Mortgage Credit and Housing Markets

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Motivation

Research questions:

- How mortgage credit conditions affect housing demand, house prices, housing market liquidity, buyer-seller bargaining power?
- What is the role of expectations in housing markets?

Challenges:

1. **Endogeneity:** Mortgage credit conditions are determined by housing demand and prices
2. **Dynamic problem:** Expectations of future housing value and prices can affect housing market outcomes
3. **Market frictions:** High transaction costs, illiquid market.

Contribution

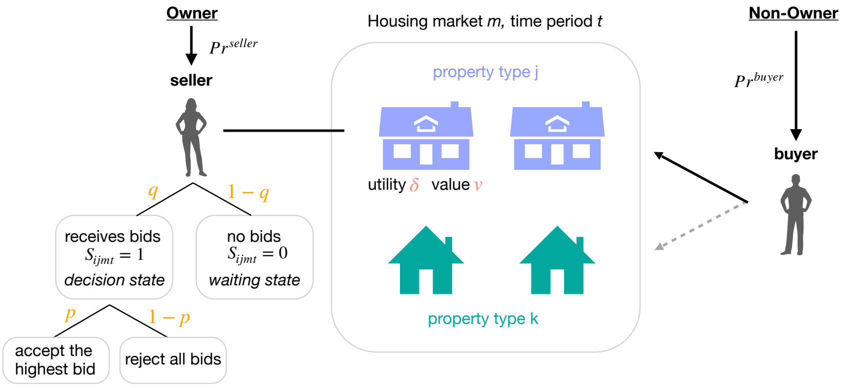
I build a **dynamic structural model** to

- estimate *utility* and *value functions* of property ownership
  - willingness to pay, expectation channel
- disentangle housing *supply* and *demand*
- understand the *structure* of housing markets
  - market liquidity from buyers and sellers, bargaining power

Counterfactual experiments to study

- the impact of mortgage credit conditions on housing market outcomes
- the role of *expectations* in housing markets.

Model Outline More



- The utility δ and the value v of property ownership
- Market liquidity from buyers q and sellers p
- Demand $\Pr^{buyer}$ and supply $\Pr^{seller}$ in housing markets
- The highest bid and house prices

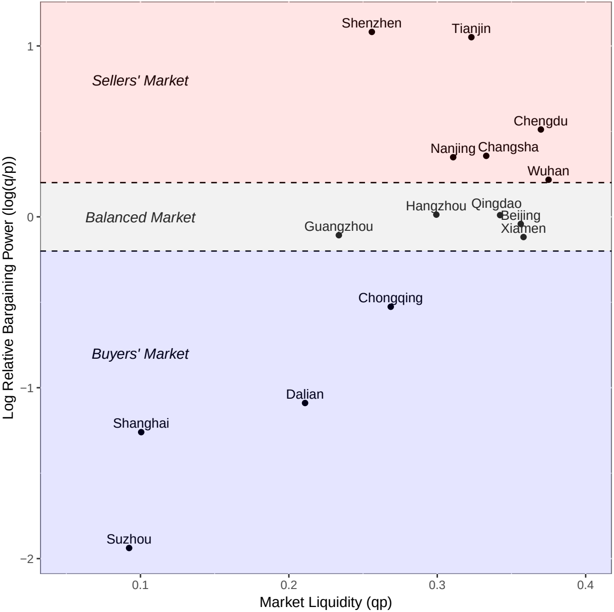
Data

I use hand-collected data from the largest Chinese real estate service company Lianjia. The sample contains 368,128 *second-hand residential* real estate transactions in 15 major cities from December 2015 to January 2018 with information on

- **listings and transactions** (e.g., the ask price, transaction price, time of listing, time of transaction)
- **properties** (e.g., living space, year of construction, number of rooms, location, decoration, etc.)

Monthly bank-city level mortgage data of the 67 largest banks in China.

Results: Market Liquidity More



Per Period Utility

	Value Function	Per Period Utility
	(1)	(2)
Transaction Cost (θ)	1.423	
	(0.000)	
Interest Expense (α_y)		-0.007
		(0.001)
Size Decile (α_x)		0.006
		(0.000)
Age Quintile (α_x)		-0.003
		(0.001)
District Fixed Effects (α_x)		Yes
Market-Time Fixed Effects (α_{mt})		Yes
Observations	368,128	152,800

The WTP for property attributes is $-\alpha_x/\alpha_y$. Households are willing to pay

- 800 CNY (approx. 110 USD) more per month for a larger property type
- 460 CNY (approx. 70 USD) more per month for a younger property type

Counterfactuals

- **No expectation:** Increase mortgage credit conditions in utility functions.
- **With expectation:** Increase mortgage credit conditions in both utility functions and expected value functions

Table: 10 Percentage Points Increase In Down Payment Requirements

	No Expectation			With Expectation		
	Mean	**50p**	**SD**	**Mean**	**50p**	**SD**
Δ Liquidity from buyers (q)	-13.8	-9.4	27.1	-7.0	-0.5	48.0
Δ Liquidity from sellers (p)	13.4	10.3	20.2	9.0	2.2	35.9
Δ Liquidity (qp)	-3.5	-0.8	33.6	-5.7	-5.3	37.4
Δ Bargaining Power (q/p)	-21.2	-18.5	28.3	9.6	-0.4	106.9
Δ Price (P_{ijmt})	-0.9	-0.3	1.5	0.4	0.2	3.1
Δ Demand ($\Pr^{buyer}$)	-0.5	1.2	14.3	-1.7	1.7	22.2
Δ Supply ($\Pr^{seller}$)	39.7	22.5	50.3	718.6	-4.8	5661.7

Counterfactuals

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Table: 1 Percentage Point Increase In Mortgage Interest Rates

	No Expectation			With Expectation		
	Mean	50p	SD	Mean	50p	SD
Δ Liquidity from buyers (q)	-1.1	-0.9	21.2	0.0	-0.0	40.3
Δ Liquidity from sellers (p)	1.6	1.2	13.6	-0.4	0.4	26.3
Δ Liquidity (qp)	1.1	0.1	29.1	-2.8	-4.5	34.5
Δ Bargaining Power (q/p)	-1.7	-2.3	21.6	15.9	4.1	66.6
Δ Price (P_{ijmt})	-0.1	-0.0	0.2	0.9	0.2	2.9
Δ Demand ($\Pr^{buyer}$)	-0.0	0.2	1.4	-1.7	0.5	18.0
Δ Supply ($\Pr^{seller}$)	2.8	2.0	2.2	943.7	-7.8	6051.9

Summary

This paper studies how mortgage credit affect housing markets and quantify the effect on buyers and sellers' behavior using a dynamic structural model.

Utility and willingness to pay:

- Mortgage interest expenses have a negative effect on the **utility** of homeownership
- Higher down payment requirements have a negative effect on the **value** of homeownership

Counterfactuals:

- Higher mortgage interest rates / down payment requirements reduce housing demand, increase housing supply, decrease house prices, decrease market liquidity, and decrease seller's relative bargaining power.
- The expectation channel plays an important role. On average, it mitigates mortgage credit policy interventions.

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Thank You!

Appendix: Model - Seller's Problem

Normalizing the utility of no property to zero. The utility of owning and selling property i of type j in market m at time t is

$$\begin{aligned} u(\Omega_{jmt}, \varepsilon_{ijmt,0}, 0) &= \delta(\Omega_{jmt}) + \varepsilon_{ijmt,0}; \\ u(\Omega_{jmt}, \varepsilon_{ijmt,1}, 1) &= \theta(P_{jmt} - M_{jmt} - C_{jmt}) + \varepsilon_{ijmt,1}. \end{aligned}$$

- Ω_{jmt} includes type attributes X_j (age, size, location), Mortgage credit conditions Y_{mt}, property price P_{jmt}, unobservable quality ξ_{jmt}.
- M_{jmt} Mortgages, C_{jmt} transaction costs.
- $\varepsilon_{ijmt,d}$ idiosyncratic utility, IID type I extreme value distributed.
- d^s_{ijmt} seller's decision to sell (=1) or not (=0).

Appendix: Model - Seller's Problem

The expected value of owning property is:

$$v_{jmt} = \delta(\Omega_{jmt}) + \beta\mathbb{E}\left[q_{jmt+1}\ln(e^{\theta(P_{jmt}-M_{jmt}-C_{jmt})} + e^{v_{jmt}}) + (1 - q_{jmt+1})v_{jmt+1}|\Omega_{jmt}\right]$$

The owner list her property if $v_{jmt} + \varepsilon_0 > \theta(P_{jmt} - M_{jmt}) + \varepsilon_1$. The probability of being a seller for type j property owner

$$\mathrm{Pr}_{jmt}^{seller} = (1 + e^{v_{jmt}-\theta(P_{jmt}-M_{jmt})})^{-1}$$

The probability of selling for sellers conditional on there exists potential buyers is

$$p_{jmt} = \frac{1}{1 + e^{v_{jmt}-\theta(P_{jmt}-M_{jmt}-C_{jmt})+\ln \mathrm{Pr}_{jmt}^{seller}}}.$$

Appendix: Model - Buyer's Problem

Buyers choose the property type j that yields the highest value of ownership among all property types

$$v_{jmt} - \theta(P_{jmt} - M_{jmt} + C_{jmt}) + \varepsilon_{ijmt,0} > \max_{\substack{k \in \{1,\ldots,J_m\} \\ k \neq j}} v_{kmt} - \theta(P_{kmt} - M_{kmt} + C_{kmt}) + \varepsilon_{ikmt,0}$$

Conditional on purchasing, the probability of choosing property type j is

$$\pi_{jmt} = \frac{e^{v_{jmt} - \theta(P_{jmt} - M_{jmt} + C_{jmt})}}{\sum_{k=1}^{J_m} e^{v_{kmt} - \theta(P_{kmt} - M_{kmt} + C_{kmt})}}.$$

Non-owners enter the market as buyers when owning a property makes them better off. The probability of being buyers is

$$\Pr_{mt}^{buyer} = \frac{\sum_{k=1}^{J_m} e^{v_{kmt} - \theta(P_{kmt} - M_{kmt} + C_{kmt})}}{1 + \sum_{k=1}^{J_m} e^{v_{kmt} - \theta(P_{kmt} - M_{kmt} + C_{kmt})}}.$$

Appendix: Econometric Model - First Stage

Use observed buyers' property type choice $\widehat{\pi}_{jmt}$ to derive buyers' expected value function, normalized by their market-time average $\bar{\nu}_{mt}$

$$\widetilde{v}_{jmt} = \log(\widehat{\pi}_{jmt}) - \frac{1}{J_m} \sum_{k=1}^{J_m} \log(\widehat{\pi}_{kmt}),$$

where $\widetilde{v}_{jmt} = v_{jmt} - \theta(P_{jmt} - M_{jmt} + C_{jmt}) - \bar{\nu}_{mt}$.

Appendix: Econometric Model - Second Stage

Market liquidity provided by

- Sellers: $\widehat{p}_{jmt} = \frac{1}{1+e^{\widehat{\widehat{v}}_{jmt}+\bar{\nu}_{mt}+2\theta C_{jmt}+\ln \widehat{\Pr}^{seller}_{jmt}}}$.
- Buyers: arrive as a poisson process with rate $\lambda_{jmt} = \phi_m \gamma_{jmt}$
  - ϕ_m buyers bidding frequency in market m
  - γ_{jmt} the market tightness for type j, i.e., the ratio of the number of buyers to sellers
  - The probability of receiving bids $\widehat{q}_{jmt} = 1 - \exp(-\phi_m \widehat{\gamma}_{jmt})$

Maximize the log-likelihood function of the observed time-on-the-market

$$L_{TOM}(\phi_m, \bar{\nu}_{mt}, \theta) = \sum_{i=1}^{N} \sum_{t=t_{i,0}+1}^{t_{i,1}-1} \log\left(1 - \widehat{q}_{jmt}\widehat{p}^{s}_{jmt}\right) + \sum_{i=1}^{N} \log \widehat{p}_{jmt_{i,1}} \widehat{q}_{jmt_{i,1}}.$$

Appendix: Econometric Model - House Prices

Assume that the observed transaction price is the highest bid received by the seller in that month

$$\log(P_{ijmt}) = \eta_j + \eta_{mt} + e_{ijmt},$$

- P_{ijmt} transaction price
- η_j type fixed effects, η_{mt} market time fixed effects
- $e_{ijmt} = \max\{e^{(1)}_{ijmt}, \cdots, e^{(n)}_{ijmt}\}$ and $e^{(\cdot)}_{ijmt} \sim \mathcal{N}(\mu_m, \sigma_m)$. The distribution of the nth largest draw is $F^{(n)}(x) = n\Phi(\frac{x-\mu_m}{\sigma_m})^{n-1}\psi(\frac{x-\mu_m}{\sigma_m})$
- The price of property type j is $\widehat{P}_{jmt} = \exp(\hat{\eta}_j + \hat{\eta}_{mt}), \quad \forall\ t_{i,0} \leq t \leq t_{i,1}$.

The log-likelihood of observing the transaction prices

$$L_{Price}(\mu_m, \sigma_m) = \sum_{i=1}^{N} \log \left(\sum_{n=0}^{\infty} \frac{\widehat{\lambda}^n_{jmt} e^{-\widehat{\lambda}_{jmt}}}{n!} F^{(n)}(\log(P_{ijmt_{i,1}}) - \log(\widehat{P}_{jmt_{i,1}})) \right).$$

Appendix: Econometric Model - Per period utility

- Assume expected value functions v_{jmt} and property prices P_{jmt} evolve as AR(2) processes $\Rightarrow F_v(v_{jmt+1}|\Omega_{jmt})$ and $F_P(P_{jmt+1}|\Omega_{jmt})$.
- Calculate per period utility $\widehat{\delta}(\Omega_{jmt})$ using $\widehat{q}_{jmt}$, $\widehat{v}_{jmt}$
- Estimate the determinants of utility function

$$\widehat{\delta}(\Omega_{jmt}) = \alpha_y(M_{jmt}Y^r_{mt} - R_{jmt}) + \alpha_x X_j + \alpha_{mt} + \xi_{jmt}.$$

  - $M_{jmt}Y^r_{mt}$ mortgage interest expense per month
  - R_{jmt} rental expense per month

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Appendix: Estimation Results - Market Liquidity

	Bids			Value	Liquidity	
	Freq ($\widehat{\phi}_m$)	Mean ($\widehat{\mu}_m$)	Std ($\widehat{\sigma}_m$)	Ownership ($\widehat{\overline{\nu}}_{mt}$) 50p	Buyer ($\widehat{q}_{jmt}$) 50p	Seller ($\widehat{p}_{jmt}$) 50p
Tianjin	20.95	-0.35	0.29	5.45	0.96	0.34
Shenzhen	13.05	-0.17	0.21	5.17	0.87	0.30
Nanjing	7.93	-0.10	0.19	4.63	0.66	0.47
Changsha	7.58	-0.09	0.17	3.55	0.69	0.49
Xiamen	7.09	-0.07	0.16	4.08	0.56	0.64
Chengdu	6.89	-0.13	0.22	4.95	0.79	0.47
Hangzhou	6.04	-0.07	0.20	4.53	0.55	0.55
Wuhan	5.99	-0.09	0.19	4.18	0.68	0.55
Qingdao	5.94	-0.08	0.18	4.63	0.59	0.58
Guangzhou	4.56	-0.05	0.21	3.78	0.46	0.51
Beijing	3.89	-0.07	0.19	3.44	0.59	0.62
Shanghai	3.47	-0.02	0.20	3.57	0.17	0.60
Chongqing	2.81	-0.04	0.18	2.79	0.40	0.67
Suzhou	2.40	-0.01	0.17	1.97	0.12	0.80
Dalian	1.86	-0.03	0.18	2.74	0.27	0.79

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Appendix: Reduced-Form Results I

Table: Housing Price Growth, Demand, and Mortgage Market Condition

	log(TransPrice)	log(ListPrice)	Alternatives	Transaction	Like
	(1)	(2)	(3)	(4)	(5)
T	0.038***	0.031***			
	(0.004)	(0.005)			
T × Post	−0.025***	−0.018**			
	(0.007)	(0.007)			
T × Policy	−0.002	−0.012*			
	(0.006)	(0.007)			
T × Post × Policy	−0.029***	−0.007			
	(0.011)	(0.009)			
Post			32.995	−72.882***	−0.244
			(28.053)	(15.432)	(0.180)
Policy			19.175	473.771***	1.655***
			(25.717)	(44.160)	(0.135)
Post × Policy			178.961**	−200.338*	−0.382
			(71.207)	(121.091)	(0.381)
Constant	0.447**	9.527***	711.847***	178.141***	0.761**
	(0.226)	(0.160)	(11.694)	(7.033)	(0.355)
Attributes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes
Observations	76,544	73,568	73,568	73,568	73,568
R^2	0.924	0.922	0.953	0.677	0.182

Appendix: Reduced-form Results II

Table: The Impact of Down Payment Requirements on Old Houses

	Down Payment Requirement Increases			Down Payment Requirement Decreases		
	(1)	(2)	(3)	(4)	(5)	(6)
T	0.018***	0.018***	0.019***	0.021***	0.021***	0.021***
	(0.0001)	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0003)
T×Event	0.028***	0.033***	0.029***	−0.011***	−0.006***	−0.013***
	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)	(0.003)
T×Event×Post	−0.030***	−0.022***	−0.027***	0.014***	−0.006	0.017***
	(0.001)	(0.004)	(0.005)	(0.002)	(0.005)	(0.007)
Age	−0.006***	−0.010***		−0.006***	−0.009***	
	(0.0001)	(0.0001)		(0.0001)	(0.0001)	
T×Event×Age		−0.001***			−0.001***	
		(0.0001)			(0.0001)	
T×Event×Post×Age		0.001***			0.001***	
		(0.0002)			(0.0002)	
New		−0.086***	0.013***		−0.092***	0.006**
		(0.002)	(0.003)		(0.002)	(0.003)
T×Event×Post×New		−0.016***	−0.012***		0.013***	0.017***
		(0.003)	(0.004)		(0.003)	(0.006)
Constant	1.033***	1.145***	0.975***	1.000***	1.114***	0.967***
	(0.012)	(0.012)	(0.046)	(0.012)	(0.012)	(0.045)
Attributes	Yes	Yes	Yes	Yes	Yes	Yes
Event FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	338,789	338,789	15,477	338,789	338,789	15,477
R^2	0.911	0.912	0.945	0.909	0.909	0.944

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Appendix: Model Fit

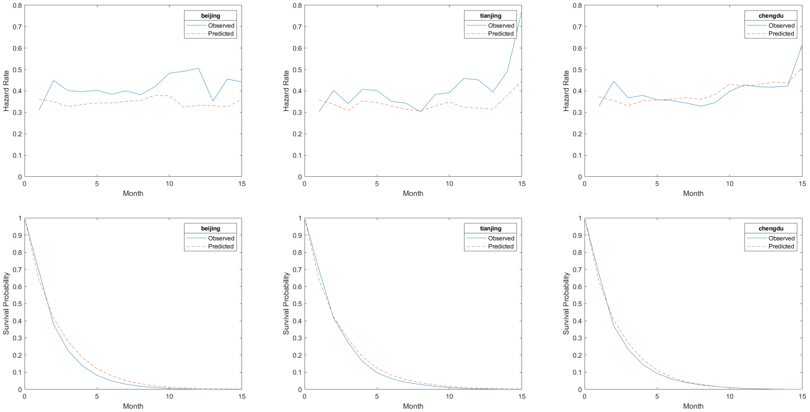

Figure: Hazard Rate and Survival Probability

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