

# Instant Payment Systems and Competition for Deposits

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## Motivation and question

- Banking industry is concentrated
  - ⇒ market power enables large banks **to pay low deposit rates**
- Payment services (credit cards, payment apps) are an important dimension of market power
- **Instant payment systems (IPS)** – technologies for fast payments [Details](#)
- Examples: UPI (India), FedNow (US), Pix (Brazil)
- IPS have low entry costs compared to traditional payments

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**Question:** How do instant payment systems change the competition among banks?

## Overview of the results

- Exploit natural experiment in exposure to **the launch of Pix in Brazil**
  - Pix was easily accessible for small banks to join

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  - **Increase** in deposits overall
  - Channel:** **small banks** offer *more payment convenience*
- 2. **Small banks reduce** interest rates relative to **large banks**
- 3. Depositors' welfare **increases** by \$380 in deposit-equivalent terms

# Outline

1 Institutional setting

2 Data

3 Identification and main results

4 Model estimation

# Pix in Brazil

- Launched in November 2020 by the central bank
  - Allows within-second transfers and payments
- Requires bank account to use
  - Large banks were required to join, small banks had cheap access
- Offered by >95% intermediaries and used by >80% people
- Free for banked households, cheap for banks
- Cheap for merchants: fees  $\sim 0.2\%$  compared to 2.2% credit card fee

[IPS examples](#)[Other payment methods](#)[Card fees](#)

## Banking landscape in Brazil before Pix

- Concentrated deposit markets (national HHI  $\simeq$  0.17 vs 0.2 in the US)
- **Large banks** pay lower deposit rates than **small banks**  
Large banks – banks with  $>$  50 million depositors

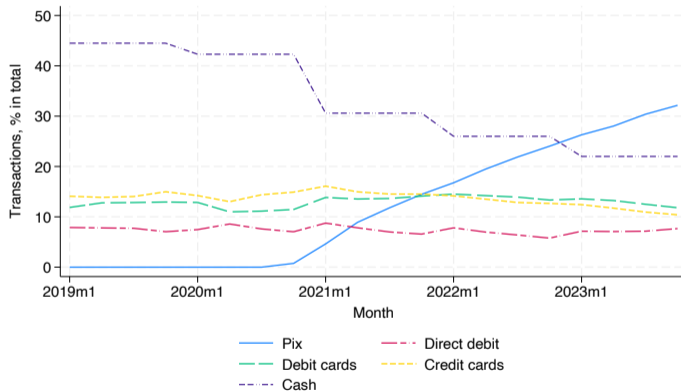
## Banking landscape in Brazil before Pix

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Large banks – banks with > 50 million depositors

	Average large bank	Average small bank
Regional offices	2,064	52
Number of ATMs	23,550	1,763
Direct deposits	100% of banks	5.2% of banks
Online banking app	100% of banks	61% of banks
Deposit insurance	100% of banks	81% of banks
Fee to open an account	0	30.3
Fee to maintain an account	51.1	73.6

- Large banks offer greater payment convenience

# Pix dominates other electronic means of payments



Quantities

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## Novel dataset

- **Municipality-level monthly data on Pix transactions** (Central Bank of Brazil)
  - Number of transactions, value of transactions
- **Branch-level monthly data on banks' balance sheet** (ESTBAN)
  - Deposits by type, loans, financing, assets, alternative funds
- **Bank-level data on interest rates and equity** (Central Bank of Brazil and Bloomberg)
  - Deposit rates (interest expense), personal loan rates, equity returns
- **Municipality-level demographic and economic data** (IBGE)
  - HHI, Census, capital investments, savings, GDP
- **Macro variables** (IPEA and Central Bank of Brazil)

# Small banks increase deposits relative to large banks

$$\log D_{imt} = \delta \cdot \log Pix_{mt} \cdot S_i + \gamma X_{imt} + \theta_t + \alpha_i + \eta_{mt} + \varepsilon_{imt}$$

	<i>Dependent variable:</i>		
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)
Pix · Small	0.030*** (0.005)	0.032*** (0.005)	0.043*** (0.006)
Bank FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Muni × Time FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	32,097	32,097	32,097
R <sup>2</sup>	0.882	0.961	0.923

Standard errors are clustered at the municipality level

Significance: 10%\*, 5%\*\* , 1%\*\*\*

Lending

HHI

Boleto

Swish

Deposit graph

Investments

Income

Stocks

ROA

Deposit betas

Branches

Small bank branches

# Small banks reduce interest rates relative to large banks

$$r_{it} = \delta \cdot \log Pix_{mt} \cdot S_i + \gamma X_{imt} + \theta_t + \alpha_i + \varepsilon_{imt}$$

	<i>Dependent variable:</i>		
	Deposit rates		Personal loan rates
	(1)	(2)	(3)
Pix	-0.289 (0.188)	-0.352 (0.267)	0.021*** (0.003)
Pix · Small	-0.137*** (0.010)	-0.137*** (0.017)	-0.047*** (0.000)
Denominator	All deposits	Time deposits	-
Bank FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	18,247	18,196	35,256
R <sup>2</sup>	0.122	0.963	0.932

Standard errors are clustered at the municipality level

Significance: 10%\*, 5%\*\* , 1%\*\*\*

# Outline

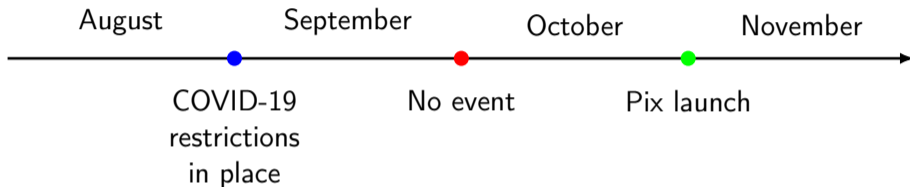
- 1 Institutional setting
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## Identification assumptions

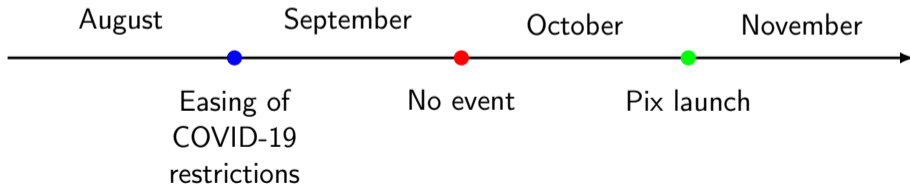
- Easing of COVID-19 restrictions in Brazilian municipalities by **September 2020**
  - *Treated* – eased restrictions, *control* – did not ease restrictions [Stats](#)
- **Relevance condition**: easing of restrictions by September **increases** Pix usage in November
- **Exclusion restriction**: easing of restrictions by September changes deposit concentration in November **only through Pix**

## Relevance condition

Pix transactions in *control* group

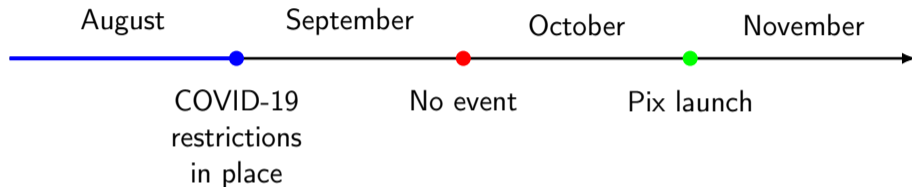


Pix transactions in *treatment* group

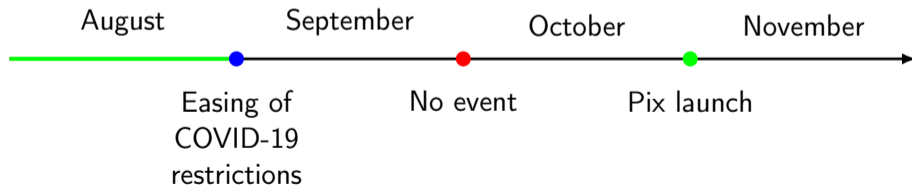


## Relevance condition

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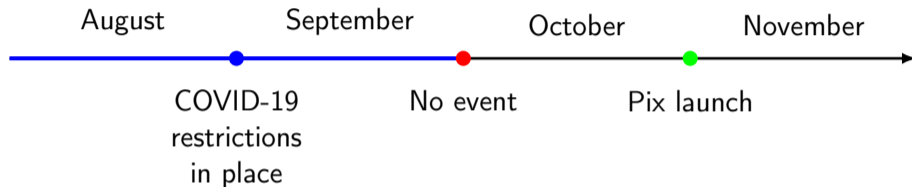


Pix transactions in *treatment* group

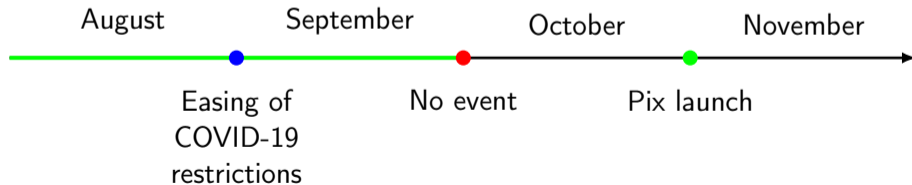


## Relevance condition

Pix transactions in *control* group

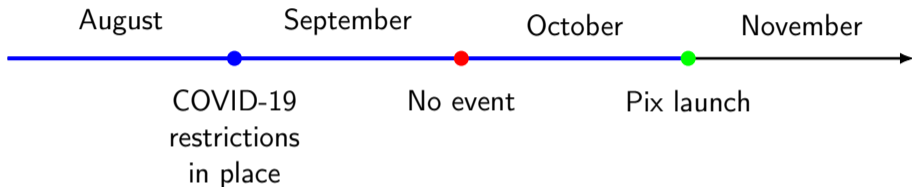


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## Relevance condition

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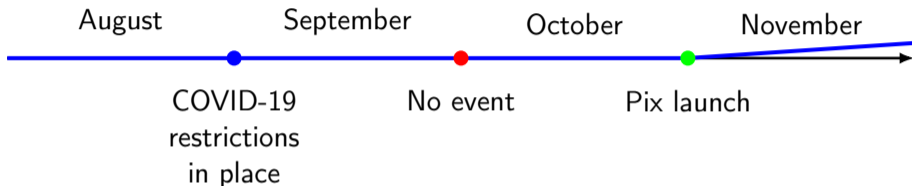


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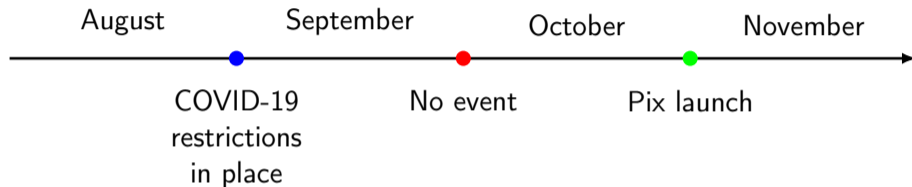


Pix transactions in *treatment* group

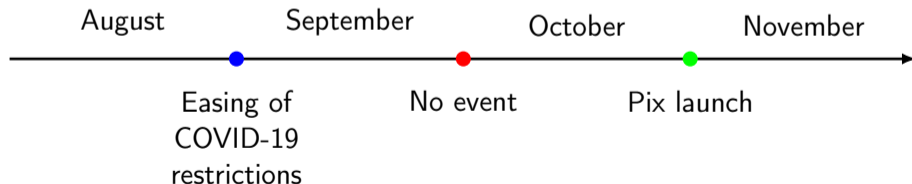


## Exclusion restriction

Deposit concentration in *control* group

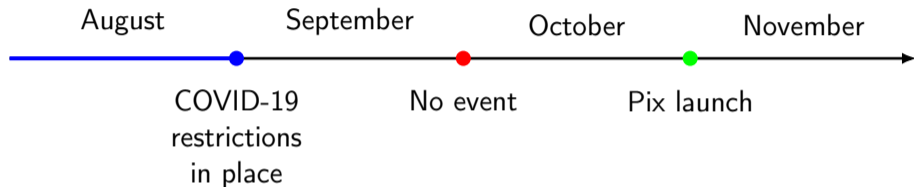


Deposit concentration in *treatment* group

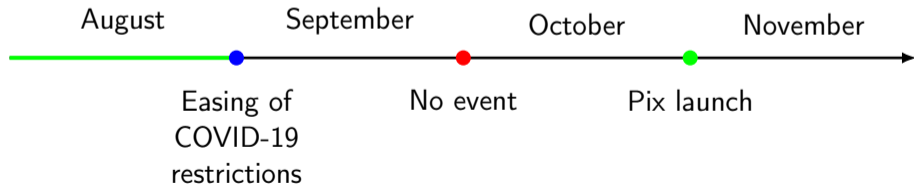


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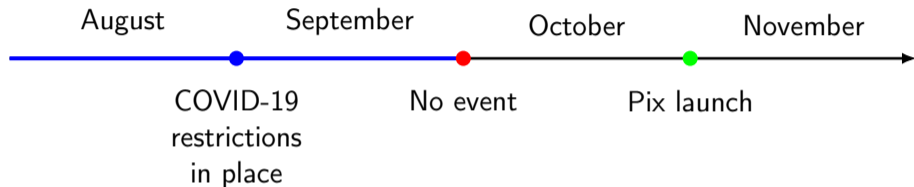


Deposit concentration in *treatment* group

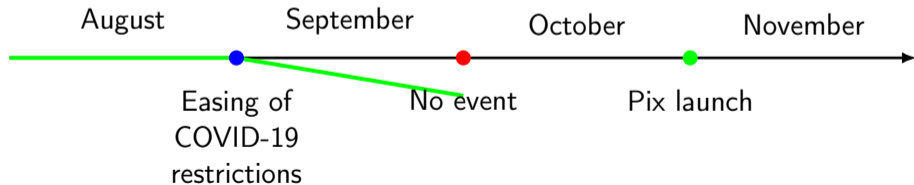


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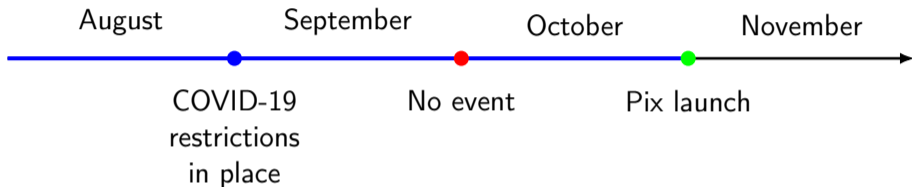


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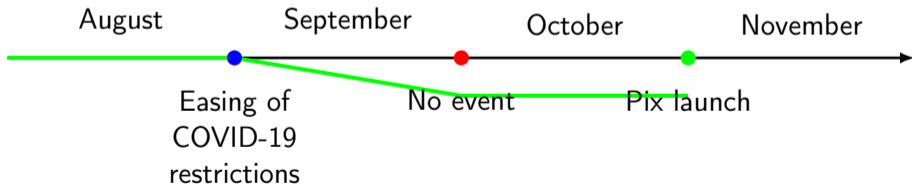


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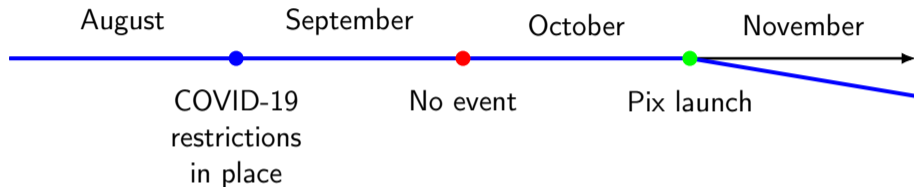


Deposit concentration in *treatment* group

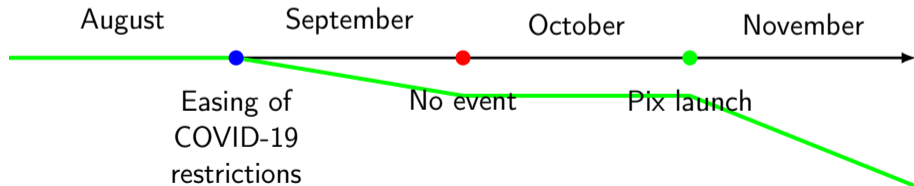


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Deposit concentration in *control* group



Deposit concentration in *treatment* group



# Pix increases deposits of small banks relative to large banks

$$\log D_{imt} = \delta \cdot \widehat{\log Pix}_{mt} \cdot S_i + \gamma X_{imt} + \eta_{mt} + \varepsilon_{imt}$$

	<i>Dependent variable:</i>			
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)	Total loans (4)
Pix · Small	0.019*** (0.007)	-0.008 (0.006)	0.174*** (0.021)	0.046*** (0.008)
Muni × Time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	7,123	7,123	7,123	7,123
R <sup>2</sup>	0.636	0.545	0.072	0.289

Standard errors are clustered at the municipality level

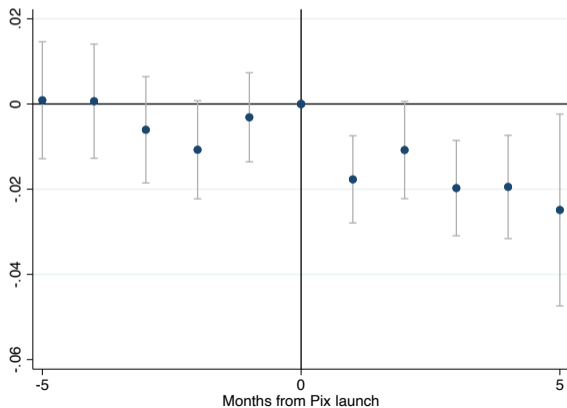
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Lending Standard IV Bank FEs Longer window Boletto Swish Deposit graph Investments Income Stocks ROA

Deposit betas Branches Small bank branches First stage COVID Definition No muni-time FEs

# Pix causes a reduction in deposit market concentration

$$HHI_{m,t+s} = \theta \widehat{PixPerCap}_{mt} + \gamma X_{mt} + \eta_{mt}$$



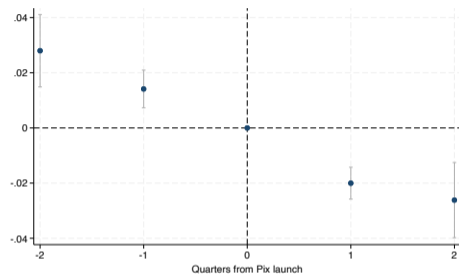
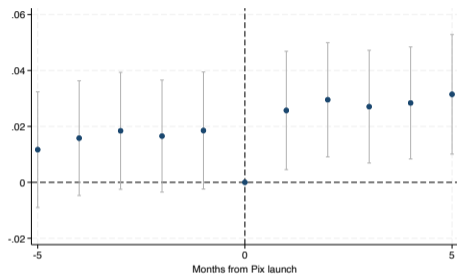
\$200 ↑ in per capita Pix transactions ⇒ ↑  
**from 5 to 6**  
**equally large**  
**banks**

Seasonality

Access to Pix

FHS pre-trend test

# Deposits and deposit rates



- Altonji et al (2005) test: selection on observables is indicative of selection on unobservables

Details

- Rambachan and Roth (2023): pre-trends must be unreasonably large to kill results

Details

## Why? Payment convenience

- Pix increases payment and transfer convenience of small banks
  - Richer and poorer households value convenience differently
  - Increase in **small bank** deposits **stronger** in **richer** areas

## Why? Payment convenience

- Pix increases payment and transfer convenience of small banks
  - Richer and poorer households value convenience differently
  - Increase in **small bank** deposits **stronger** in **richer** areas
- The results are mostly driven by already banked population
  - Increase in deposits of **small banks** **stronger** in **banked** areas
  - Increase in deposits of **large banks** **stronger** in **unbanked** areas
  - The number of accounts increases [Details](#)

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## Deposit demand estimation

- How does Pix impact deposit demand conditional on interest rates?
- How does Pix change sensitivity of deposit demand to interest rates?
  - IO-style model of deposit demand
- How does Pix impact depositors' welfare?
  - How much are deposits ready to pay to have Pix?

## Estimation results: overview

- Deposit demand becomes **more sensitive** to deposit rates after Pix
  - Indication of reduced **market power** and **deposit stickiness**
- Deposit demand of **small banks** **increases** relative to **large banks**
- Pix increases consumers' welfare

# Conclusion

- Payment systems are developing in many countries and the effects on banks are a key concern
- Instant payment systems can increase the competition for deposits among banks
  - Implications for deposit market power and lending competition
- Pix in Brazil leads to an increase in deposits and loans and a reduction in bank interest rates
  - Changes in the choice of payment methods and consumers' welfare
- Related work: Liang, Sampaio, Sarkisyan (2024), Ding, Gonzales, Ma, Zeng (2024), Lu, Song, Zeng (2023), Sampaio and Ornelas (2024), Burga, Cespedes, Parra, Ricca (2024)

# Outline

## 5 Appendix

# Payment technology

- Large banks in the US offer payment technology
  - Zelle, PayPal, Venmo instant transfer
- Retail payments are still dominated by credit/debit cards and checks
- Instant payment systems are
  1. Fast – settled within seconds
  2. Universal – cheap for most banks to join
  3. Used for retail payments

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## Would the results apply to the US?

- Brazil and the US have many similarities
  - Concentrated banking sector
  - Large banks offering more convenience and lower rates
  - Many banks concentrated in their localities
  - No digital payment systems other than Pix in Brazil
- The results may follow despite the differences

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## Relevance for Canada

- Canada has RTGS and instant transfer service used by banks
- Interac e-Transfer is used for payments
- Interac has only five participating banks (out of 34)
- Cards and cheques are still prevalent
- Potential for universal instant payments

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# IPS examples

Country	System	Launch year	Inventor
Australia	NPP	2018	Private
Brazil	Pix	2020	Central Bank
Denmark	MobilePay	2013	Central Bank
Hong Kong	FPS	2018	Central Bank
India	UPI	2016	Central Bank
Kenya	M-Pesa	2007	Private
Sweden	Swish	2014	Private
United States	Zelle	2017	Private
United States	FedNOW	2023	Central Bank
Eurozone	TIPS	2018	Central Bank

## Where is Pix more popular?

- Factors driving **initial** usage of Pix (per capita):

	Input	Standard error
Deposit Herfidahl-Hirschman index	-0.044***	(0.004)
Capital	0.048***	(0.018)
GDP per capita	0.563***	(0.092)
Income per capita	0.061***	(0.013)
Urban population %	0.759***	(0.066)
Male population %	0.128	(0.705)
Young population %	0.367	(0.327)
Illiterate population %	0.621***	(0.237)
Conservative population %	-0.253	(0.175)
Observations	3,179	
R <sup>2</sup>	0.169	

Standard errors are clustered at the municipality level

## Market concentration and bank size

- Herfindahl-Hirschman index for municipality deposit market concentration

$$HHI_{mt} = \sum_{i=1}^N \left( \frac{D_{imt}}{D_{mt}} \right)^2$$

Deposit betas

- Large banks – banks with > 50 million depositors
  - Control > 30% of all branches in Brazil and > 40% of assets
  - Main results robust to including banks with > 20 million depositors

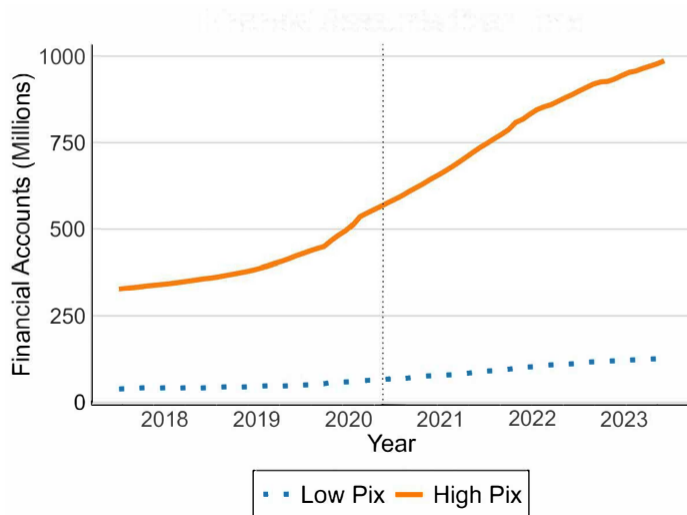
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## Other payment methods in Brazil

- Debit and credit cards used to be the most popular means of payment
- Boleto Bancário has been launched in 1993 for retail payments:
  - Piece of paper (now electronic) to scan in the bank app
- TED is used for wholesale payments

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# Number of accounts rises: Liang et al (2024)

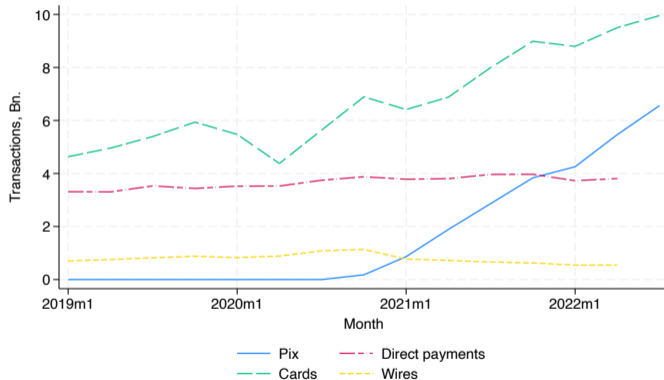


## Credit and debit card fees in Brazil

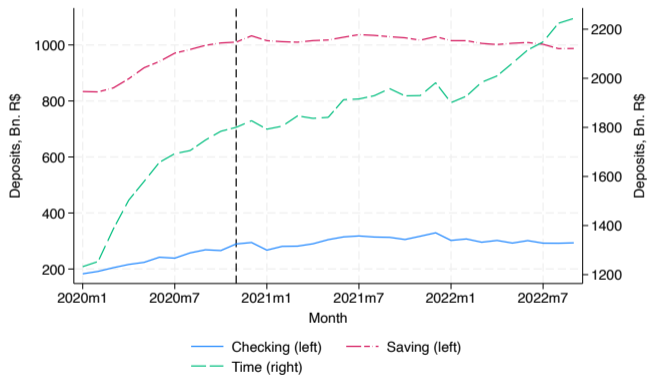
- Credit card fees are around 2.2%
- Debit card fees are around 1%
- Merchants charge customers for fees – surcharges are legal
- Paying in cash and Pix is often cheaper

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# Electronic means of payment in Brazil, quantities

[▶ Back](#)

# Deposits in Brazil


[▶ OLS results](#)
[▶ IV results](#)

## Data definitions

Name	Source	Frequency	Point of observation
Pix volume	Banco Central	Monthly	Municipality
Pix transactions	Banco Central	Monthly	Municipality
Assets	ESTBAN	Monthly	Branch
Deposits	ESTBAN	Monthly	Branch
Loans	ESTBAN	Monthly	Branch
Reserves	ESTBAN	Monthly	Branch
Loan rates	Banco Central	Monthly	Bank
Investments	IPEA	Annual	Municipality
Savings	IPEA	Annual	Municipality
GDP per capita	IBGE	Annual	Municipality
Demographics	IBGE	Only 2010	Municipality
Inflation	Banco Central	Monthly	Country
Exchange rates	Banco Central	Monthly	Country
Unemployment	Banco Central	Monthly	Country

## Summary statistics

	Large banks			Small banks		
	Mean	Median	Std. dev.	Mean	Median	Std. dev.
Panel A: Before Pix launch (ESTBAN)						
Checking deposits (bn. R\$)	21.1	21	5.5	0.39	0.09	1
Saving deposits (bn. R\$)	117.3	117.3	21.7	1.3	0	6
Time deposits (bn. R\$)	35.1	34.4	7.6	3.4	1.1	8.1
Total loans (bn. R\$)	58.5	58.7	11.6	2.2	0.6	4.3
Total financing (bn. R\$)	5.5	5.5	5.1	0.8	0.08	2.3
Total assets (tn. R\$)	2.9	2.8	2.4	0.1	0.02	0.3
Checking deposits (% in total)	12	12	3.3	23	8.1	33
Saving deposits (% in total)	67	67	9.2	6.2	0	18
Time deposits (% in total)	20	20	5.4	71	90	35
Observations (branch×month)		8,250			18,134	
Panel B: After Pix launch (ESTBAN)						
Checking deposits (bn. R\$)	22.5	22.9	6.8	0.42	0.09	1.2
Saving deposits (bn. R\$)	120.3	120.4	22.2	1.4	0	6.3
Time deposits (bn. R\$)	35.9	36.2	9.5	3.6	1.1	8.7
Total loans (bn. R\$)	61.5	61.8	11.5	2.5	0.7	4.5
Total financing (bn. R\$)	5.5	5.5	5.1	0.8	0.06	2.3
Total assets (tn. R\$)	3.1	3	2.8	0.1	0.03	0.3
Checking deposits (% in total)	13	13	3.2	23	7.2	32
Saving deposits (% in total)	67	67	10	6.2	0	18
Time deposits (% in total)	20	20	6	71	88	35
Observations (branch×month)		8,250			17,985	

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# Large banks originate riskier loans

$$\log Y_{imt} = \delta \cdot \log Pix_{mt} \cdot S_j + \gamma X_{imt} + \theta_t + \alpha_j + \eta_{mt} + o_{imt}$$

	<i>Dependent variable:</i>		
	Loans (1)	Financing (2)	Alternative funding (3)
$Pix \cdot Small$	-0.005 (0.004)	0.019** (0.008)	-0.198*** (0.017)
Bank FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Muni $\times$ Time FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	32,097	32,097	27,840
R <sup>2</sup>	0.928	0.949	0.733

Standard errors are clustered at the municipality level

# Large banks rely on uninsured financing

$$\log F_{imt} = \delta \cdot \log Pix_{mt} \cdot S_j + \gamma X_{imt} + \theta_t + \alpha_j + \eta_{mt} + o_{imt}$$

	<i>Dependent variable:</i>		
	Loans (1)	Financing (2)	Alternative funding (3)
Pix · Small	-0.005 (0.004)	0.019** (0.008)	-0.198*** (0.017)
Bank FE	Yes	Yes	Yes
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Controls	Yes	Yes	Yes
Observations	32,097	32,097	27,840
R <sup>2</sup>	0.928	0.949	0.733

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# Pix increases loans of small banks less than deposits

$$\log D_{imt} = \delta \cdot \log \widehat{Pix}_{mt} \cdot S_i + \gamma X_{imt} + \eta_{mt} + \varepsilon_{imt}$$

	<i>Dependent variable:</i>			
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)	Total loans (4)
Pix · Small	0.033*** (0.008)	0.004 (0.011)	0.150*** (0.006)	0.037*** (0.008)
Muni × Time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	7,123	7,123	7,123	7,123
R <sup>2</sup>	0.486	0.402	0.027	0.254

Standard errors are clustered at the municipality level

Significance: 10%\*, 5%\*\* , 1%\*\*\*

▶ Additional results

## Pix increases loans of all banks

$$\log D_{imt} = \delta \cdot \widehat{\log Pix}_{mt} + \gamma X_{imt} + \theta_t + \eta_{mt} + \varepsilon_{imt}$$

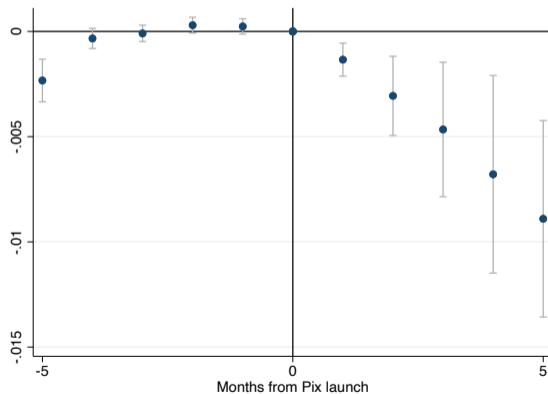
	<i>Dependent variable:</i>			
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)	Total loans (4)
Pix	0.037*** (0.003)	0.014*** (0.001)	0.040*** (0.007)	0.024*** (0.002)
Controls	Yes	Yes	Yes	Yes
Observations	4,488	4,488	4,488	4,488
R <sup>2</sup>	0.697	0.699	0.449	0.604

Standard errors are clustered at the municipality level

Significance: 10%\*, 5%\*\* , 1%\*\*\*

# Deposit markets become more competitive

$$HHI_{m,t+s} = \theta PixPerCap_{mt} + \delta HHI_{m,t-1} + \gamma X_{mt} + \eta_{mt}$$



Branches

Deposit betas

▶ OLS

## Boleto increased deposit market concentration

	<i>Dependent variable:</i>		
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)
Boleto · Small	-0.029* (0.016)	-0.761*** (0.236)	0.271*** (0.095)
Bank FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	509,088	509,088	509,088
R <sup>2</sup>	0.894	0.860	0.812



# Pix impact is dampened in concentrated areas

	<i>Dependent variable:</i>					
	Checking deposits		Saving deposits		Time deposits	
	(1)	(2)	(3)	(4)	(5)	(6)
Pix	0.043 (0.027)	0.121* (0.066)	-0.078** (0.038)	-0.083 (0.090)	0.256*** (0.048)	0.699*** (0.116)
HHI	0.044** (0.018)	-0.020 (0.019)	-0.016 (0.027)	-0.064** (0.025)	-0.257*** (0.046)	-0.213*** (0.045)
Pix · Large	-0.016** (0.006)	-0.024*** (0.008)	-0.025*** (0.006)	-0.026*** (0.008)	-0.019* (0.011)	-0.047*** (0.015)
HHI · Large		0.141*** (0.013)		0.100*** (0.020)		-0.040 (0.030)
Pix · HHI		0.001 (0.011)		-0.008 (0.013)		0.069*** (0.020)
Pix · Large · HHI		0.037*** (0.007)		0.019*** (0.007)		0.041*** (0.014)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36,496	36,496	36,496	36,496	36,496	36,496
R <sup>2</sup>	0.852	0.853	0.945	0.945	0.900	0.900

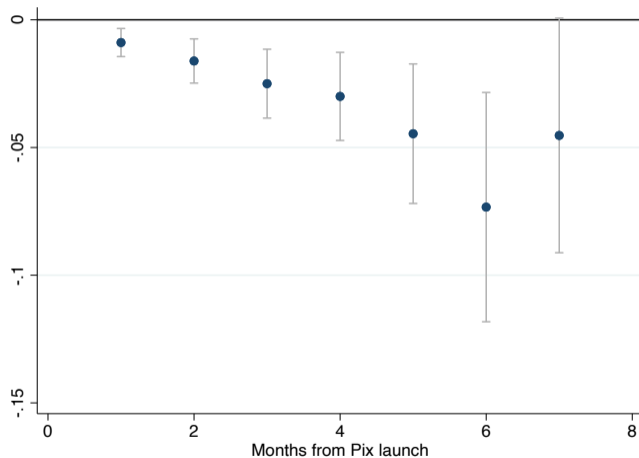
# Bootstrapped standard errors

	<i>Dependent variable:</i>		
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)
Pix · Small	0.030*** (0.010)	0.032** (0.016)	0.043*** (0.015)
Bank FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Muni × Time FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	32,097	32,097	32,097
R <sup>2</sup>	0.882	0.961	0.923

## Pix does not increase the number of small bank branches

	<i>Dependent variable:</i>			
	Number of agencies			
	(1)	(2)	(3)	(4)
Pix	0.044*** (0.008)	0.042 (0.027)	0.044*** (0.008)	0.042 (0.027)
Pix · Small	-0.042*** (0.001)	-0.073*** (0.011)	-0.042*** (0.001)	-0.073*** (0.011)
Bank FE	Yes	No	Yes	No
Time FE	Yes	Yes	No	No
Controls	Yes	Yes	Yes	Yes
Observations	18,283	18,283	18,283	18,283
R <sup>2</sup>	0.999	0.593	0.999	0.593

# Pix does not impact the number of bank branches

[▶ OLS results](#)[▶ IV results](#)

## Deposit betas

- HHI does not fully capture deposit market power
  - Payment convenience itself is a non-location source of market power
- Use deposit betas: for each bank run

$$\log D_{it} = \beta \Delta i_t + \gamma X_{it} + u_{it}$$

where  $i_t$  is a Selic rate

- $\beta < 0$ , low values imply more market power

▶ Definitions

▶ OLS results

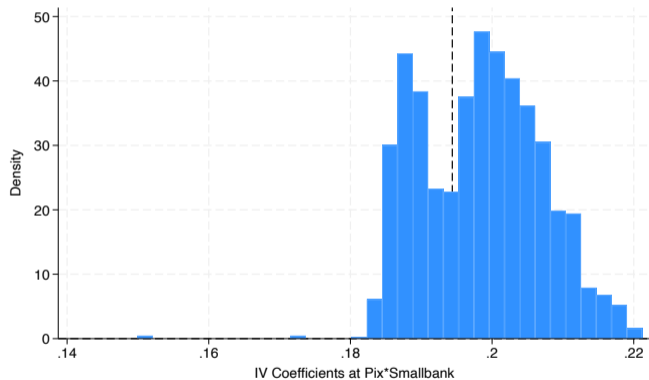
▶ IV results

▶ Additional results

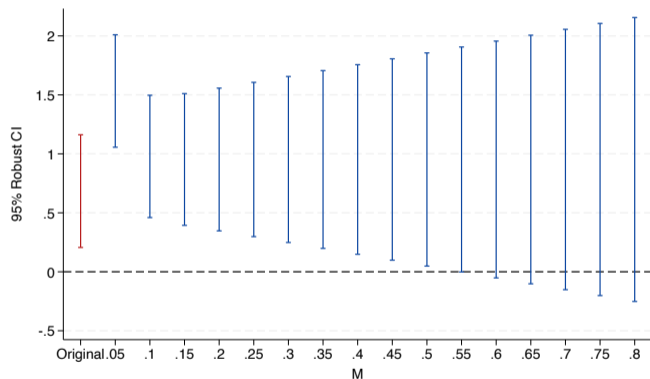
# Pix increases deposit betas of large banks relative to small banks

	<i>Dependent variable:</i>			
	Saving deposits		Time deposits	
	(1)	(2)	(3)	(4)
Pix	0.042*** (0.004)	0.043*** (0.004)	0.104*** (0.038)	0.100*** (0.039)
HHI	0.001*** (0.000)	0.000*** (0.000)	-0.013*** (0.003)	-0.000 (0.001)
Small	-0.015*** (0.000)		-0.023*** (0.001)	
Pix · Small	-0.024*** (0.000)	-0.024*** (0.000)	-0.043*** (0.002)	-0.042*** (0.002)
Bank FE	No	Yes	No	Yes
Time FE	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes
Observations	297,654	297,654	297,654	297,654
R <sup>2</sup>	0.211	0.283	0.024	0.148

## Altonji et al (2005) pre-trend tests

[▶ Back](#)

## Rambachan and Roth (2023) honest pre-trends

[▶ Back](#)

## Pix is more popular in competitive areas

	<i>Dependent variable:</i>		
		Pix	Initial Pix
	(1)	(2)	(3)
HHI	-0.107*** (0.012)	-0.107*** (0.012)	-0.0439*** (0.004)
Time FE	No	Yes	Cross-Section
Controls	Yes	Yes	Yes
Observations	6,360	6,360	3,179
R <sup>2</sup>	0.239	0.239	0.169

## Summary statistics: IV

	Eased restrictions			Kept restrictions		
	Mean	Median	Std. dev.	Mean	Median	Std. dev.
Population (th.)	56	23	148	44	19	102
% under 40 y.o.	41	41	3.1	41	41	3.1
% males	50	50	1.3	50	50	1.6
% single responsible	71	72	8	71	72	8.2
% urban	75	80	19	74	78	20
% illiterate	14	11	9.7	14	11	9.3
Deposit HHI	0.54	0.44	0.29	0.58	0.51	0.30

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# Heteroskedasticity-based identification

- Consider the model of simultaneous equations:

$$P_{ix_{mt}} = \delta D_{mt} + \gamma_P F_{mt} + u_{mt}$$

$$D_{mt} = \alpha P_{ix_{mt}} + \gamma_D F_{mt} + \varepsilon_{mt}$$

# Heteroskedasticity-based identification

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- **Standard IV:** treatment  $\Rightarrow Pix_{mNov} \Rightarrow D_{mNov} - D_{mOct}$ 
  - Assumptions on  $u_{mt}$  and  $\varepsilon_{mt}$

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First stage

- $m'$  – treated,  $m^0$  – control. Identification assumptions:

- $(\sigma_{m'Nov}^u)^2 - (\sigma_{m'Oct}^u)^2 > (\sigma_{m^0Nov}^u)^2 - (\sigma_{m^0Oct}^u)^2$

# Heteroskedasticity-based identification

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$$Pix_{mt} = \delta D_{mt} + \gamma_P F_{mt} + u_{mt}$$

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First stage

- $m'$  – treated,  $m^0$  – control. Identification assumptions:

- $(\sigma_{m'Nov}^u)^2 - (\sigma_{m'Oct}^u)^2 > (\sigma_{m^0Nov}^u)^2 - (\sigma_{m^0Oct}^u)^2$

- $(\sigma_{m'Nov}^\varepsilon)^2 - (\sigma_{m'Oct}^\varepsilon)^2 = (\sigma_{m^0Nov}^\varepsilon)^2 - (\sigma_{m^0Oct}^\varepsilon)^2$

- $(\sigma_{m'Nov}^F)^2 - (\sigma_{m'Oct}^F)^2 = (\sigma_{m^0Nov}^F)^2 - (\sigma_{m^0Oct}^F)^2$  COVID impact

## Rigobon-Sack IV procedure

- Keep October and November in the sample
- First-stage regression:

$$PixPerCap_{mt} = \alpha Eased_m + \theta Pix_t + \gamma Eased_m Pix_t + \eta Eased_m PixPerCap_{mt} + u_{mt}$$

- $Eased_m = 1$  for treated municipalities,  $Pix_t = 1$  for November 2020
- Second-stage regression:

$$HHI_{m,t+s} = \theta Pix \widehat{PerCap}_{mt} + \delta HHI_{m,t} + \gamma X_{mt} + \eta_{mt}$$

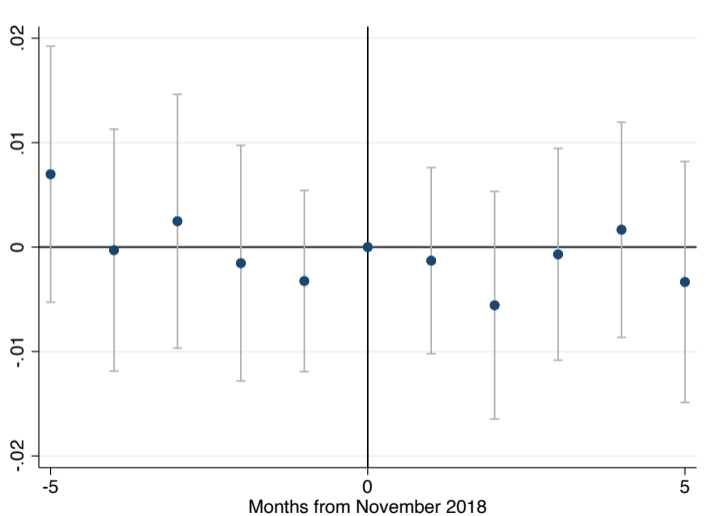
## COVID restriction did not increase deposits

	<i>Dependent variable:</i>					
	Checking deposits		Saving deposits		Time deposits	
	(1)	(2)	(3)	(4)	(5)	(6)
Masks	-0.048 (0.092)		-0.152** (0.076)		-0.371 (0.287)	
Isolation		-0.098*** (0.034)		-0.014 (0.032)		-0.142 (0.129)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,326	2,331	2,326	2,331	2,326	2,331
R <sup>2</sup>	0.773	0.774	0.792	0.793	0.486	0.487

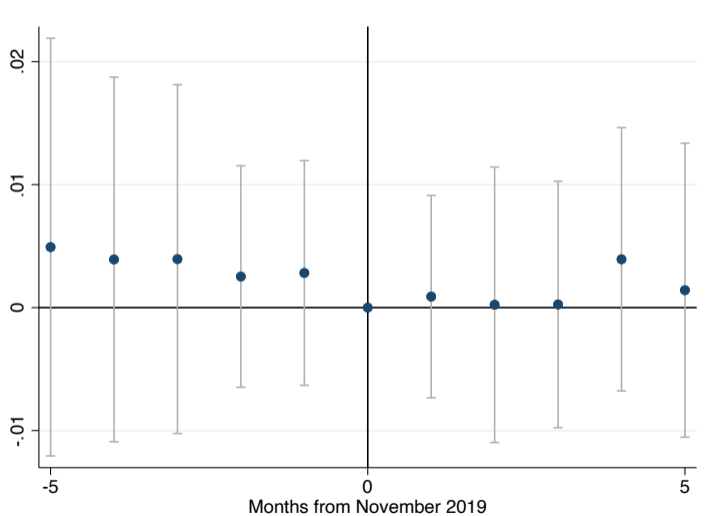
## IV first-stage estimation

	<i>Dependent variable:</i>			
	Pix			
	(1)	(2)	(3)	(4)
Eased	-0.128*** (0.027)	-0.128*** (0.027)		
Post Pix	13.750*** (0.037)		13.750*** (0.041)	
Eased · Post Pix	0.357*** (0.045)	0.357*** (0.045)	0.357*** (0.050)	0.357*** (0.050)
Municipality FE	No	No	Yes	Yes
Time FE	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes
Observations	7,124	7,124	7,122	7,122
R <sup>2</sup>	0.984	0.984	0.986	0.986

## Placebo test: 2018

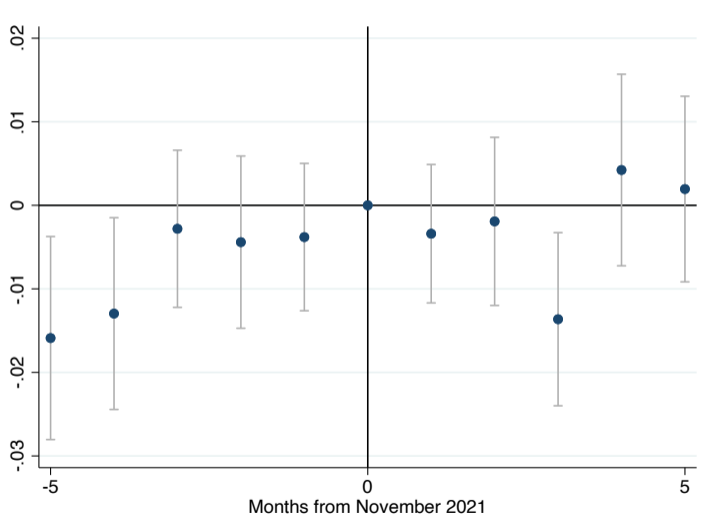
[Back](#)

## Placebo test: 2019



▶ Back

## Placebo test: 2021

[Back](#)

## FHS pre-trend test

- I formally test if there is no pre-trend
- Use [Freyaldenhoven, Hansen, and Shapiro \(2019\)](#) test
- A no-pre-trend null hypothesis is accepted with P-value of 0.8915
- Also supported by [Rambachan and Roth \(2023\)](#) "honest pre-trend" test

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## Instrumenting access to Pix

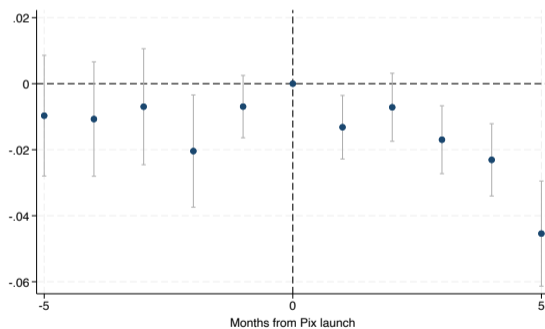
- Access to 4G and 5G internet in Brazilian municipalities as an instrument for **Pix access**
- **Relevance:** Pix is used more in areas with access to 4G and 5G internet
- **Exclusion:** Access to internet impacts deposit competition **only** via Pix
- Data from Anatel

## First-stage results: access to Pix

	<i>Dependent variable:</i>	
	Per Capita Pix	
	(1)	(2)
High Speed	-0.017*** (0.001)	-0.017*** (0.001)
Post Pix	12.87*** (0.036)	
High Speed · Post Pix	0.057*** (0.002)	0.057*** (0.002)
Time FE	No	Yes
Controls	Yes	Yes
Observations	5,719	5,719
R <sup>2</sup>	0.985	0.985

## Second-stage results: access to Pix

$$HHI_{m,t+s} = \theta \widehat{PixPerCap}_{mt} + \delta HHI_{m,t-1} + \gamma X_{mt} + \eta_{mt}$$



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## Cross-sectional Rigobon-Sack results

	<i>Dependent variable:</i>			
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)	Total loans (4)
Pix	3.340*** (0.359)	2.813*** (0.337)	12.00*** (1.905)	2.889*** (0.474)
Controls	Yes	Yes	Yes	Yes
Observations	2,243	2,243	2,243	2,243
R <sup>2</sup>	0.790	0.806	0.491	0.693

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## Large banks defined as top 5

	<i>Dependent variable:</i>			
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)	Total loans (4)
Pix · Small	0.019 (0.021)	0.387*** (0.083)	0.201*** (0.052)	0.088*** (0.029)
Muni × Time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	16,330	16,330	16,330	16,330
R <sup>2</sup>	0.161	0.224	0.587	0.009

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## Standard IV results: six-month window

	<i>Dependent variable:</i>				
	Checking (1)	Saving (2)	Time (3)	Loans (4)	Deposit rates (5)
Pix · Small	0.011** (0.006)	0.017*** (0.005)	0.009* (0.005)	0.009* (0.005)	-0.183*** (0.010)
Bank FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Muni × Time FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Observations	25,292	25,292	25,292	25,292	12,653
R <sup>2</sup>	0.848	0.936	0.899	0.856	0.902

Standard errors are clustered at the municipality level

Significance: 10%\*, 5%\*\* , 1%\*\*\*

## IV without muni-time FEs

	<i>Dependent variable:</i>			
	Checking deposits (1)	Saving deposits (2)	Time deposits (3)	Total loans (4)
Pix	0.019*** (0.003)	0.006*** (0.001)	-0.050*** (0.008)	0.003 (0.002)
Pix · Small	0.018*** (0.006)	0.002 (0.005)	0.115*** (0.015)	0.028*** (0.006)
Muni × Time FE	No	No	No	No
Controls	Yes	Yes	Yes	Yes
Observations	7,123	7,123	7,123	7,123
R <sup>2</sup>	0.181	0.112	0.020	0.110

# Pix does not increase GDP per capita in 2020

	<i>Dependent variable:</i>	
	HC (1)	Standard IV (2)
Pix	-0.004* (0.002)	-0.005*** (0.002)
Controls	Yes	Yes
Observations	7,124	7,124
R <sup>2</sup>	0.426	0.426

▶ OLS results

▶ IV results

## Pix increases capital investments and savings

	<i>Dependent variable:</i>			
	Investments 2021 (1)	Investments 2020 (2)	Savings 2021 (3)	Savings 2020 (4)
Pix	0.148*** (0.0187)	0.139*** (0.0182)	0.030*** (0.00586)	-0.013*** (0.00325)
Lag	0.545*** (0.021)	0.584*** (0.018)	1.003*** (0.009)	0.925*** (0.008)
Demographic controls	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes
Observations	3,152	3,166	3,089	3,178
R <sup>2</sup>	0.727	0.756	0.984	0.994

[▶ Deposit results](#)
[▶ Loan results](#)
[▶ IV results](#)

# Small bank equity returns rise relative to large banks

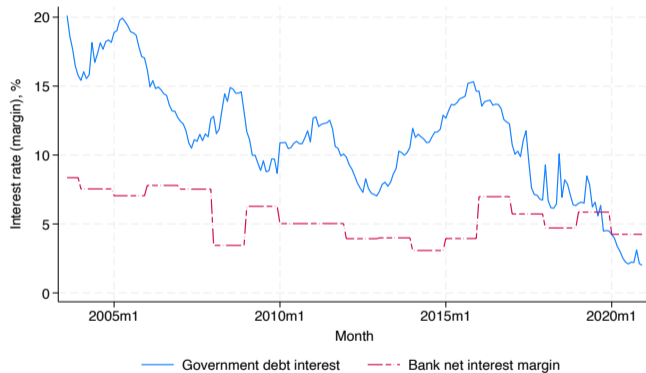
	<i>Dependent variable:</i>			
	Equity returns			
	(1)	(2)	(3)	(4)
Pix	-0.009 (0.012)	-0.025* (0.014)	-0.009 (0.013)	-0.026* (0.014)
Small	-0.001 (0.010)	-0.001 (0.009)	-0.000 (0.012)	-0.001 (0.010)
Pix · Small	0.003 (0.013)	0.003 (0.011)	0.002 (0.013)	0.003 (0.012)
Constant	0.011 (0.009)	0.010 (0.010)	0.011 (0.010)	0.010 (0.010)
Bank FE	No	No	Yes	Yes
Time FE	No	Yes	No	Yes
Observations	314	314	314	314
R <sup>2</sup>	0.053	0.349	0.087	0.386

## Small bank profitability rises relative to large banks

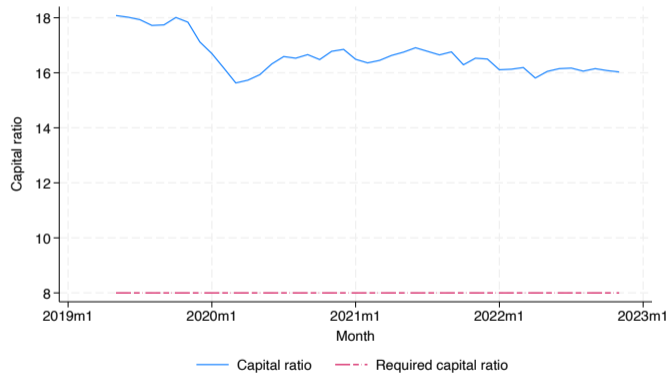
	<i>Dependent variable:</i>	
	Return on assets	
	(1)	(2)
Pix · Small	0.320*** (0.009)	0.132*** (0.003)
Bank FE	No	Yes
Muni × Time FE	Yes	Yes
Observations	15,986	15,986
R <sup>2</sup>	0.486	0.646

Small banks are able to extract more profits – increase in market power

# Net interest margins of Brazilian banks

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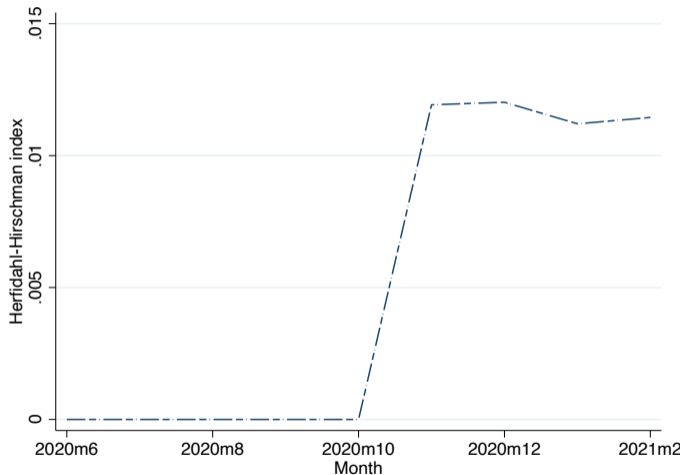
# Capital ratios of Brazilian banks

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## Competition among small banks

- Pix makes it easier to transfer money between banks
  - including between small banks
- Competition among small banks should intensify
  - Upward pressure on deposit rates
- Counterfactual where small banks do not get transfer benefits

# Fiercer competition among small banks



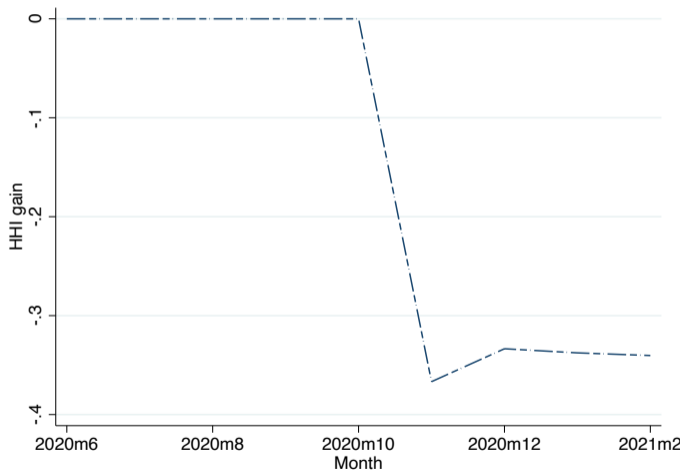
## Counterfactual: Deposits stay inelastic

- Pix makes deposits less sticky
  - Demand gets more sensitive to deposit rates

## Counterfactual: Deposits stay inelastic

- Pix makes deposits less sticky
  - Demand gets more sensitive to deposit rates
- Sticky deposits – set  $\theta^{cf} = 0$

# HHI would have been lower if deposits remained inelastic



# Intuition

- Deposit markets would have become even more competitive if deposits stayed sticky

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- Depositors **do not** move because small banks **change** deposit rates
  - They move because small banks **initially** pay higher deposit rates

# Intuition

- Deposit markets would have become even more competitive if deposits stayed sticky
- Depositors **do not** move because small banks **change** deposit rates
  - They move because small banks **initially** pay higher deposit rates
- Small banks **reduce deposit rates** in response and lose some potential depositors

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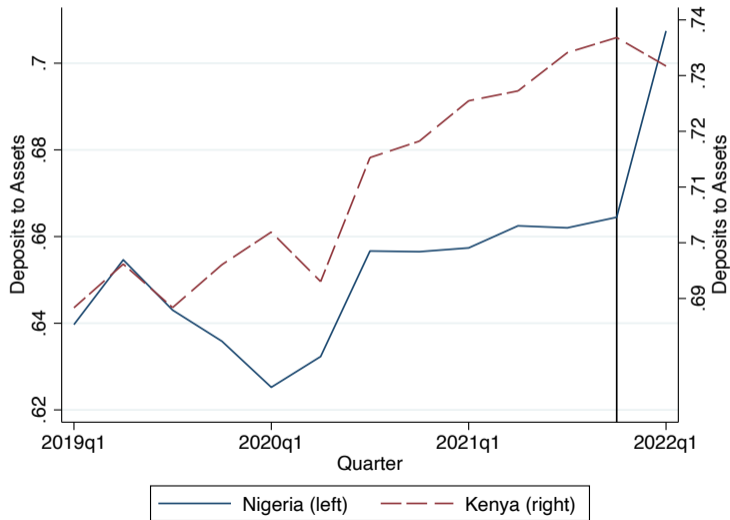
# CBDC

- Central Bank Digital Currency (CBDC) is a digital analog of cash
- 90% of central banks in the world consider CBDC, two already adopted one
- Main concern is that households will prefer CBDC to bank deposits – **crowding-out effect** which in turn leads to a **contraction in lending**
- Literature claims that CBDC will crowd out bank deposits
- CBDC is an instant payment system as well

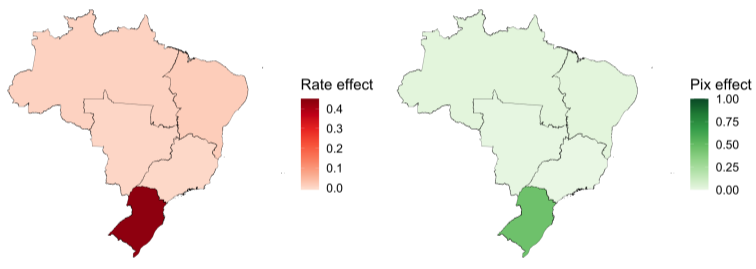
# Data

- Nigeria is the largest country to have launched CBDC – e-Naira in October 2021
- Hand-collect banking data from Nigeria
- Hand-collect banking data from Kenya to compare two neighboring countries

# CBDC increases deposits in Nigeria



# Regional estimation



## Separate post- and pre-Pix estimation

Parameter	Symbol	Pre-Pix	Post-Pix
Sensitivity to deposit rates	$\alpha$	0.129	
Sensitivity to deposit rate with Pix	$\theta$		0.136
Relative sensitivity to Pix for small banks	$\delta$		0.099

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# Households

- Choose consumption and deposits to maximize their utility

$$U_0^i = \sum_{t=0}^T \log C_t^i$$

subject to

$$C_t^i + DL_{t+1}^i + DS_{t+1}^i \leq Y_t^i + DL_t^i(1 + r_t^{d\ell}) + DS_t^i(1 + r_t^{ds})$$

## Households

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subject to

$$C_t^i + DL_{t+1}^i + DS_{t+1}^i \leq Y_t^i + DL_t^i(1 + r_t^{dl}) + DS_t^i(1 + r_t^{ds})$$

$$\eta C_t^i \leq DL_t^i + \varepsilon_t^i DS_t^i$$

- $\eta$  – share of goods that require large bank deposits,  $\varepsilon_t^i$  is an iid shock with support  $[0, \varepsilon^u]$

# Timeline

1. Decide on composition of portfolio
  2.  $\varepsilon^i$  is realized
  3. Decide on consumption
- Such structure results in **precautionary savings**

## Banks

- Both large and small banks choose deposits and loans to maximize their value

$$V(D_t^b, L_t^b) = \max_{D_{t+1}^b, L_{t+1}^b} \phi N_t^b + \beta \mathbb{E}_t V(D_{t+1}^b, L_{t+1}^b)$$

where  $N_t = L_t - D_t$

subject to the budget constraint

$$(1 - \phi) N_t^b \geq \frac{1}{1 + r_{t+1}^{lb}} L_{t+1}^b - \frac{1}{1 + r_{t+1}^{db}} D_{t+1}^b$$

and leverage constraint

$$\frac{1}{1 + r_{t+1}^{db}} D_{t+1}^b \leq \xi \frac{1}{1 + r_{t+1}^{lb}} L_{t+1}^b$$

# Instant payment system

- Instant payment system can be launched with two designs:
  - ① Available to all banks (like Pix)
  - ② Available to large banks (like Zelle and Swish)
- If IPS is available only to large banks, **it does not impact deposits**
  - **Increase in deposit market concentration** in the model with cash

Economy with cash

## Cashless economy results

### Proposition

*In partial equilibrium, i.e., with fixed interest rates and exogenous endowment,  $Y_t$ , increase in support of  $\varepsilon_t^i$  from  $[0, \varepsilon^u)$  to  $(\varepsilon^l, 1]$  in the evening of the preceding period leads to an increase in  $DS_t$  relative to  $DL_t$ .*

# Cashless economy results

## Proposition

*In partial equilibrium, i.e., with fixed interest rates and exogenous endowment,  $Y_t$ , increase in support of  $\varepsilon_t^i$  from  $[0, \varepsilon^u)$  to  $(\varepsilon^l, 1]$  in the evening of the preceding period leads to an increase in  $DS_t$  relative to  $DL_t$ .*

- Reduction in deposit market concentration

Economy with cash

# Interest rates

## Proposition

Assume an increase (or no change) in  $\frac{DS_t^i}{DL_t^i}$  for all households and an increase for at least one household. Then, the following holds:

- 1 reduction in  $r_t^{ds} - r_t^{dl}$ ;
- 2 increase in  $\frac{L_t^s}{L_t^l}$ ;
- 3 reduction in  $r_t^{ls} - r_t^{ll}$ .

# Interest rates

## Proposition

Assume an increase (or no change) in  $\frac{DS_t^i}{DL_t^i}$  for all households and an increase for at least one household. Then, the following holds:

- 1 reduction in  $r_t^{ds} - r_t^{dl}$ ;
- 2 increase in  $\frac{L_t^s}{L_t^l}$ ;
- 3 reduction in  $r_t^{ls} - r_t^{ll}$ .

- Small banks pay relatively lower deposit rates and charge relatively lower loan rates

## Model predictions

- ① Instant payment systems available to all banks **reduce** deposit market concentration
  - Magnitudes depend on available functions and mitigated frictions
- ② Spreads between interest rates of small and large banks **shrink**
- ③ Deposits and loans **increase**
- ④ Instant payment systems available only to large banks **increase** deposit market concentration

## Model with cash

- Choose consumption and deposits to maximize their utility

$$U_0^i = \sum_{t=0}^T \log C_t^i$$

subject to

$$C_t^i + DL_{t+1}^i + DS_{t+1}^i + M_{t+1}^i \leq Y_t^i + DL_t^i(1 + r_t^{dl}) + DS_t^i(1 + r_t^{ds}) + M_t^i$$

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$$\eta^l C_t^i \leq M_t + u_t^i DL_t^i$$

$$\eta^s C_t^i \leq M_t + DL_t^i + \varepsilon_t^i DS_t^i$$

- $\varepsilon_t^i$  and  $u_t^i$  are iid shocks with supports  $[0, \varepsilon^u)$  and  $[0, u^u)$

# Timeline

1. Decide on composition of portfolio
2.  $\varepsilon^i$  and  $u^i$  are realized
3. Decide on consumption
  - Such structure results in **precautionary savings** of cash and large bank deposits

▶ Back

## Results for the economy with cash

### Proposition

*In partial equilibrium, i.e., with fixed interest rates and exogenous endowment,  $Y_t$ ,*

- ① *increase in support of  $\varepsilon_t^i$  from  $[0, \varepsilon^u)$  to  $(\varepsilon^l, 1]$  in the evening of the preceding period leads to an increase in  $DS_t$  relative to  $DL_t$  and  $M_t$ ;*
- ② *increase in support of  $\varepsilon_s^i$  from  $[0, \varepsilon^u)$  to  $(\varepsilon^l, 1]$  in the evening of the preceding where  $s > t$  leads to an increase in  $DS_t$  relative to  $DL_t$  if the horizon of the model is finite;*
- ③ *increase in support of  $u_t^i$  from  $[0, u^u)$  to  $(u^l, 1]$  in the evening of the preceding period leads to an increase in  $DL_t$  relative to  $DS_t$  and  $M_t$ ;*
- ④ *increase in support of  $u_s^i$  from  $[0, u^u)$  to  $(u^l, 1]$  in the evening of the preceding period where  $s > t$  leads to an increase in  $DL_t$  relative to  $DS_t$  and  $M_t$  if the horizon of the model is finite.*