THE GEORGE WASHINGTON UNIVERSITY
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Open Payment Infrastructure and Market Participation:

The Role of Interoperability in Financial Inclusion

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Motivation

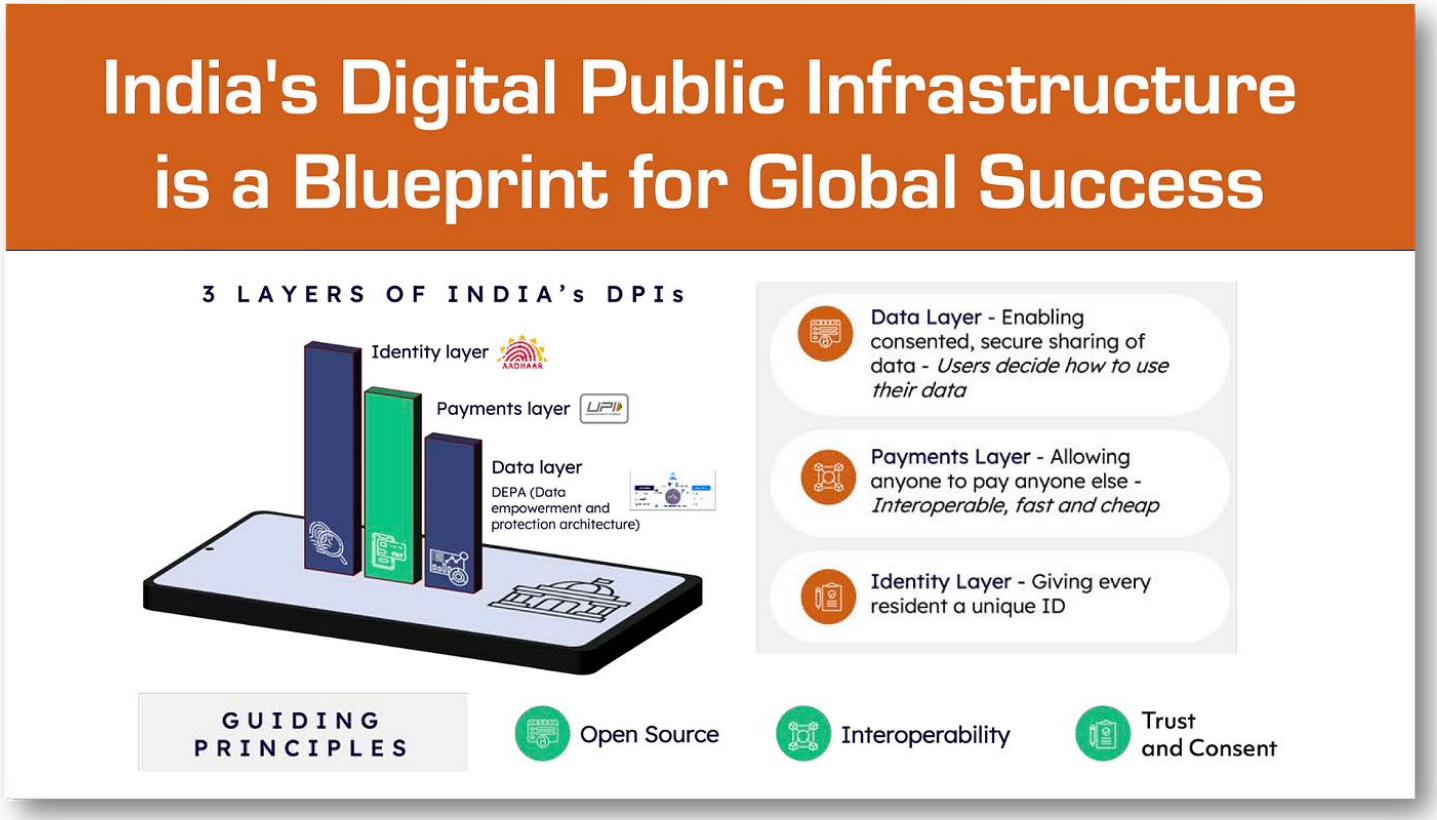
Rise of the Retail Investor

The confluence of social media and technology has led to a resurgence of retail investor trading activity in financial markets around the world

India is the world's fourth-largest stock market (~USD 4.3T) with ~151M investors.

Motivation

India Stack



Rich academic literature examining impact of digital rails to credit access (Digital ID (Aadhaar), (PMJDY), Infrastructure (PMGSY), etc., Payment systems (UPI))

Unanswered Question:

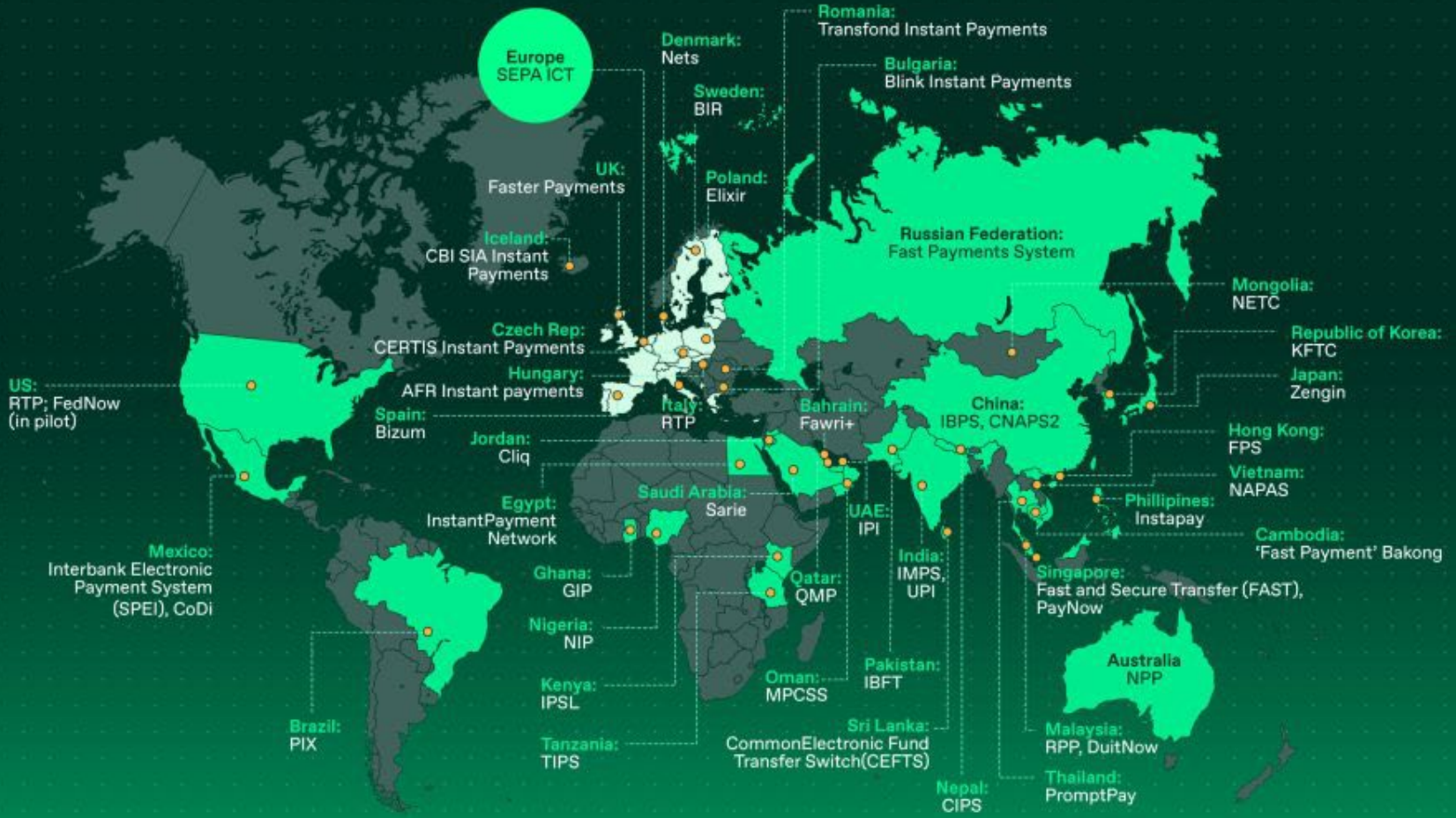
Role of Payment Systems in financial market access

But one piece is often overlooked: payments.

- Legacy rails = delays/fees/hours.
- Open, real-time, interoperable rails remove these costs. If moving ₹ is instant and free, entry and reaction speed change.
  - Could change who can participate in financial markets—and how quickly they can respond to them.
- Note: Open ≠ just digital.
  - Interoperability lets any bank account fund any broker/app
- Not just an India-specific question→

Global Real-Time Payment Adoption

Thunes.



This paper asks:

1. Does open payment infrastructure increase retail trading activity and market participation?

- Use India's Unified Payments Interface (UPI) as the context
- Is it architecture (open vs closed) or general digitization?

2. Who benefits?

- Heterogeneity by gender, age, location, Fintech vs traditional

3. Through what mechanisms?

- Reduction in Transaction Cost and Speed
- Lowering entry barriers
- Digital ecosystem effects
- Financialization of savings

4. Should we care?

- Are investors, especially previously disadvantaged investors, making money?

What we find:

1. UPI expands participation

- +6.1% transactions, +8.6% investors (per 1 s.d. UPI exposure)

2. It's the architecture, not just digitization

- UPI >> YONO (closed system)

3. Who benefits?

- Young, women, small investors
- FinTech platforms see largest gains

What we find:

4. Mechanisms

- Faster Funding → Lower Costs
  - High-UPI areas trade more during flash crashes
- Lower Entry Barriers
  - More small-value trades, more small investors enter
- Digital Spillovers
  - Stronger effects in urban areas & FinTech platforms
- Savings Formalization
  - Cash-heavy regions shift savings into markets

5. Unintended consequences

- Less diversification, negative long-run returns for small investors

Related Literature

Next-Generation Payment Systems:

- Dubey and Purnanandam (2023), Ouyang (2021), Ghosh et al. (2022), Sarkisyan (2023), Liang et al. (2024), Cramer et al. (2024), Alok et al. (2024)
- First paper to show that payment innovation affects retail investor participation.

Open Banking - Market Structure & Consumer Welfare:

- Parlour et al. (2022), He et al. (2023), Goldstein et al. (2022), Babina et al. (2024)., Copestake et al. (2025a, b)
- Our paper highlights the importance of interoperability

Technological Innovation and Retail Investor (Small) Behavior:

- Barber and Odean (2001), Parlour et al. (2022), Campbell (2006), Barber et al., Frydman and Wang (2020), Hong et al. (2020), Gonzalez et al. (2024)
- We show how reducing payment frictions through technological innovation can alter trading patterns while potentially introducing new risks.

Data

- **Deposit Data (Reserve Bank of India – BSR)**
  - Bank-wise deposit data at the pincode level.
  - Used to construct UPI Exposure Measure

- **Universe of Retail Trading Data from National Stock Exchange of India (NSE), 2015-2020Q1**
  - More than 20 million retail investor and 3 billion observations
  - Includes daily trade details: date, stock ticker, quantity sold (buy), price at sold(buy)
  - Investor demographics: age, gender, and pincode
  - Brokerage information - mapped

- **Telecom Tower location data**
  - Geo-coordinates for every Telecom tower : 2G/3G/4G; time and provider (airtel/JIO/BSNL etc)

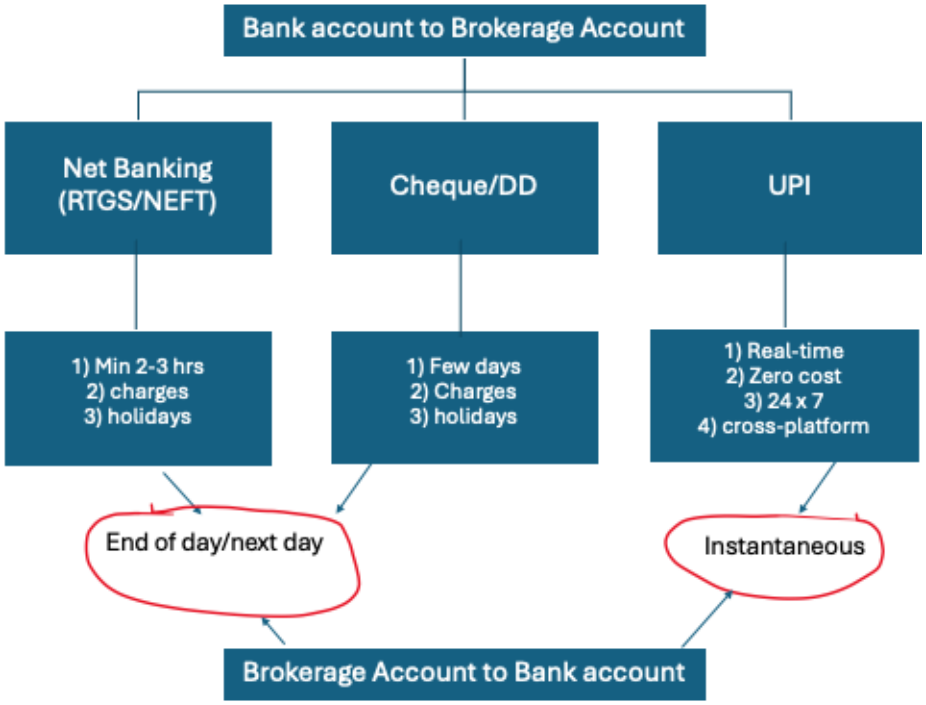
Unified Payments Interface (UPI)

Institutional Details

- A payment system and an interoperable protocol that allows third-party vendors to build apps providing payment services to all customers of participating banks

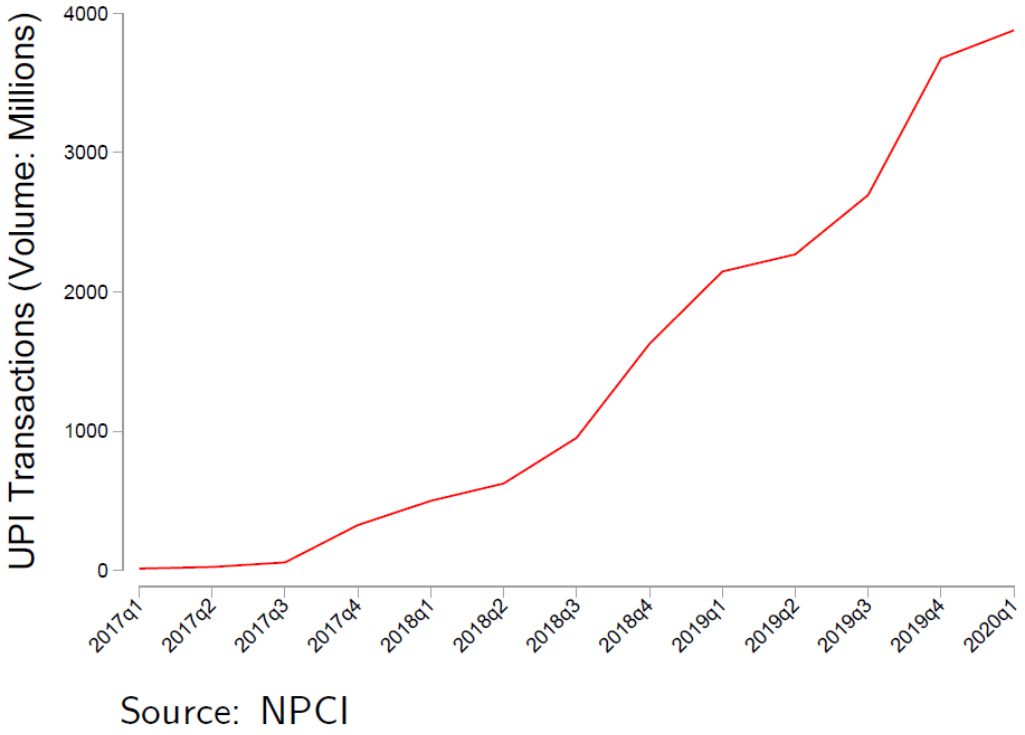
- Connects customer to multiple banks through one single unified API.

- Enables instant, interoperable, zero-cost transfer of funds to and from bank account and brokerage account



Unified Payments Interface (UPI)

Institutional Details



- India leads globally in real-time payment transactions.
- In 2023, India processed 129 billion real-time transactions, exceeding the combined total of the next nine largest real-time payment markets.

UPI Exposure Measure

$$\text{UPI Exposure}_p = \frac{\text{Total Deposits of Early Adopter Banks}_p}{\text{Total Deposits of All Banks}_p}$$

- Exploit two sources of variation:
  - Variation in **bank-level adoption timing** - Early adopter banks live on UPI as of November 2016 (GoI website).
  - **Geographic** deposit variation
    - Regions where early UPI adopter banks are dominant players are more likely to be extensive adopters of digital transactions due to strong network externalities as documented in Higgins (2022) and Crouzet et al. (2023).
  - Following Dubey and Purnanandam (2024); Alok et al., (2024)

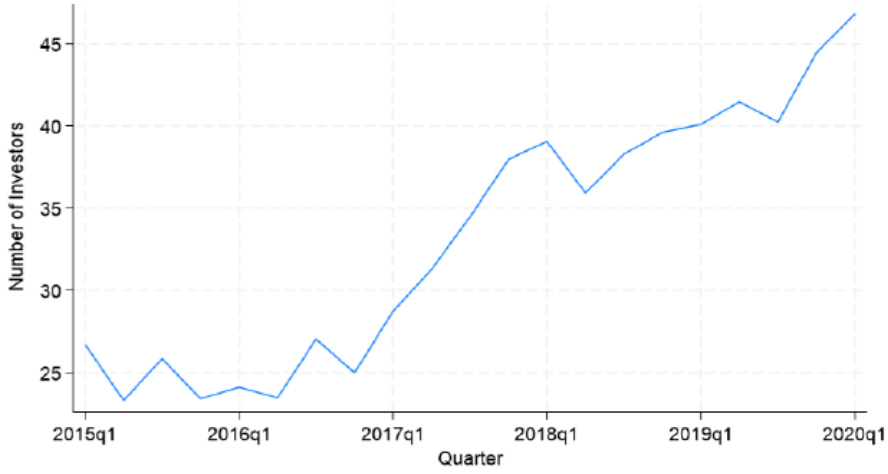
Trading Data

- **Main Outcomes**
  - Number of Transactions: number of trades in a pincode-year-month
  - Number of Investors: total number of active investors in a pincode-year-month
- **Investor-level measures:**
  - BHR for different time horizons (1, 10, 25, 140 trading days)
  - Risk Taking (ratio of the number of transactions in risky assets over the total number of transactions per investor-month)
  - Trading Speed (average number of days between consecutive transactions for each investor within the same month)
  - Portfolio Diversification (HHI) following Koch et al. (2021)

$$\text{Portfolio Diversification}_{i,t} = 1 - \sum_{T} \left(\frac{Turnover_{i,S,t}}{\sum_{T} Turnover_{i,S,t}} \right)^2$$

Descriptive Patterns

(a) Diff. in # Transactions (High-Low)



(b) Diff. in # Investors (High-Low)

The gap between high- and low-exposure areas widens over time, suggesting a positive correlation between UPI adoption and increased market participation.

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Empirical Strategy

- For pincode p in district d in month t, we estimate:

$$Y_{p,d,t} = \alpha_{d,t} + \gamma_p + \beta\ \text{Post} \times \text{UPI Exposure}_p + \varepsilon_{p,d,t}$$

  - The dependent variable $Y_{p,d,t}$ is the Number of transactions or investors.
  - Post is a dummy that equals 1 post Q3 2016 and 0 otherwise.
  - $\alpha_{d,t}$ and γ_p represent district-time fixed effects and pincode fixed effects.
  - Standard errors are clustered at the pincode level.
  - Coefficient of interest, **β**, measures differential change in stock market activity in each pincode

Balance Test

Variable	(1) High UPI Exposure N	(1) High UPI Exposure Mean/(SE)	(2) Low UPI Exposure N	(2) Low UPI Exposure Mean/(SE)	(3) Mean Difference (1)-(2)
Pincode: NSE Sample					
Economic Activity	9,306	10.684	9,307	8.059	2.625
		(13.894)		(13.323)	
Number of Transactions	204,754	1103.085	204,732	805.672	297.413
		(3047.097)		(2463.475)	
Number of Investors	204,754	78.103	204,732	55.675	22.428
		(222.424)		(175.743)	
Growth in Number of Transactions	204,754	0.230	204,732	0.260	-0.03
		(2.009)		(2.429)	
Growth in Number of Investors	204,754	0.047	204,732	0.048	-0.001
		(0.418)		(0.440)	
Investor: NSE Sample					
Age	659,504	37.768	659,646	37.998	-0.23
		(12.849)		(13.253)	
Female	659,504	0.119	659,646	0.134	-0.015
		(0.324)		(0.341)	

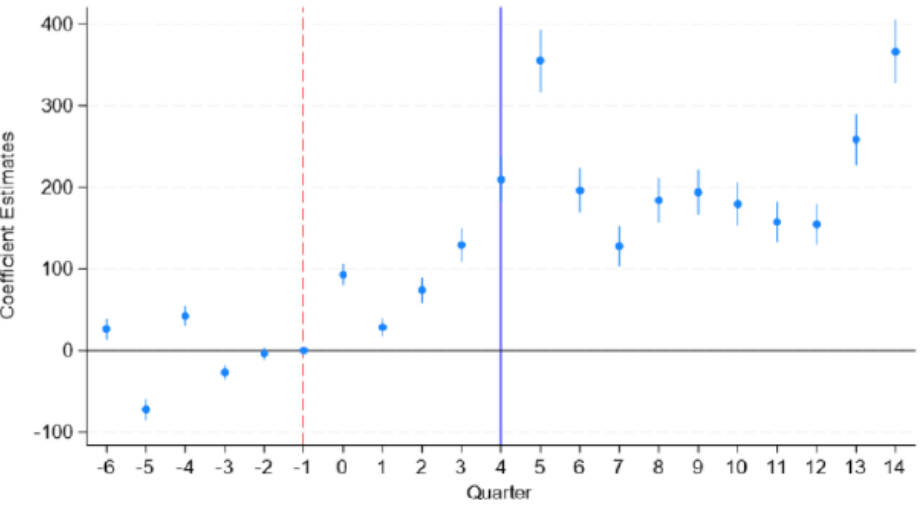
UPI Exposure is not correlated with ex-ante differences in number of transactions OR number of investors (both levels and growth) or the age and gender profile of investors.

UPI and Stock Market Participation

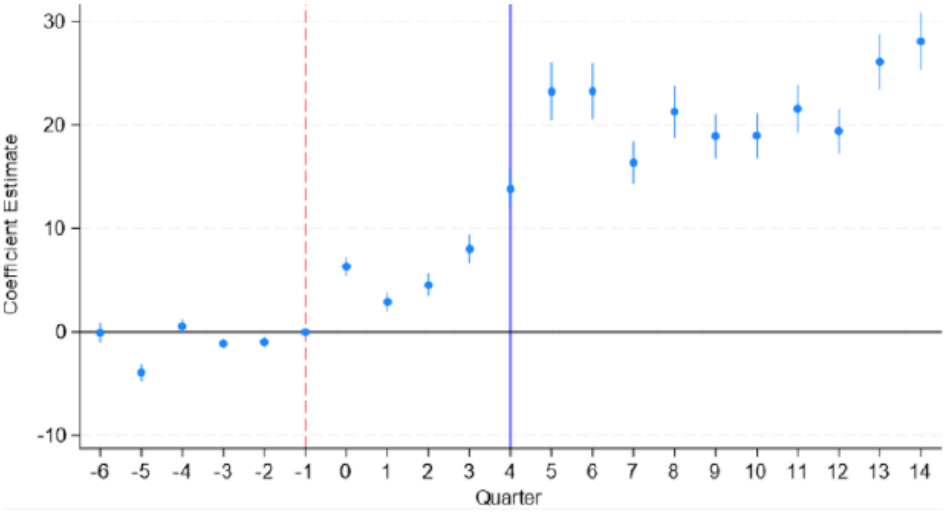
DV	Number of Transactions (1)	Number of Investors (2)	Number of Transactions (3)	Number of Investors (4)
UPI Exposure X Post	197.761***	20.323***		
	(11.706)	(1.060)		
UPI Bartik			113.149***	13.410***
			(4.256)	(0.366)
Pincode FE	Y	Y	Y	Y
District-Month FE	Y	Y	Y	Y
N	1,121,351	1,121,396	1,121,351	1,121,396
Adj. R^2	0.964	0.964	0.965	0.967

A 1 s.d. increase in UPI exposure leads to 6.1% increase in monthly transactions; 8.6% increase in active investors relative to pretreatment

No evidence of pre-trends



(a) Number of Transactions



(b) Number of Investors

Enhancement of interoperability in September 2017 through a multi-bank PSP model (shown by the vertical blue line) increases effects

UPI vs Yono:

Why Architecture Matters

Yono Measure	Value		Volume	
	Number of Transactions	Number of Investors	Number of Transactions	Number of Investors
	(1)	(2)	(3)	(4)
UPI Exposure	12.848***	1.219***	13.480***	1.259***
	(1.001)	(0.087)	(0.821)	(0.071)
Yono	0.000*	0.000	0.019***	0.002***
	(0.000)	(0.000)	(0.007)	(0.001)
District-Month FE	Y	Y	Y	Y
N	1,014,920	1,015,360	1,014,920	1,015,360
Adj. R^2	0.221	0.295	0.210	0.285

Strengthening Identification

1. Within investor tests

- Are there pincode-time confounding effects?
- For same investor, compare trading in brokerage accounts linked to early adopter banks vs others. Addresses concerns about time varying confounders at pincode level.

2. Regional variation in bank holidays

- Is it UPI or bank specific characteristics?

3. Exogenous Variation in Internet Connectivity

- Effect of UPI should be stronger in areas that had early access to affordable 4G connectivity which is a critical enabler of UPI usage.

Strengthening Identification:
1. *Within-Investor Tests*

- If UPI adoption indeed facilitates stock market participation, should see that the same investor would execute more transactions through accounts linked to early UPI-adopting banks compared to their other accounts

$$Y_{i,b,t} = \alpha_{i,t} + \gamma_b + \beta \cdot \text{Post}_t \times \text{Early Adopter}_b + \varepsilon_{i,b,t}$$

  - Early adopter equals 1 if the brokerage account b is associated with early UPI-adopting banks, and 0 otherwise
  - Include investor and brokerage fixed effects ala Khwaja and Mian (2008)
  - The coefficient of interest β captures the difference in transactions for a UPI-enabled brokerage versus others

Strengthening Identification:
1. Within-Investor Tests

Sample	Investor with two or more brokers during entire sample period	Investor with two or more brokers in each month	
DV	Number of Transactions		
	(1)	(2)	(3)
Post X Early UPI Enabled Brokerage	52.060**	41.626*	13.968**
	(21.218)	(23.568)	(6.846)
Investor FE	Y	Y	
District-Month FE	Y	Y	Y
Broker FE	Y	Y	Y
Investor-Month FE			Y
N	54,946,106	15,264,352	15,078,443
Adj. R^2	0.303	0.294	0.341

The same investor execute more transactions through brokerage accounts linked to early adopting banks compared to other accounts

Strengthening Identification:
2. Bank Holidays

- One concern is that results might be driven by early-adopting banks having other special features – more innovative, better infrastructure, etc

- We use *bank holidays*, which differ across states, to separate bank characteristics from UPI's effect.

- If superior bank quality were driving our results, we would expect customers of early-adopting banks to continue enjoying an edge during bank holidays, when only digital channels are available.

Strengthening Identification:

2. Bank Holidays

	Number of Transactions (1)	Number of Investors (2)	Number of Transactions (3)	Number of Investors (4)
Bank Holiday	-0.679***	-0.485***		
	(0.151)	(0.044)		
Post X UPI Exposure	10.109***	3.324***	10.097***	3.331***
	(0.673)	(0.205)	(0.677)	(0.208)
Bank Holiday X UPI Exposure	-2.667***	-0.917***	-2.953***	-0.936***
	(0.240)	(0.066)	(0.257)	(0.072)
Post X Bank Holiday	1.471***	0.535***		
	(0.350)	(0.103)		
Post X Bank Holiday X UPI Exposure	-0.903*	-0.600***	-0.890	-0.644***
	(0.500)	(0.143)	(0.555)	(0.159)
Pincode FE	Y	Y	Y	Y
Day FE	Y	Y		
State-Day FE			Y	Y
District-Month FE	Y	Y	Y	Y
N	2058065	2058068	2058019	2058022
Adj. R2	0.952	0.962	0.953	0.963

Instead, we see the opposite: the gap narrows. UPI reduces the relative advantage of being tied to an early-adopting bank, confirming that it's the infrastructure — not bank selection — that matters.

Strengthening Identification:
3. Exogenous placement of Jio towers

- Another concern is that our results may be picking up general digital adoption trends, not UPI specifically.

- Use Reliance Jio's 4G rollout (critical enabler of UPI usage) as a natural experiment
  - Jio's rollout was massive, rapid, and not driven by local demand conditions -- it depended more on technical and regulatory factors like tower placement and spectrum availability → plausibly exogenous variation in early internet access.

- If UPI is the real driver, then areas with early Jio coverage should see stronger effects of UPI exposure on stock market participation.
  - Note: Also, if this were just about better banks, the timing of Jio's 4G rollout should be irrelevant.

Strengthening Identification:

3. Exogenous placement of Jio towers

	Number of Transactions (1)	Number of Investors (2)	Number of Transactions (3)	Number of Investors (4)
UPI Exposure X Post	105.546***	10.344***	50.069**	4.162**
	(12.088)	(1.116)	(22.912)	(2.086)
Post X Early JIO	127.663***	12.777***	116.467***	11.698***
	(14.292)	(1.242)	(14.139)	(1.238)
UPI Exposure X Post X Early JIO	154.594***	16.907***	148.936***	16.225***
	(20.446)	(1.808)	(20.174)	(1.798)
Post X High No-JIO			95.509***	9.410***
			(17.910)	(1.679)
UPI Exposure X Post X High No-JIO			63.459***	7.148***
			(23.673)	(2.175)
Pincode FE	Y	Y	Y	Y
District-Month FE	Y	Y	Y	Y
N	1,121,351	1,121,396	1,121,351	1,121,396
Adj. R^2	0.964	0.964	0.964	0.965

UPI's impact on market participation was substantially stronger in areas that gained early access to affordable 4G connectivity.

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Mechanism 1:
Reduction in Transaction Costs

- During sharp market movements, ability to instantly transfer money (or receive money) to the brokerage account is crucial.

- We use two flash crashes:
  - September 11, 2019: Market crashed 793 points erasing 3.3 trillion INR
  - March 12, 2020: Sharp fall (8.18%) due to global fears of recession

- High-frequency time-stamped transaction level (tick by tick) data from BSE: 2019-2023

- Calculate trading activity of each active investor in a 12-hour trading window before and after each crash

Event Study around flash crashes

BSE Test

Event	2019 & 2020		2019		2020	
DV	Number of Trans-actions (1)	Number of Tickers Traded (2)	Number of Trans-actions (3)	Number of Tickers Traded (4)	Number of Trans-actions (5)	Number of Tickers Traded (6)
Post Crash X UPI Exposure	0.007**	0.003***	0.004**	0.002*	0.010***	0.004***
	(0.003)	(0.001)	(0.002)	(0.001)	(0.003)	(0.002)
Investor FE	Y	Y	Y	Y	Y	Y
Hour FE	Y	Y	Y	Y	Y	Y
N	16,113,715	16,183,280	6,042,175	6069809	10,071,520	10,113,454
Adj. R^2	0.117	0.133	0.164	0.184	0.116	0.132

Investors in high UPI Exposure regions engage in more transactions around the flash crash

Mechanism 2A:

Democratization of Investment

DV	Number of Transactions			
Cut-Off	Trading Value – 30,000		Trading Value –50,000	
Small Investors	Y	N	Y	N
	(1)	(2)	(3)	(4)
UPI Exposure X Post	156.271***	90.024***	175.951***	71.470***
	(8.041)	(4.983)	(9.141)	(3.875)
Pincode FE	Y	Y	Y	Y
District-Month FE	Y	Y	Y	Y
N	1,231,401	1,231,455	1,231,400	1,231,466
Adj. R^2	0.917	0.924	0.920	0.919
T-test	(2)-(1)		(4)-(3)	
	-66.247***		-104.481***	
	(9.459)		(9.928)	

Impact of UPI is larger for small investors (defined as bottom 30% of transactions in terms of trading value in a month following Lee & Radhakrishna, 2000; Malmendier & Shanthikumar, 2007)

Mechanism 2B:
Democratization of Investment

DV	Number of Investors			
Cut-Off	Trading Value – 30,000		Trading Value –50,000	
Small Investors	Y	N	Y	N
	(1)	(2)	(3)	(4)
UPI Exposure X Post	19.060***	9.999***	20.076***	8.139***
	(0.917)	(0.529)	(0.978)	(0.427)
Pincode FE	Y	Y	Y	Y
District-Month FE	Y	Y	Y	Y
N	1,231,439	1,231,440	1,231,448	1,231,447
Adj. R^2	0.929	0.933	0.931	0.929
T-test	(2)-(1)		(4)-(3)	
	-9.061***		-11.937***	
	(1.059)		(1.067)	

Greater number of small investors participate in market in high UPI exposed regions

Mechanism 3:
Digital Ecosystem

DV	Number of Transactions		Number of Investors	
	Rural	Urban	Rural	Urban
	(1)	(2)	(3)	(4)
UPI Exposure X Post	140.987***	456.202***	13.325***	45.739***
	(9.596)	(87.759)	(0.859)	(7.771)
Pincode FE	Y	Y	Y	Y
District-Month FE	Y	Y	Y	Y
N	950,779	161,140	950,715	161,260
Adj. R^2	0.934	0.969	0.928	0.975
T-test	(2)-(1)		(5)-(4)	
	315.215***		32.414***	
	(88.202)		(7.818)	

Stronger effects in urban areas → suggestive evidence that UPI's impact on stock market participation operates through broader digital financial literacy and network effects. Self reinforcing mechanism

Mechanism 4:

Financialization of Savings

DV	Number of Transactions (1)	Number of Investors (2)
$\mathbb{1}_{Top\ Tercile} \times$ UPI Exposure $\times \mathbb{1}_{Post}$	309.773***	36.636***
	(36.852)	(3.309)
$\mathbb{1}_{Top\ Tercile} \times \mathbb{1}_{Post}$	220.990***	23.613***
	(25.100)	(2.217)
UPI Exposure $\times \mathbb{1}_{Post}$	63.057***	5.317***
	(13.594)	(1.224)
R^2	0.967	0.968
Disym FE	Y	Y
Pin FE	Y	Y
N	981336	981377

High UPI Pincodes with higher ex-ante cash usage (i.e. top terciles of ATM withdrawls per capita in March 2016) see biggest shifts in market participation.
→Moves households from cash into formal financial markets

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Excess Return

DV	Excess Return							
Holding Period	1 Trading Day	10 Tradingy Days	25 Trading Days	140 Trading Days	1 Trading Day	10 Tradingy Days	25 Trading Days	140 Trading Days
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UPI Exposure X Post	0.000	0.000	-0.000	-0.003***	-0.000	-0.001**	-0.001**	-0.003***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
Small					0.004***	0.002***	-0.001	-0.015***
					(0.000)	(0.000)	(0.000)	(0.001)
UPI Exposure X Small					-0.001	-0.001	-0.000	0.005***
					(0.000)	(0.000)	(0.001)	(0.001)
Post X Small					0.000	0.001**	0.005***	-0.000
					(0.000)	(0.000)	(0.000)	(0.001)
UPI Exposure X Post X Small					0.001***	0.002***	0.001	-0.002**
					(0.000)	(0.001)	(0.001)	(0.001)
Investor FE	Y	Y	Y	Y	Y	Y	Y	Y
District-Month FE	Y	Y	Y	Y	Y	Y	Y	Y
N	108,045,406	108,016,403	107,971,591	100,480,494	108,045,406	108,016,403	107,971,591	100,480,494
Adj. R^2	0.105	0.095	0.078	0.070	0.105	0.095	0.078	0.070

Negative returns over 140-day horizon for overall sample, and small investors in particular.

→ Suggestive of suboptimal investment choices by small (likely uninformed, less financially savvy) traders

Trading Behavior

DV	Risk Taking (1)	Diversification (2)	Trading Speed (3)	Risk Taking (4)	Diversification (5)	Trading Speed (6)
UPI Exposure X Post	-0.003***	0.004***	0.001	-0.003***	0.005***	0.023*
	(0.001)	(0.001)	(0.011)	(0.001)	(0.001)	(0.012)
Small				0.107***	-0.445***	-2.214***
				(0.001)	(0.001)	(0.015)
UPI Exposure X Small				0.003**	0.001	0.072***
				(0.001)	(0.001)	(0.019)
Post X Small				-0.021***	0.023***	0.339***
				(0.001)	(0.001)	(0.015)
UPI Exposure X Post X Small				0.002**	-0.003**	-0.055***
				(0.001)	(0.001)	(0.019)
Investor FE	Y	Y	Y	Y	Y	Y
District-Month FE	Y	Y	Y	Y	Y	Y
N	108,131,872	108,131,872	108,131,872	108,131,872	108,131,872	108,131,872
Adj. R^2	0.324	0.351	0.341	0.490	0.070	0.095

Small Investors seem to

- Trade more frequently
- Invest in more risky securities
- Diversify Less

Additional Tests/Robustness

1. Heterogeneity Tests

Results

- While all investors benefit, greatest impact is for young investors (18-30yrs), women, and investors trading through fin-tech brokerages
- UPI appears to shifts trading activity toward digital channels

2. Placebo: Randomize UPI Exposure

Results

- No effects

3. Placebo: Use institutional investor sample

Results

- No relationship between UPI exposure and institutional trading patterns

Additional Tests/Robustness

5. Alternate measure of UPI Exposure – Bartik instrument

Results

6. Rule out demonetization as a confounder

New

- Distance to currency chests (a measure of cash availability during demonetization as shown by Chodorow-Reich et al., 2020) is uncorrelated with UPI exposure measure → implying that our baseline UPI exposure measure captures UPI variation orthogonal to the demonetization-induced UPI uptake
- Baseline results hold controlling for the interaction between a pincode's distance from the currency chest and with year-quarter dummies

New

7. Transformation of DV

- Inverse hyperbolic sine transformation to address skewness

Conclusion

- **Interoperable payments → more market participation.**
  - +6.1% txns; +8.6% active investors per 1 s.d. UPI exposure
- **It's the openness, not just 'going digital'.**
  - UPI >> YONO
- **Access is more democratic...**
  - young, women, small investors; FinTech channels

  ...via four channels:
  - faster funding, lower entry tickets, digital-ecosystem spillovers, savings → markets
- **But participation ≠ performance.**
  - lower diversification; negative long-run excess returns for small investors

Key Takeaway

- **Payment design matters**—open, interoperable systems can broaden access to markets.

- But to make that access welfare-enhancing, we need complementary policy and design—whether it's investor education, defaults, or protective guardrails.