estimators. $D_t(\ln(W_{t-1}) > K)$ indicates households with lagged liquid wealth above W^*_{buy}. The full-sample estimation uses households with lagged log liquid wealth between 1% and 99% of the data. Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1

Robustness Check

- Discrete choice regressions in each year: given unit changes in lagged housing shares, changes in the probabilities of upsizing, downsizing and selling vary with aggregate housing market conditions.
- Thresholds separately identified in each year: thresholds shift relative to the distribution of lagged housing shares, which affects the probabilities and magnitudes of changes in housing shares.
  - Predicted slope differences are generally overestimated in both the upsizing and downsizing samples.
  - Renters' conditional housing shares become downward-sloping in 2007 and 2009 due to lower purchase probabilities.
- Partial linear regressions: exhibit a hump-shaped function of relative housing shares, showing renters with higher liquid wealth have lower conditional housing shares.

Conclusion

- Optimal housing allocations have discontinuities and kinks due to discrete changes in the probabilities of making transactions.
- Within an optimal region, households save more in liquid wealth if higher housing shares lead to higher portfolio returns, but save less if lower housing shares lead to lower portfolio returns.
- After crossing the optimal region, lower housing shares make households more likely to buy or upsize housing assets, while higher housing shares make them more likely to downsize or sell housing assets.
- Probabilities of housing transactions jump up when lagged housing shares or lagged liquid wealth reach the thresholds due to the constant fixed costs.
- Homeowners' function of housing shares has an upward kink due to the jump in upsizing probabilities and also a downward kink due to the jump in downsizing probabilities. Renters have a hump-shaped function for the housing allocations given home purchases.