Gradual Optimization Against Heterogeneous Moral Hazard: Evidence from a Fintech Lending Firm

Chengzheng Li **Xiang Ma** **Kangkai Wang**

Jinan University
Southwestern University of Finance and Economics
Peking University

2024 North American Winter Meeting of Econometric Society
San Antonio, Jan. 6th 2024

Introduction

- Information asymmetries lead to moral hazard and adverse selection.
- Moral hazard effects are heterogeneous and individuals select on this heterogeneity (Einav et al., 2013).

This Paper

We relate a Fintech lending firm's actual behavior to its borrowers' heterogeneity in moral hazard. With unique loan-level data, we

- quantify moral hazard;
- quantity heterogeneity in moral hazard;
- calculate optimal loan caps;
- compare firm's actual behavior with theoretical predictions.

Setup

- Model Setup (Ghosh, Mookherjee and Ray (1999))
  - Consider an indivisible project requiring funds of amount L to be viable.
  - Output takes values of either Q (good state) with a probability $p(e; a)$ or 0 (bad state) with $1 - p(e; a)$, where e is the effort level of the agent who oversees the project, and a is the agent's ability.
  - Assume that $\frac{\partial p}{\partial e} > 0$ and $\frac{\partial^2 p}{\partial e^2} < 0$.
  - Let r denote interest rate, a positive constant.
- Optimization problem for a debt-financed risk-neutral individual is:

$$\max_e p(e; a)[Q - (1 + r)L] + [1 - p(e; a)] \cdot 0 - e$$

where we do not consider the collateral, which the platform does not require.

Solution

- First-order condition

$$\frac{\partial p(e^*; a)}{\partial e} = \frac{1}{Q - (1 + r)L}$$

The optimal effort level e^* is a function of Q project output, L loan amount, r interest rate, and a ability level.

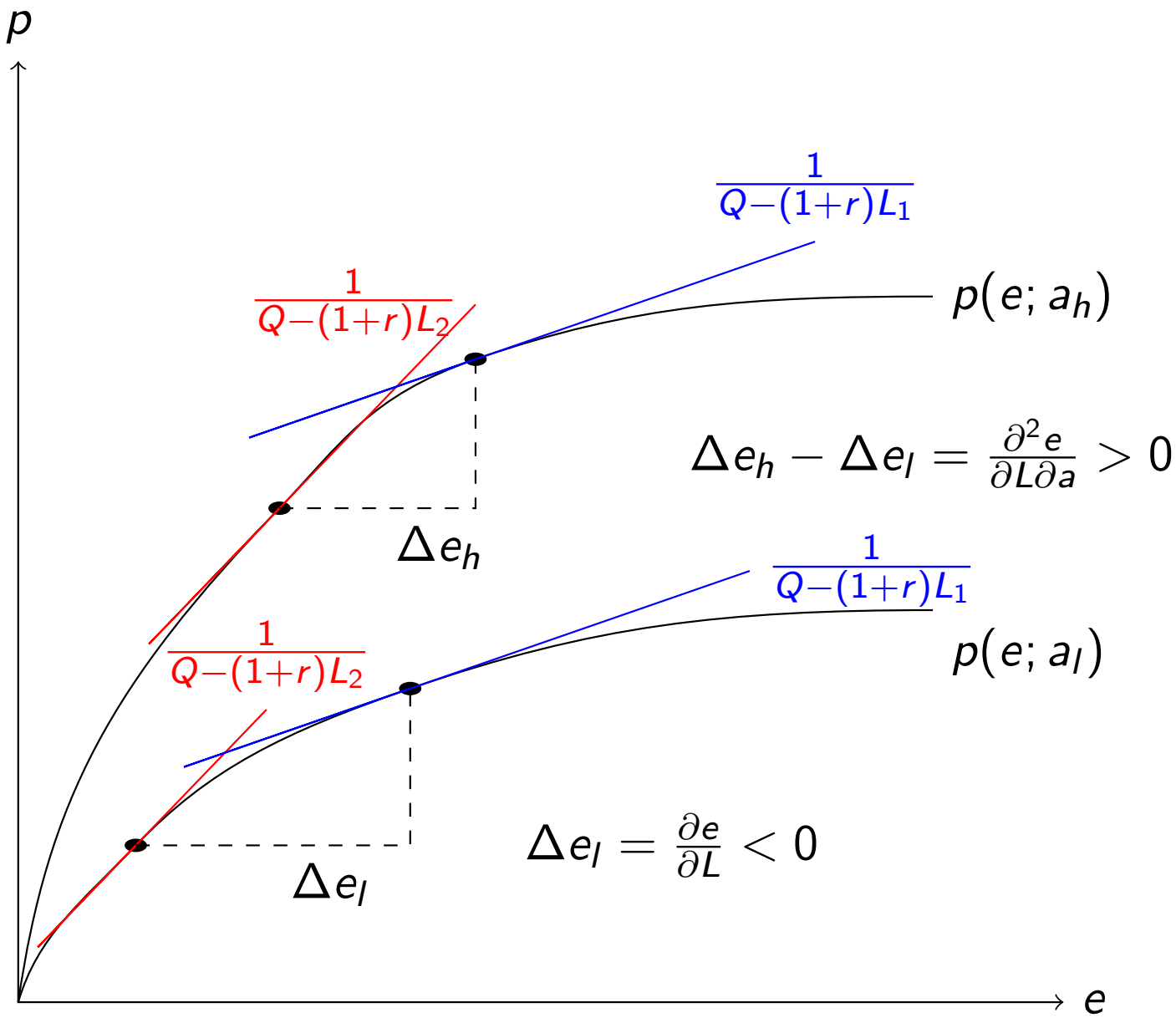


Figure 1: Illustrative Graph of the Theoretical Framework

Dataset

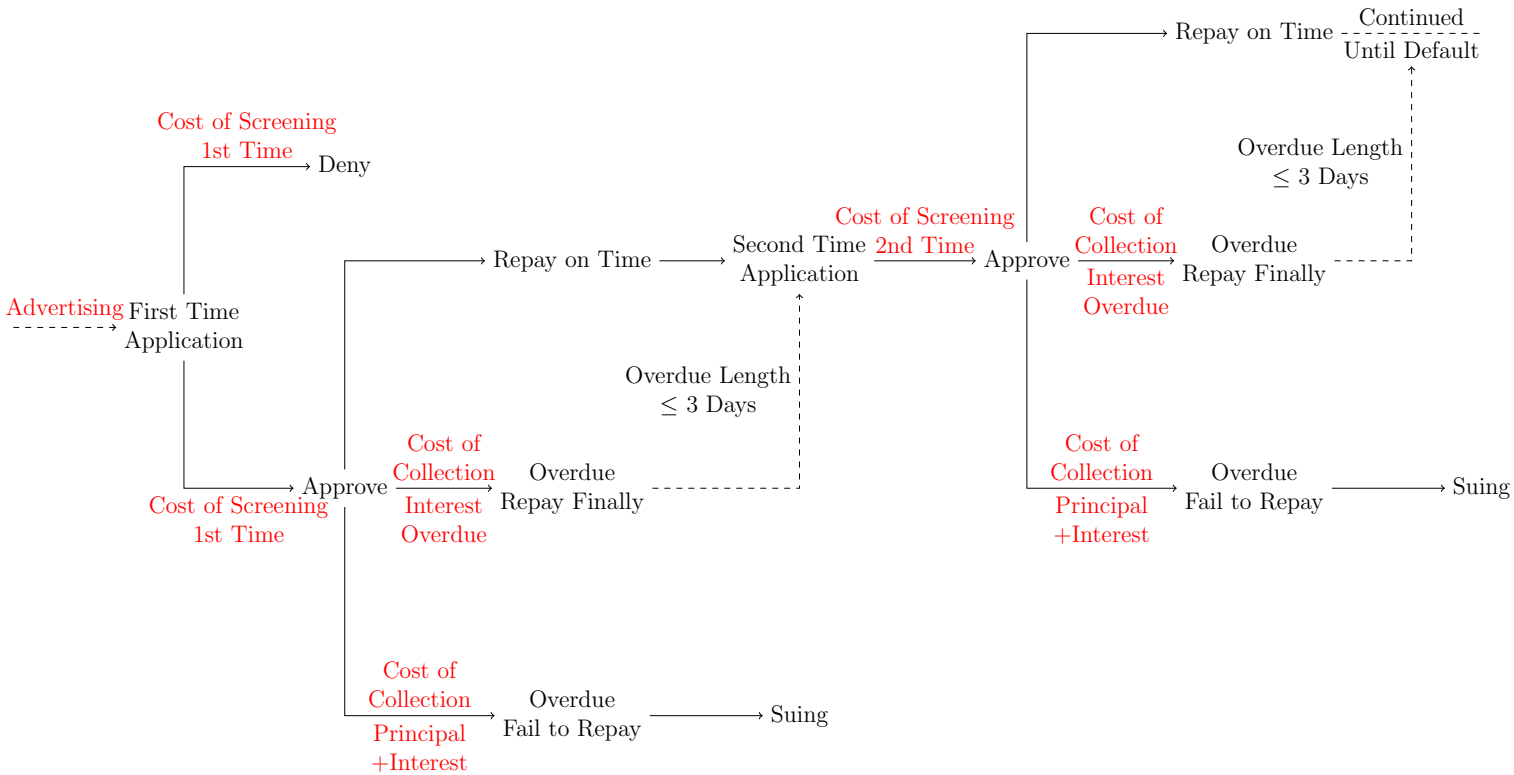
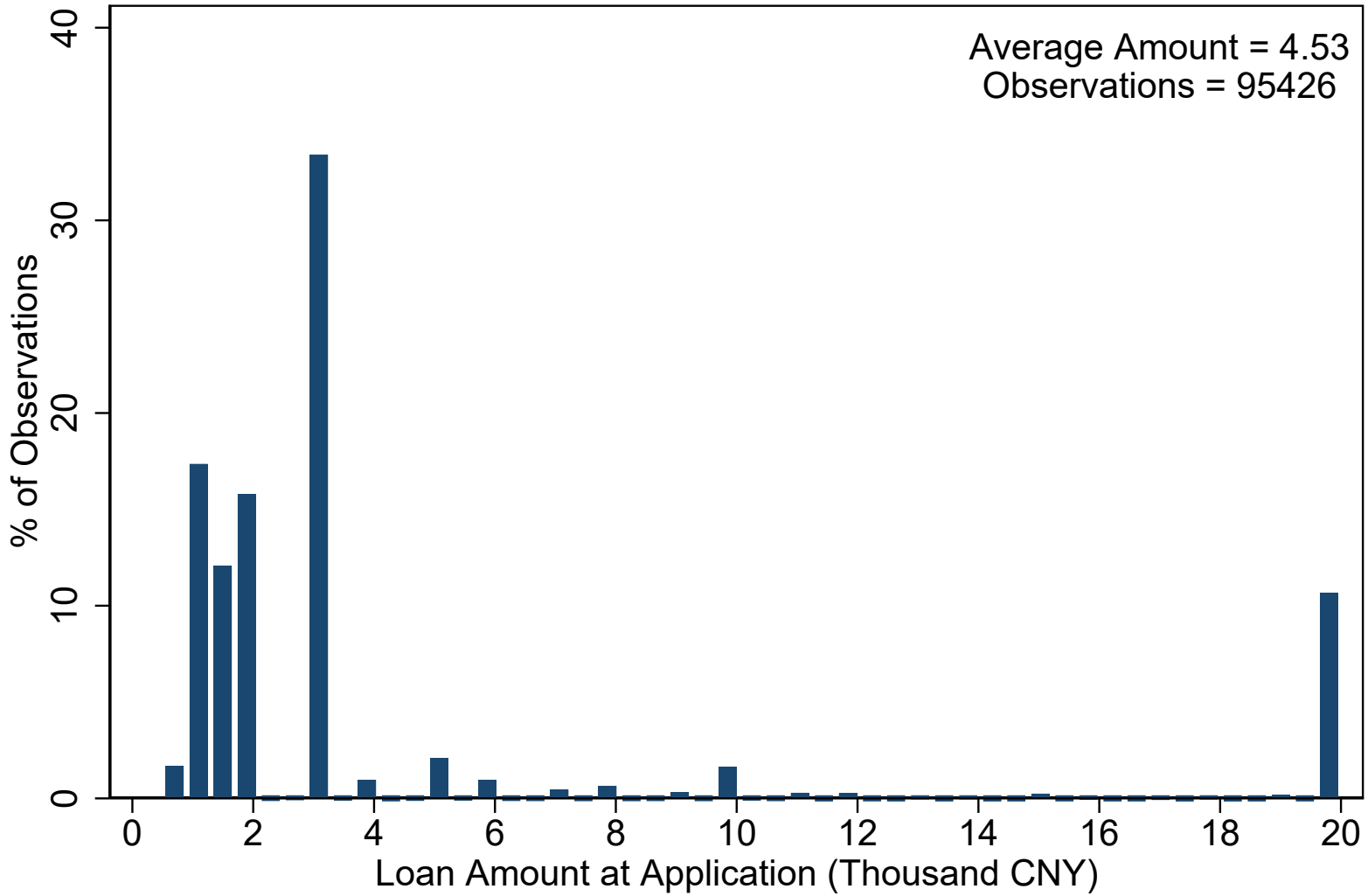


Figure 2: Operation Process of the Firm

The Fintech Lending Firm

- sample size: around 100,000 loan transactions;
- interest rate: 24%;
- term length: 14 days;
- approval decision: mostly done by algorithm;
- Once a loan is selected into our sample, all subsequent loans by the same individual would also be;
  - control for individual fixed effects to control for adverse selection.
- The default behavior would not affect one's official credit score, but could be known by other similar online lending platforms.

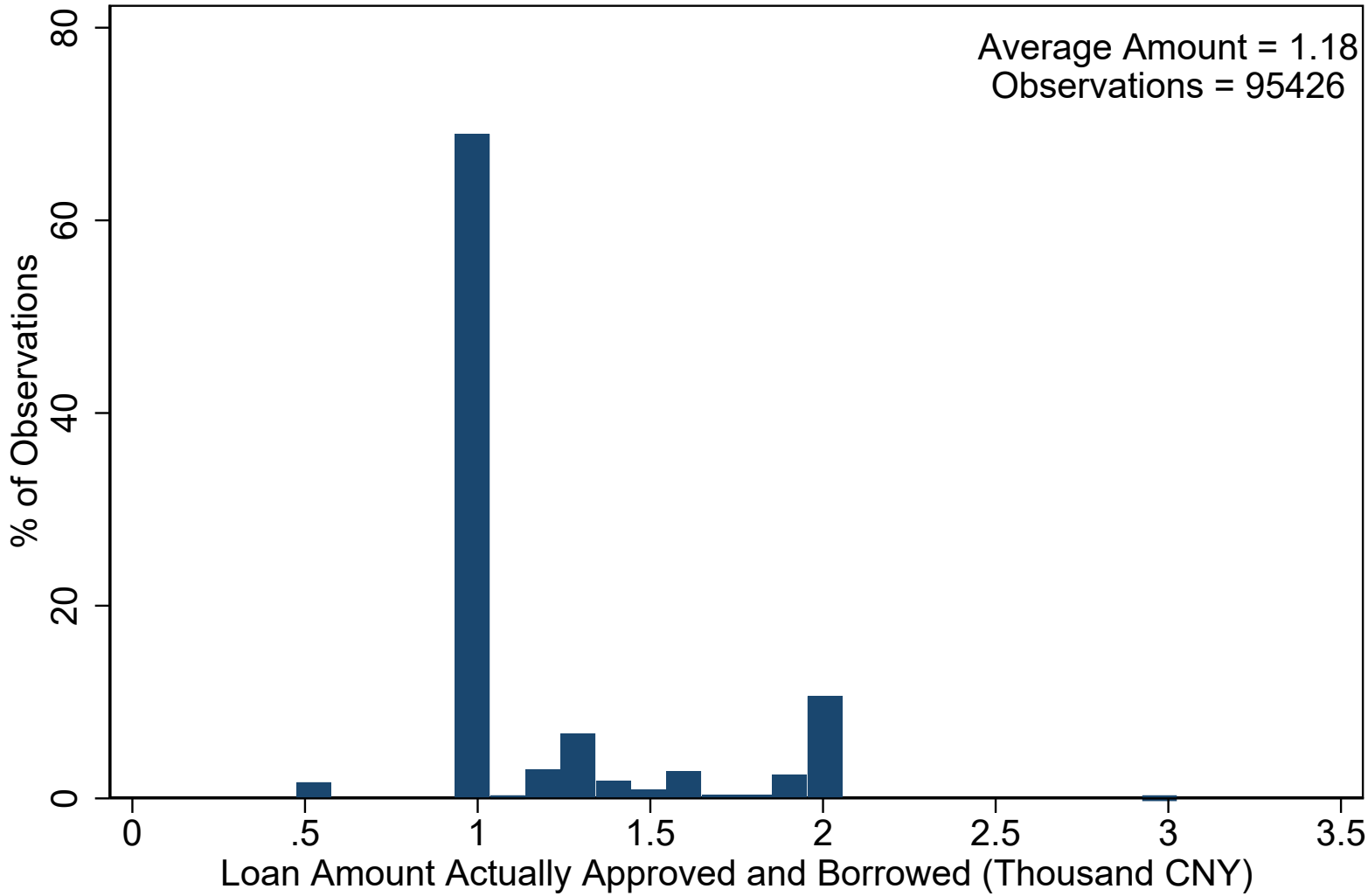
Amount of Loan at Application



Notes: Loan amount actually approved and borrowed from the platform is smaller than or equal to that at application for all individuals.

Figure 3: The Distribution of the Amount of Loan at Application

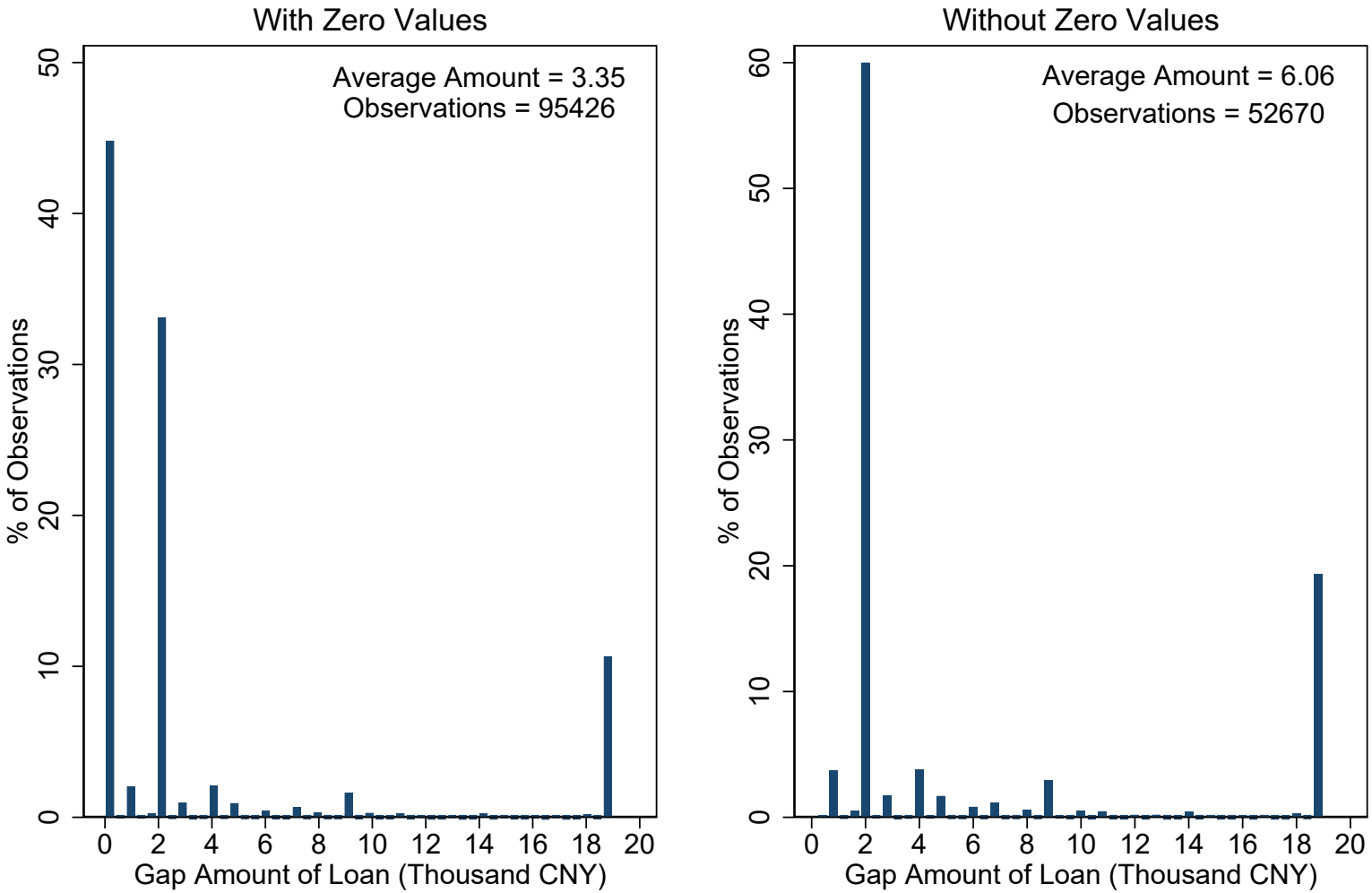
Amount of Loan Actually Borrowed



Notes: Loan mount actually approved and borrowed from the platform is smaller than or equal to that at application for all individuals.

Figure 4: The Distribution of the Amount of Loan Actually Borrowed

Gap Amount of Loan



Notes: The gap amount of loan is the difference between loan amount at application and that actually approved and borrowed from the platform. It is non-negtive for all individuals in our sample.

Figure 5: The Distribution of the Gap Amount of Loan

Number of Loans

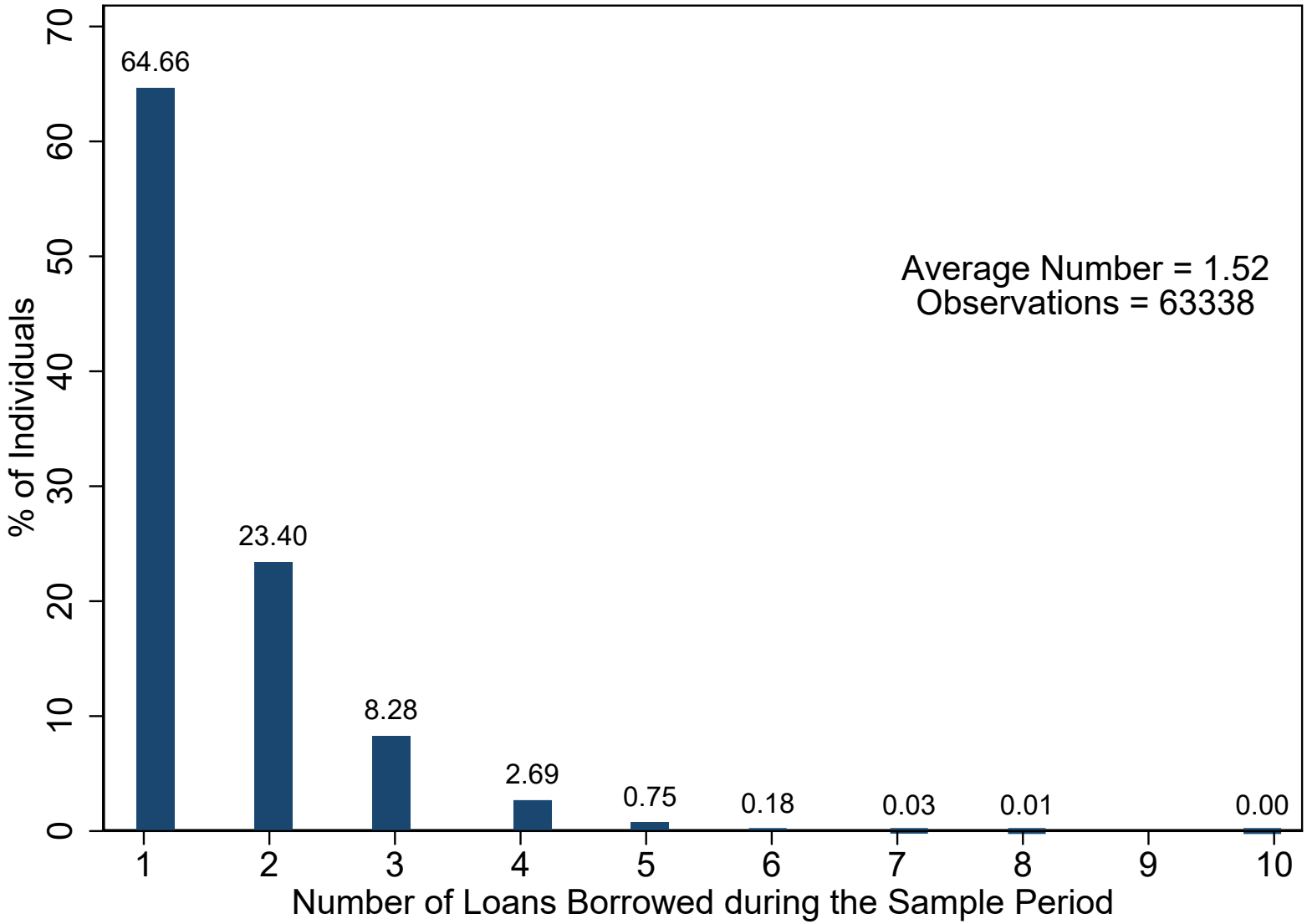


Figure 6: The Distribution of the Number of Loans

Table 1: Nonrepayment by Loan Order

Loan Order	Repayment	Nonrepayment	Total
1	58999	4336	63335
	(93.15%)	(6.85%)	(100.00%)
2	20456	1496	21952
	(93.19%)	(6.81%)	(100.00%)
3	6771	476	7247
	(93.43%)	(6.57%)	(100.00%)
4	2039	137	2176
	(93.70%)	(6.30%)	(100.00%)
5	523	31	554
	(94.40%)	(5.60%)	(100.00%)
Total	88788	6476	95264
	(93.20%)	(6.80%)	(100.00%)

Row Percentages in Parentheses

Table 2: Nonrepayment by Difference in Loan Amount

	Difference in Loan Amount		Total
2^{nd} Loan	$2^{nd} - 1^{st} = 0$	$2^{nd} - 1^{st} > 0$	
Repayment	12,393	8,017	20,410
	(93.22%)	(93.16%)	(93.19%)
Nonrepayment	902	589	1,491
	(6.78%)	(6.84%)	(6.81%)
3^{rd} Loan	$3^{rd} - 2^{nd} = 0$	$3^{rd} - 2^{nd} > 0$	
Repayment	3,852	2,869	6,721
	(93.86%)	(92.76%)	(93.39%)
Nonrepayment	252	224	476
	(6.14%)	(7.24%)	(6.61%)
4^{th} Loan	$4^{th} - 3^{rd} = 0$	$4^{th} - 3^{rd} > 0$	
Repayment	1,171	854	2,025
	(94.21%)	(93.03%)	(93.71%)
Nonrepayment	72	64	136
	(5.79%)	(6.97%)	(6.29%)

IV Strategy

IV for L_{it}

- average size of loans originated on previous day $t-1$, $\bar{L}_{jt-1}$.
  - If i borrows on date t, she could not borrow on date $t-1$.

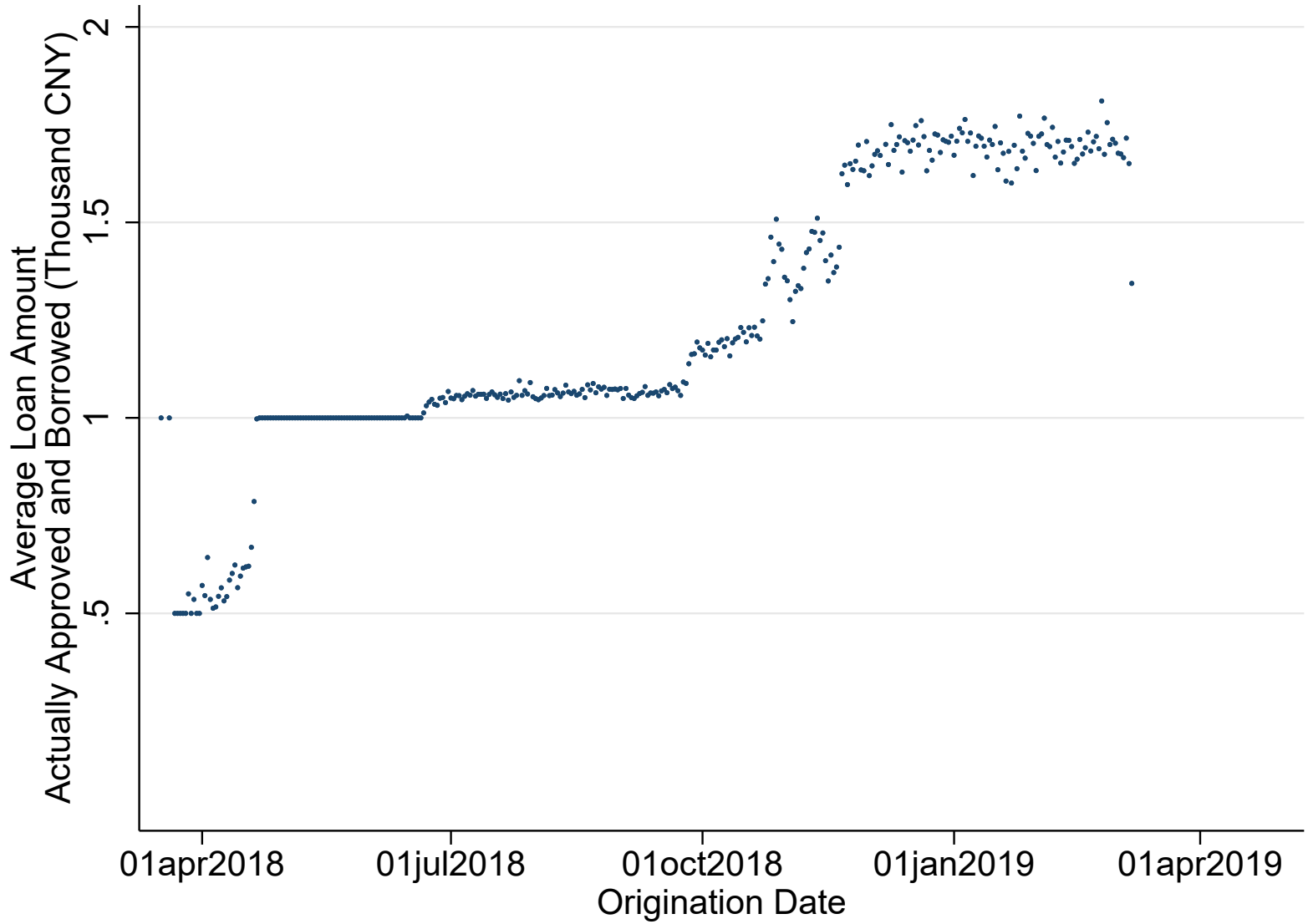


Figure 7: Amount of Loan Actually Approved and Borrowed Over Time

Table 3: Determinants of Loan Amount

	Loan Amount Approved and Borrowed
	FE
Lag Average Loan Amount Approved	0.9664***
	(0.0086)
Loan Amount Applied	-0.0070***
	(0.0002)
Credit Score: Anti-Fraud	0.0002
	(0.0002)
Credit Score: Flash	0.0003***
	(0.0001)
Controls	Yes
Individual FE	Yes
Observations	93,294

(1) Robust standard errors clustered at individual level in parentheses. (2) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (3) Purpose of loan and loan order are also controlled for in the FE regression.

Table 4: Loan Amount on Defaults: IV-FE

	Overdue	No. Collections	Nonrepayment
1st and 2nd Loans:			
Loan Amount Approved	0.1870***	1.3647***	0.1262***
	(0.0115)	(0.0770)	(0.0062)
Loan Amount Applied	-0.0001	0.0028	0.0002
	(0.0005)	(0.0028)	(0.0003)
Observations	83,335	83,335	83,335
2nd and 3rd Loans:			
Loan Amount Approved	0.1721***	1.4336***	0.1393***
	(0.0205)	(0.1206)	(0.0108)
Loan Amount Applied	-0.0014	0.0014	0.0005
	(0.0011)	(0.0063)	(0.0006)
Observations	28,719	28,719	28,719
3rd and 4th Loans:			
Loan Amount Approved	0.1446***	1.3734***	0.1424***
	(0.0379)	(0.2586)	(0.0207)
Loan Amount Applied	0.0024	0.0115	0.0011
	(0.0022)	(0.0143)	(0.0013)
Observations	9,259	9,259	9,259
Controls	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes

(1) Robust standard errors in parentheses. (2) * $p < 0.10$, ** $p < 0.05$,

Table 5: Heterogeneity in Education: IV-FE

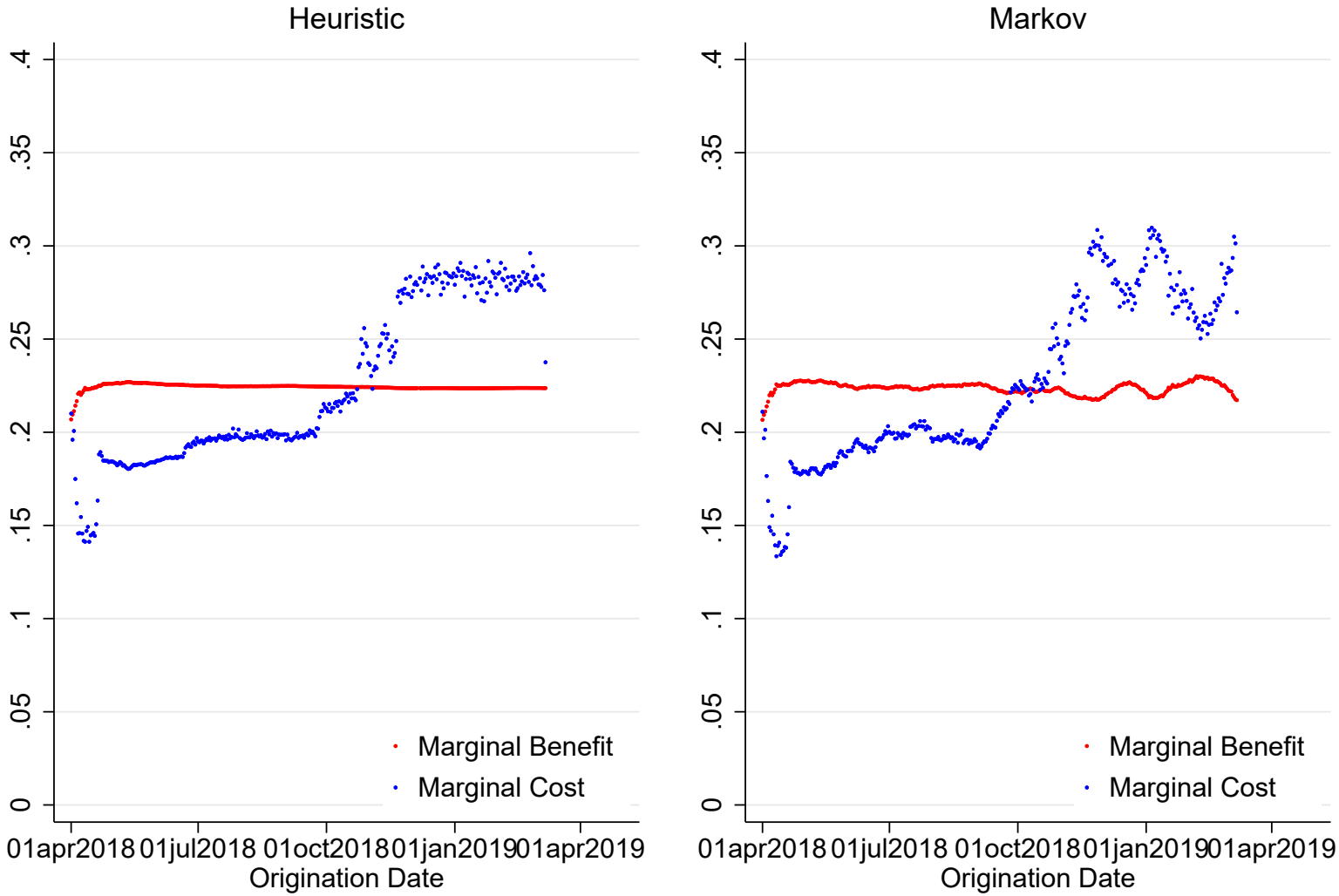
	Overdue	No. Collections	Nonrepayment
1st and 2nd Loans:			
Loan Amount	0.2075***	1.6275***	0.1509***
	(0.0176)	(0.1268)	(0.0103)
Loan Amount∗Higher Education	-0.0408*	-0.4630***	-0.0439***
	(0.0220)	(0.1536)	(0.0124)
Observations	78,963	78,966	78,966
2nd and 3rd Loans:			
Loan Amount	0.2074***	1.8553***	0.1867***
	(0.0347)	(0.2063)	(0.0198)
Loan Amount∗Higher Education	-0.0540	-0.6402***	-0.0727***
	(0.0408)	(0.2464)	(0.0228)
Observations	28,141	28,141	28,141
3rd and 4th Loans:			
Loan Amount	0.1674***	1.4817***	0.1738***
	(0.0591)	(0.3362)	(0.0334)
Loan Amount∗Higher Education	-0.0419	-0.1881	-0.0560
	(0.0724)	(0.4697)	(0.0401)
Observations	9,178	9,178	9,178
Controls	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes

(1) Robust standard errors in parentheses. (2) * $p < 0.10$, ** $p < 0.05$, ***

Quantify Marginal Cost and Marginal Benefit

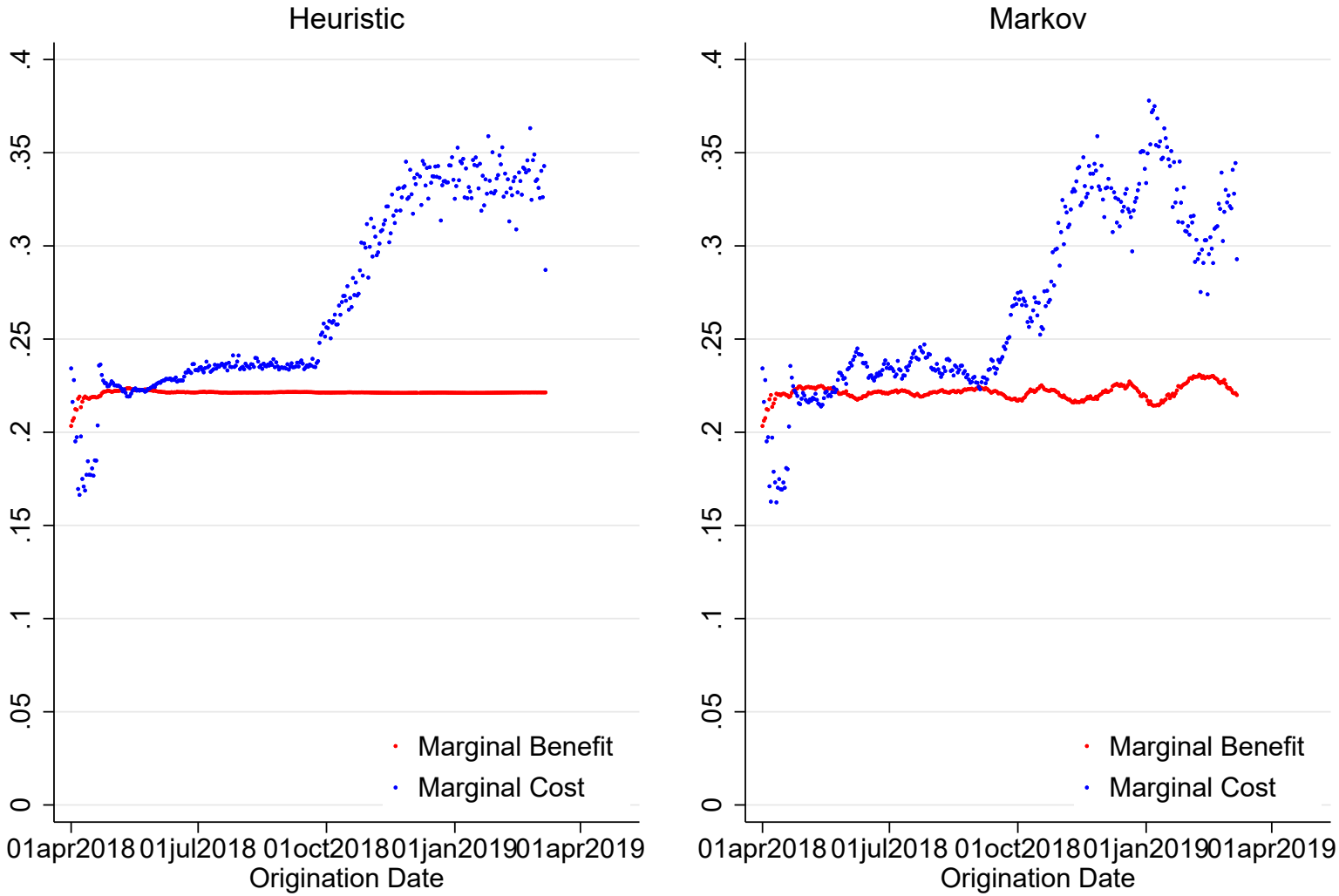
$$MB_t = r \times [1 - (NR_t + \Delta NR)]$$
$$MC_t \approx L \times 1000 \times \Delta NR + NR_t$$

- r: interest rate;
- NR_t: nonrepayment rate realized at time t; data;
- ΔNR: the marginal impact of one CNY on nonrepayment rate; regression results;
- L: loan size.



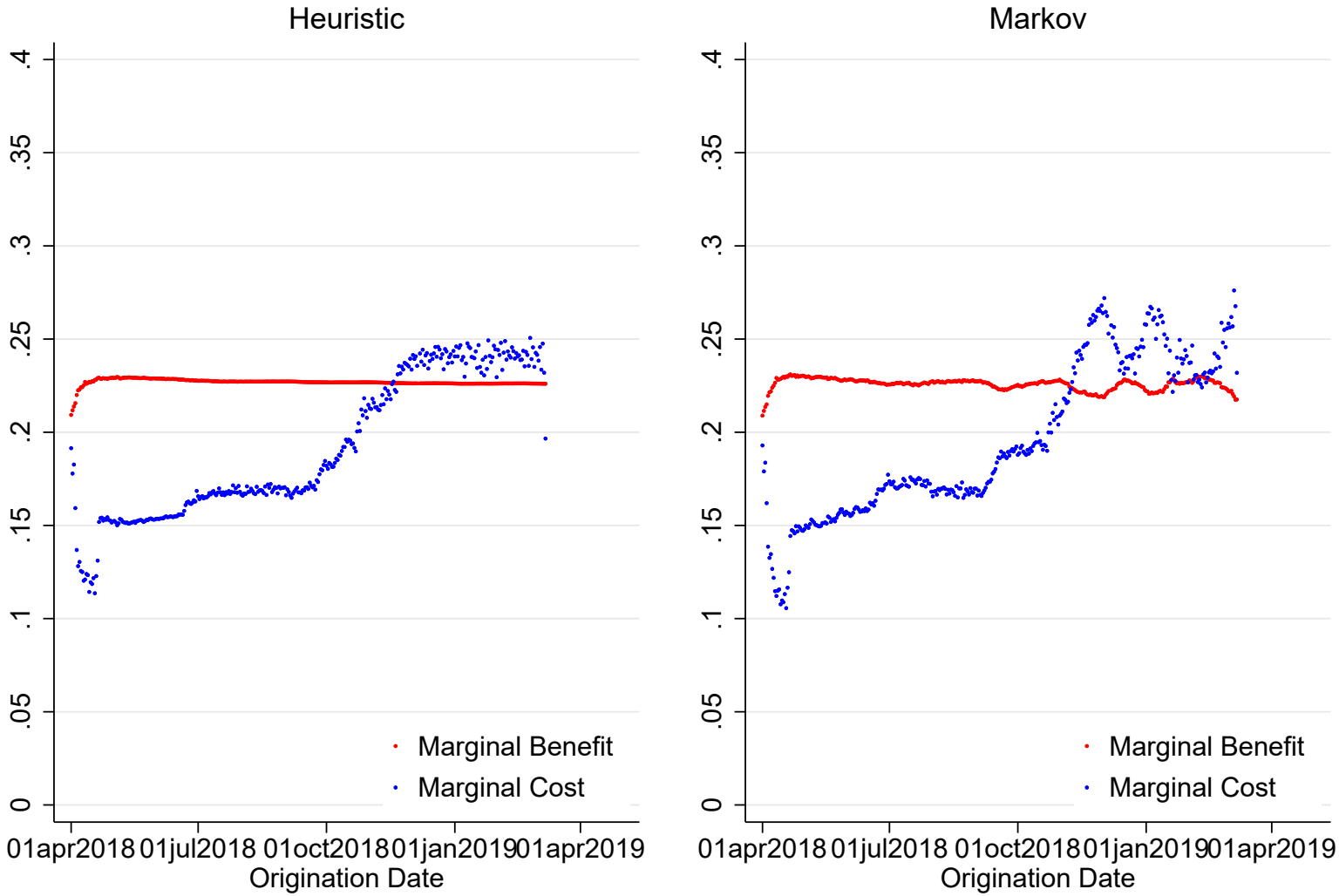
MB=Interest Rate*(1-Nonrepayment Rate); MC=Nonrepayment Rate+β*Loan Amount

Figure 8: Marginal Benefit vs. Marginal Cost



MB=Interest Rate*(1-Nonrepayment Rate); MC=Nonrepayment Rate+β*Loan Amount

Figure 9: MB and MC of the Low Education



MB=Interest Rate*(1-Nonrepayment Rate); MC=Nonrepayment Rate+β*Loan Amount

Figure 10: MB and MC of the High Education

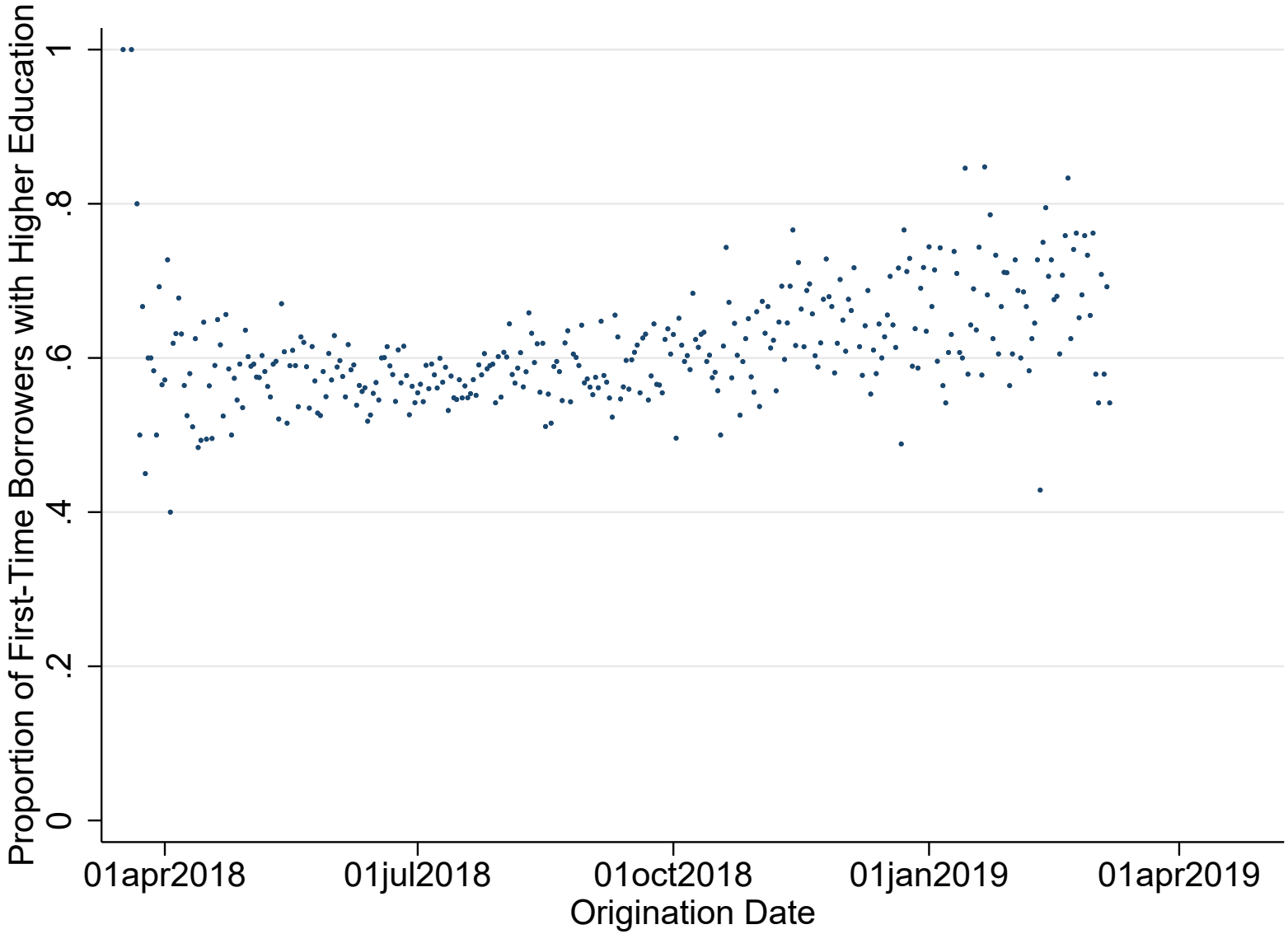


Figure 11: Proportion of First-Time Borrowers with High Education

Conclusion

- Moral Hazard
  - Heterogeneity in moral hazard;
  - Firm counter-selected on this heterogeneity.
- Quantification of marginal cost arising from moral hazard
  - Firm was gradually optimizing against moral hazard

THANK YOU!