Demographics and Technology Diffusion: Evidence from Mobile Payments

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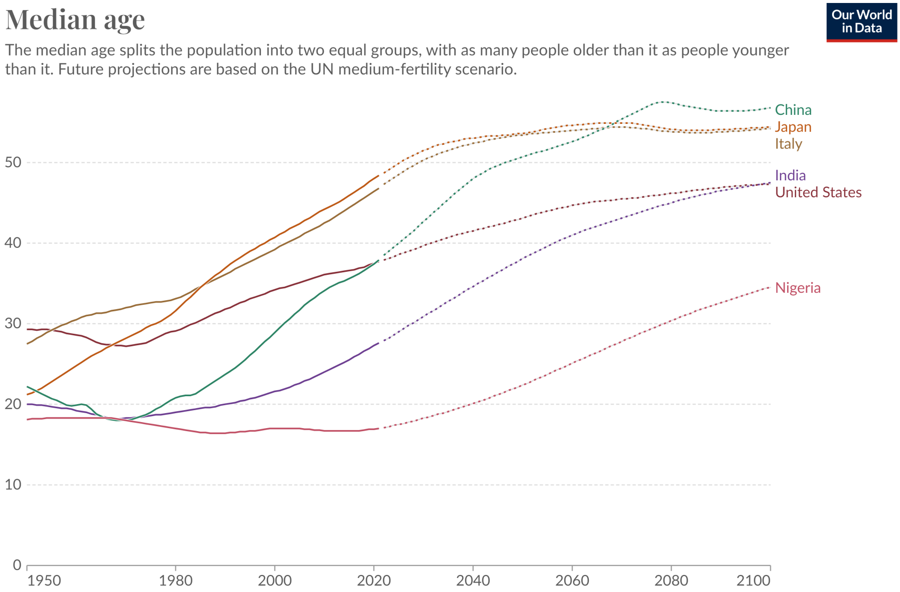
Michigan Ross, Dec 2024

Demographic Changes and Economic Activity



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Aging and Innovation:

Acemoglu and Restrepo (2022); Abeliansky and Prettner (2023); Derrien et al. (2023)

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Aging and Technology **Diffusion**:

- In customer-facing industries, users may have preferences over the technology used;
- Preference for technologies may different across cohort of consumers (old vs. young);
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To examine this hypothesis, we focus on the rise of **mobile payments** in **India**.

This Paper

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    - Younger consumers $\Rightarrow$ larger share of spending through mobile payments relative to cards

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   [B.] Younger consumers are characterized by preference for mobile payments

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Indirect effect: firms facing more young customers adopt mobile payments more

$\Longrightarrow$ the diffusion of tech improvements is slower when there are more older customers

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3. Test model implications using a fintech's introduction of mobile payments in 2019

$\star$ Firms' demand for mobile payments reflect the demographic of their clients:

... firms with **younger** customers demand mobile payments significantly **more**

Contribution

① (Slow) technology diffusion in absence of frictions

[Hall and Khan (2003); Comin and Hobijn (2010); Foster and Rosenzweig (2010); Manuelli and Seshadri (2014)]

② Financial technology adoption: drivers and impacts

[Chodorow-Reich et al. (2019); Hu et al. (2019); Aggarwal et al. (2023); Crouzet et al. (2023); Dubey and Purnanandam (2023); Alok et al. (2024); Higgins (2024); Sarkisyan (2024); Vallee et al. (2024)]

③ Productivity implications of large demographic transitions

[Feyrer (2007, 2008); Acemoglu and Restrepo (2017,2022); Maestas et al. (2023); Derrien et al. (2023)]

⋆ Consumers' preference an important factor explaining the diffusion of new technologies:

... service sector vs. manufacturing

... multi-homing

Roadmap

1. Background: Mobile Payments in India
2. Age and Mobile Preferences
3. Model
4. Firm's Adoption and Demographics
5. Conclusion

1. Background: Mobile Payments in India

Electronic Payments in India

Phase 1: Traditional Cards

- India had all major players in the card space;
- In 2015, cards' volume were >90% of electronic payments.

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Phase 2: Mobile Payments ⇒ Mobile Wallets

- Preload payment method using a digital device;
- Became very popular after the Demonetization in 2016 [Chodorow-Reich et al. 2019; Crouzet et al. 2023]

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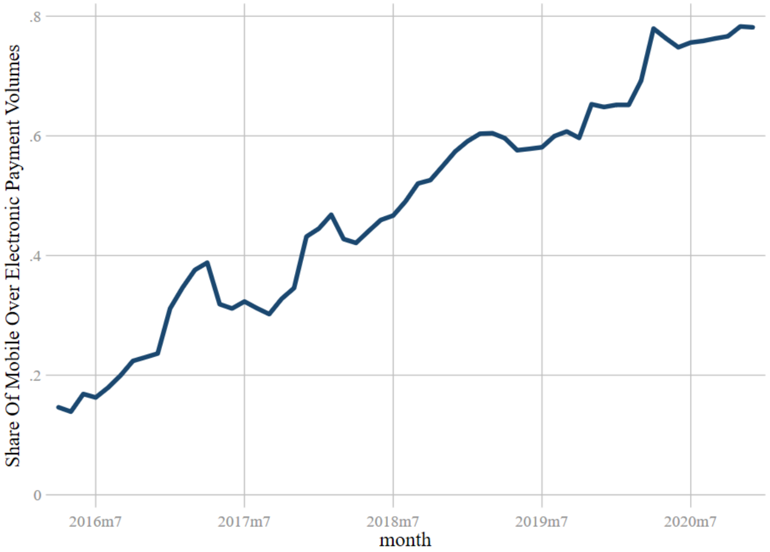
Phase 3: Mobile Payments ⇒ Unified Payment Interface (UPI)

- Real time bank-to-bank transfer, and interoperability;
- Introduced in 2016, but took off after 2017.

Mobile payments vs. Cards



Mobile payments vs. Cards

1. Mobile payment has lower adoption cost than cards;
2. For merchants, mobile payments has usually lower fees;
   - Consumers normally do not pay fees either ways.
3. Different customer experience;
   - Physical card vs. QR code.
   - Digital Integration through payment app.

Mobile payments vs. Cards

- India experienced an impressive shift from card to mobile payments.
- This is striking, in particular compared to how prevalent are cards in other countries:
  - Europe and US are still mostly card-centric.
  - In 2023, ApplePay only accounted for 3.1% of in-store transactions in US [CapitalOne Research]

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  - Europe and US are still mostly card-centric.
  - In 2023, ApplePay only accounted for 3.1% of in-store transactions in US [CapitalOne Research]
- Could demographic differences explain some of these differences?
  - Hard to examine this question with cross-country data.
  - Test the underlying mechanism using Indian Data

2. Age and Mobile Payments

Measuring the use of mobile payments

- Use data from one of the top four bank in India [Agarwal et al., 2023]
- Full account info on about 200,000 customers (period: Jan-Feb 2020)
  - age distribution close to representative survey of Indian households (head) Figure
  - have wealthier individuals than the typical Indian household Figure

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  - have wealthier individuals than the typical Indian household Figure
- In this data, we can measure:
  1. Individual Age
  2. Share of mobile Payments over total electronic payments

Mobile Payments and Age

- Does age explain the relative use of mobile vs. cards?
- How much of the variance in behavior is explained by age vs. other demographic variable?
- Shapley R-squared decomposition method [Huettner and Sunder 2012; Israeli 2007]

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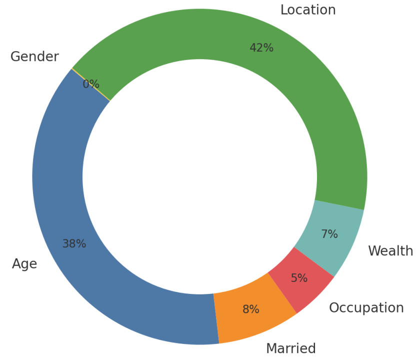

FIGURE 1: Mobile Share: Variance Decomposition

Mobile Payments and Age

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    - Examine the relative use of mobile vs. cards across the age distribution.

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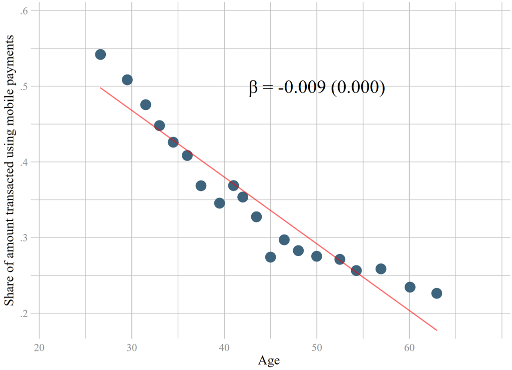


FIGURE 2: Mobile vs. Cards

Mobile Payments and Age

- Does age explain the relative use of mobile vs. cards?
  - **Yes!** Age explains as much variance as location (i.e., pincode).
- Are younger individuals using mobile relatively more?
  - **Yes!** The use of mobile by the oldest group is about half than the youngest group.
- Potential confounding: Controls
  - Younger people are different (e.g., poorer) than older people.

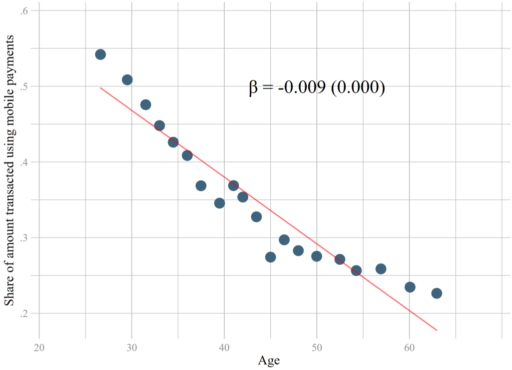
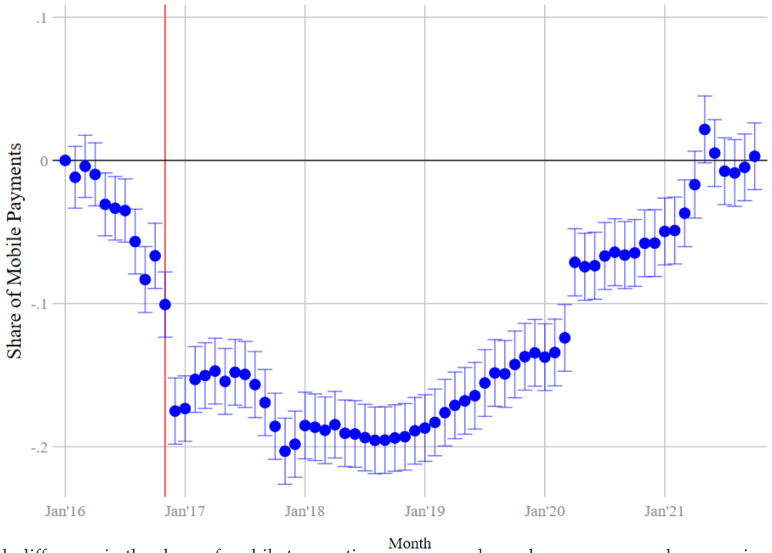


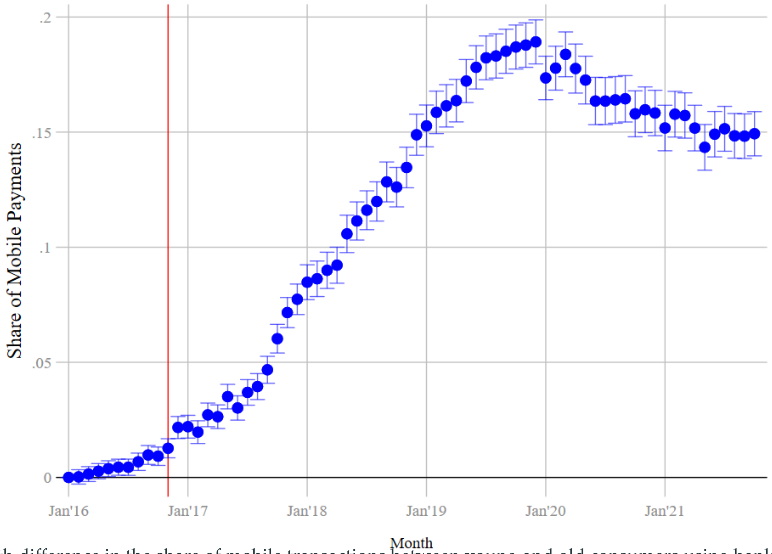
FIGURE 3: Mobile vs. Cards

Difference in Mobile Payments Penetration Among Early Card Users vs. Not



Notes: Month-by-month difference in the share of mobile transactions among early card users vs no card users using bank panel data

Growth in Mobile Payments: Young vs. Old



Notes: Month-by-month difference in the share of mobile transactions between young and old consumers using bank panel data

Taking stock: Mobile Payments and Age

- Does age explain the relative use of mobile vs. cards?
  - **Yes!** Age explains as much variance as location (i.e., pincode)
- Are younger individuals using mobile relatively more?
  - **Yes!** The use of mobile by the oldest group is about half than the youngest group
  - Hard to rationalize by differences in observable
- Younger adults generally prefer mobile to traditional cards

3. Model

Key elements

Businesses $j = 1, ..., J$

$a(j)$: investment in technology

[e.g., offering mobile payment]

Consumers $i \in [0, 1]$

Each i chooses which business j to make purchases from.

Surplus from transacting with business j can depend on $a(j)$

[e.g., young consumers enjoy mobile payments]

Static, partial equilibrium (wage w fixed)

Consumer problem

$$\max_{j,\ c(i,j)} \quad \frac{\log(c(i,j))}{\nu - 1} + \varepsilon(i,j)$$
$$\text{s.t.} \quad p(j)c(i,j) \leq w$$

- $\varepsilon(i,j)$: taste shifters

$$i \in \text{ Old } : \qquad \varepsilon(i,j) \sim \exp\Big(-\exp(-z)\Big)$$
$$i \in \text{ Young } : \qquad \varepsilon(i,j) \sim \exp\Big(-\exp(-z - \log(a(j)))\Big)$$

- $a(j) \uparrow \quad \implies$ first-order stochastic shift in $\varepsilon(i,j)$

Consumer demand

$$\overbrace{\text{\% young consumers picking } j}^{\equiv s_Y(p(j), a(j))} = \frac{a(j)}{J} \left(\frac{p(j)}{P_Y} \right)^{-\frac{1}{\nu-1}}$$

$$P_Y \equiv \left(\frac{1}{J} \sum_{j=1}^{J} a(j) p(j)^{-\frac{1}{\nu-1}} \right)^{-(\nu-1)}$$

$$\overbrace{\text{\% old consumers picking } j}^{\equiv s_O(p(j))} = \frac{1}{J} \left(\frac{p(j)}{P_O} \right)^{-\frac{1}{\nu-1}}$$

$$P_O \equiv \left(\frac{1}{J} \sum_{j=1}^{J} p(j)^{-\frac{1}{\nu-1}} \right)^{-(\nu-1)}$$

Only young consumers' preferences are sensitive to technology choices.

Businesses (1/2)

Total demand for business j:

$$D(j) = \theta\, s_Y(p(j), a(j))\frac{w}{p(j)} + (1-\theta)\, S_O(p(j))\frac{w}{p(j)}$$

$$\theta = \text{fraction of young in population}$$

Production costs $= w\, D(j)$

marginal cost $= w$

Technology adoption costs $= w\, c(a(j))$ $[c(0) > 0,\;\; c' > 0,\;\; c'' > 0]$

marginal cost $= wc'(a(j))$

could capture cost of workforce training; uncertainty about profitability

Businesses (2/2)

$$\begin{aligned} p(j) &= \nu\, w \\ c'(a(j)) &= \frac{\theta}{J}\left(\frac{p(j)}{P_Y}\right)^{-\frac{1}{\nu-1}}\left(1-\frac{w}{p(j)}\right) \end{aligned}$$

Young and old have <u>the same</u> price elasticity of demand $\implies$ markup $= \nu$

For an <u>individual</u> firm, increasing $a(j)$ raises market share of young.

On which they earn a markup

Symmetric businesses $\implies$ $ac'(a) = \frac{\theta}{J}\left(1-\frac{1}{\nu}\right)$

Key predictions

P1: Technology adoption by businesses increases with the young share:

$$\frac{da}{d\theta} > 0.$$

[*Even if* in equilibrium, their efforts cancel out.]

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Assume: $c(a) = \frac{\gamma}{2}(a-1)^2$.

P2: A higher young share magnifies the effects of changes in adoption costs $[\gamma]$

$$\frac{da}{d\gamma} < 0, \quad \frac{d^2 a}{d\theta d\gamma} < 0.$$

[We don't need that particular functional form.]

4. Demographics and Firm's Mobile Payments Adoption

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Is the propensity to adopt mobile payments **higher** when business face more young customers?

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Setting:

- We study the demand for service provided by an important fintech payment Company.
- Up to 2019, the company only sold traditional point-of-sales (POS) machines.

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- Up to 2019, the company only sold traditional point-of-sales (POS) machines.
- In May 2019, the Company introduced mobile payment option (QR-code) as an additional service.

Test: We compare how overall adoption for our Company’s services:

(A) After vs. Before May 2019: with vs. without mobile payment option

(B) Across districts with different age composition

Empirical Framework

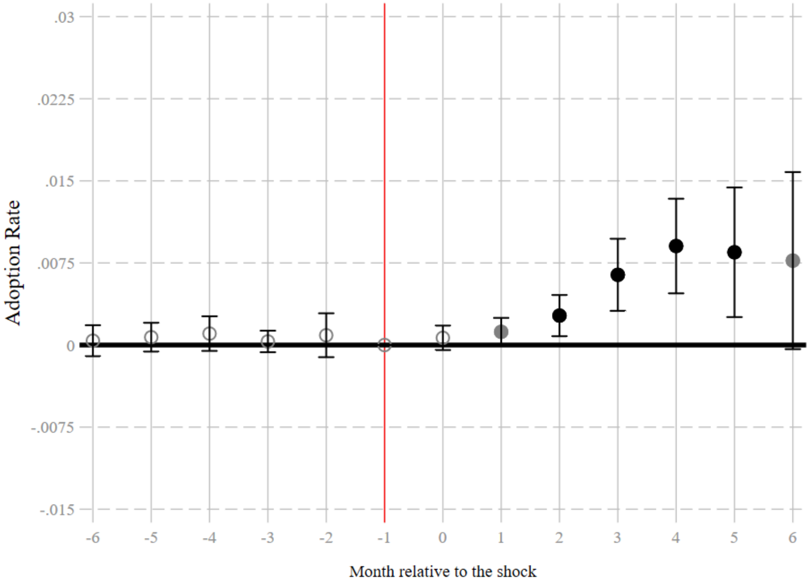
Differences-in-differences framework:

$$AdoptionRate_{d,t} = \alpha_d + \alpha_t + \sum_{k=-6,k\neq-1}^{k=+6} \beta_k \left(Young_d \times 1_{\{t=t_0+k\}} \right) + \Gamma_t^{'} \mathbf{X}_d + \epsilon_{dt}.$$

where:

- $AdoptionRate_{d,t} = \frac{\text{number of stores joining the platform in district } d \text{ and month } t}{\text{\# of firms (in 100s) in the district (Census)}}$
- $Young_d$: share of adults that are less than 30 years old (more later);
- $\mathbf{X}_d$: district-level characteristics (more later);
- We focus on a 6-month window before and after t_0 = May 2019

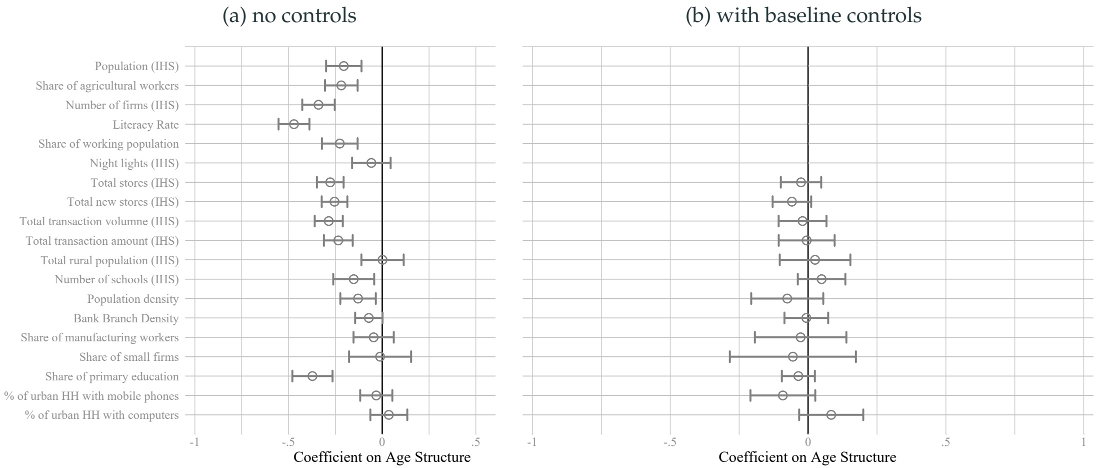
Demographics and Firms' Mobile Payment Adoption



Demographics and Firms' Mobile Payment Adoption

- After the introduction of mobile payments, the adoption increased relatively more in areas with a younger population
- This effect is sizable: 1 s.d. increase in the share of young adult $\Rightarrow \approx 25\%$ increase relative to the baseline adoption rate
- Main concerns:
  1. areas with a younger population are different?

Age Structure and District characteristics



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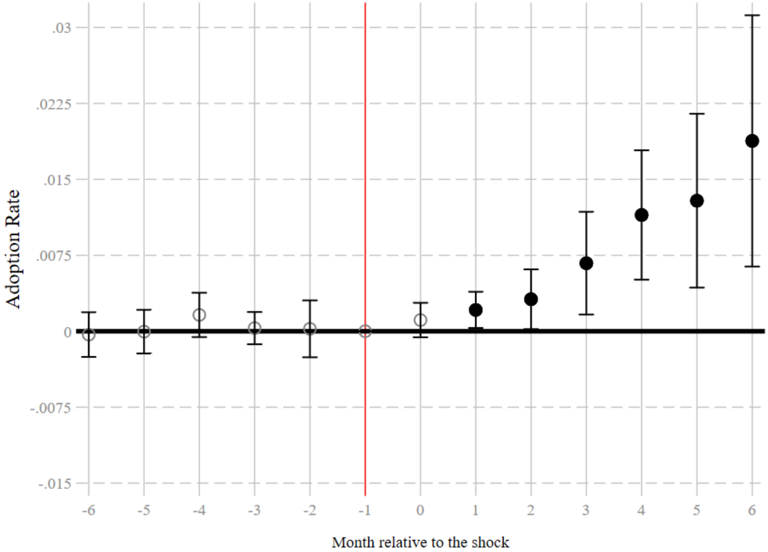
(1) Demographics and Mobile Adoption: with baseline controls x month f.e.



baseline controls: population; share of agri. workers; number of firms; literacy rate; share of working pop.; nightlight intensity Robustness

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(2) Demographics and Mobile Adoption: an IV-2SLS approach

- We exploit **historical determinants of fertility** as an instrument for the share of young people
- **Idea**: areas with higher expected fertility in early 1990s $\rightarrow$ larger share of younger population in late 2010s

  $\star$ variation orthogonal to recent migration trends

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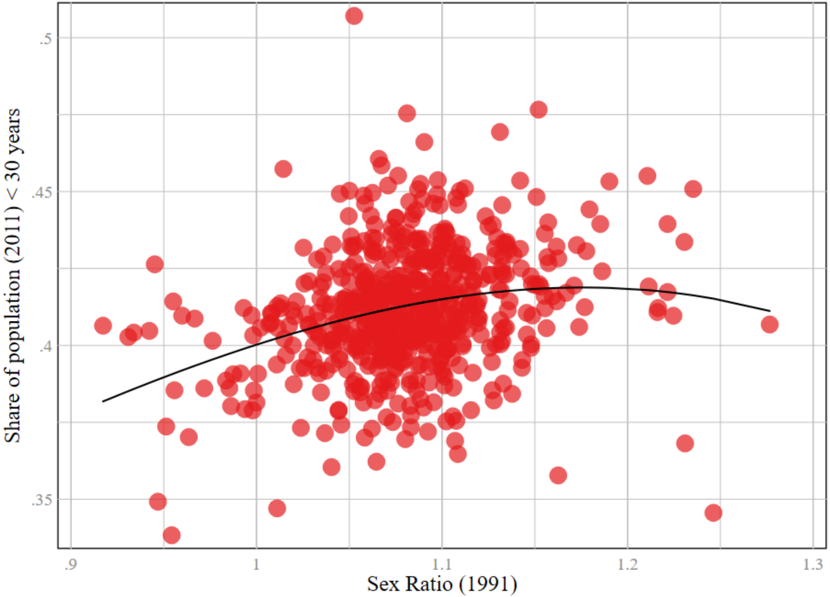
- **District-Level Sex Ratio in 1990:** a skewed sex ratio should affect the marriage market and consequently fertility [Guilmoto 2012; Dyson 2012; Angrist 2000]

(2) Correlation: Sex Ratio$_{d,1991}$ and Age Structure$_{d,2011}$



(2) Demographics and Mobile Adoption: an IV-2SLS approach

	First Stage	2SLS	
	AgeStructure_d $\times$ Post_t	Adoption rate	# Adoptions (IHS)
	(1)	(2)	(3)
$(\text{Sex Ratio})_{d,1991} \times \text{Post}_t$	61.04***		
	(11.71)		
$(\text{Sex Ratio})^2{}_{d,1991} \times \text{Post}_t$	-25.70***		
	(5.332)		
$\text{AgeStructure}_d \times \text{Post}_t$		0.020***	0.256***
		(0.0046)	(0.085)
Observations	7,722	7,722	7,722
SW F-statistic	43.46		
District f.e.	✓	✓	✓
Month f.e.	✓	✓	✓
Controls $\times$ Month f.e.	✓	✓	✓

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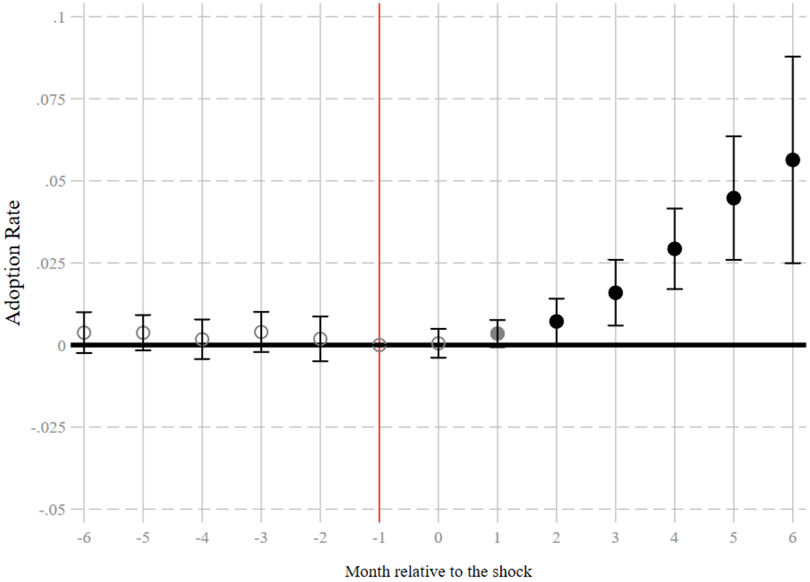

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  3. other district-level confounders [within-district comparison in areas with and w/o universities]

(3) Demographics and Mobile Adoption: University Analysis

- Within a city, neighborhoods with universities:
  - Should have similar culture, institutions, type of business owners than other neighborhoods.
  - **but** a larger share of customers should be young adults (i.e., students).

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- Within a city, neighborhoods with universities:
  - Should have similar culture, institutions, type of business owners than other neighborhoods.
  - **but** a larger share of customers should be young adults (i.e., students).

- We manually collect the main pincode of operation for all Indian Universities

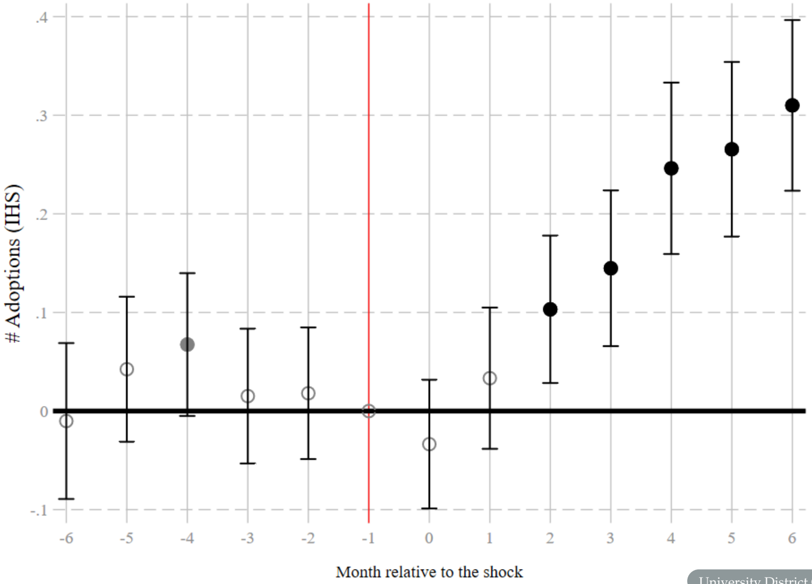
- Compare adoption across pincodes with and without universities, **within** the same district:

$$Adoption_{p,t} = \alpha_{dt} + \alpha_p + \sum_{k=-6,k\neq-1}^{k=+6} \gamma_k \left(1\{Univ\}_p \times 1_{\{t=t_0+k\}}\right) + \nu_{pt}$$

where:

$1\{Univ\}_p$ = 1 if there is university in pincode p in district d; 0 otherwise

(3) Demographics and Mobile Adoption: University Analysis



University District Only

Level Outcome

(3) University Analysis: Sub-sample results

	# Adoption (IHS)			
	(1)	(2)	(3)	(4)
$1(\text{has university})_p \times \text{Post}_t$	0.065***	0.076***	0.000	0.171***
	(3.30)	(3.75)	(0.00)	(6.93)
Sample	Student businesses	Student businesses (expanded)	Placebo	Others
Pincode FE	Y	Y	Y	Y
District × Month FE	Y	Y	Y	Y
Adj R-Sq	0.674	0.693	0.310	0.628
Obs	109,626	109,626	109,626	109,626

Figures

Taking stock: Demographics and Mobile Payments Diffusion

After the introduction of mobile payments, the adoption increased relatively more in areas with a younger population

.... result consistently using different methodologies and samples

... confirms the prediction of the model: a younger population leads store to more likely adopt new payment technologies

5. Conclusion

Summary and Next Steps

Mobile payments surpassed cards as the leading electronic payment option b/w 2016-20.

Using a model and data to show:

1. Young adults show a preference for mobile versus cards.
2. Firms tend to internalize this preference, fostering more adoption of the new technology where young adults are a sizable share of the customer base.

Evidence suggests that demographic differences may explain the diffusion of new technologies

.... an older society can be slower at picking up new technologies

\+ similar evidence with Brazil's instant payment system Pix

Figure

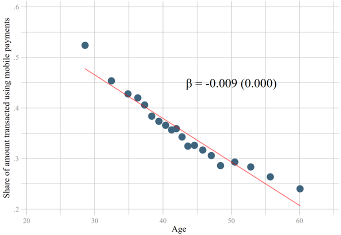
Next steps:

implications of demographics $\times$ strategic complementarities (in network-based technologies) for technology adoption and diffusion

Appendix

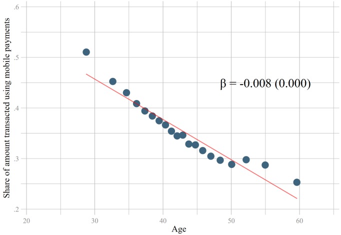
Mobile vs. Cards: with controls

(a) + baseline controls



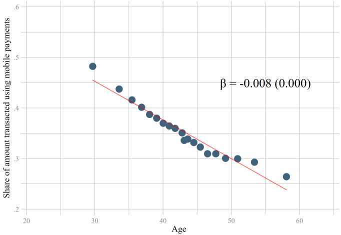
Baseline Controls: Gender f.e., Marital status f.e., Occupation f.e.

(b) + pincode-month



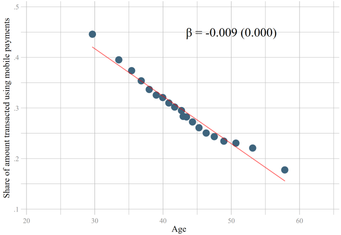
Controls: Baseline controls, pincode-month f.e.

(c) + pincode-wealth-month



Controls: Baseline controls, pincode-wealth bin-month f.e.

(d) conditional on holding a credit card



Controls: Baseline controls, pincode-wealth bin-month f.e.

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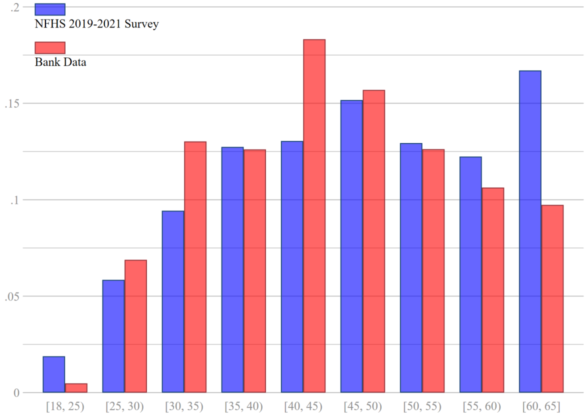
Age Comparison, Bank data



Bank sample compared to data from the National Family Health Survey (NFHS) from 2019-2021.

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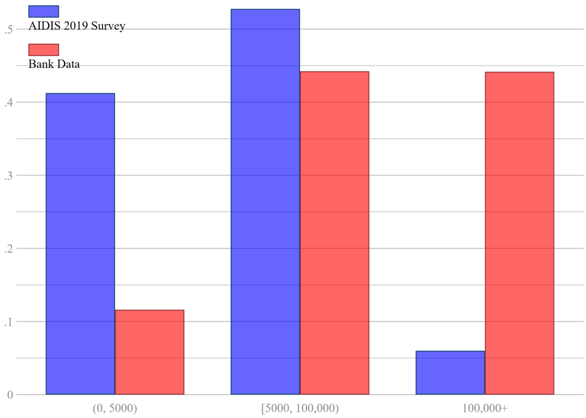
Deposit Amount Comparison, Bank data



Bank sample compared to data from the AIDIS (2019).

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Basic robustness tests

1. Alternative ”young” definition (i.e., 40 years); Figure
2. Alternative reference population (i.e., full); Figure
3. Use log-transformed (IHS) outcome; Figure
4. Scale outcome by population; Figure
5. Focus on all outcomes in the platform; Figure

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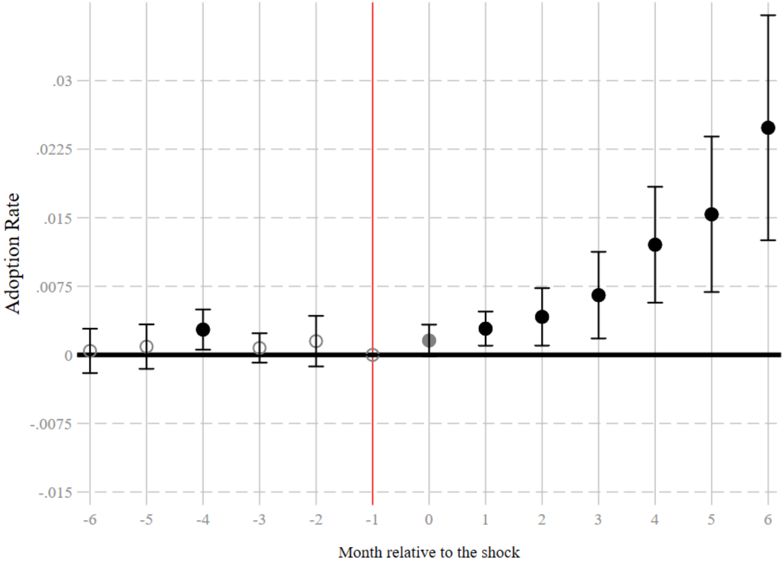
Robustness: Young as less than 40yr.



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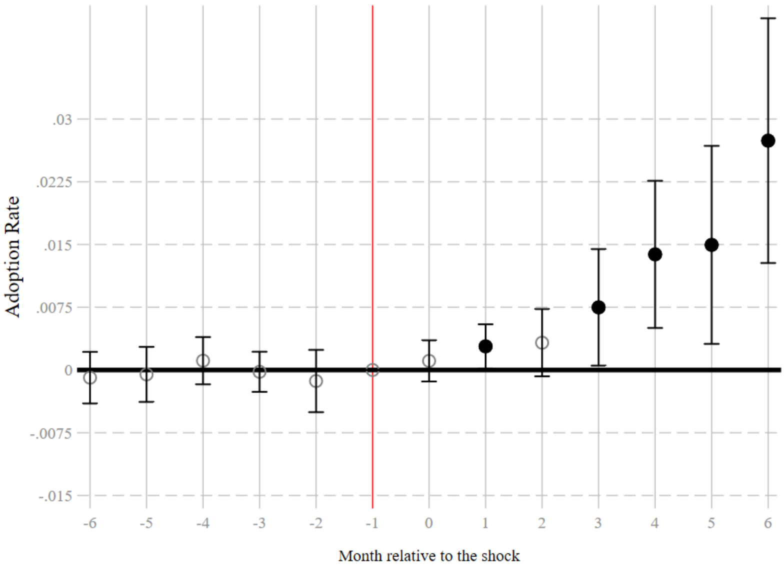
Robustness: treatment based on the full population



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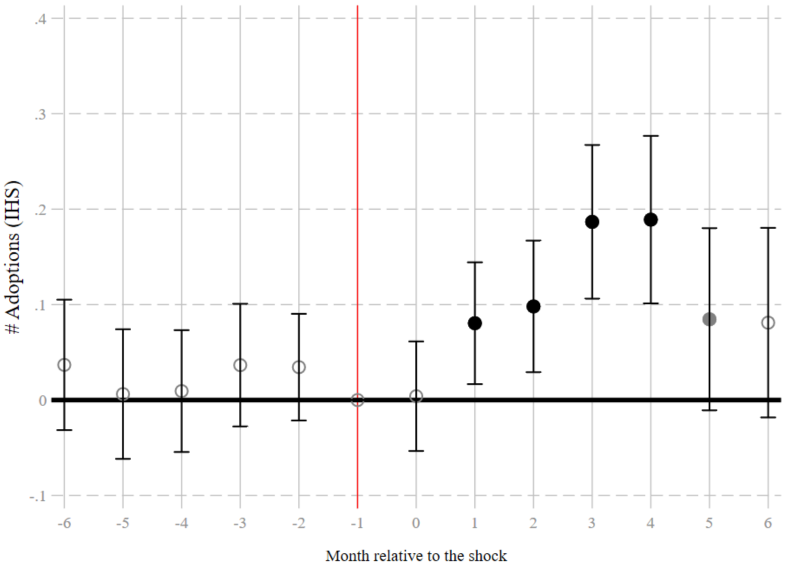
Robustness: IHS specification (w/o contr.)



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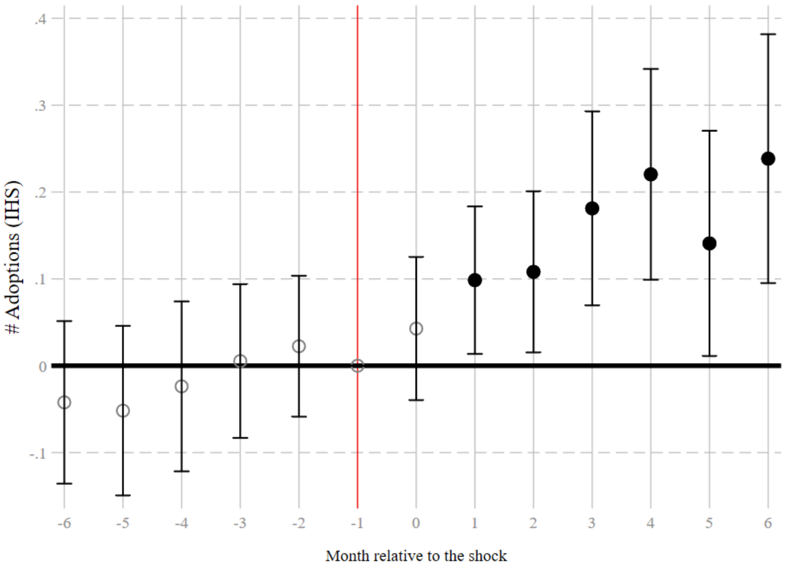
Robustness: IHS specification (w/ contr.)



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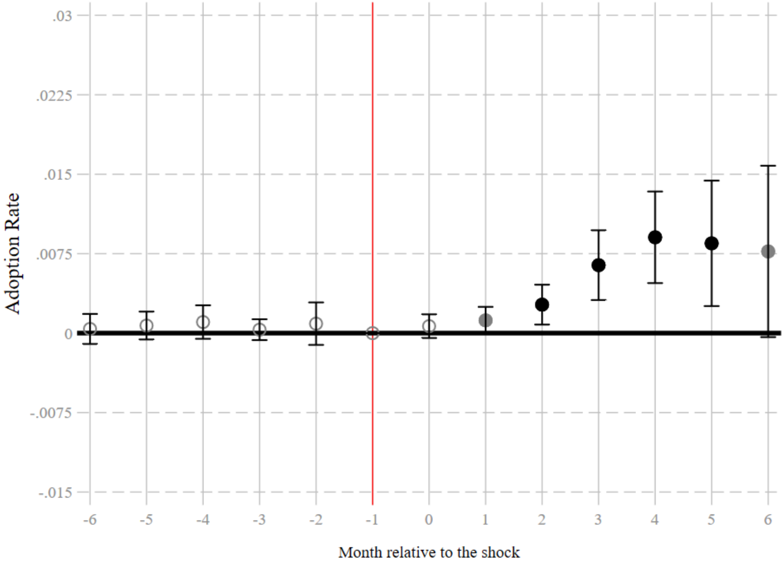
Robustness: outcome scaled by population



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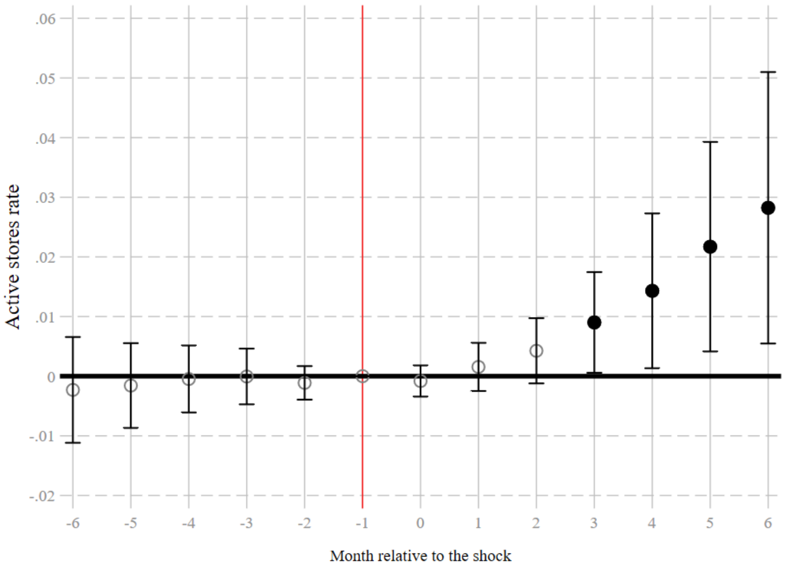
Robustness: total stores in the platform



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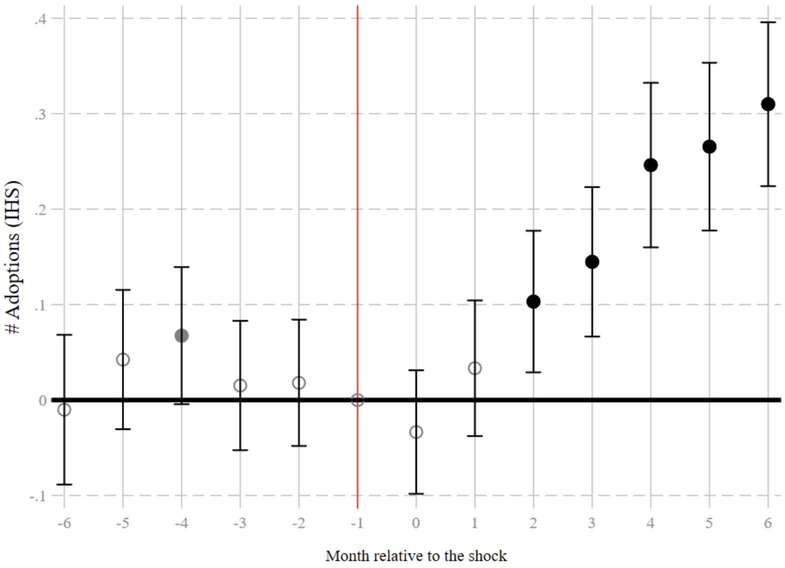
University Analysis: only University districts



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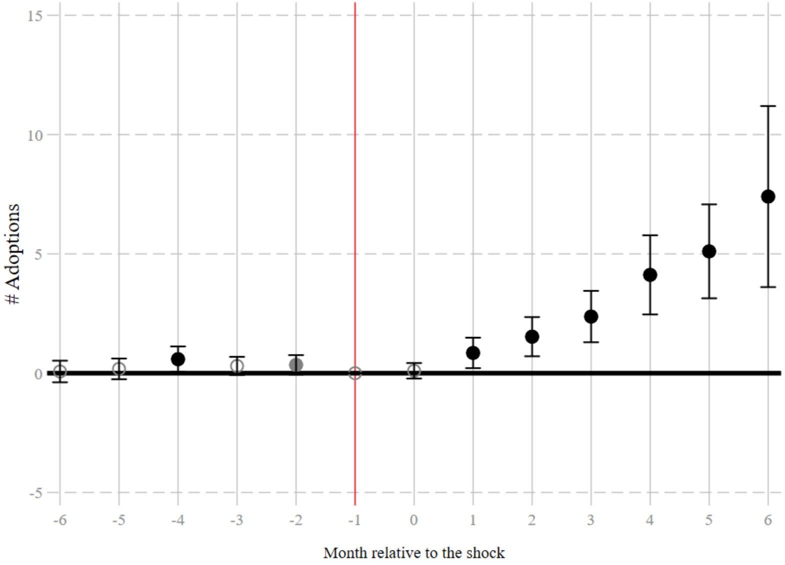
University Analysis: in level (no adj.)



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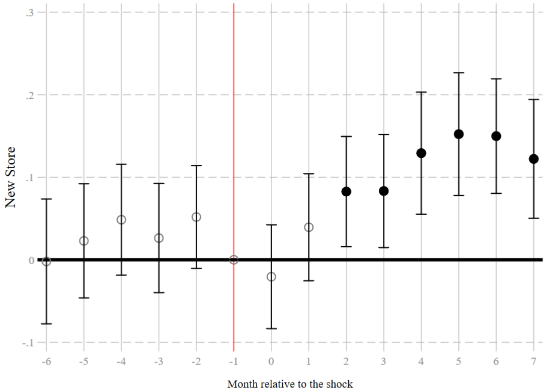
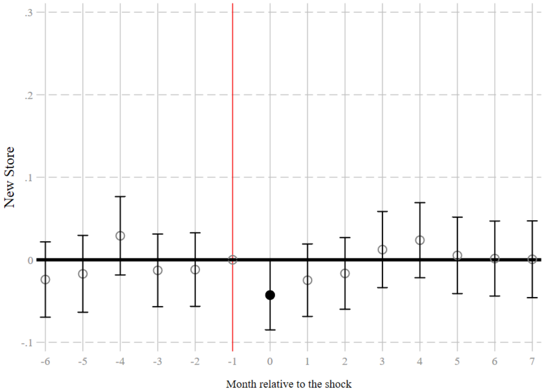
(3) University Analysis: Sub-sample results

student-as-consumer businesses



“placebo” businesses



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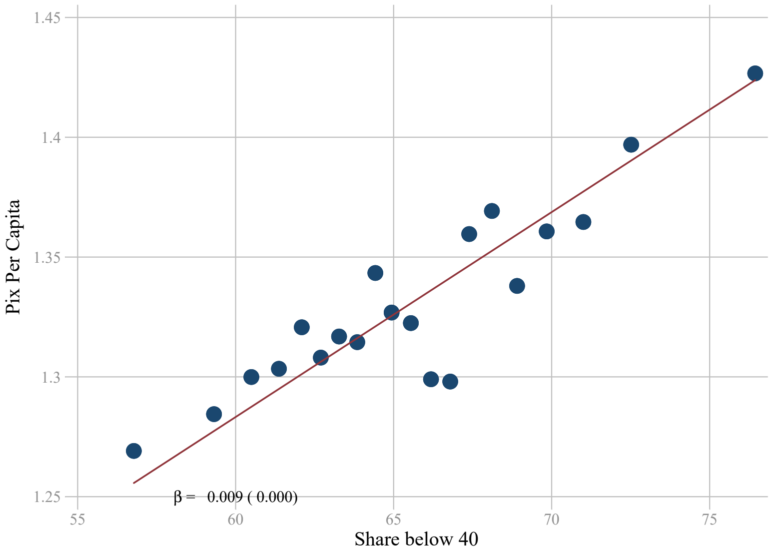
Similar Evidence From Brazil



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