Asymmetric Information and the Supply Chain of Mortgages: The Case of Ginnie Mae Loans

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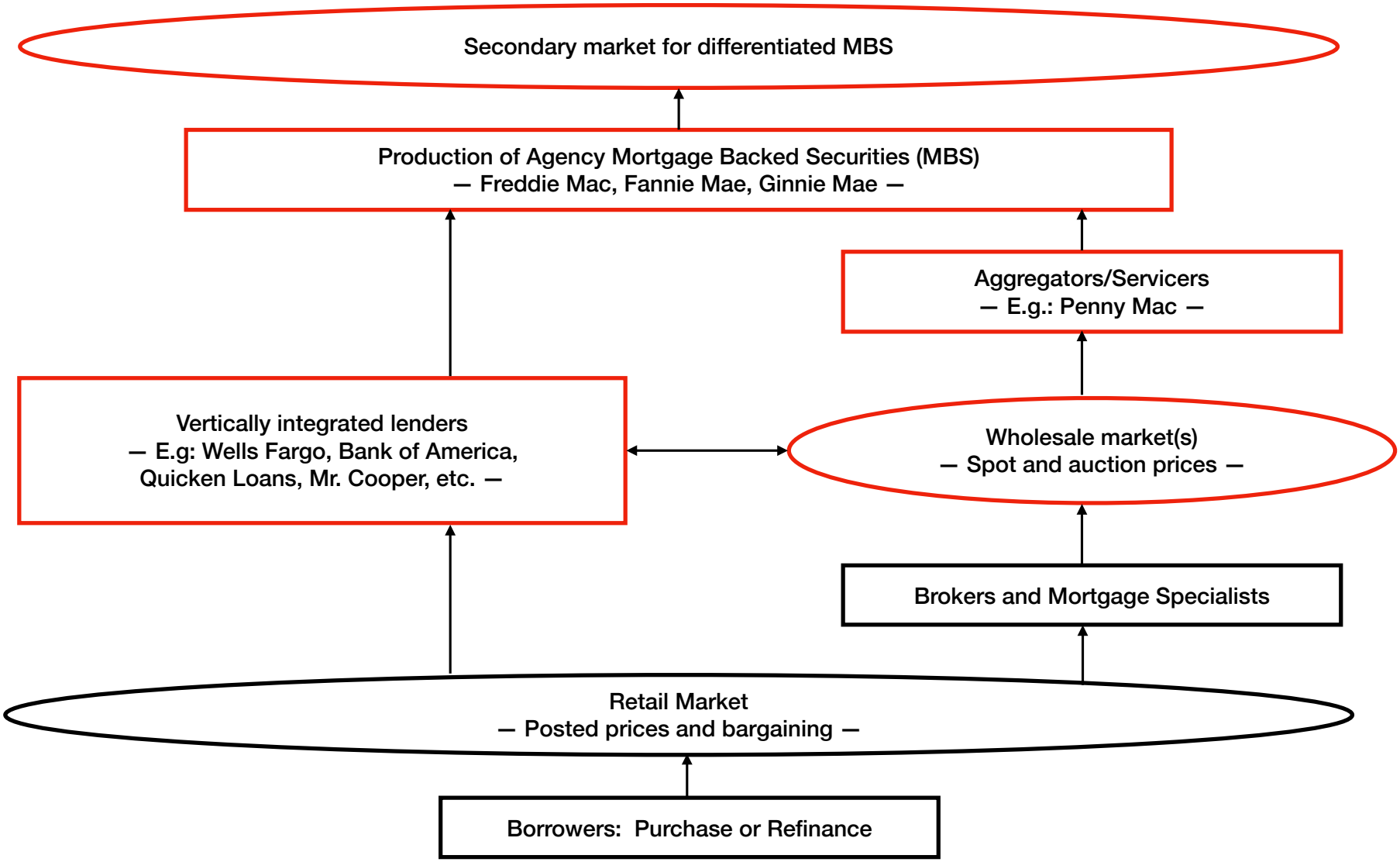
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Originate-to-Distribution (OTD) Supply Chain of Mortgages



Motivation

- The value created by this intermediation chain is summarized by:

$$\text{Loan value} = \underbrace{(r - c - g) \times E\left[\text{Duration}|Z\right]}_{\text{Mortgage servicing income (MSR)}} + \underbrace{P(c, Z)}_{\text{Security price}} - \text{Cost}$$

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- While the MSR depends of models of prepayment risk, the security price depends on the *best execution* strategy of the bank
  1. *Pool choice:* Trade-off between servicing markup and upfront payment
  2. *Trenching:* Pool in "multi-issuer" security, or create differentiated MBS (or "spec-pool")

What determines the value to security customization across banks?

- The return to customization depends on the private information that MBS issuers have about loan duration
- Why?
  - The default option is to securitize loans in multi-issuer securities
  - Spec-pool securities are traded in an OTC market, while multi-issuer securities are traded in a very liquid TBA market
  - TBA prices do not depend on the characteristics of individual loans
- Key trade-off:
  - Multi-issuer securities and high-coupon MBS are *adversely selected*
  - But customization is costly...
    - ★ Spec-pool transactions require credible signals of loan quality
    - ★ Customization require high levels of liquidity and transaction costs

Research questions

1. What is the effect of security customization on loan prices and profits from intermediation?
2. What are the sources of the private information that leads to customization choices?
   - Unpriced loan attributes
   - Private information
   - Issuer-specific unobserved heterogeneity
3. What determines the dispersion in the return to customization across banks?
   - Economies of scale
   - Screening and selection
   - Consumer retention strategy

What do we do?

Case study: Wholesale/secondary markets for Ginnie Mae mortgages

1. Develop a model of loan valuation with asymmetric information
   - *Servicing income:* Expected duration
   - *Optimal securitization:* Loan resale value
2. Empirical analysis:
   1. Pass-through of custom security prices on loan values
   2. Test for asymmetric information in the MBS market (à la Chiappori and Salanié)
   3. Analyze heterogeneity in return to customization across issuers

Outline

1. Data and market description
2. Loan valuation model
3. Empirical analysis:
   - Return to customization
   - Asymmetric information
   - Bank heterogeneity
4. Conclusion

Secondary (MBS) market

- To-Be-Announced (TBA) forward market: Multi-issuers
  - Bank agrees to delivery a pool of agency-insured loans to a buyer at a specified price, par value, coupon, maturity, and delivery date.
  - Identity of loans unknown to buyer at trade date.
- Custom pool market: Single-issuer.
  - Identities of the loans are known to buyer at the trade date.
  - Securities are differentiated based on loan size (primarily)
  - Roughly 25% in our sample (up from less than 10% in 2010)
- Security customization decisions:
  - *Coupon:* Service markup $(r - c)$
  - *Pool:* Spec-pool or Multi-issuer

Wholesale Market

- *Online auctions:* Flexible real-time pricing (or Bulk price)
  - Information: Originator, Note-rate, Zip-code, Agency, Income, DTI, Size, FICO, Purchase/Refi

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  - 75% of loan exchanges done via auctions
- Auction design (starting in 2017):
  - Loan-level first-price sealed bid auction ($\approx$ 1-2 hrs)
  - Sellers invite buyers form their network (fixed)
  - Buyer-specific reserve price: Bid $=$ max$\{$Bulk, Lock$\}$

Data Sources

- **eMBS:** Provides detailed information on all agency MBSs and their component loans from August 2013 to present.
  - Loan performance: Monthly payment history until loan is prepaid.
  - Security information: (i) coupon choice, and (ii) multi-issuer or single-issuer pool
- **Optimal Blue:** Auction data from Jan 2018 to present.
  - Loan-level first-price sealed bid auction ($\approx$ 1-2 hrs)
  - Buyer-specific reserve price: Bid $=$ max$\{$Bulk, Lock$\}$
  - Information: Originator, Note-rate, Zip-code, Agency, Income, DTI, Size, FICO, Purchase/Refi
- **CoreLogic:** House-level mortgage transactions
  - Identify mortgage lender and loan size for all single-family houses
  - Lender/servicer retention: Identify refinancing events for which the borrower used the same lender and/or servicer

Sample

- 30 year fixed-rate mortgages that benefit from Federal housing subsidies (FHA and VA) and insured by Ginnie Mae
  - FHA: high LTV (max 96%); VA: zero down-payment
  - Ginnie does not securitize loans; banks deliver loan packages and incur the securitization costs.
- Why Ginnie?
  - No competition, loans not eligible for Fannie Mae, Freddie Mac
  - Securitization choices are made by lenders/servicers
  - Restrictions on coupon choice
  - Guarantee fee is fixed at 6 basis points for all lenders
- Ginne Mae $\simeq$ 25% of agency loan origination.

Summary statistics: Ginnie-MBS Sample

Source: eMBS and Optimal Blue

	MBS Sample		MBS Sample		OB+MBS Sample	
	mean	sd	mean	sd	mean	sd
Interest Rate	4.1	0.56	4.4	0.65	4.4	0.66
Loan Amount (100k)	2.2	1.1	2.4	1.1	2.4	1.1
Loan-to-Value	94.9	8.9	94.8	8.9	95.2	8.5
Credit Score (Min)	688	55	683	56	684	54
Debt-to-Income	36.4	15.9	39.4	14.4	40.2	13.9
1(DTI $>$ 42)	0.44	0.50	0.52	0.50	0.54	0.50
1(VA-Backed)	0.36	0.48	0.38	0.49	0.35	0.48
1(Retail)	0.40	0.49	0.40	0.49	0.11	0.31
1(Correspondent)	0.47	0.50	0.47	0.50	0.85	0.36
Survival: 12-month	85.8	34.9	80.6	39.6	80.9	39.3
Survival: 36-month	0.51	0.50	0.25	0.43	0.17	0.38
Observations	8,517,991		2,821,131		112,510	
Period	2013-2019		2018-2019		2018-2019	

Summary statistics: Wholesale auctions

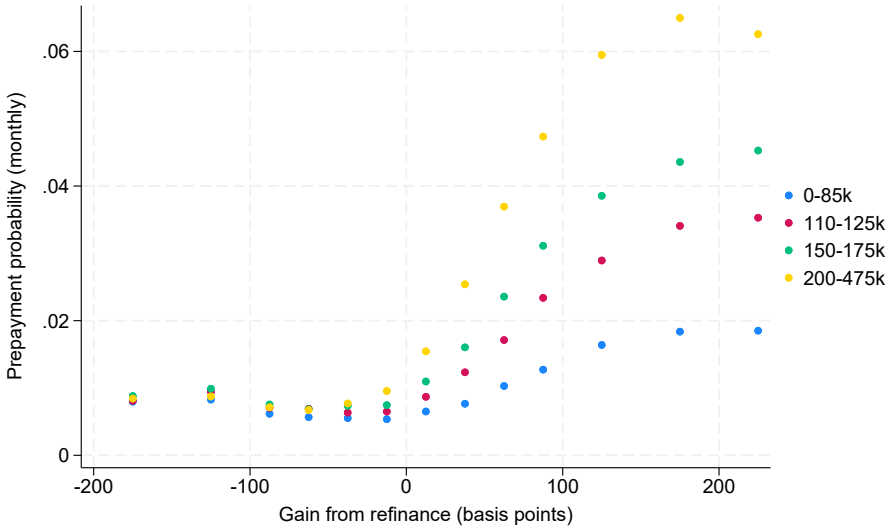
Bids are for $100 loan; lower bound on resale value = TBA price

	mean	sd	count
Client network size	17	4.8	87,084
TBA Price ($)	103	1	952,559
Bulk - TBA ($)	1.4	.89	678,850
Winning bid: Bid - TBA ($)	2	.79	87,084
Winning margin: 1st - 2nd bid ($)	.24	.26	87,084
Observations	952,559		

Fact 1: Prepayment risk varies across borrowers *and* servicers

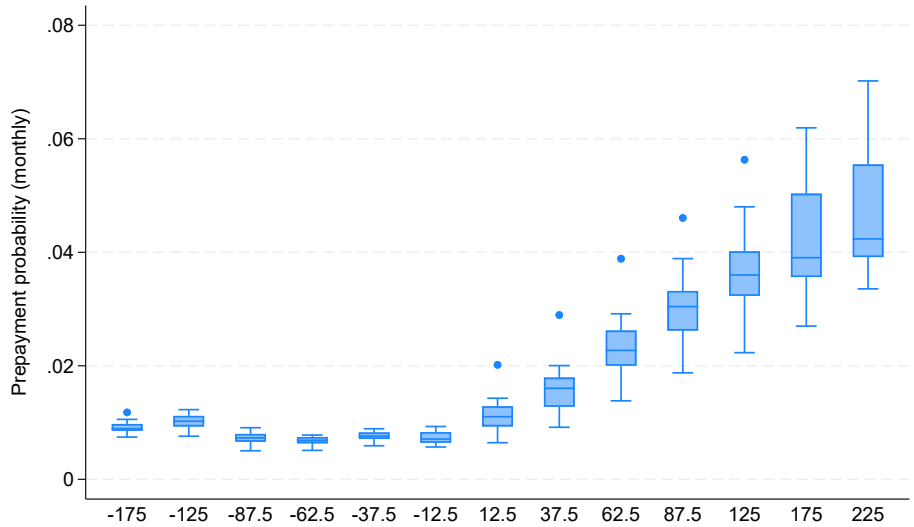
Gain from refinancing: $\bar{r}_t - r_i$

Prepayment risk across loan size bins

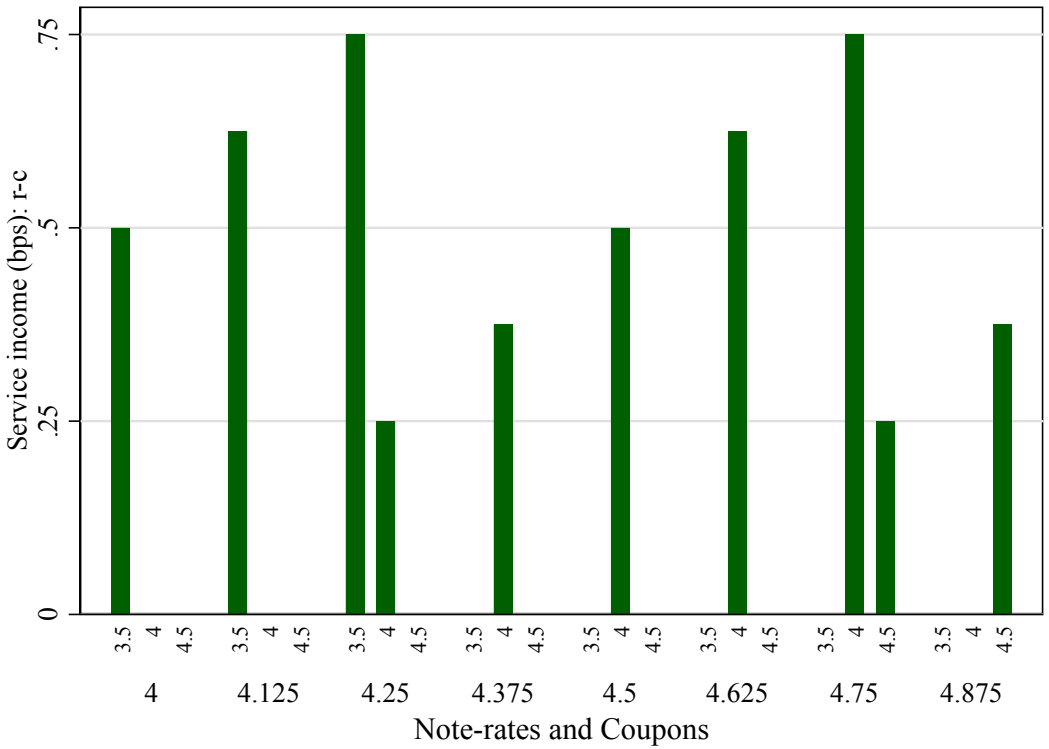


Refinancing boom

Prepayment risk across top-20 servicers



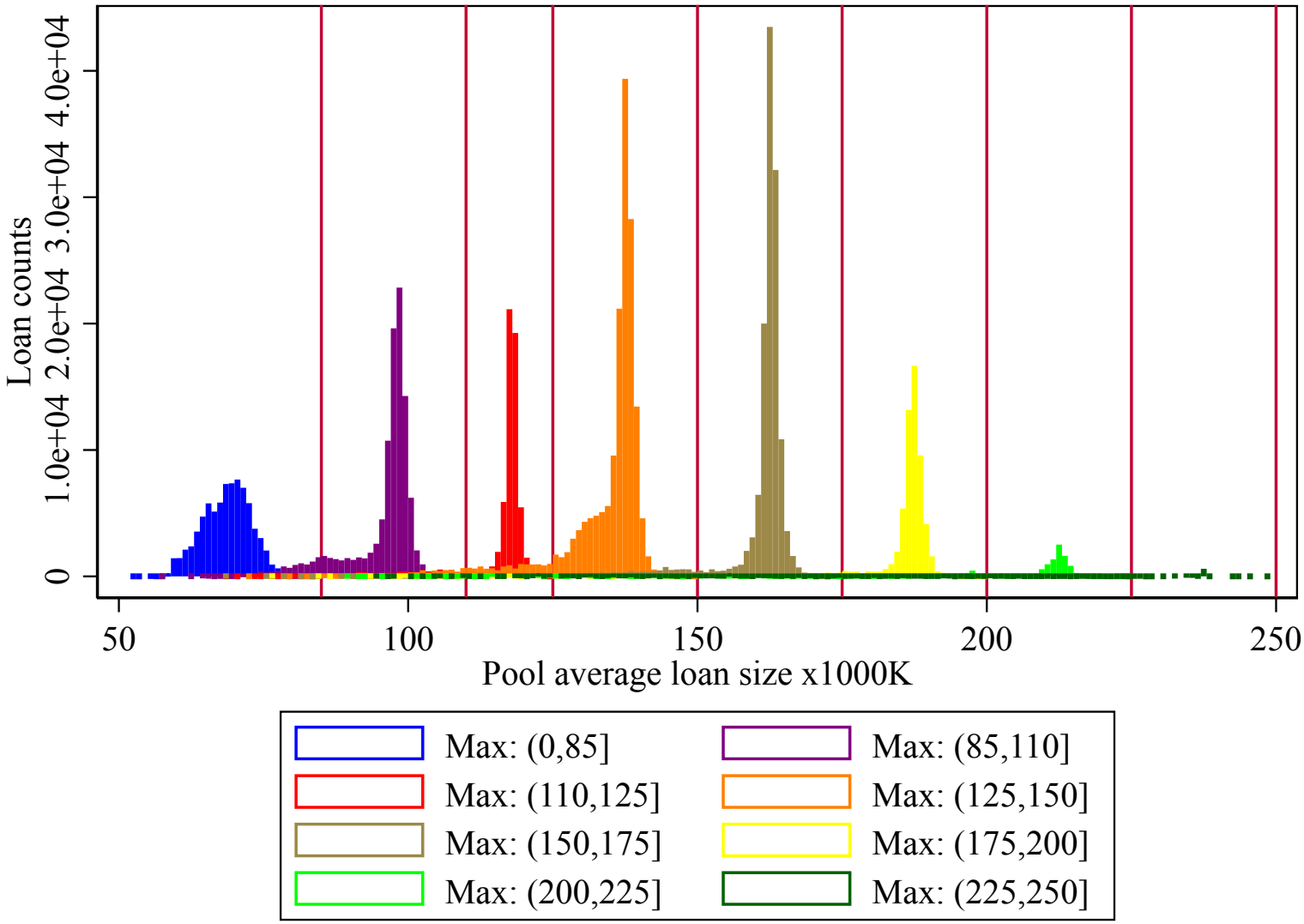
Fact 2: Discrete pricing rate grid induces variation in the servicing income (i.e. markup)



- Pricing grid: MBS coupon (0.5) vs Mortgage rate (1/8)
- Ginnie imposes a minimum and maximum service income

$$(r - c) \in [0.25, 0.75]$$

Fact 3: Custom securities are segmented by loan size and sold in a separate specified-pool (or spec-pool) market



Model of Loan Valuations

- **Objectives:**
  - Develop a framework to measure the willingness-to-pay for servicing and securitizing mortgages
  - Derive testable predictions to learn the information structure generating securitization decisions
- Willingess to pay:

$$WTP = \underbrace{(r - c - g) \times \text{Loan duration}}_{\text{Mortgage servicing rights (MSR)}} + \underbrace{\text{Security price}}_{\text{Resale value}} - \text{Servicing cost}$$

The value of mortgage servicing rights (MSR)

- *Realized monthly cash flows* for \$100 loan i to bank j:

$$\underbrace{\sum_{\tau=1}^{t_i} \delta^{\tau} \frac{L_{\tau}}{1200}}_{\text{service multiple: } M(T_i)} \times \underbrace{r_i - g - c}_{\text{service fee}}$$

  - L_τ is unpaid balance at end of month τ.
  - t_i is the realized duration of loan i (random variable)
- Ex-ante, the expected value of the servicing income is:

$$MSR_{ij} = (r_i - g - c) \times E[M(T_i)|s_i, Z_i] = (r_i - g - c) \times \bar{M}(s_{ij}, Z_i)$$

where s_{ij} is a signal about loan duration (drop Z_i below)

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- Continuation value?
  - Vertically integrated servicers can *retain* borrowers post-refinancing
  - Moral hazard: Incentive to trigger refinancing to collect origination fees

Security valuation: Pooling and Trenching

- *Coupon choice:* $P(c_H) > P(c_L)$ vs $(r_i - c_H - g) < (r_i - c_L - g)$
- *Trenching:*
  - *Multi-issuer:* Common resale price, $P^{tba}(c)$, for all j and i
  - *Spec pools:* Segmented by loan size (single issuer)
    - ★ Let $\bar{l}_i$ denotes the size segment of loan i
    - ★ Price set *after* pool creation (*spec-pool* market): $P_j^{\bar{l}}(c, Z_i)$

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- The value of loan i for bank j:

$$\begin{aligned} WTP_j(s_i) = \max_{c,k} \quad & (r_i - c - g)\bar{M}(s_i) + P_j^k(c, Z_i) - \text{Servicing cost} \\ s.t. \quad & (r_i - c) \in [0.25, 0.75] \\ & k \in \{TBA, \bar{l}_i\} \end{aligned}$$

Security valuation: Coupon choice

- Recall that for loans with interest-rates ending in 0.25 and 0.75, banks can select a "high" or "low" coupon
- For loans in TBA-eligible securities c_H is better if:

$$\begin{aligned}(r_i - c_H)\bar{M}(s_i) + P^{tba}(c_H) = 0.25\bar{M}(s_i) + P^{tba}(c_H) > \\ (r_i - c_L)\bar{M}(s_i) + P^{tba}(c_L) = 0.75\bar{M}(s_i) + P^{tba}(c_L) \\ \Leftrightarrow \bar{M}(s_i) < 2\left(P^{tba}(c_H) - P^{tba}(c_L)\right)\end{aligned}$$

- **Takeaway:** Loans pooled in low-coupon securities have longer duration

Security valuation: Trenching

Focus on loans without a coupon choice option

- Value of loan i to MBS investors:

$$v_i(c) = c \times E[M(T_i)|s_i] + E\left[\delta^{T_i} L_{T_i}|s_i\right]$$

where loan i has i^{th} value (descending order) among the Q_{ck} loans in the bank portfolio with coupon c and size-segment k

- Optimization problem for segment (c, k):

$$\max_{q\in[0,1]} \sum_{i=1}^{Q_{ck}} MSR_i + qP^k(q;c) + (Q_{ck} - q)P^{tba}(c) - \kappa 1(q > 0)$$

Competitive spec-pool market: $P^k(q;c) = \frac{1}{q}\sum_{i=1}^{q} v_i(c)$

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  Competitive spec-pool market: $P^k(q;c) = \frac{1}{q}\sum_{i=1}^{q} v_i(c)$

- **Optimal pooling strategy:**
  - $q_k^* \in (0,1)$: Marginal loan $v_{q_k^*}(c) = P^{TBA}(c)$ (independent of k)
  - $q_k^* = 1$: Marginal loan $v_Q(c) > P^{TBA}(c)$ (different across k)
  - $q_k^* = 0$: Issuer does not have enough volume to justify κ

Security customization

Testable Implication

1. *Custom securities have higher resale values than the TBA price:*

$$P^{85}(c) > P^{110}(c) > \cdots > P^{200} > P^{tba}(c)$$

2. *Selection: Loans pooled in multi-issuer securities (TBA) and loans pooled in high-coupon securities have shorter duration*

Empirical Analysis: Roadmap

1. Measure the return to customization due to trenching
   - Loan resale values are discontinuous in size
2. Quantify the importance of asymmetric information between issuers and MBS investors
   - Decomposition: (i) loan attributes, (ii) servicer unobserved heterogeneity, and (iii) private signals
3. Explain heterogeneity in the return to customization across issuers

What is the effect security customization on wholesale prices?

- **Goal:** Measure the gain from security customization using wholesale auction bids
  - *Spec-pool pay-up:* Difference in resale value due to the availability of the spec-pool option (lower bound)
- **Assumption:** Signals about cash-flows are continuous in loan size

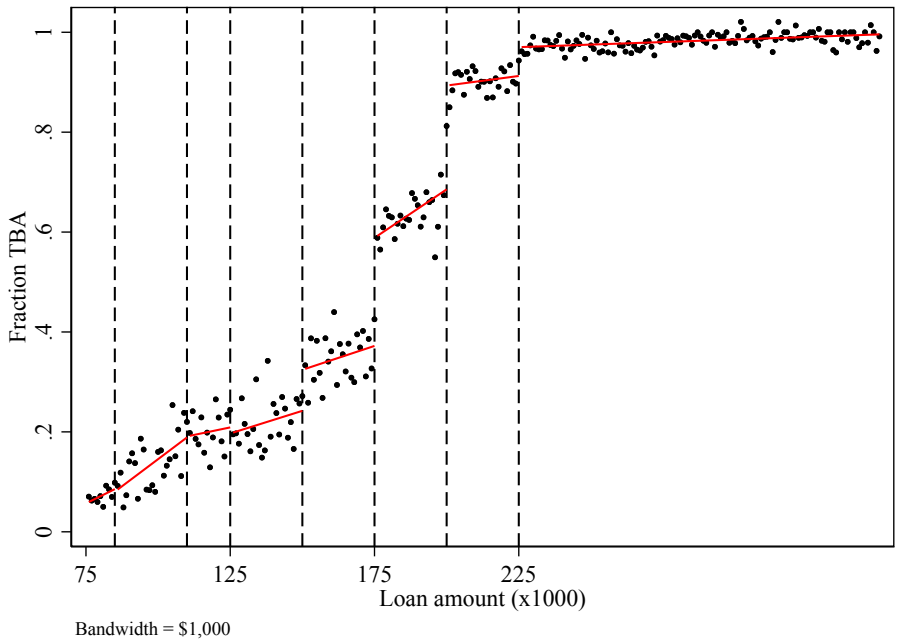
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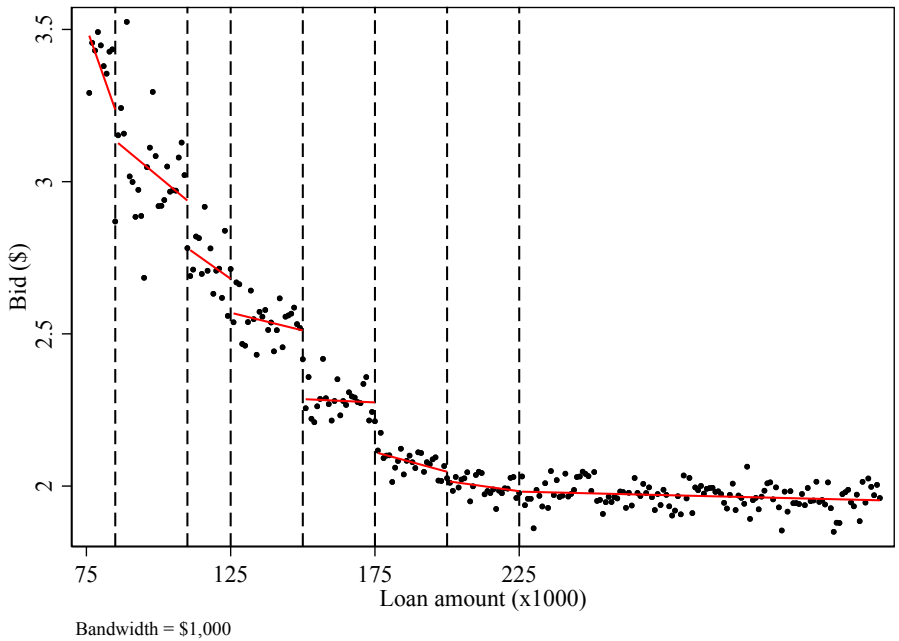
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  - *Spec-pool pay-up:* Difference in resale value due to the availability of the spec-pool option (lower bound)
- **Assumption:** Signals about cash-flows are continuous in loan size
- Regression discontinuity: For each loan size segment k

$$\beta_k^{rf} = \lim_{\epsilon^+ \to 0} E[\text{Winning bid}_i | l_i = \bar{l}_k + \epsilon] - E[\text{Winning bid}_i | l_i = \bar{l}_k - \epsilon]$$

  where β_k^{rf} measures the change in price associated with being above security k size cutoff (fuzzy RDD)
  - **IV:** β_k^{iv} is the causal effect of being pooled with larger loans
- Estimation sample:
  - Loans without a coupon-choice
  - Size: $l_i \in (\bar{l}_{k-1}, \bar{l}_{k+1})$

Effect of loan size on customization and wholesale prices?





Balance tests

Regression discontinuity results

	85k		110k		125k	
	RF	IV	RF	IV	RF	IV
Winning bid	-0.341	-0.0151	-0.224	-0.0133	-0.105	-0.00842
	(0.0709)	(0.00308)	(0.0570)	(0.00336)	(0.0441)	(0.00330)
			150k		175k	
			RF	IV	RF	IV
Winning bid			-0.255	-0.00956	-0.189	-0.00585
			(0.0346)	(0.00122)	(0.0251)	(0.000874)

- IV results: Change in resale value for large loans is \$0.14 (i.e. $0.005x25K$), compared to \$0.37 for small loans
- Cumulative effect of customization on winning bids:

$$1.21 > 0.85 > 0.50 > 0.38 > 0.146$$

Return to customization: Takeaways

- The ability to create custom securities by pooling small loans together raise the value of loans in the wholesale market

Return to customization: Takeaways

- The ability to create custom securities by pooling small loans together raise the value of loans in the wholesale market
- However, this value is not reflected in the price that consumers pay
  - Balance tests: No differences in survival, origination, retail price or interest rate
  - Pass-through results
- And the return to customization is different across firms
  - Within-auction dispersion in bids is decreasing in the fraction of loans in multi-issuer pools
  - This leads to market power in the wholesale and retail markets
  - Dispersion results

Asymmetric information and the return to customization

- The value of security customization comes from the ability of banks to exploit their information advantage when assembling MBS pools
- We consider three sources of private information:
  - Loan attributes: Unpriced loan attributes in the TBA market
  - Private signals from proprietary risk models
  - Systemic differences in loan duration across banks

Testing for asymmetric information

Reference: Chiappori and Salanié (2000)

- **Sample:** All Ginnie-Mae loans securitized between 2013 and 2021
- Estimating equations:

$$\begin{aligned} 100 \times 1(t_i > 12) &= \lambda 1\{\text{Multi-issuer MBS}\} + FE_i + \gamma Z_i + \epsilon_i \\ 100 \times 1(t_i > 12) &= \lambda 1\{\text{High-coupon}\} + FE_i + \gamma Z_i + \epsilon_i \end{aligned}$$

  where FE_i is a Date x Rate fixed-effect.
- We use three sets of controls:
  - *Selection on observables and unobservables:* Z_i includes only loan size
  - *Selection on unobservables:* Z_i includes full set of loan characteristics
  - *Selection on unobservables within firms:* Issuer FE
- List of controls

Asymmetric information tests: Single- vs Multi-issuer

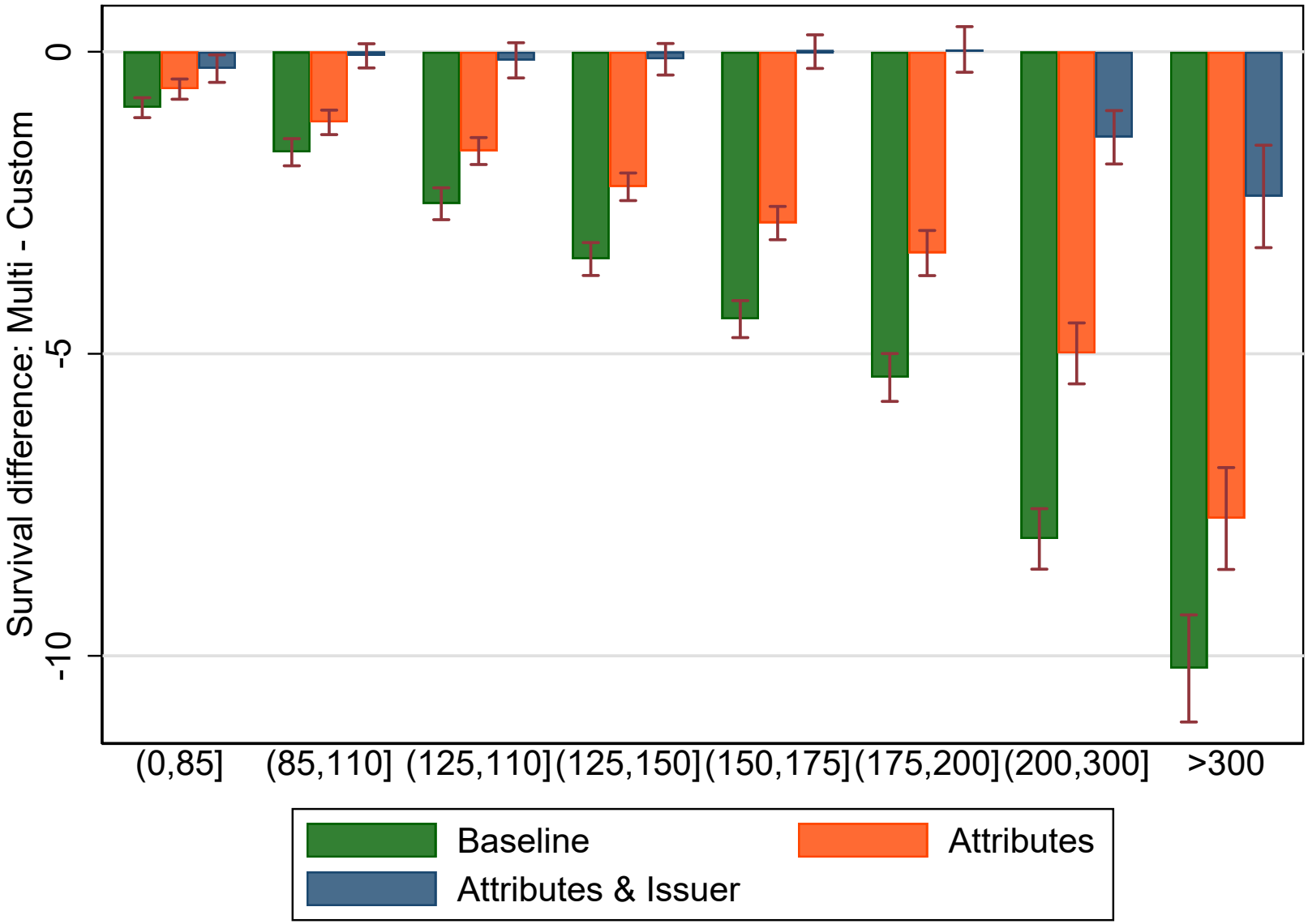
Sample: Loans without a coupon choice

VARIABLES	(1)	(2)	(3)	(4)
1(Multi-issuer pool)	-10.6	-4.21	-2.59	-2.26
	(0.24)	(0.17)	(0.20)	(0.19)
Observations	11,949,064	11,949,063	11,842,884	11,801,775
R-squared	0.071	0.125	0.139	0.177
Loan characteristics	no	yes	yes	yes
Issuer FE	no	no	yes (+)	yes (x)
Latest issuance date	2021/2	2021/2	2021/2	2021/2
Fixed effects	Month x rate	Month x rate	Month x rate	Month x rate
Mean dep. var.	87.7	87.7	87.7	87.7
Fraction multi-issuer pool	0.83	0.83	0.83	0.83

Dependent variable: 12-month survival. Specification 3: Issuer fixed-effect. Specification 4: Issuer x Month x Rate fixed-effects.

Asymmetric information tests by loan size

Dependent variable: 12-month survival x 100



Asymmetric information tests: High vs Low coupon

Sample: Loans with a coupon choice above 200K

VARIABLES	(1)	(2)	(3)	(4)
1(High coupon)	-5.16	-3.35	-1.83	-1.58
	(0.36)	(0.29)	(0.35)	(0.38)
Observations	2,452,225	2,452,225	2,429,087	2,418,415
R-squared	0.117	0.152	0.165	0.206
Loan characteristics	no	yes	yes	yes
Issuer FE	no	no	yes (+)	yes (x)
Latest issuance date	2021/2	2021/2	2021/2	2021/2
Fixed effects	Month x rate	Month x rate	Month x rate	Month x rate
Mean dep. var.	83.7	83.7	83.7	83.7
Fraction c_H	0.85	0.85	0.85	0.85

Dependent variable: 12-month survival. Specification 3: Issuer fixed-effect. Specification 4: Issuer x Month x Rate fixed-effects.

Asymmetric information tests: Takeaways

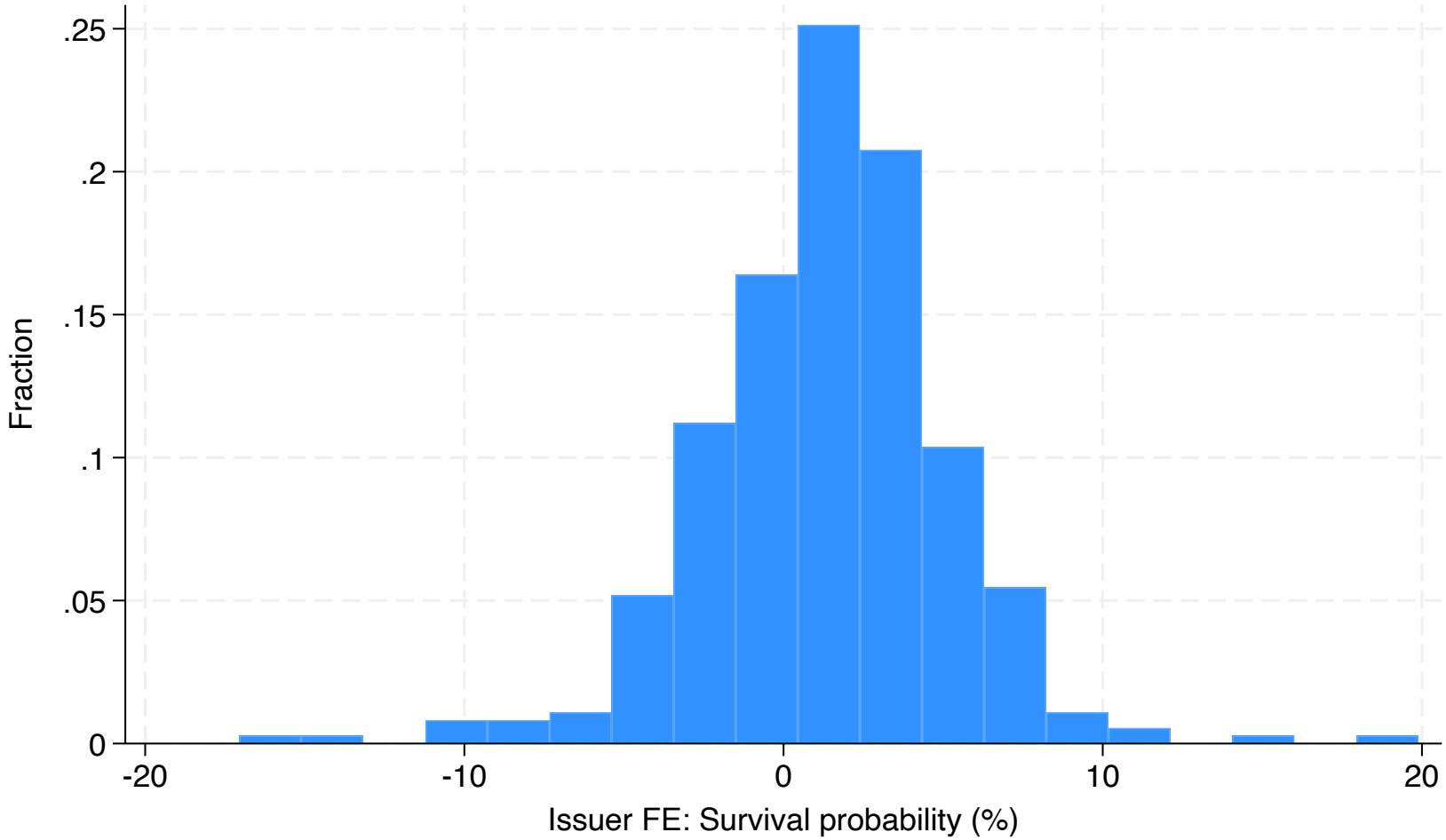
- Holding fixed r and originate date:
  - Loans placed in multi-pools are 10% more likely to get pre-paid within 12 mo
  - Loans placed in high-coupon securities are 5% more likely to be pre-paid within 12 mo
  - Weak evidence of moral-hazard: Results
- Sources of asymmetric information:
  - *Large loans:* Roughly 1/3 of adverse selection is due to private signals about loan duration
  - *Small loans:* Selection based on observed loan attributes **and** bank unobserved heterogeneity
- **Firm asymmetries:** The return to customization differ across banks
  - Banks who rarely use low-coupon/multi-issuer pools (i.e. high liquidity needs) produce lower duration loans

What explains the heterogeneity in the return to customization across banks?

- Three channels:
  - Loan screening
  - Economies of scale and transaction costs
  - Loan retention (or moral hazard)

Motivating Fact: Dispersion in loan duration across issuers

$$100 \times 1(t_i > 12) = g(r_i, L_i) + \gamma Z_i + \text{Date x Rate FE} + \textbf{Issuer FE} + \epsilon_i$$



Screening channel: Heterogeneity in pricing models quality

Data: Bids and survival outcomes for all loans above 200K sold between 2018-2019

$$\text{RF pricing model: } \text{Bid}_{ij} - P_i^{tba}(c) = \hat{\boldsymbol{\mu}}_j(Z_i, \text{Bulk}_{ij}) + e_{ij}$$

$$\text{RF survival model: } 100 \times 1(T_i > 12) = \bar{Y}_i(Z_i) + e_i$$

$$\text{Model quality: } \bar{Y}_i = \boldsymbol{\lambda_j}^m \widehat{\mu}_{ij}/(r_i - g - c_i) + \text{Fixed effects} + \epsilon$$

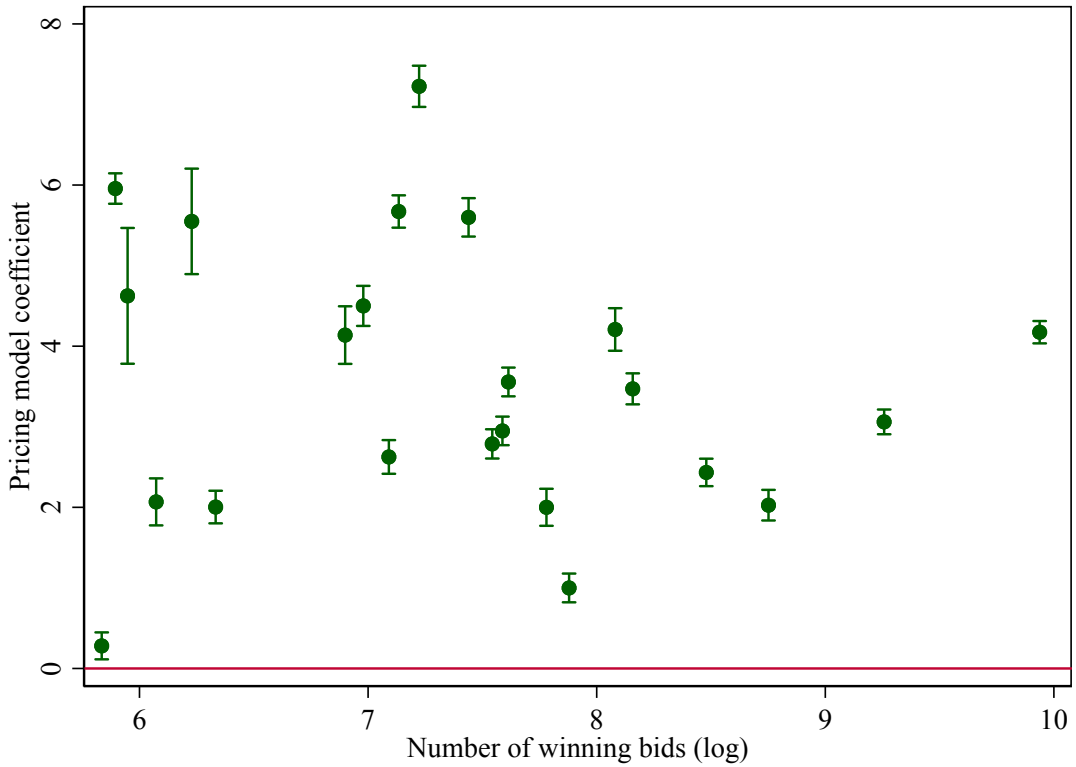
Screening channel: Heterogeneity in pricing models quality

Data: Bids and survival outcomes for all loans above 200K sold between 2018-2019

$$\text{RF pricing model: } \text{Bid}_{ij} - P_i^{tba}(c) = \hat{\boldsymbol{\mu}}_j(Z_i, \text{Bulk}_{ij}) + e_{ij}$$

$$\text{RF survival model: } 100 \times 1(T_i > 12) = \bar{Y}_i(Z_i) + e_i$$

$$\text{Model quality: } \bar{Y}_i = \boldsymbol{\lambda_j}^m \widehat{\mu}_{ij}/(r_i - g - c_i) + \text{Fixed effects} + \epsilon$$



Screening channel: Do bidders with "better" pricing models acquire better loans?

- **Unconditional average survival and prices:**

$$\bar{Y}_i = \text{Fixed effects} + \omega_j^s 1(\text{Bank } j \text{ wins}) + \epsilon$$

$$\hat{\mu}_{ij} = \text{Fixed effects} + \omega_j^p 1(\text{Bank } j \text{ wins}) + \epsilon$$

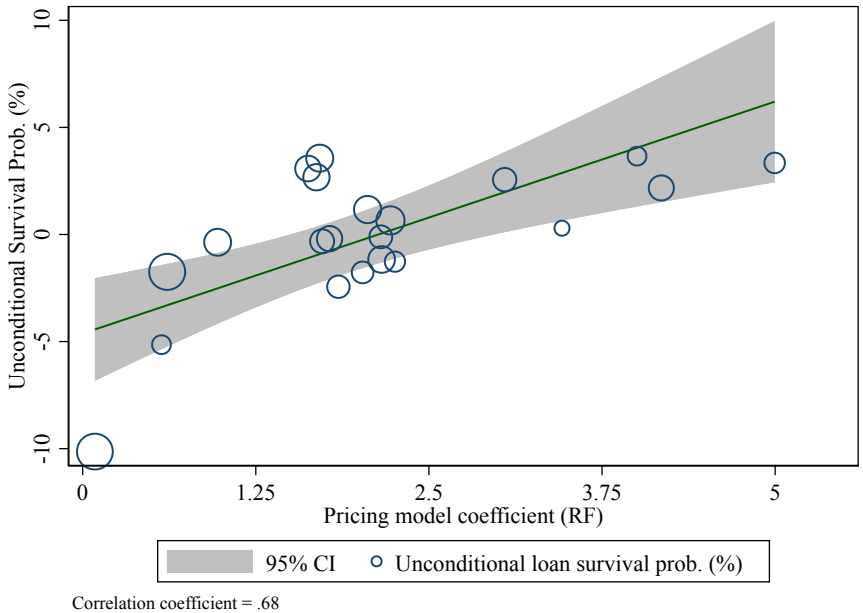
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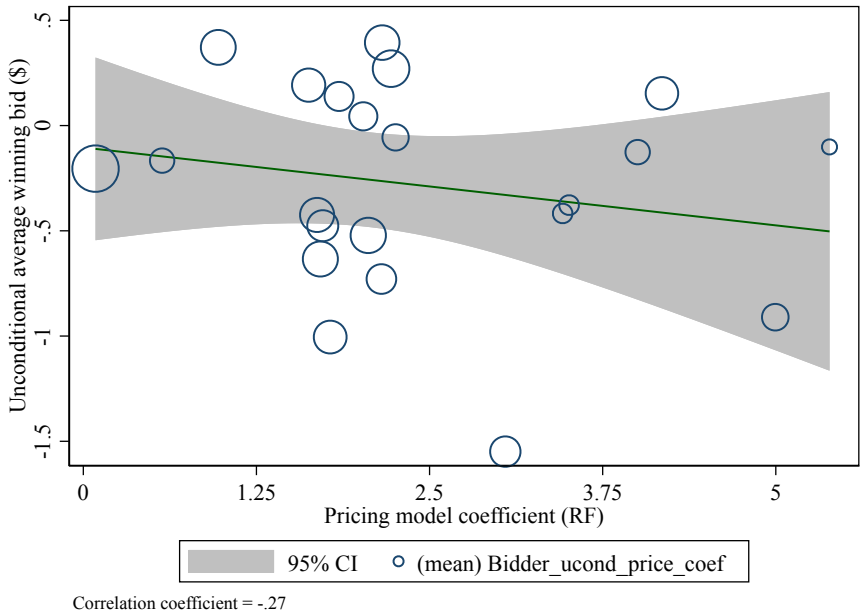
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Average survival



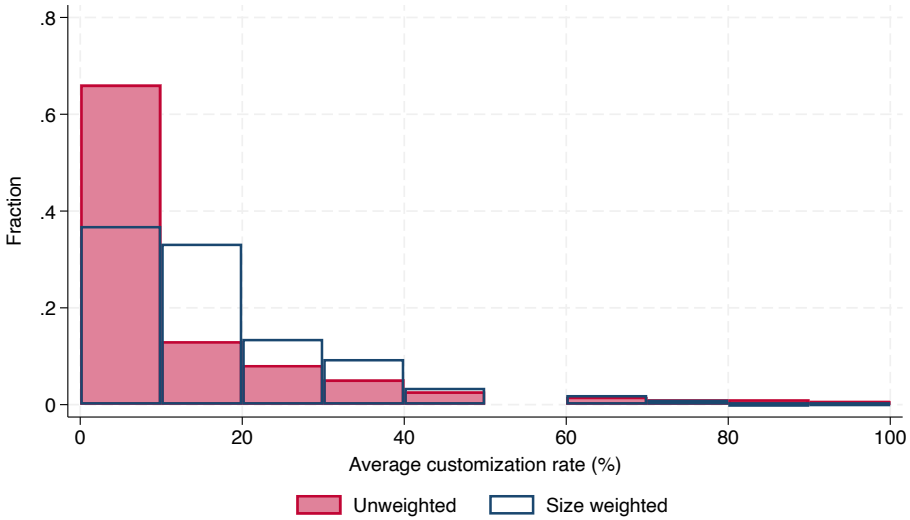
Average winning price



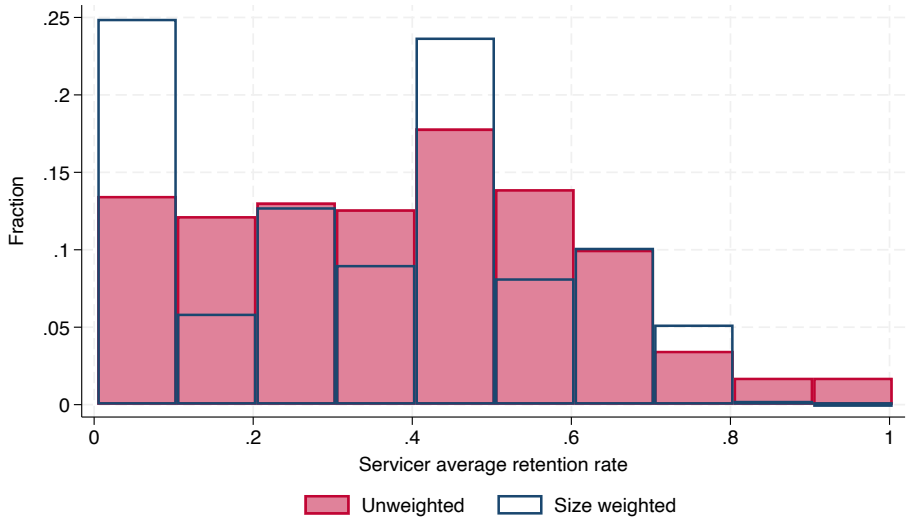
Variance decomposition

Economies and retention of scale channels

Customization rate



Servicer retention rate



- Large issuers are more likely to produce spec-pools securities due to transaction costs and/or liquidity needs
- Retention rates vary across two types of issuers: Vertically integrated vs Aggregators

Channel decomposition

- **Question:** How much of the dispersion in loan duration across issuers is explained by heterogeneity in *scale*, *customization*, and *retention*?
- Regression:

$$\begin{aligned}\text{Survival issuer FE}_j &= \beta_1 \text{Custom issuer FE}_j + \beta_2 \text{Retention rate}_j \\ &\quad + \beta_3 \text{Log monthly volume}_j + e_j\end{aligned}$$

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- **Hypothesis:**
  1. *Selection:* Larger volume is associated with shorter durations ($\beta_3 < 0$)
  2. *Moral hazard:* Retention is associated with shorter durations ($\beta_2 < 0$)
  3. *Customization:* Return to customization is larger for banks with longer duration pools ($\beta_1 > 0$)

Regression results

VARIABLES	(1) Customization	(2) Survival	(3) Survival	(4) Survival.
Monthly volume (log)	0.389***	-0.284***	-0.221***	-0.277***
	(0.0577)	(0.0514)	(0.0494)	(0.0546)
Customization		0.174***		0.172***
		(0.0610)		(0.0608)
Survival	0.199***			
	(0.0619)			
Retention rate			-0.204***	-0.201***
			(0.0623)	(0.0609)
Retail origination			0.151**	0.157***
			(0.0614)	(0.0602)
1(Zero retention)			-0.445***	-0.411***
			(0.151)	(0.153)
Constant	-1.717***	1.124***	1.061***	1.307***
	(0.177)	(0.165)	(0.169)	(0.197)
Observations	250	250	250	250
R-squared	0.209	0.128	0.174	0.204

All variables are divided by the standard-deviation across issuers.

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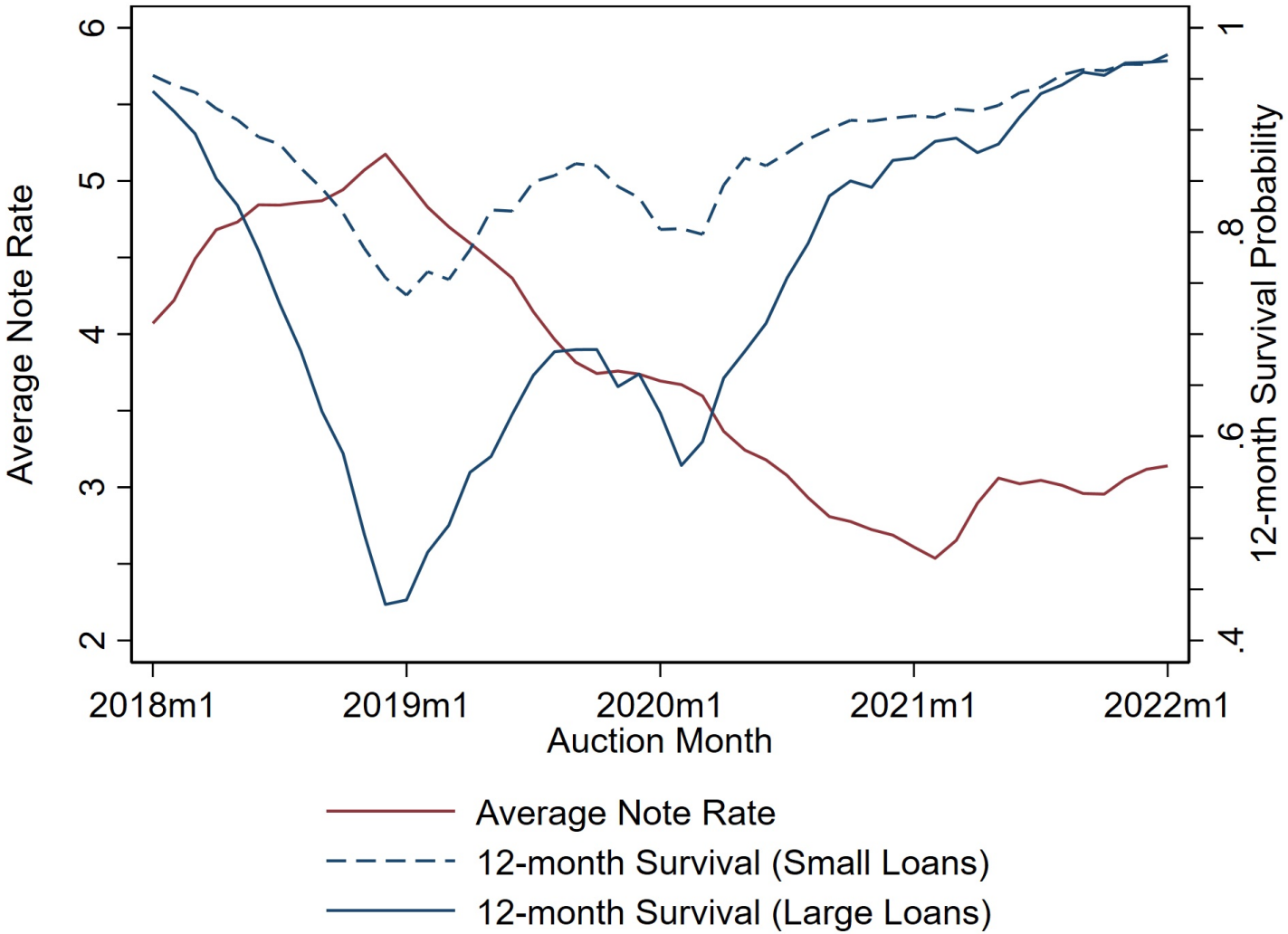
Issuer heterogeneity: Takeaways

- The return to customization depends on:
  - *Scale:* Banks need enough loans to justify transaction costs in the OTC market, but must acquire lower duration loans to increase volume
  - *Loan quality:* Banks with systematically better pools are more likely to produce single-issuer pools
- Servicers that invest in an *origination arm* (vertical integration) have shorter duration loans
  - *Moral hazard:* Integrated servicers have an incentive to reduce expected loan duration in order to collect closing fees
  - Limited evidence that moral hazard affects the value of spec-pools

Conclusion

- Identify large returns to security customization
  - Asymmetric information between servicers and investors allow banks to earn higher returns profits by customizing securities
  - Returns to customization vary across banks due to economies of scale and systematic differences in loan duration
- Next steps:
  - How are these information rents split between borrowers, originators and servicers?
    - ★ Hint: originators get almost everything
  - What is the effect of customization on concentration and market power?
  - What are the frictions that limit the ability of smaller originators to customize securities?
    - ★ Hint: Liquidity vs search/matching frictions in the OTC market

Fact 1: Loan duration over the refinancing boom and bust



Return

Fact 5: Price dispersion is caused by idiosyncratic factors **and** differences in pricing models across banks

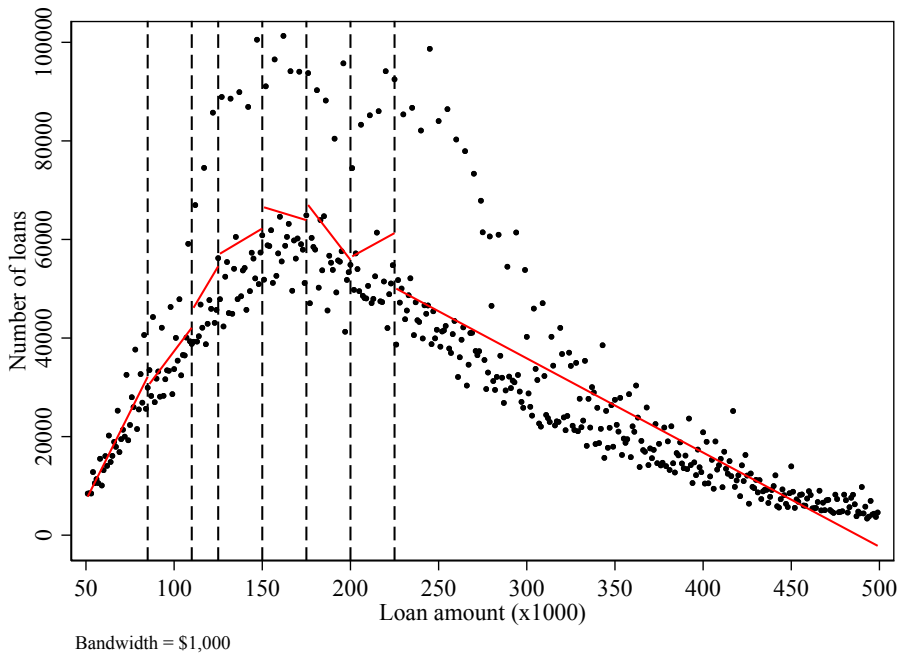
	Sample		
	Full	$L_i < 200$k	$L_i > 200$k
Baseline	0.46	0.41	0.54
Buyer FE	0.52	0.49	0.60
Buyer-specific slopes	0.72	0.74	0.76
Buyer-Seller FE	0.75	0.77	0.80

- Dependent variable: Price of \$100 loan - Resale value (TBA market)
- Baseline: Loan size, FICO, DTI, Income, Purchase, FHA, Fixed-effects (Sellers, date x rate, state)
- 30 bps improvement in fit due to bidder asymmetries
- Residual bid dispersion is smaller for **large** loans

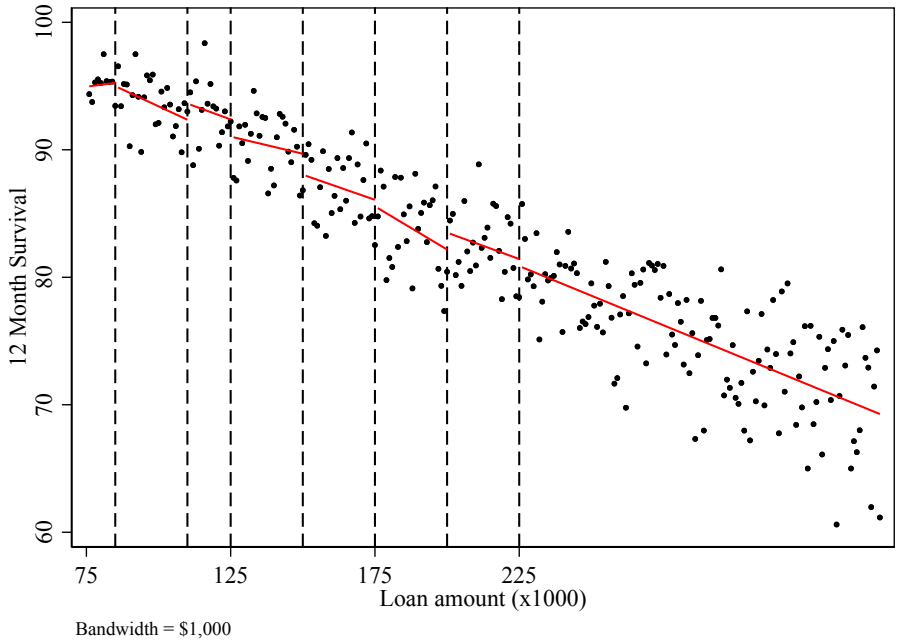
Return

Balance test: What is the effect of customization on loan survival and origination?

Number of loans



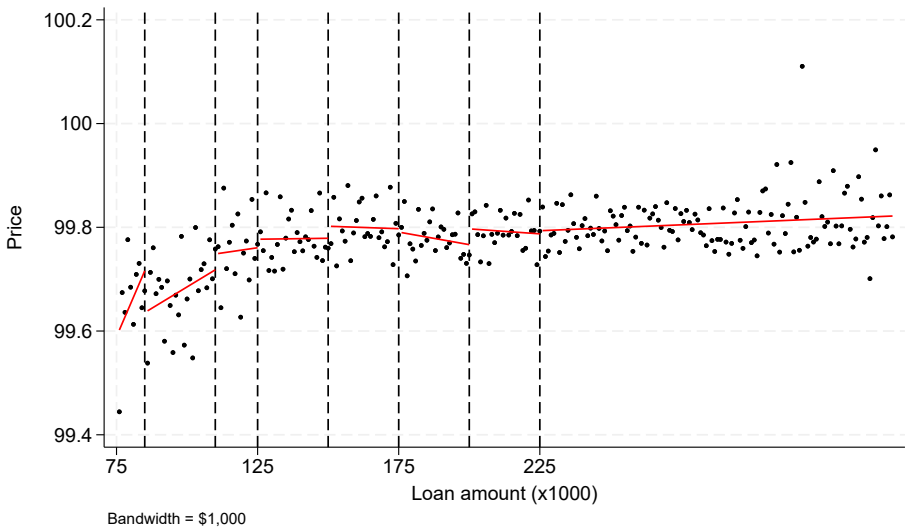
Loan duration (12-month)



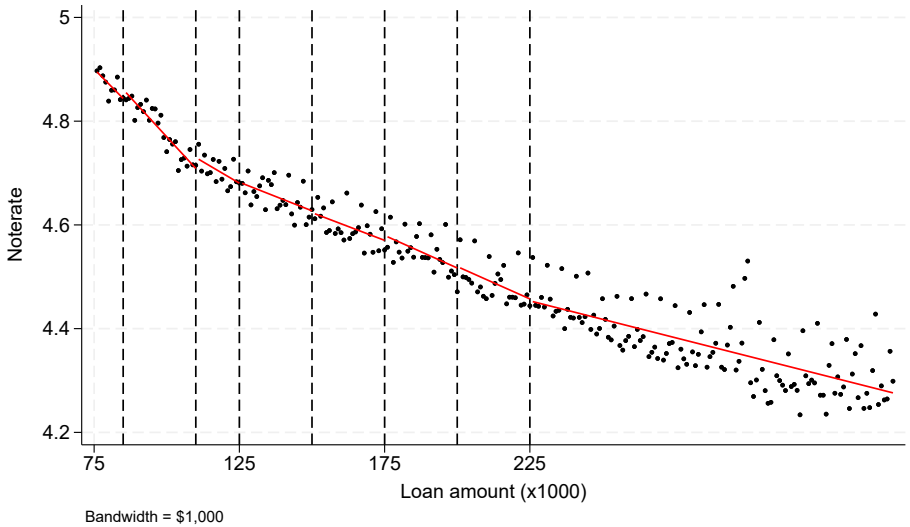
Return

Are spec-pool *pay-ups* pass-through to consumers?

Loan price (100 = par value)



Interest rate

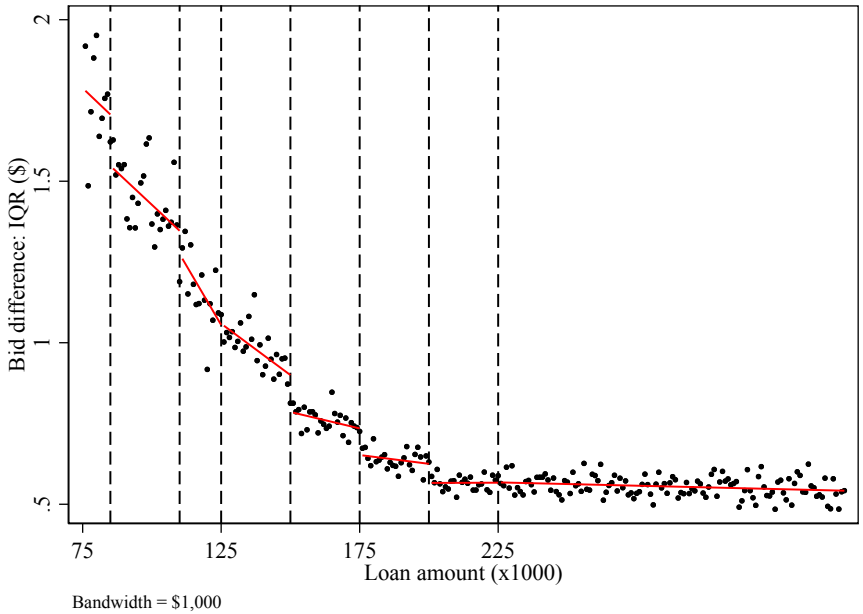


Return

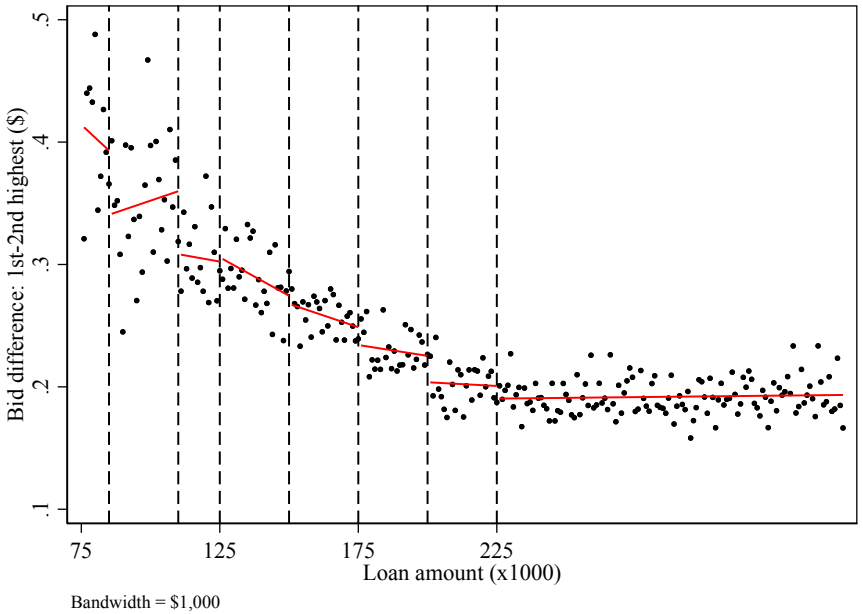
Securitization and Dispersion in Loan Resale Values

Each dot is the average within-auction dispersion in bids within $1,000 loan size bins

Within auction IQR



Winning margin



Return

Asymmetric information: Adverse-selection vs moral-hazard?

- The previous result shows that banks put long duration loans in *low coupon* and *spec-pools*.
- Two interpretations:
  - *AS:* Private signals about loan duration
  - *MH:* Servicers trigger refinancing to collect closing fees
- **Prediction:** The value of triggering a refinance is lower for "high markup" loans
  - Servicer profit margin: $r_i - c_i = s_i \in \{25, 37.5, 50, 62.5, 75\}$
  - Regression:

$$100 \times 1(t_i > 12) = \sum_k \lambda_k 1\{(r_i - c_i) = s_k\} + FE_i + g(r_i, L_i) + \gamma Z_i + \epsilon_i$$

  - Sample: Loans above 200K without a coupon choice.

Return

Moral-hazard test result

VARIABLES	(1)	(2)	(3)	(4)
Spread $(r - c)$: 500 bbs	0.33	-0.48	0.26	-0.27
	(0.11)	(0.099)	(0.099)	(0.096)
Spread $(r - c)$: 625 bbs	0.46	-0.54	0.63	-0.083
	(0.16)	(0.14)	(0.15)	(0.14)
Observations	5,808,894	5,759,706	5,808,894	5,759,706
R-squared	0.090	0.135	0.125	0.157
Loan characteristics	Rate and Loan	Rate and Loan	all	all
Issuer FE	no	yes	no	yes
Latest issuance date	2021/2	2021/2	2021/2	2021/2
Fixed effects	Month	Month	Month	Month
Mean dep. var.	86.7	86.7	86.7	86.7

All variables are divided by the standard-deviation across issuers.

Return

Control Variables

- Baseline specifications: Period x Note-rate fixed effects
  - MBS sample: Issuance month
  - Auction sample: Auction date
- Loan attributes:
  - Loan size, FICO, LTV, Refi/Purchase, Income (auction), DTI, Agency (VA/FHA), Zip-code house value
  - Geography: County (Auction), State (MBS)
- Origination channel:
  - Auction: Originator (Seller) fixed-effects
  - MBS: Channel, Issuer fixed-effects

Return (AS)