Instant Payment Systems and Competition for Deposits

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Motivation and question

- Substantial frictions when making payments and transfers $\Rightarrow$ demand for payment technologies
- **Instant payment systems** (IPS) – bank-dependent technologies for fast payments without fees for users (unlike credit cards)
- Examples: UPI (India), FedNow (US), Pix (Brazil), Swish (Sweden)

Question: How do instant payment systems impact banking landscape?

Introduction of Pix in Brazil

- Introduction of **Pix** in Brazil in November 2020
- Pix became a dominant means of payments
- Larger banks required to offer, smaller banks have cheap access
- >95% of banks joined $\Rightarrow$ potential changes to market concentration

Overview of the results

- Granular data on *Pix* transactions

1. Persistent reduction in deposit market concentration

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

- Small banks **increase** deposits and **reduce** interest rates relative to large banks

2. **Increase** in deposits and loans

Channel: banks offer *more payment convenience*, especially small banks

Pix in Brazil

- Launched in November 2020 by the central bank for within-second transfers and payments
- Requires bank account to use – large banks were forced to offer
- Offered by >95% intermediaries and used by >65% people in all municipalities
- Free for banked households, cheap for banks
- Cheap for merchants – fees ∼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

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	Average large bank	Average small bank
Regional offices	2,064	52
Number of ATMs	23,550	1,763
Online banking app users	27,5 million	0.8 million
Salary accounts	w.p. 100%	w.p. 5.2%
Credit card user base	15 million	1.7 million

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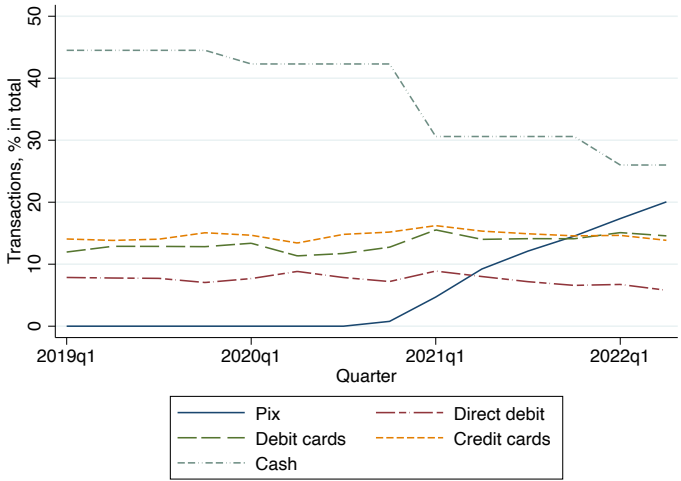
Salary accounts	w.p. 100%	w.p. 5.2%
Credit card user base	15 million	1.7 million

- **Large banks dominated small banks in terms of payment convenience**

Transfers and payments before Pix

- Wait times and/or fees for transfers unless within the same bank
- 2.2% credit card fee, 1% debit card fee – merchants passed on customers
- Cashless payment slip (*Boleto Bancario*) only available to clients of ∼15% of banks
- Cash-only 'underground economy' – roughly 20% of Brazilian GDP

Pix dominates other electronic means of payments



Quantities

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)

Details Summary statistics

Benchmark empirical strategy

- How does Pix impact **deposits of small banks**?

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

municipality m, bank i, month t, S_i – small bank dummy

time window – 3 months before the Pix launch and 3 months after

- How does Pix impact **interest rates**?

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

municipality m, bank i, month t, S_i – small bank dummy

time window – 3 months before the Pix launch and 3 months after

Small banks increase deposits relative to large banks

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

	Dependent variable:		
	Checking deposits	Saving deposits	Time deposits
	(1)	(2)	(3)
Pix · Small	0.030***	0.032***	0.043***
	(0.005)	(0.005)	(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^2	0.882	0.961	0.923

Standard errors are clustered at the municipality level

Small banks reduce interest rates relative to large banks

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

	Dependent variable:			
	Deposit rates		Public loans	Private loans
	(1)	(2)	(3)	(4)
Pix	−2.894	−3.523	0.021***	−0.000
	(1.881)	(2.671)	(0.003)	(0.005)
Pix · Small	−1.372***	−1.365***	−0.047***	−0.016***
	(0.099)	(0.166)	(0.000)	(0.001)
Denominator	All deposits	Time deposits	–	–
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	18,247	18,196	35,256	34,805
R^2	0.122	0.963	0.932	0.974

Standard errors are clustered at the municipality level

Net interest margins

Identification challenges

1. Reverse causality – Pix is more popular in areas with many banks Details

2. Potential omitted variables – political beliefs unobservables, COVID stimuli, etc

Easing of COVID-19 restrictions

- Easing of COVID-19 restrictions in Brazilian municipalities **by September 2020**
- *Treated* – eased restrictions, *control* – did not ease restrictions
- Assumption: treatment in Sep $\Rightarrow Pix_{mNov} \Rightarrow HHI_{mNov} - HHI_{mOct}$
- Condition on **October 2020** – Pix introduced in **November 2020**
- Heteroskedasticity-based identification – Rigobon (2003), Rigobon and Sack (2004), Hebert and Schreger (2017) Details

Pix increases deposits and loans of small banks relative to large banks

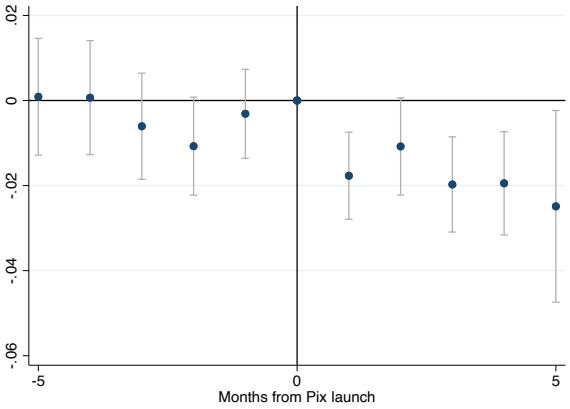
$$\log D_{imt} = \delta \cdot \widehat{\log Pix_{mt}} \cdot S_i + \gamma X_{imt} + \eta_{mt} + \varepsilon_{imt}$$

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

Standard IV Income

Pix causes a reduction in deposit market concentration

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



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

Pix increases deposits and loans

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

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

Why? Payment convenience

- Pix makes deposits more convenient relative to cash – **inflow of deposits**
  - Should be especially relevant for financially constrained households
- Small banks join Pix – boost in their payment convenience relative to large banks
  - Less relevant for constrained households
  - Costs of opening new bank account, social stimuli through large banks
- Interact with municipality-level income per capita

Small bank deposits increase more in less financially constrained municipalities

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

	Dependent variable:			
	Checking deposits	Saving deposits	Time deposits	Total loans
	(1)	(2)	(3)	(4)
Pix · Income	−0.019	−0.038***	−0.304***	−0.049***
	(0.015)	(0.010)	(0.036)	(0.010)
Pix · Small · Income	0.090***	0.060***	0.778***	0.058
	(0.032)	(0.026)	(0.084)	(0.035)
Controls	Yes	Yes	Yes	Yes
Observations	7,123	7,123	7,123	7,123
R^2	0.501	0.406	0.034	0.292

Bank deposits increase less in less financially constrained municipalities

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

	Dependent variable:			
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Deposit demand estimation

- How does Pix impact deposit demand conditional on interest rates?

- IO-style model of deposit demand

- What if Pix were **not introduced** or were available to **only** large banks?

- Study model counterfactuals

Brief estimation results

- Deposit rates **positively** impact deposit demand
- Pix increases **demand for small bank deposits**
- Deposit demand becomes **more sensitive** to deposit rates after Pix

Brief estimation results

- Deposit rates **positively** impact deposit demand
- Pix increases **demand for small bank deposits**
- Deposit demand becomes **more sensitive** to deposit rates after Pix
- Deposit markets more concentrated absent Pix
- Deposit markets more concentrated if Pix available **only to large banks**

Conclusion

- Instant payment systems can promote deposit market competition

- Implications for monetary policy, investments and access to credit

- Pix in Brazil leads to an increase in deposits and loans and a reduction in bank interest rates

- Implications for consumers' welfare and choice of payment methods

Model set-up

- Households (mass W_t) choose to invest one dollar to one out of J banks or cash
- Banks face deposit demand and choose their deposits and assets following the equity ratio
  Capital ratios
- All banks offer instant payment systems starting from November 2020
- Banks are split into large and small based on number of depositors

Households' problem

- Households choose the best investment to maximize their utility:

$$\max_{j \in \mathscr{A}^d} u_{i,j}^t = \alpha^d r_j^t + \beta^d p_j^t + \delta^d p_j^t \ell_j + \gamma^d x_j^t + \xi_j + \varepsilon_{i,j}^t$$

  - r_j^t – deposit interest rate of bank j
  - p_j^t – mean of Pix values in municipalities of bank j presence
  - ℓ_j – dummy for large banks
  - ξ_j – product invariant quality difference (bank FEs)
  - $\varepsilon_{i,j}^t$ – relation-specific shock, follows a generalized extreme-value distribution

Large banks originate riskier loans and rely on uninsured financing

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

	Dependent variable:		
	Loans	Financing	Alternative funding
	(1)	(2)	(3)
Pix · Small	0.005	−0.019**	0.198***
	(0.004)	(0.008)	(0.017)
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	27,840
R^2	0.928	0.949	0.733

Standard errors are clustered at the municipality level

Investments Equity returns

Identification concerns

- **Identification concern 1**: interest rates are correlated with unobservable deposit demand

- Fixed costs and provision for loan losses as instruments

- **Identification concern 2**: Pix is correlated with unobservable deposit demand

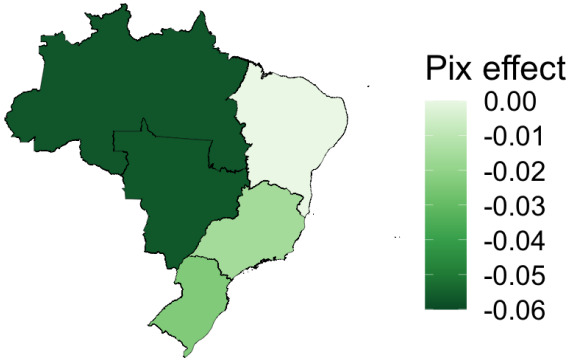
- Easing of COVID-19 restrictions as instruments

GMM estimation results

Parameter	Symbol	Estimate	Standard error
Sensitivity to deposit rates	α^d	0.80^{***}	(0.141)
Sensitivity to Pix	β^d	0.107^{***}	(0.025)
Additional sensitivity to Pix for large banks	δ^d	-0.023^{***}	(0.004)
Observations		2,097	
R^2		0.980	

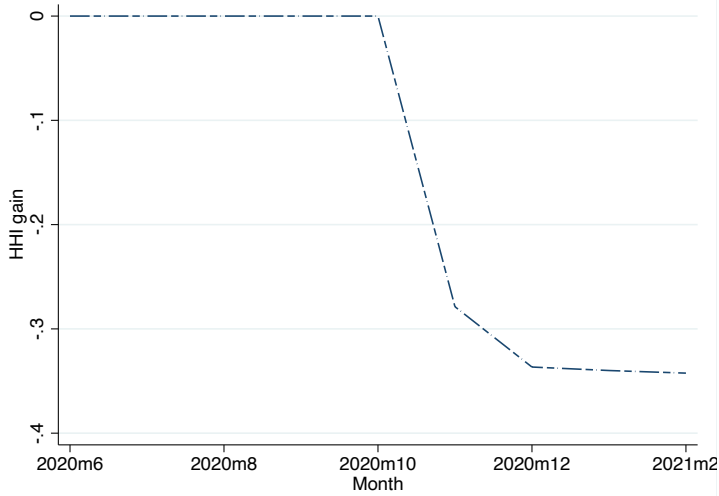
- 1 p.p. $\uparrow$ in deposit rates $\Rightarrow$ 0.8% $\uparrow$ in deposit share
- 1 % $\uparrow$ in Pix $\Rightarrow$ 2.3% $\uparrow$ in small bank deposit shares relative to large banks

Regional estimation

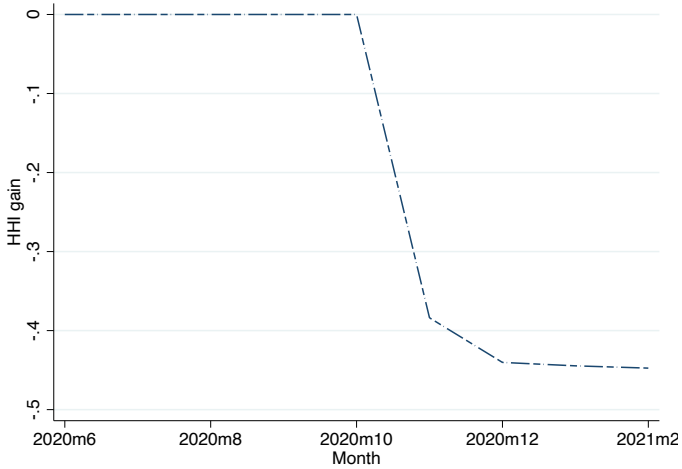


Rate sensitivity Table

HHI would have increased without Pix



HHI would have increased if Pix were available only to large banks



Impact of Boleto
Swish

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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

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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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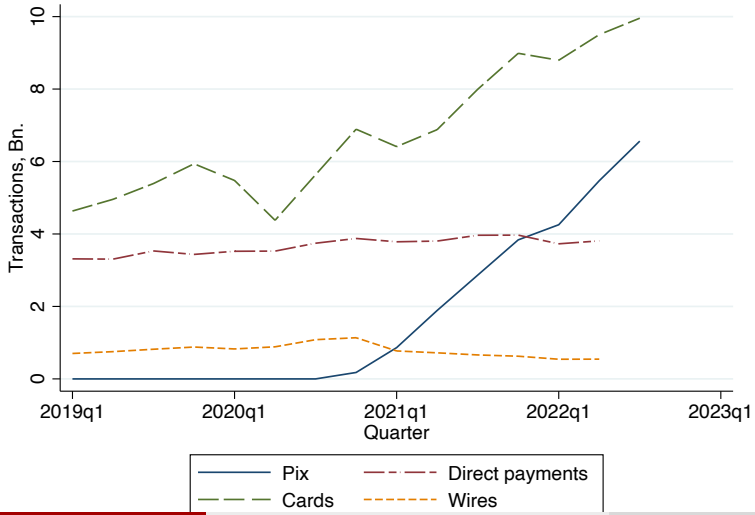
Credit and debit card fees in Brazil

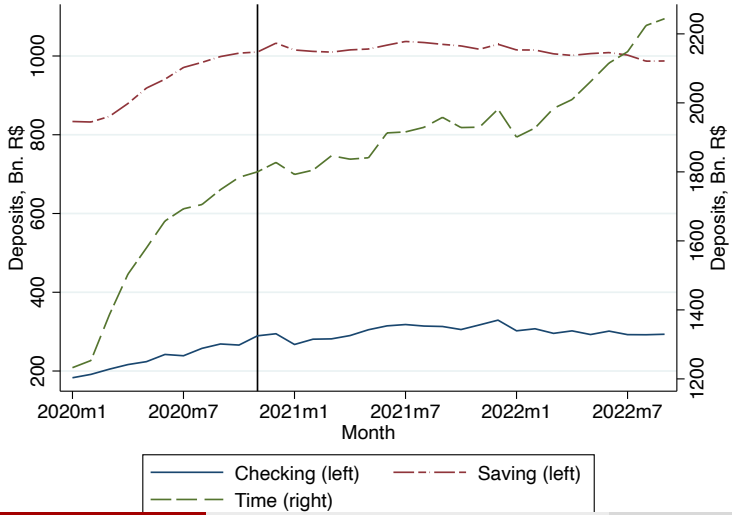
- Credit card fees are around 2.2%
- Debit card fees are around 1%
- Merchants charge customers for fees – surcharges are legal
- Paying in cash and Pix is often cheaper

Back

Electronic means of payment in Brazil, quantities



Deposits in Brazil



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$)	21.1	21	5.5	0.4	0.09	1
Saving deposits (bn. R$)	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	
Observations (bank×month)		4			194	
Panel B: After Pix launch (ESTBAN)						
Checking deposits (bn. R$)	22.5	22.9	6.8	0.4	0.09	1.2
Saving deposits (bn. R$)	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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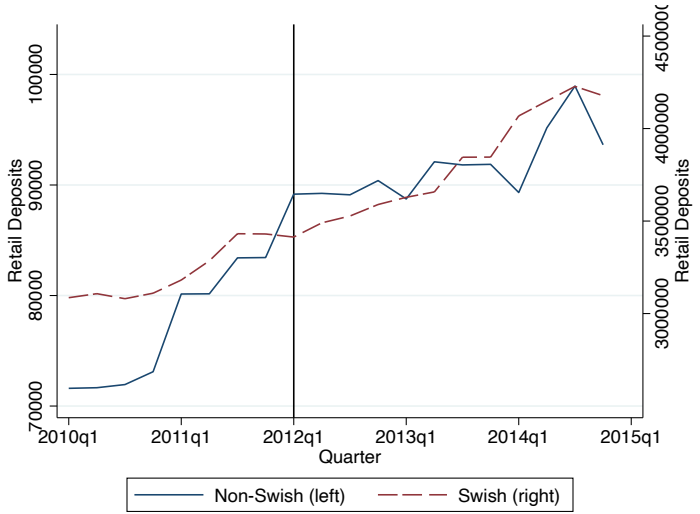
Boleto increased deposit market concentration

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

Results Additional Counterfactual

Swish increases deposit market concentration slightly



Pix impact is dampened in concentrated areas

	Dependent variable:					
	Checking deposits		Saving deposits		Time deposits	
	(1)	(2)	(3)	(4)	(5)	(6)
Pix	0.043	0.121*	−0.078**	−0.083	0.256***	0.699***
	(0.027)	(0.066)	(0.038)	(0.090)	(0.048)	(0.116)
HHI	0.044**	−0.020	−0.016	−0.064**	−0.257***	−0.213***
	(0.018)	(0.019)	(0.027)	(0.025)	(0.046)	(0.045)
Pix · Large	−0.016**	−0.024***	−0.025***	−0.026***	−0.019*	−0.047***
	(0.006)	(0.008)	(0.006)	(0.008)	(0.011)	(0.015)
HHI · Large		0.141***		0.100***		−0.040
		(0.013)		(0.020)		(0.030)
Pix · HHI		0.001		−0.008		0.069***
		(0.011)		(0.013)		(0.020)
Pix · Large · HHI		0.037***		0.019***		0.041***
		(0.007)		(0.007)		(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^2	0.852	0.853	0.945	0.945	0.900	0.900

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Bootstrapped standard errors

	Dependent variable:		
	Checking deposits	Saving deposits	Time deposits
	(1)	(2)	(3)
Pix · Small	0.030***	0.032**	0.043***
	(0.010)	(0.016)	(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^2	0.882	0.961	0.923

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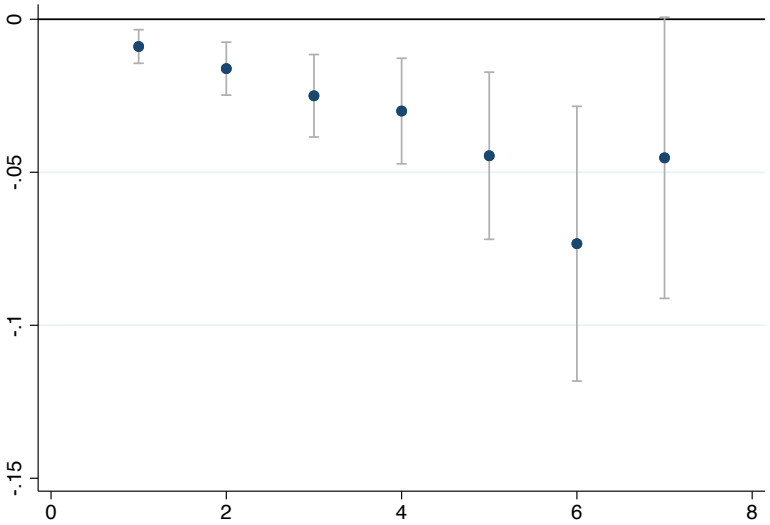
Pix does not impact the number of bank branches



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

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Pix increases deposit betas of large banks relative to small banks

	Dependent variable:			
	Saving deposits		Time deposits	
	(1)	(2)	(3)	(4)
Pix	0.004^{***}	0.042^{***}	0.031^{***}	0.104^{***}
	(0.000)	(0.004)	(0.001)	(0.038)
HHI	0.000	0.001^{***}	-0.013^{***}	-0.013^{***}
	(0.000)	(0.000)	(0.002)	(0.003)
Small	-0.015^{***}	-0.015^{***}	-0.022^{***}	-0.023^{***}
	(0.000)	(0.000)	(0.001)	(0.001)
Pix · Small	-0.022^{***}	-0.024^{***}	-0.039^{***}	-0.043^{***}
	(0.001)	(0.000)	(0.003)	(0.002)
Time FE	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes
Observations	297,654	297,654	297,654	297,654
R^2	0.043	0.211	0.008	0.024

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Pix is more popular in competitive areas

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

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Heteroskedasticity-based identification

- Consider the model of simultaneous equations:

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

Heteroskedasticity-based identification

- Consider the model of simultaneous equations:

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

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

Heteroskedasticity-based identification

- Consider the model of simultaneous equations:

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

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

First stage

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

1. $(\sigma^u_{m'Nov})^2 - (\sigma^u_{m'Oct})^2 > (\sigma^u_{m^0Nov})^2 - (\sigma^u_{m^0Oct})^2$

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1. $(\sigma^u_{m'Nov})^2 - (\sigma^u_{m'Oct})^2 > (\sigma^u_{m^0Nov})^2 - (\sigma^u_{m^0Oct})^2$
2. $(\sigma^\varepsilon_{m'Nov})^2 - (\sigma^\varepsilon_{m'Oct})^2 = (\sigma^\varepsilon_{m^0Nov})^2 - (\sigma^\varepsilon_{m^0Oct})^2$
3. $(\sigma^F_{m'Nov})^2 - (\sigma^F_{m'Oct})^2 = (\sigma^F_{m^0Nov})^2 - (\sigma^F_{m^0Oct})^2$ 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:

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

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COVID restriction did not increase deposits

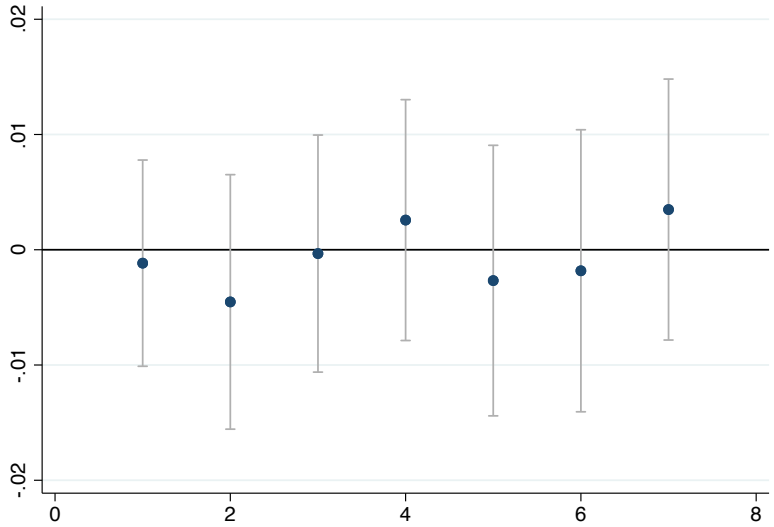
	Dependent variable:					
	Checking deposits		Saving deposits		Time deposits	
	(1)	(2)	(3)	(4)	(5)	(6)
Masks	−0.048		−0.152**		−0.371	
	(0.092)		(0.076)		(0.287)	
Isolation		−0.098***		−0.014		−0.142
		(0.034)		(0.032)		(0.129)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,326	2,331	2,326	2,331	2,326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

Back

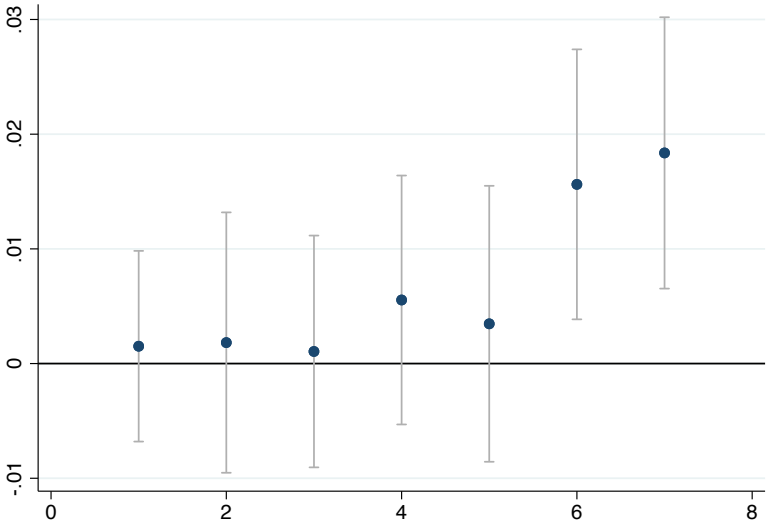
IV first-stage estimation

	Dependent variable:			
	Pix			
	(1)	(2)	(3)	(4)
Eased	-0.128^{***}	-0.128^{***}		
	(0.027)	(0.027)		
Post Pix	13.750^{***}		13.750^{***}	
	(0.037)		(0.041)	
Eased · Post Pix	0.357^{***}	0.357^{***}	0.357^{***}	0.357^{***}
	(0.045)	(0.045)	(0.050)	(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^2	0.984	0.984	0.986	0.986

Placebo test: 2018



Placebo test: 2019



Instrumenting access to Pix

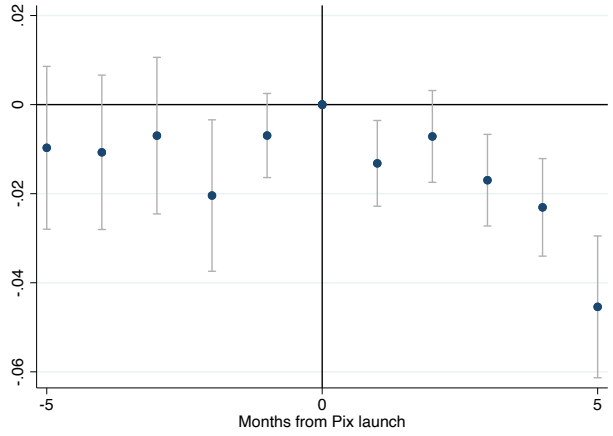
- Access to 4G and 5G internet in Brazilian municipalities as an instrument for **Pix access**
- **Relevance:** Pix is used more in areas with access to 4G and 5G internet
- **Exclusion:** Access to internet impacts deposit competition **only** via Pix
- Data from Anatel

First-stage results: access to Pix

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

Second-stage results: access to Pix

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



Cross-sectional Rigobon-Sack results

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

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Rigobon-Sack with bootstrapped standard errors

	Dependent variable:			
	Checking deposits	Saving deposits	Time deposits	Total loans
	(1)	(2)	(3)	(4)
Pix	3.340***	2.813***	12.00***	2.889***
	(0.352)	(0.332)	(1.992)	(0.477)
Controls	Yes	Yes	Yes	Yes
Observations	2,243	2,243	2,243	2,243
R^2	0.790	0.806	0.491	0.693

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Standard IV results

	Dependent variable:			
	Checking deposits	Saving deposits	Time deposits	Total loans
	(1)	(2)	(3)	(4)
Pix	0.013**	-0.011**	-0.051**	0.015**
	(0.006)	(0.005)	(0.024)	(0.007)
Pix · Small	0.029**	0.035***	0.113**	0.005
	(0.012)	(0.011)	(0.047)	(0.016)
Controls	Yes	Yes	Yes	Yes
Observations	7,123	7,123	7,123	7,123
R^2	0.653	0.598	0.384	0.526

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Pix does not increase GDP per capita in 2020

	Dependent variable:	
	HC	Standard IV
	(1)	(2)
Pix	-0.004^{*}	-0.005^{***}
	(0.002)	(0.002)
Controls	Yes	Yes
Observations	7,124	7,124
R^2	0.426	0.426

▸ Deposit results ▸ IV results

Pix increases capital investments and savings

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

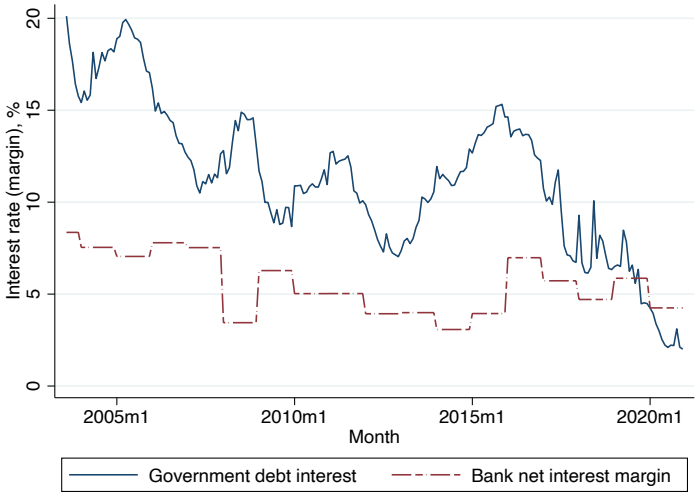
▸ Additional results ▸ Deposit results ▸ Loan results

Large bank equity returns drop relative to small banks

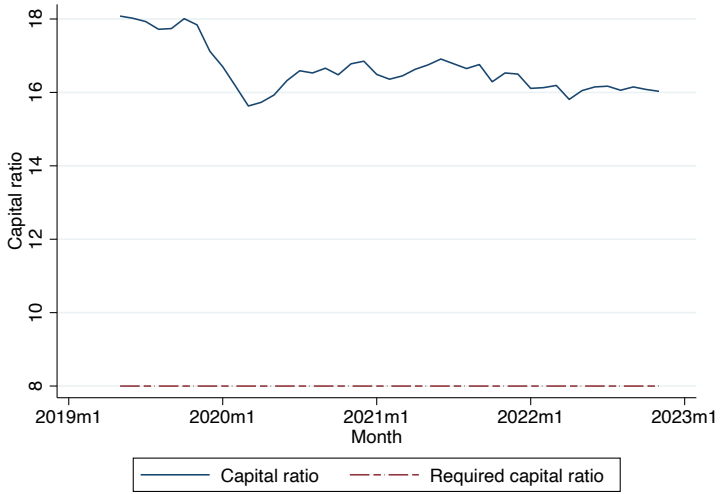
	Dependent variable:			
	Equity returns			
	(1)	(2)	(3)	(4)
Pix	0.015***	0.015	0.015***	0.014
	(0.004)	(0.010)	(0.004)	(0.010)
Large	0.003	0.002	0.0002	−0.0001
	(0.010)	(0.009)	(0.013)	(0.011)
Pix · Large	−0.002	−0.002	−0.002	−0.001
	(0.015)	(0.013)	(0.015)	(0.013)
Constant	−0.005*	0.008	−0.002	0.011
	(0.003)	(0.007)	(0.008)	(0.009)
Bank FE	No	No	Yes	Yes
Time FE	No	Yes	No	Yes
Observations	314	314	314	314
R^2	0.053	0.349	0.087	0.386

▸ Deposit results ▸ Loan results

Net interest margins of Brazilian banks



Capital ratios of Brazilian banks



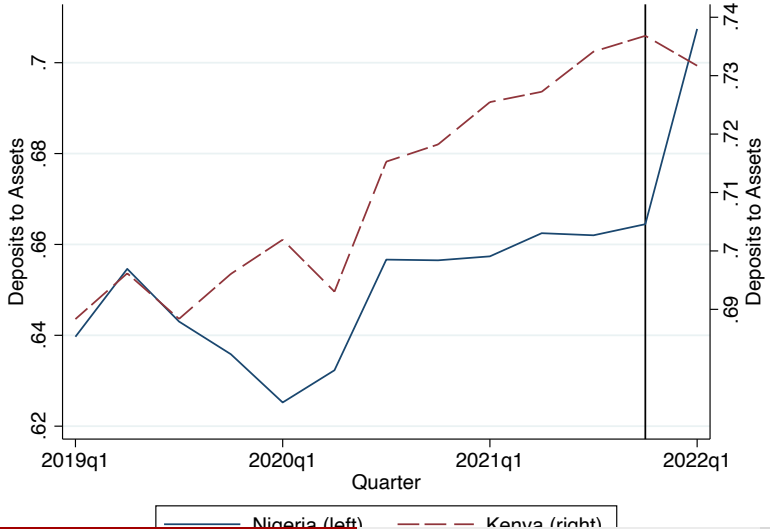
CBDC

- 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

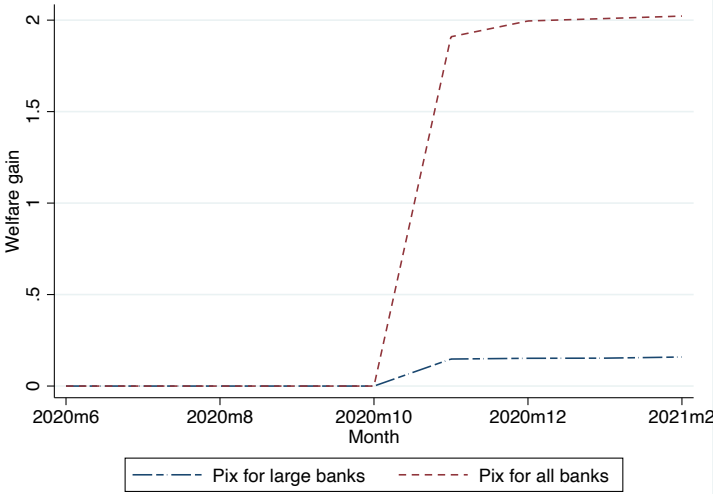
Data

- 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

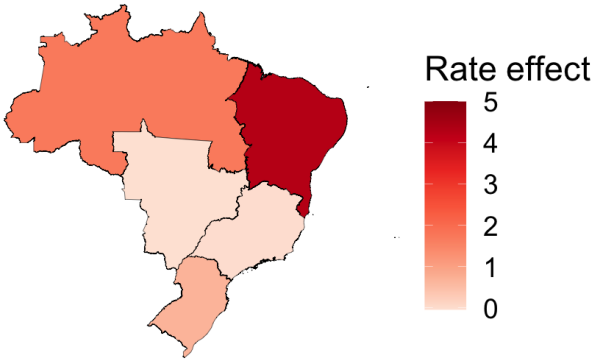
CBDC increases deposits in Nigeria



Pix launch is welfare-improving



Regional estimation: deposit rate sensitivity



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Regional estimation table

Parameter	Symbol	Estimate	Standard error
Panel A: North			
Sensitivity to deposit rates	α^d	0.732^{***}	(0.253)
Sensitivity to Pix	β^d	-0.721^{***}	(0.151)
Additional sensitivity to Pix for large banks	δ^d	-0.057^{***}	(0.011)
R^2		0.984	
Panel B: Northeast			
Sensitivity to deposit rates	α^d	4.298^{**}	(2.134)
Sensitivity to Pix	β^d	0.043	(0.460)
Additional sensitivity to Pix for large banks	δ^d	0.035	(0.031)
R^2		0.734	
Panel C: Central-West			
Sensitivity to deposit rates	α^d	-0.039^{***}	(0.010)
Sensitivity to Pix	β^d	-0.095^{***}	(0.015)
Additional sensitivity to Pix for large banks	δ^d	-0.057^{***}	(0.006)
R^2		0.999	
Panel D: Southeast			
Sensitivity to deposit rates	α^d	-0.010	(2.507)
Sensitivity to Pix	β^d	0.380^{**}	(0.181)
Additional sensitivity to Pix for large banks	δ^d	-0.016	(0.011)
R^2		0.915	
Panel E: South			
Sensitivity to deposit rates	α^d	0.684^{***}	(0.244)
Sensitivity to Pix	β^d	0.379^{***}	(0.111)
Additional sensitivity to Pix for large banks	δ^d	-0.024^{***}	(0.007)
R^2		0.997	

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

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

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

Model with cash Back

Timeline

1. Decide on composition of portfolio
2. ε^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

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

and leverage constraint

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

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 ε_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 ε_t^j 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* $r_t^{ds} - r_t^{d\ell}$;
2. *increase in* $\frac{L_t^s}{L_t^\ell}$;
3. *reduction in* $r_t^{\ell s} - r_t^{\ell\ell}$.

Interest rates

Proposition

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2. *increase in* $\frac{L_t^s}{L_t^\ell}$;
3. *reduction in* $r_t^{\ell s} - r_t^{\ell\ell}$.

- 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

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

Model with cash

- Choose consumption and deposits to maximize their utility

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$$\eta^{\ell} C_t^i \leq M_t + u_t^i DL_t^i$$

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

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

Back

Timeline

1. Decide on composition of portfolio
2. ε^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 ε_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 ε_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_t^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.*

Back