Cash and the Economy:
Evidence from India's Demonetization

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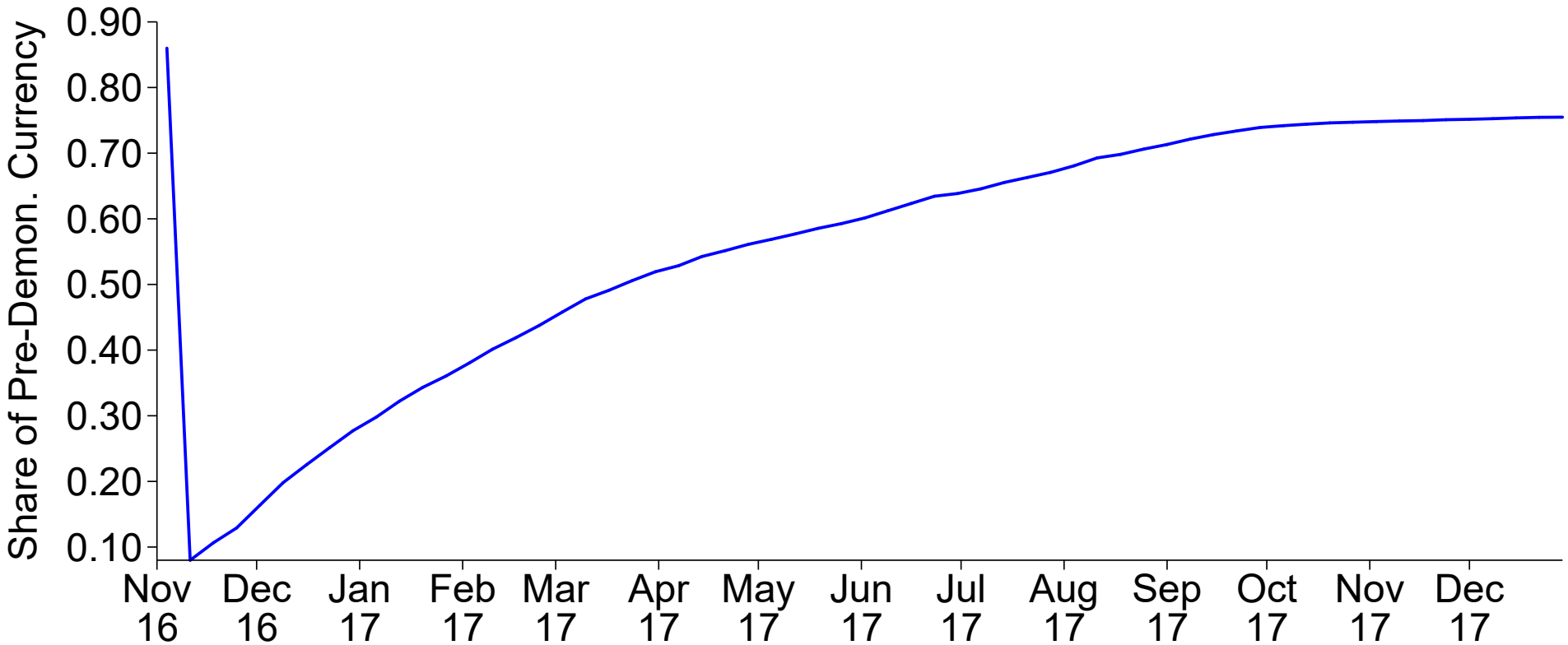
THE EVENT: DEMONETIZATION OF LARGE NOTES



- November 8, 2016: 1000 ($15) and 500 ($7.50) rupee notes declared not legal tender, replaced by 2000 and new 500 note.

OLD AND NEW NOTES

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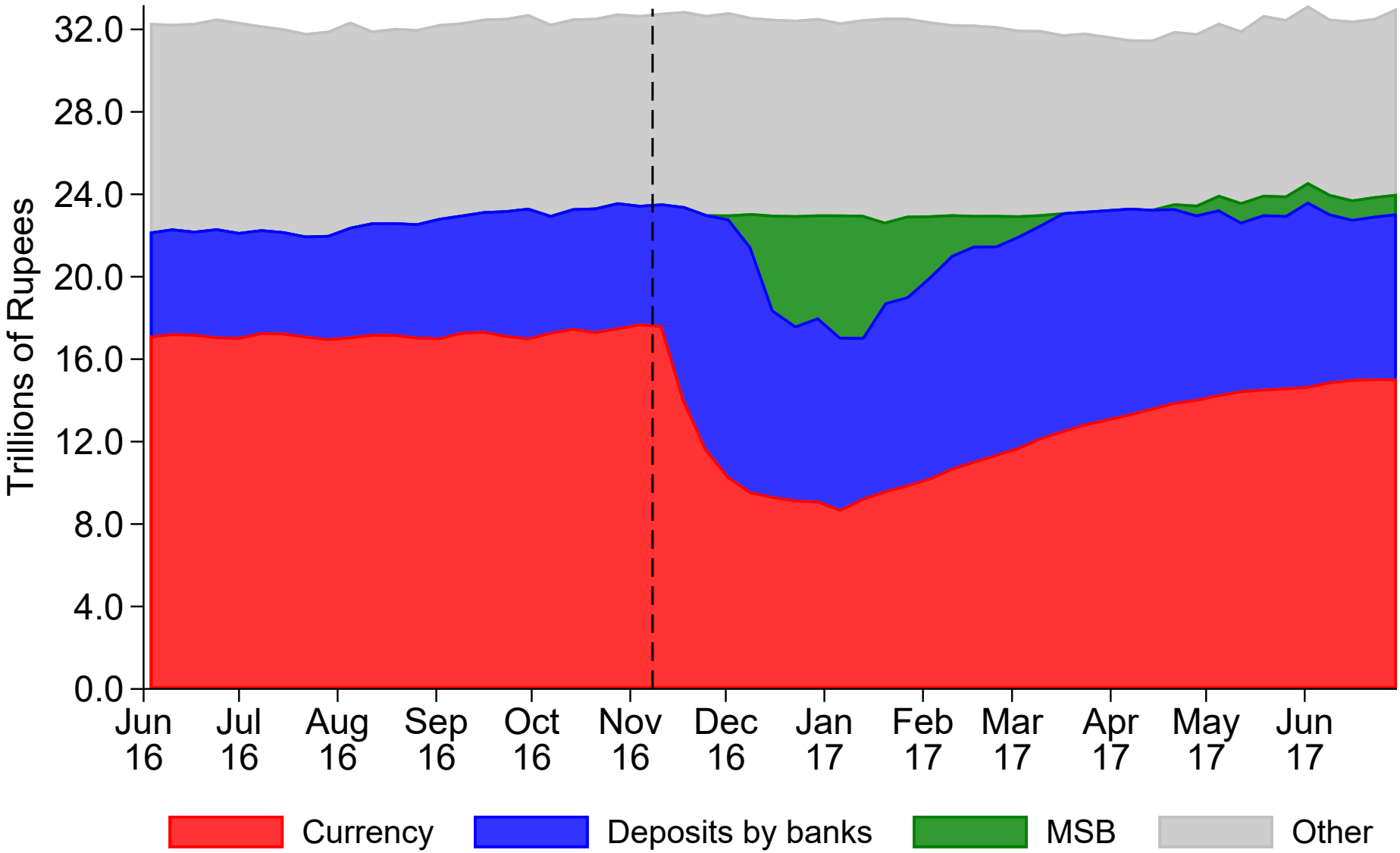
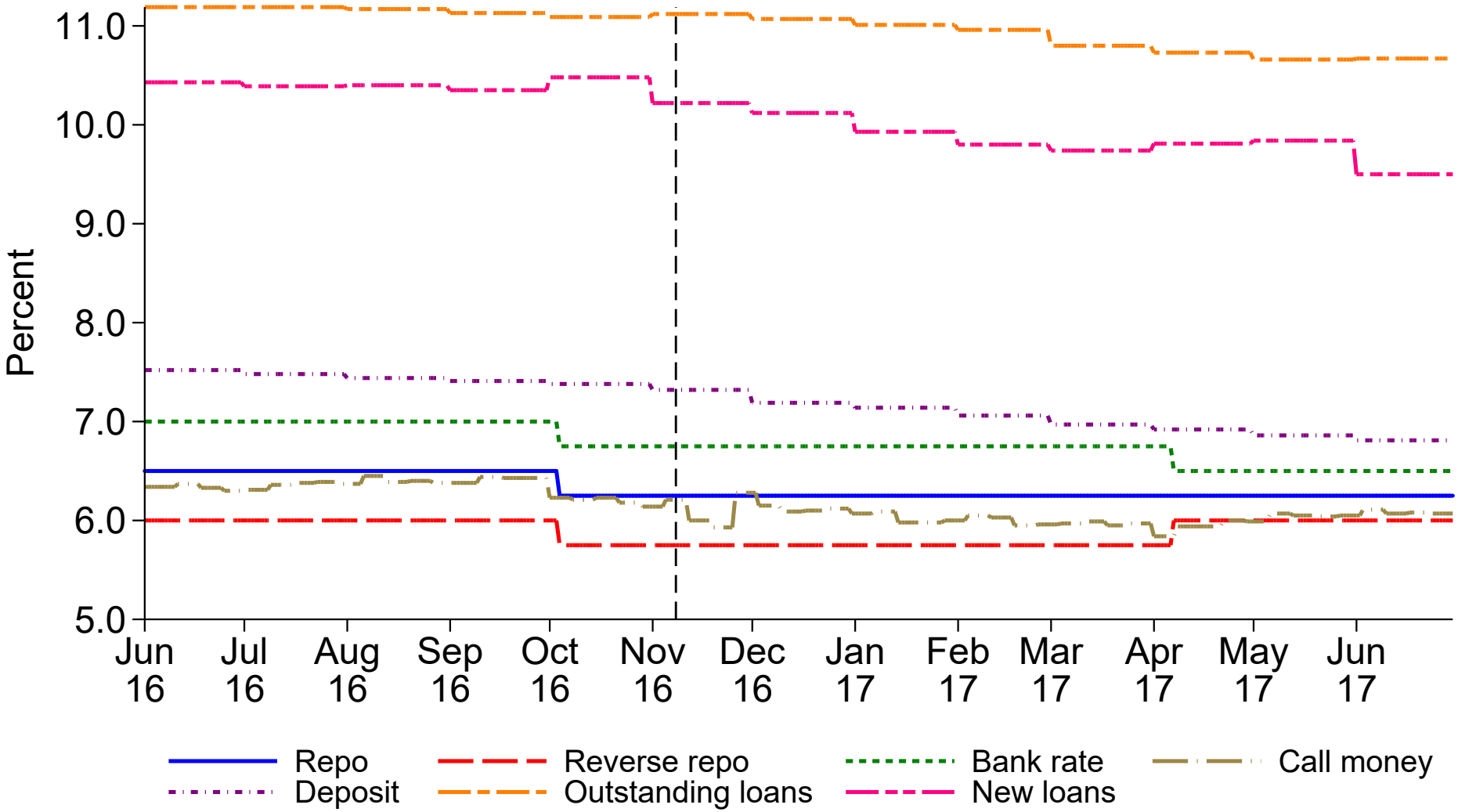
RBI LIABILITIES DO NOT CHANGE



FORCED SWAP: INTEREST RATES UNCHANGED



Our paper

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   - Endogenous adoption of non-cash payment mechanisms: not subject to Lucas critique.

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   - Measures of formal and informal sector activity, adoption of non-cash payment mechanisms, banking outcomes.

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2. Empirical evidence from India:
   - Cross-sectional variation in cash replacement for causal identification.
   - Measures of formal and informal sector activity, adoption of non-cash payment mechanisms, banking outcomes.
3. Main results:
   - Economically large effect on output and statistically strong. Reject monetary neutrality and cashless limit.
   - Decline in output smaller than decline in $M \Rightarrow$ endogenous adoption of alternative payment methods.

Preview of results

1. Districts experiencing more severe demonetization had:
   - Relative reductions in economic activity with interdecile difference 4.5% of output.
   - Faster adoption of alternative payment technologies.
   - Lower bank credit growth.
2. Aggregate effects (relative to counterfactual):
   - Output and employment decline in 2016Q4: $\geq 2\%$.
   - Bank credit decline in 2016Q4: $\geq 2\%$
   - Effects peak immediately and substantially dissipate by 2017Q2.

Relation to Literature

- Evidence of monetary non-neutrality: Velde, 2009; Ramey, 2016.
- Role of cash: CIA constraint (Lucas, 1982; Lucas and Stokey, 1987; Svensson, 1985); new monetarist perspective (Kocherlakota, 1998; Williamson and Wright, 2010); New Keynesian synthesis (Woodford, 2003); cash demand (Baomol, 1952; Tobin, 1956; Alvarez and Lippi, 2009); phaseout (Rogoff, 2016).
- Cross-section evidence and empirical macro: Nakamura and Steinsson, 2018; Chodorow-Reich, 2019.
- Effects of demonetization: RBI, 2017; Krishnan and Siegel, 2017; Aggarwal and Narayanan, 2017; Banerjee and Kala, 2017; Crouzet, Gupta, Mezzanotti, 2018.

Outline

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Model

- Continuum of identically sized regions i produce traded ($Y^T_{i,t}$) and non-traded ($Y^N_{i,t}$) good using labor: $Y^j_{i,t} = N^j_{i,t}$.
- Households hold cash for transaction (CIA) and tax evasion purposes.
- Firms obtain working capital from banks to finance wage payments.
- Government sets money supply M.
- Downward nominal wage rigidity (Kaur, 2016): $W_{i,t} \geq \gamma W_{i,t-1}$.
- Demonetization: sudden, unexpected, temporary decline in M.

HOUSEHOLDS

- Hold cash for transaction (Lucas, 1982; Svensson, 1985) *and* tax evasion purposes:

$$\max_{C_{i,t}^T, C_{i,t}^N, D_{i,t}, M_{i,t}} \sum_{t=0}^{\infty} \beta^t U(C_{i,t})$$

s.t.

$$P_{i,t}C_{i,t} + D_{i,t} + M_{i,t} \leq R_{t-1}D_{i,t-1} + M_{i,t-1} + (1 - \tau(\eta_{i,t}))W_{i,t}N_{i,t} + T_{i,t},$$

$$\kappa P_{i,t}C_{i,t} \leq M_{i,t-1} + T_{i,t}^M, \ 0 < \kappa \leq 1,$$

$$C_{i,t} = (C_{i,t}^T)^{\alpha}(C_{i,t}^N)^{1-\alpha}, C_{i,t}^T = \left(\int_0^1 C_{i,t}^T(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}},$$

$$\eta_{i,t} = \frac{M_{i,t}}{W_{i,t}N_{i,t}}, \ -1 < \tau'(\eta_{i,t}) < 0.$$

Banks/firms

- (Perfectly competitive) Banks take deposits and lend to firms and government:

$$\int_i A^f_{i,t} di + A^g_t = \int_i D_{i,t} di$$

- (Perfectly competitive) firms hire workers and take working capital loans:

$$P^T_t(\omega) = P^N_{i,t} = (1 + \varphi(R_t - 1))W_{i,t}.$$

Government and timing

- Budget constraint:

$$\int_0^1 \left(M_{i,t}^s + B_{i,t}^g + \tau(\eta_{i,t}) W_{i,t} N_{i,t} \right) di =$$
$$\int_0^1 \left(T_{i,t}^M + T_{i,t}^g + M_{i,t-1}^s + R_{t-1} B_{i,t-1}^g \right) di,$$

$$T_{i,t}^M = M_{i,t}^s - M_{i,t-1}^s.$$

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$$T_{i,t}^M = M_{i,t}^s - M_{i,t-1}^s.$$

- Timeline of shock
  - Period -1: pre-demonetization steady state with no binding CIA.
  - Period 0: demonetization, $T^M < 0$, $Z = \frac{M_0^s}{M_{-1}^s}$.
  - Period 1 onwards: revert to steady state with no binding CIA.

Demonetization equilibrium ▸ Details

- Equilibrium conditions in period 0 with symmetry:

$$\text{Surprise demonetization:} \qquad Z = M_0/M_{-1},$$

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- Solution for output/employment:

$$\frac{Y_0}{Y_{-1}} = \frac{N_0}{N_{-1}} = \frac{M_{-1}/(W_{-1}N_{-1})}{\kappa\gamma(1+\varphi r_{-1})} Z.$$

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- Non-uniform demonetization with tradeable share α:

$$\frac{Y_{i,0}}{Y_{i,-1}} = \frac{N_{i,0}}{N_{i,-1}} = \frac{M_{-1}/(W_{-1}N_{-1})}{\kappa\gamma(1+\varphi r_{-1})} \left(\alpha Z + (1-\alpha) Z_i\right).$$

Endogenous κ

- Modify household objective function and CIA constraint:

$$\max_{C^T_{i,t}, C^N_{i,t}, D_{i,t}, M_{i,t}, f_{i,t}} \sum_{t=0}^{\infty} \beta^t U(C_{i,t} - h(f_{i,t})),$$

$$\kappa_{i,t} P_{i,t} C_{i,t} \leq M_{i,t-1} + T^M_{i,t},$$

with $\kappa'(f_{i,t}) < 0, \kappa(0) = \bar{\kappa}, h'(f_{i,t}) > 0, h''(f_{i,t}) \geq 0, h(0) = 0.$

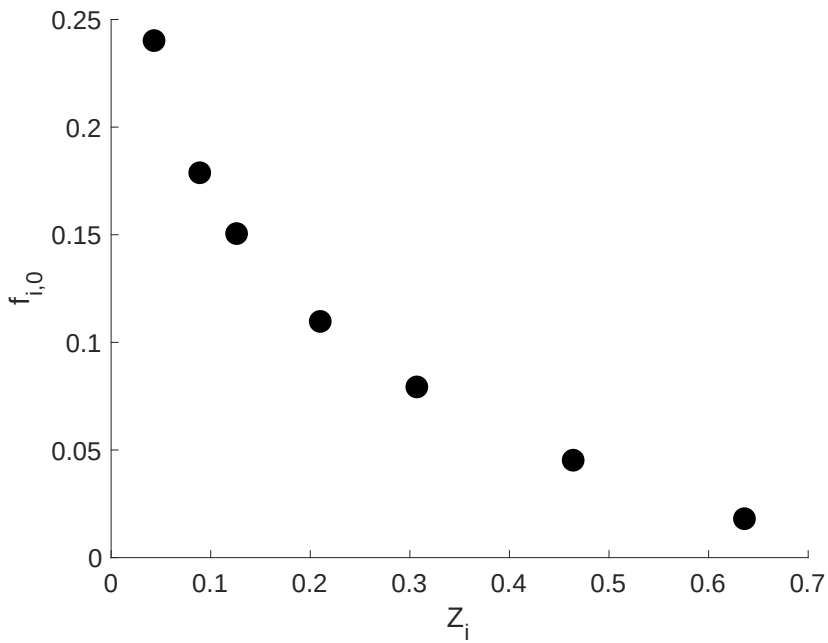
- Additional FOC with Lagrange multiplier on CIA constraint $\theta_{i,0}$:

$$h'(f_{i,t}) = -\theta_{i,t} \kappa'(f_{i,t}) P_{i,t} C_{i,t}.$$

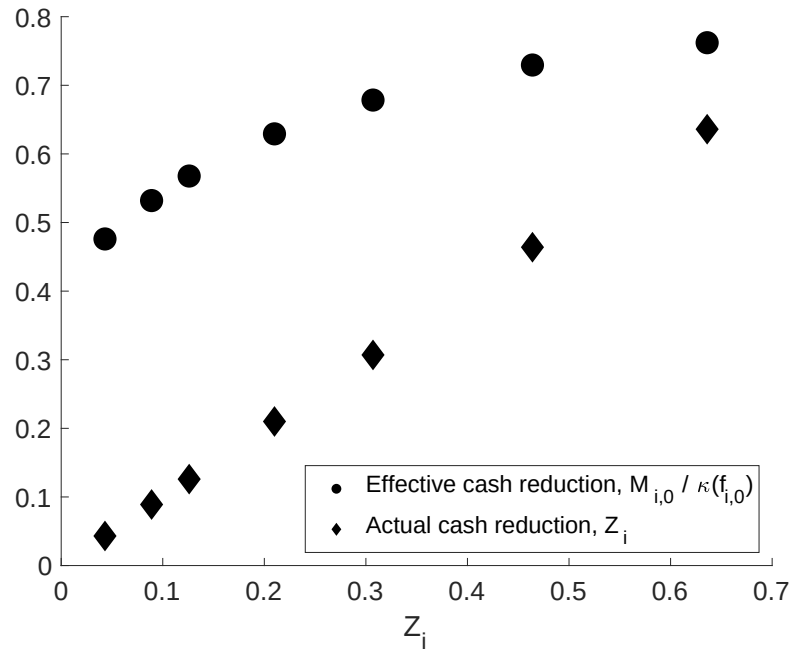
- Solve numerically.

Alternative payment technology

$$M_{i,0} = \kappa(f_{i,0}) P_{i,0} C_{i,0},$$
$$h'(f_{i,0}) = -\theta_{i,0} \kappa'(f_{i,0}) P_{i,0} C_{i,0}.$$



(a) Financial Services



(b) Effective Cash Shortage

Predictions

Districts experiencing more severe demonetization will have:

1. Relative reductions in employment and output.
2. Faster adoption of alternative payment technologies.
3. Lower bank credit growth.
4. Cross-sectional estimates provide lower bound for aggregate effects.

Outline

Data sets

Name	Source	Coverage
Currency chests	RBI	Daily cash flow accounting statements by denomination for all currency chests in India aggregated to district level
Consumer Pyramids	Centre for Monitoring the Indian Economy (CMIE)	Monthly household survey containing employment status of 110,000 adults
Nightlights	VIIRS DNB	Low-light imaging data collected by satellite and filtered to measure the quantity of artificial light
ATM transactions	National Payments Corporation of India (NPCI)	Monthly value of all ATM withdrawals covered by NPCI
POS transactions	National Payments Corporation of India (NPCI)	Monthly value of all point-of-sale (POS) transactions covered by NPCI
E-wallet transactions	E-wallet firm	Monthly index of value of all transactions
Bank data	RBI	End-of-quarter deposits and credit outstanding at all bank branches

Demonetization shock

Demonetization shock is ratio of post-demonetization currency to pre-demonetization currency:

$$Z_{i,t} = \frac{M_{i,t}^{new} + M_i^{small}}{M_i^{1000} + M_i^{500,old} + M_i^{small}}.$$

- $M_{i,t}^{new}$: new notes received in district i.
- M_i^{1000}: demonetized 1000 notes from district i.
- $M_i^{500,old}$: demonetized 500 notes from district i.
- M_i^{small}: pre-demonetization small notes in district i.

CURRENCY CHEST DATA

Example of Currency Chest Statement

Date	Note		Inflows			Outflows			
		Open	*Remit*	*DI*	*Dep*	*Soiled*	*DO*	*Wit*	*Close*
11/15/2016	2000	100	50	20	0	0	10	80	80
11/15/2016	1000	800	0	0	200	600	0	0	400
11/15/2016	500	400	10	0	20	100	0	10	320

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New 2000 notes: $$M_{i,t}^{2000} = \sum_{s=\text{Oct 26, 2016}}^{t} \left(Remit_{i,p}^{2000} + ND_{i,p}^{2000} \right),$$

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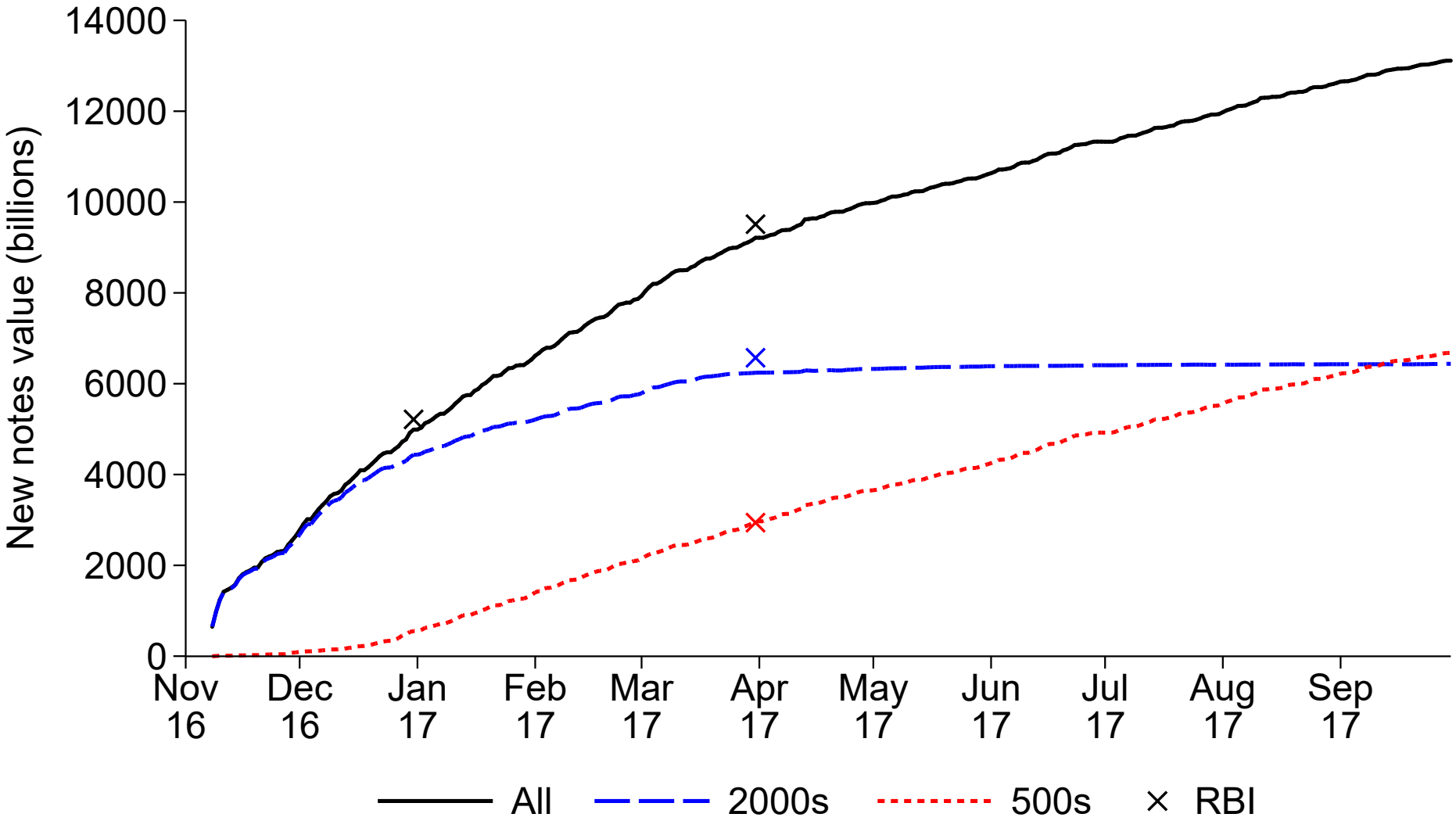
Pre demon. small notes: $$M_{i}^{small} = \left(\frac{\sum_{s=\text{Jan 1, 2014}}^{\text{Dec 31, 2015}} \left(Dep_{i,p}^{small} + Wit_{i,p}^{small} \right)}{\sum_{s=\text{Jan 1, 2014}}^{\text{Dec 31, 2015}} \left(Dep_{i,p}^{500} + Wit_{i,p}^{500} \right)} \right) M_{i}^{500,old}.$$

VALIDATION OF ALGORITHM FOR NEW NOTES

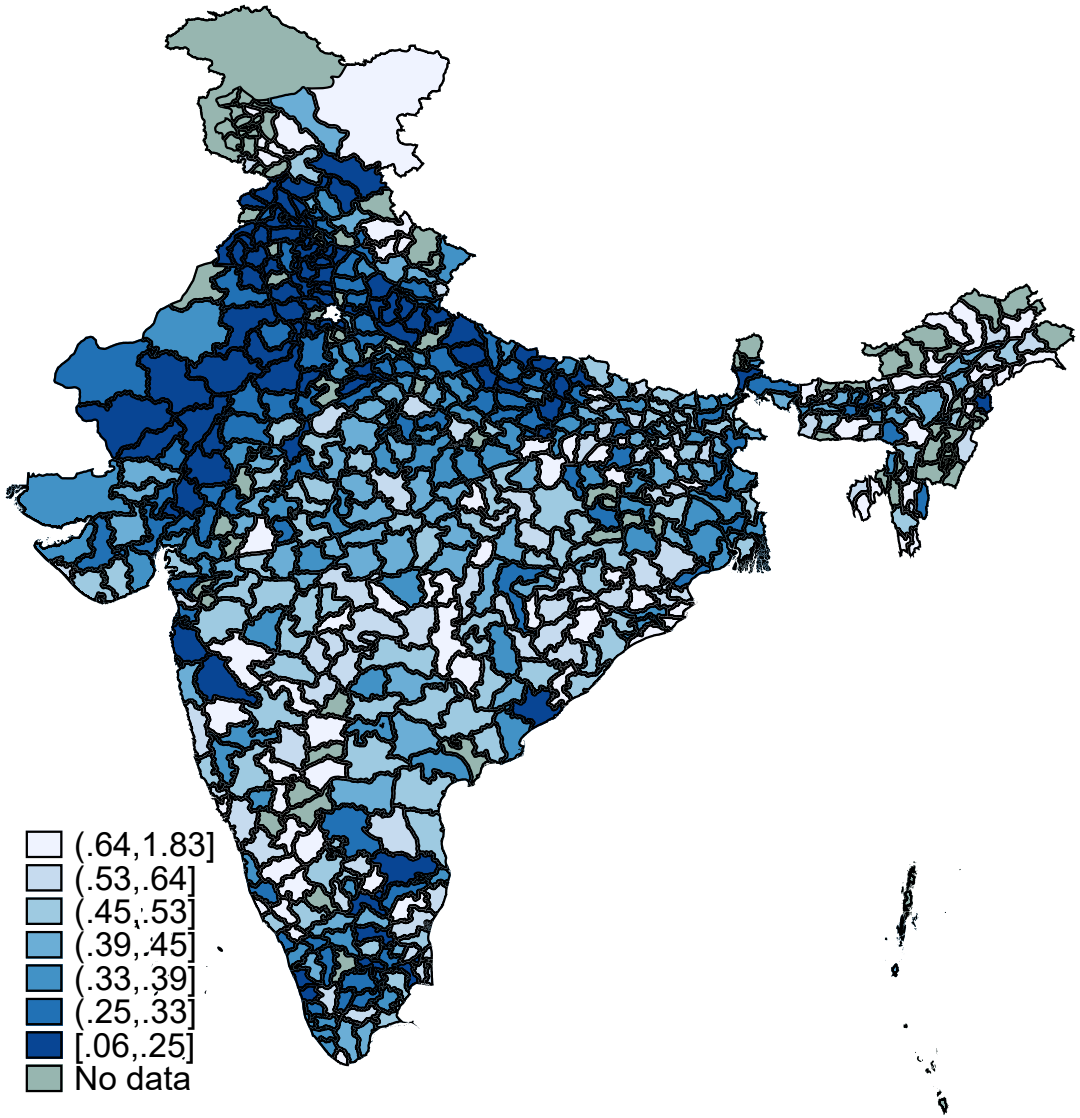


DEMONETIZATION SHOCK

$$Z_{i,t} = \frac{M_{i,t}^{new} + M_i^{small}}{M_i^{1000} + M_i^{500,old} + M_i^{small}}.$$

	Mean	SD	P10	P50	P90	Count
2016m12						
$Z_{i,t}$	0.45	0.23	0.22	0.42	0.70	542
$\left[\frac{M_i^{1000}+M_i^{500,old}}{M_i^{1000}+M_i^{500,old}+M_i^{small}}\right]$	0.89	0.04	0.83	0.89	0.95	542
2017m3						
$Z_{i,t}$	0.90	0.42	0.48	0.83	1.36	550
2017m6						
$Z_{i,t}$	1.23	0.60	0.61	1.11	1.95	548

Geography of demonetization shock in Dec-2016



NARRATIVE RECORD OF SHOCKS

RBI (2017): *In view of the logistical difficulties in supplying banknotes to all currency chests in a short span, the Hub and Spoke model was adopted for distribution of notes across the country. Fresh notes were distributed to every Issue Office in accordance with a planned allocation. The Regional Office-wise allocation of notes was revised during the last quarter of 2016-17 based on the SBNs deposited and cash supplied in issue circles during the demonetisation period.*

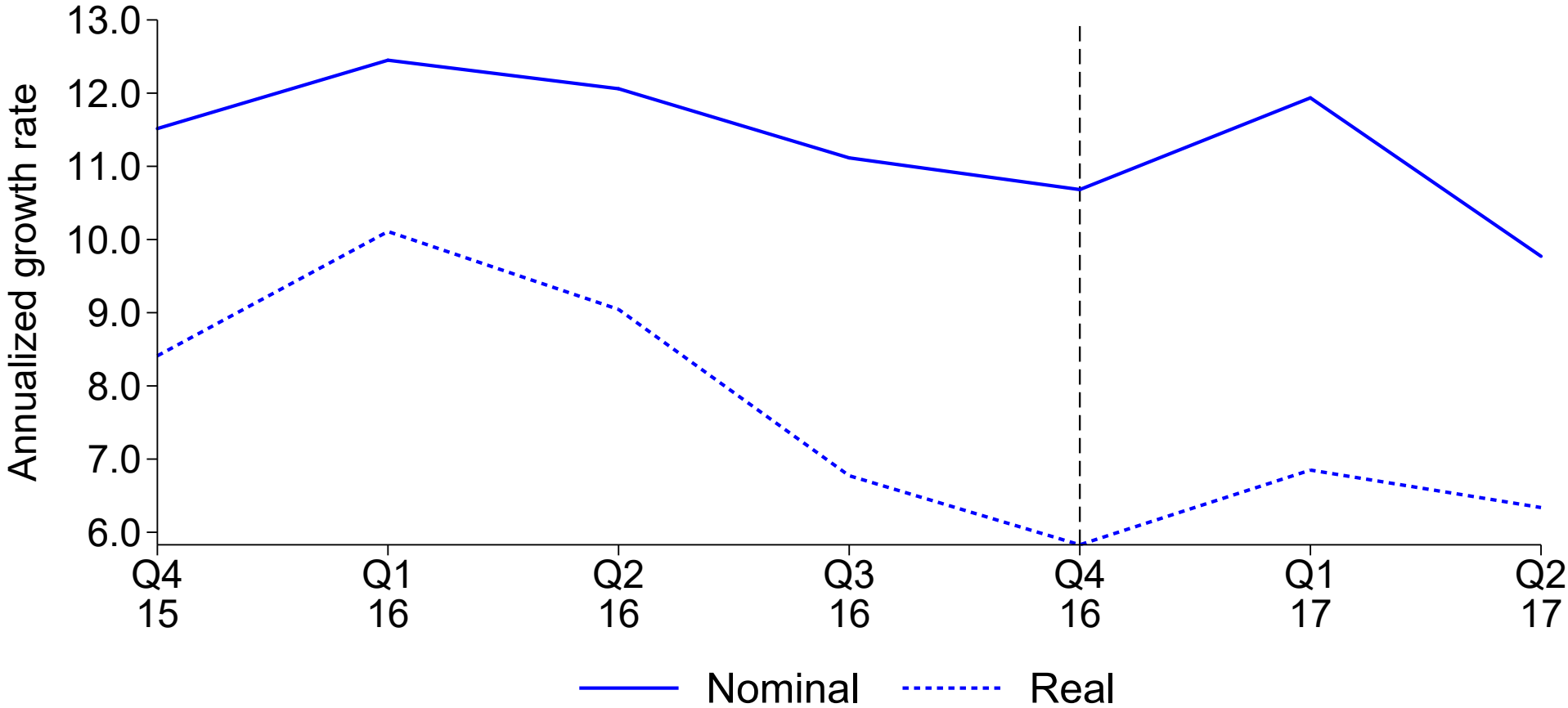
- Pre-announcement secrecy $\Rightarrow$ limited planning of distribution.
- Allocation not revised until calendar quarter 2017Q1.
- RBI could not know distribution of demonetized currency in real time.

SHOCK DETERMINANTS: STATISTICAL CORRELATES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log GDP per capita	−0.21						0.02
	(0.15)						(0.22)
Ag. share of GDP		0.00					−0.13^{+}
		(0.07)					(0.07)
Log distance			0.13*				−0.11
to RBI office			(0.06)				(0.06)
Log bank branches p.c.				−0.21			−0.12
				(0.12)			(0.17)
Log pop. density					−0.32**		−0.39**
					(0.10)		(0.12)
Log demon. notes p.c.						−0.33**	−0.32**
						(0.08)	(0.09)
BM df	13.0	9.8	19.7	18.6	16.9	13.9	
R^2	0.04	0.00	0.02	0.04	0.10	0.11	0.22
Clusters	31	31	33	31	31	31	31
Observations	540	532	542	540	539	540	531

Outline

Aggregate GDP



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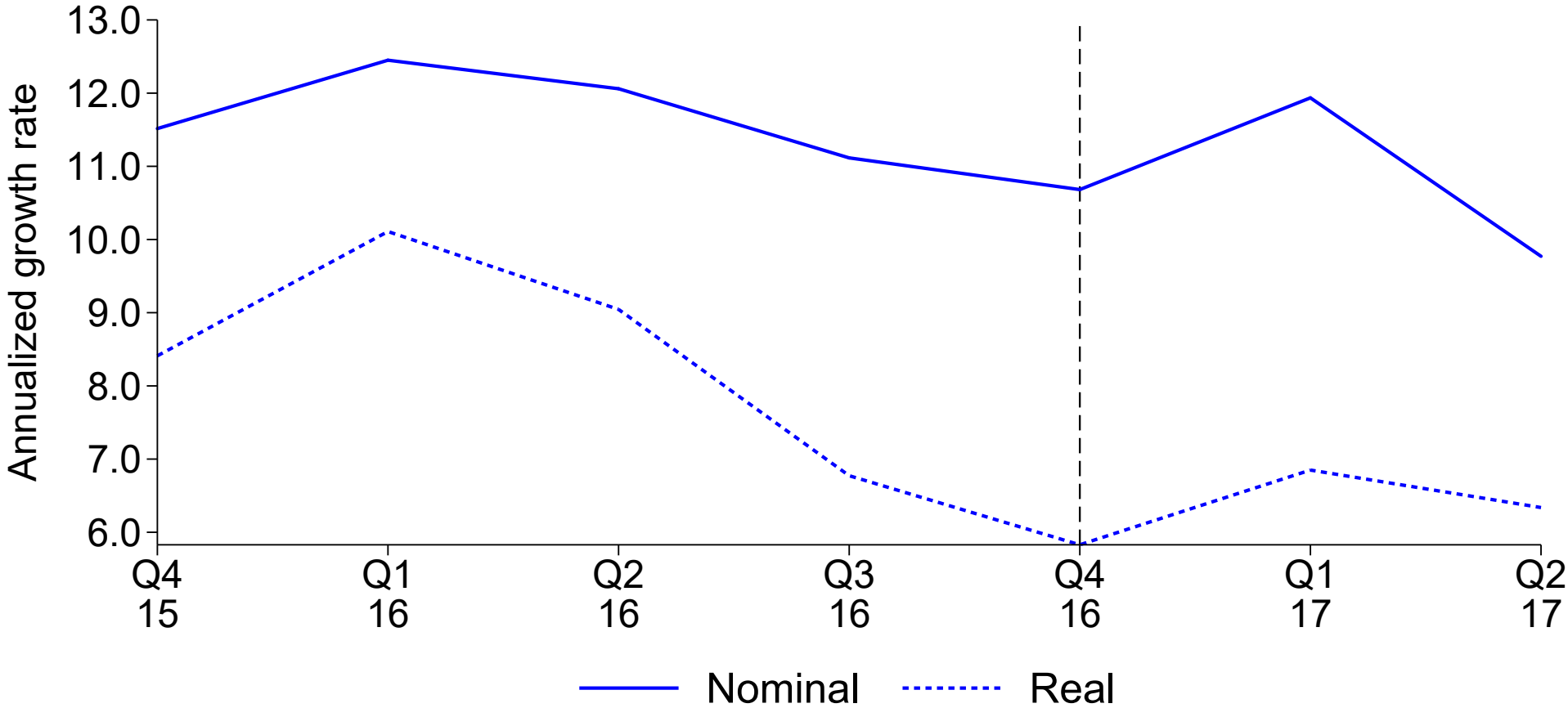


- Quarterly GDP growth not based on source data covering informal sector (81% of employment and 44% of output).
- Possible confounds: U.S. election on same date; 60% rise in price of oil Jan-Oct 2016; better monsoon season; tax reform in summer 2017.

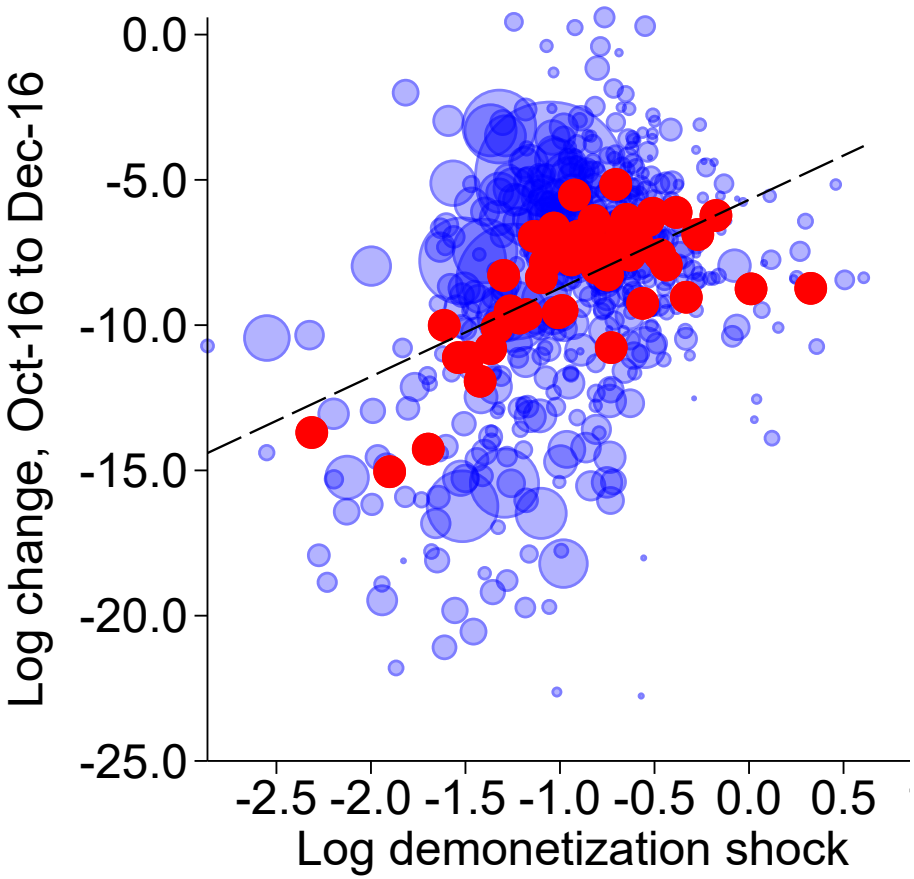
Empirical specification

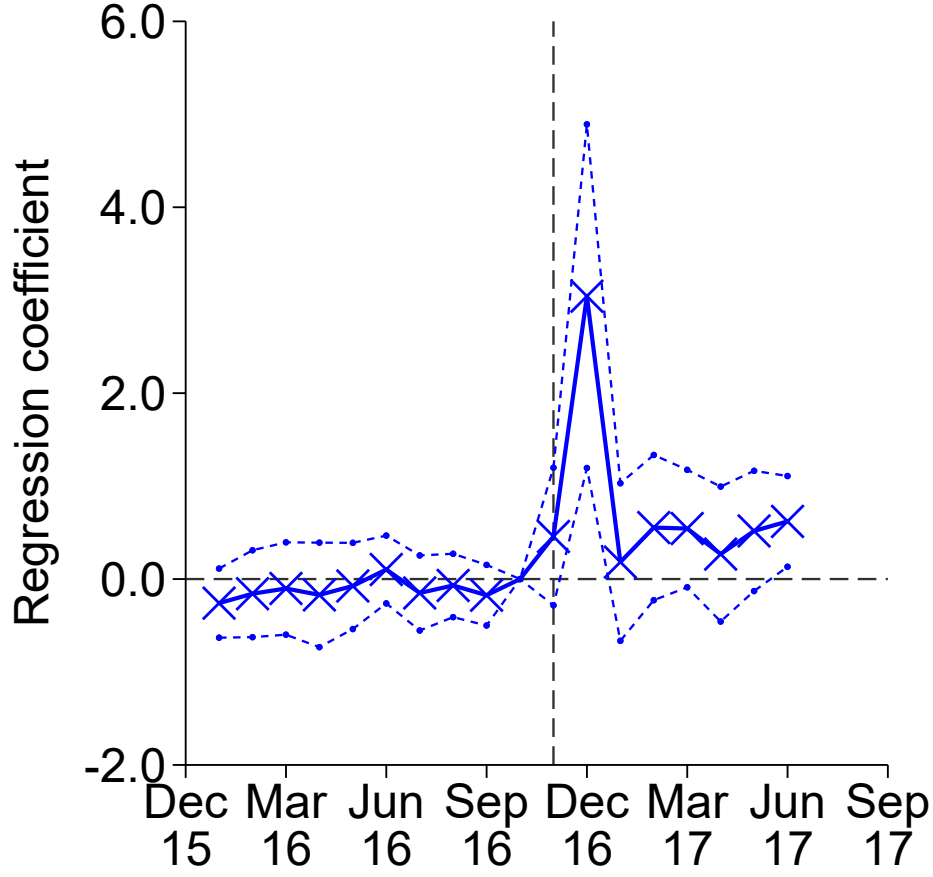
$$(y_{i,t} - y_{i,baseline}) = \beta_{0,t} + \beta_{1,t} z_{i,treatment} + \Gamma_t X_i + \varepsilon_{i,t},$$

- $y_{i,baseline}$: (log) value in period immediately preceding demonetization.
- $z_{i,treatment}$: (log) demonetization shock in Nov. or Dec. 2016.
- $\beta_{1,t}$: cumulative response at horizon t.
  - Reflects persistence in $z_{i,t}$ and true lagged effects of $z_{i,treatment}$.
- Standard errors clustered by state using Imbens & Kolesar (2016) "LZ2" confidence intervals:
  - DoF adjustment for finite sample bias and p-value from t-distribution with degrees of freedom suggested by Bell and McCaffrey (2002).
  - Imbens & Kolesar (2016) show CIs have appropriate coverage even with very few clusters.

ATM WITHDRAWALS

▸ ROBUSTNESS





Source for dependent variable: National Payment Corporation of India.

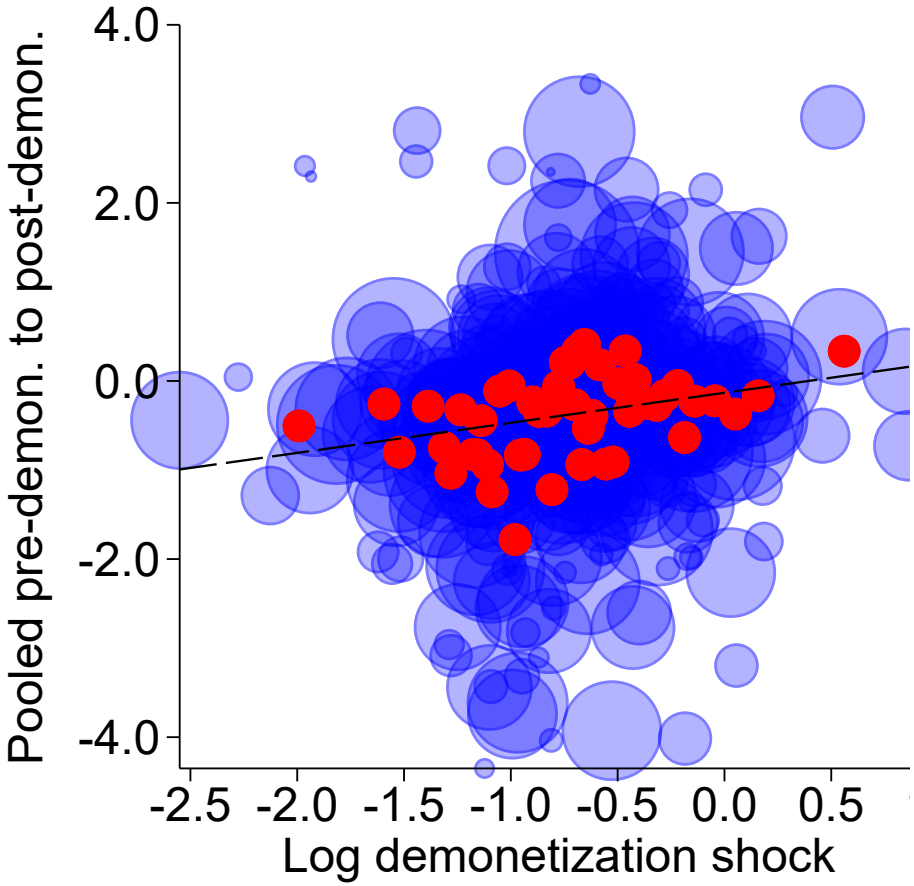
- Areas that received fewer notes had sharper reduction in ATM activity.
- Parallel trend growth of ATM withdrawals before the shock occurred.

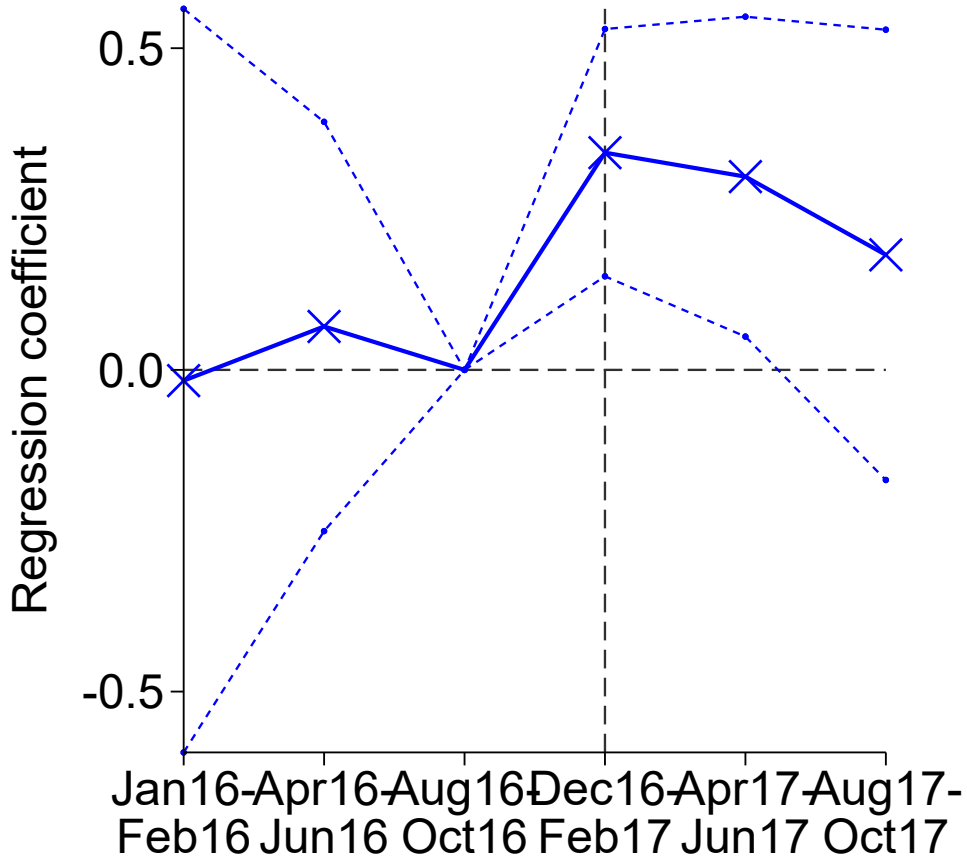
ATM WITHDRAWALS: ROBUSTNESS

	(1)	(2)	(3)
Demonetization shock	3.04**	2.86**	3.08*
	(0.85)	(0.92)	(1.12)
Log GDP per capita		0.04	0.17
		(0.85)	(0.76)
Agriculture share of GDP		0.02	−0.01
		(0.03)	(0.03)
Log population density		−0.39	−0.04
		(0.43)	(0.29)
Control lagged outcomes	No	Yes	Yes
Weight	No	No	Yes
Fitted 90-10 differential	35.3	33.2	35.8
Treatment BM df	12.8	14.6	12.8
R^2	0.13	0.18	0.17
Clusters	33	31	31
Observations	531	521	521

EMPLOYMENT

▸ ROBUSTNESS

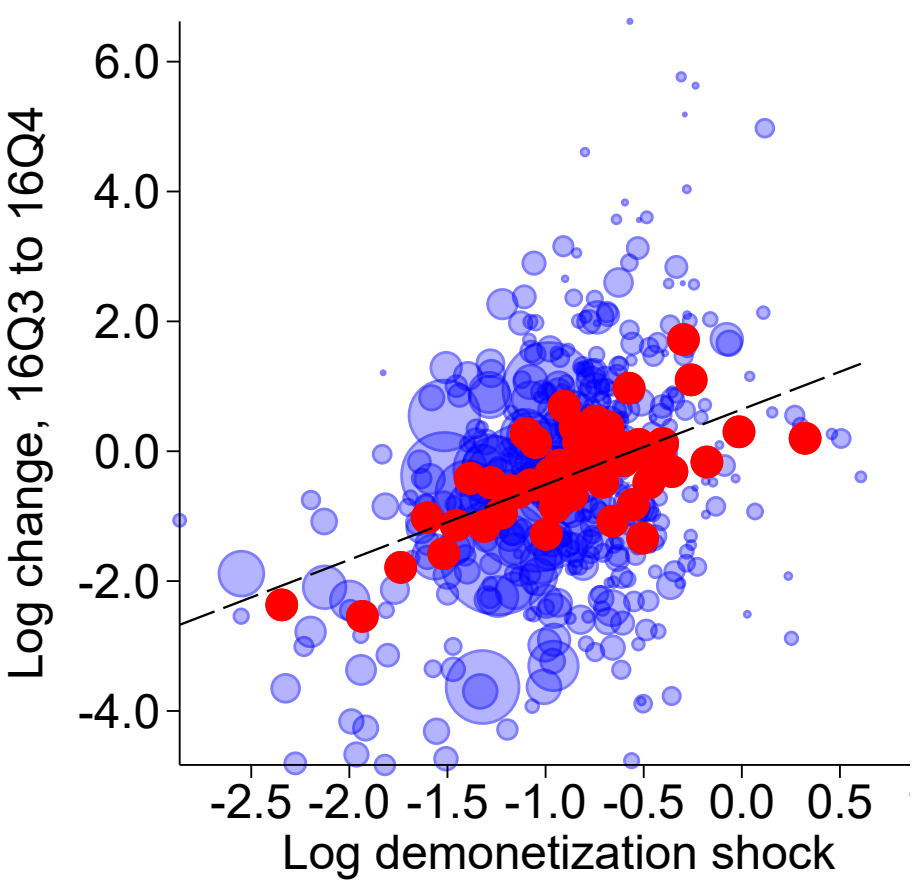


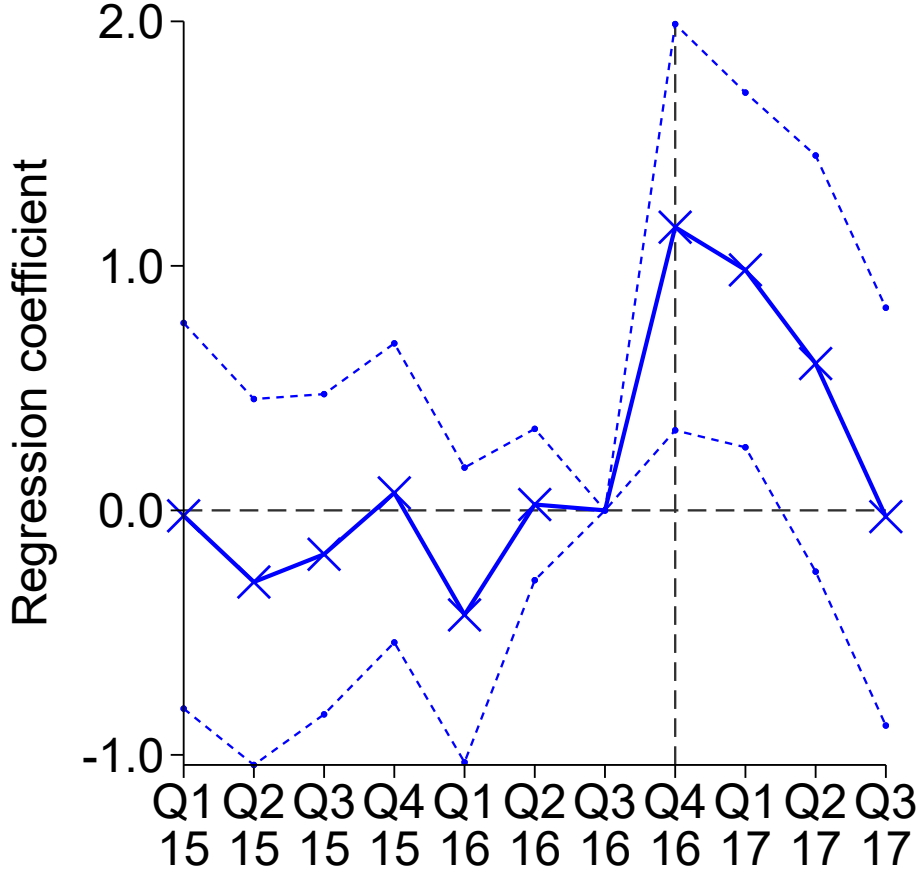


Source for dependent variable: CMIE Consumer Pyramids.

- Fitted 90-10 differential = 4.0 p.p.

NIGHT LIGHTS ▸ ROBUSTNESS





Source for dependent variable: VIIRS DNB.

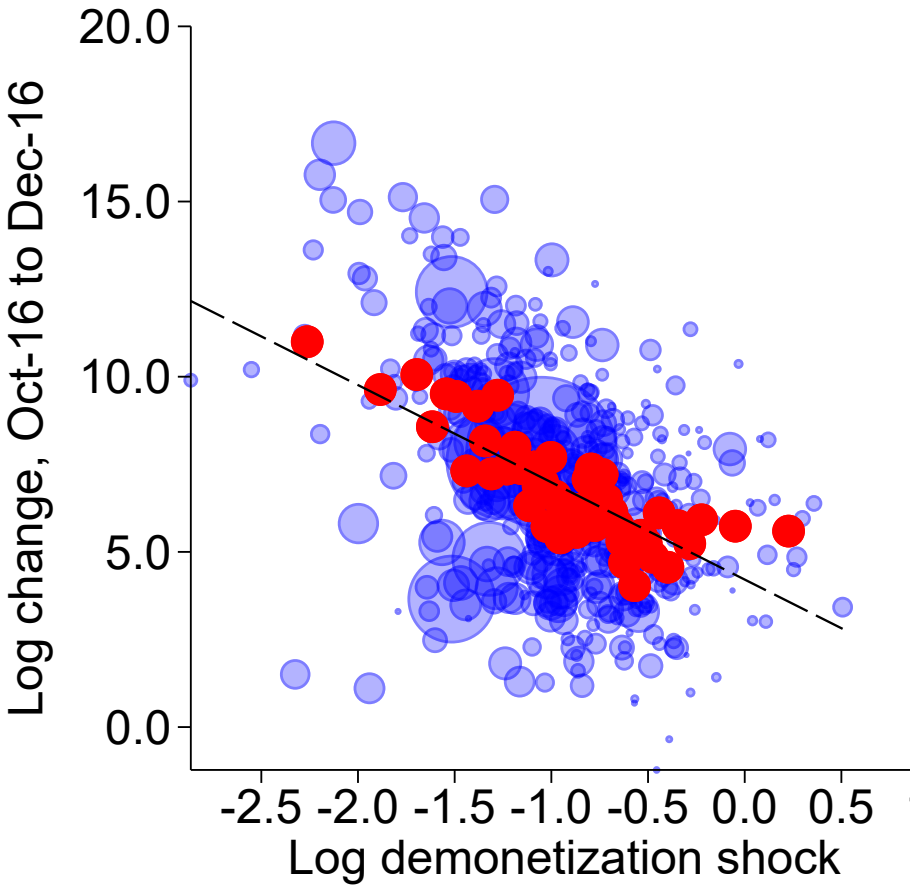
- Henderson, Storeygard, Weil (AER 2012): Elasticity of GDP growth to nightlight growth$\approx 0.3 \Rightarrow$ Fitted 90-10 differential $= 4.2$ p.p.

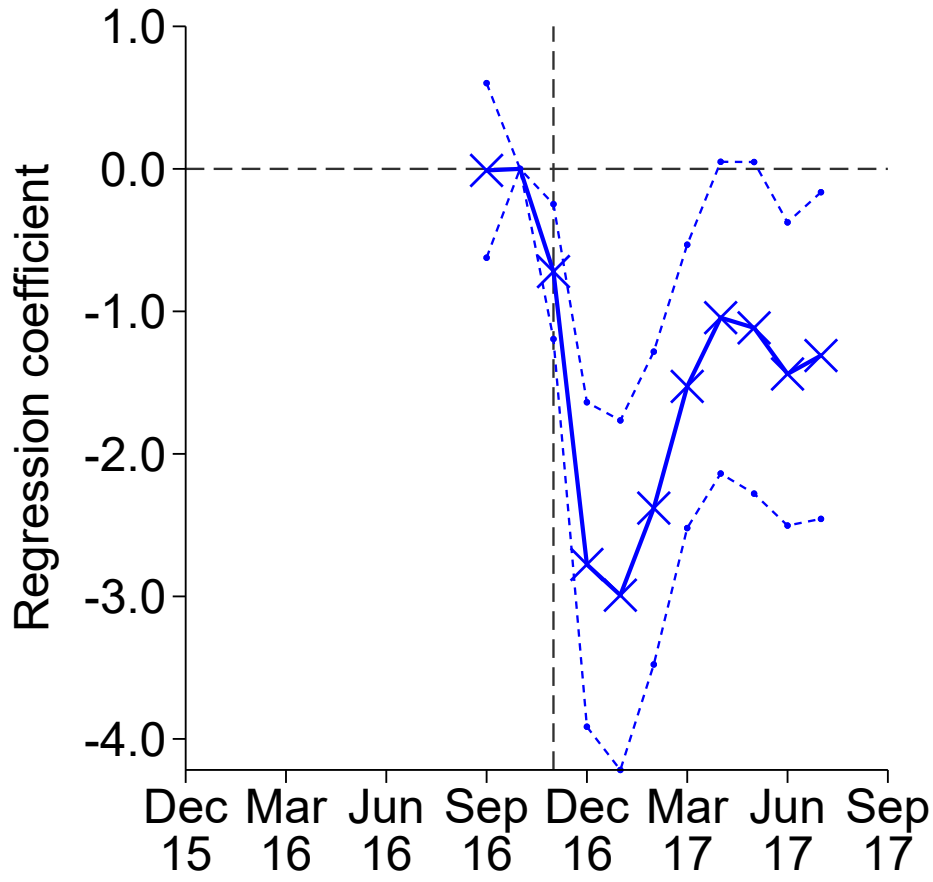
REAL ACTIVITY: ROBUSTNESS ▸ MORE

Dep. var.: log change in	Employment			Nightlights			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Demonetization shock	0.34**	0.47**	0.22	1.20**	1.15**	1.44*	1.19**
	(0.09)	(0.08)	(0.16)	(0.37)	(0.34)	(0.46)	(0.31)
Log GDP per capita		0.22+	0.04		−0.25	0.22	
		(0.11)	(0.25)		(0.20)	(0.30)	
Agriculture share of GDP		0.00	0.00		0.01	−0.00	
		(0.00)	(0.00)		(0.01)	(0.01)	
Lop population density		0.11+	0.03		0.03	−0.18	
		(0.05)	(0.07)		(0.10)	(0.23)	
Control lagged outcomes	No	Yes	Yes	No	Yes	Yes	No
Month span FE	No	Yes	Yes	No	No	No	No
Weight	Yes	Yes	No	No	No	Yes	No
Fitted 90-10 differential	4.0	5.6	2.6	14.0	13.3	16.7	13.9
R^2	0.03	0.30	0.21	0.11	0.50	0.49	0.10
Clusters	22	22	22	32	30	30	33
Observations	407	396	396	473	464	464	537

E-WALLET TRANSACTIONS

▸ ROBUSTNESS



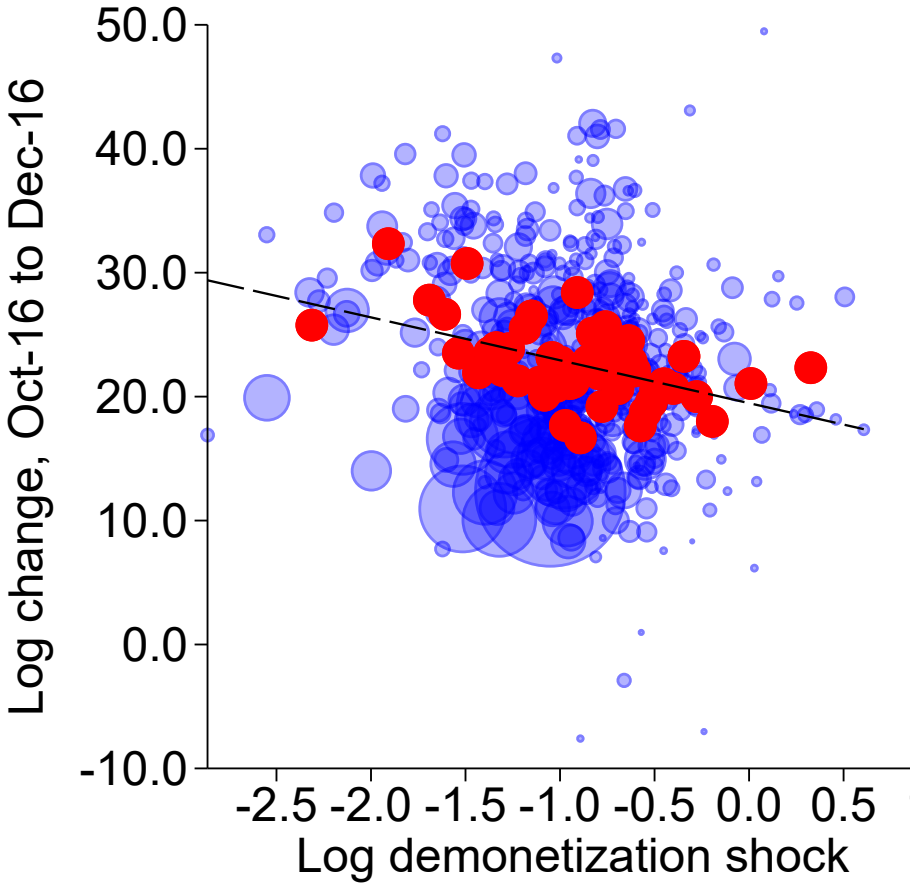


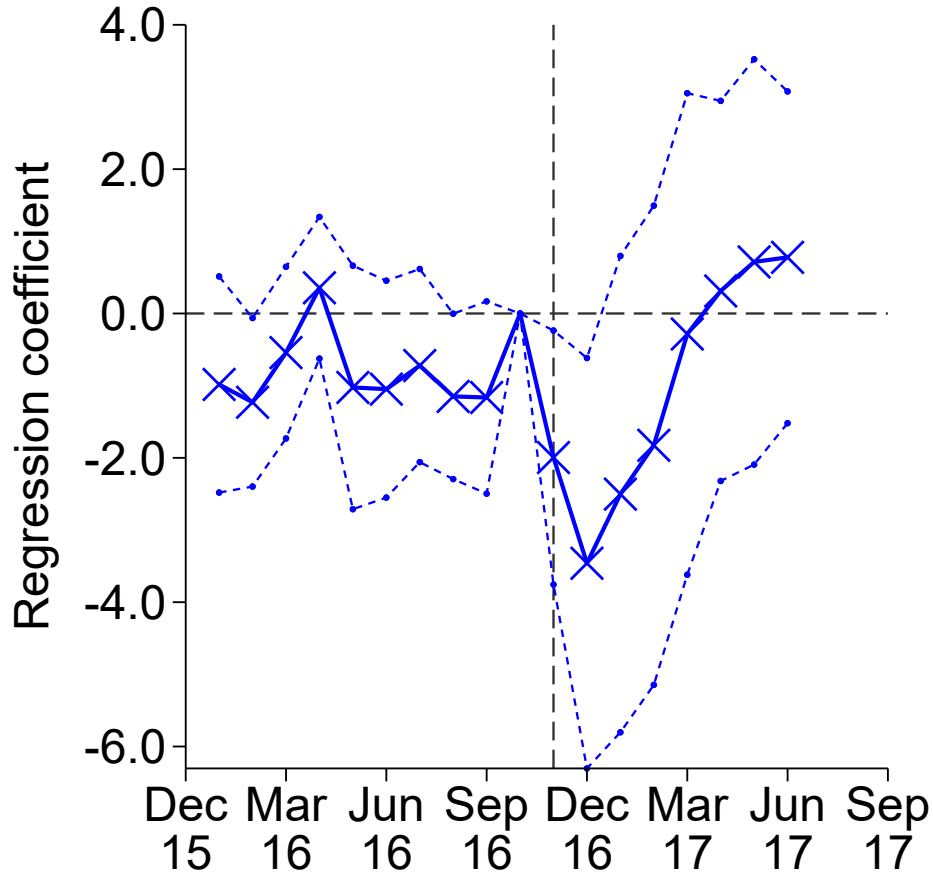
Source for dependent variable: E-wallet company.

- Measurable shift to non-cash payment mechanism.
- Validation: output effects due to cash shortage and not demand shock.

Point of sale transactions

▸ Robustness





Source for dependent variable: National Payment Corporation of India.

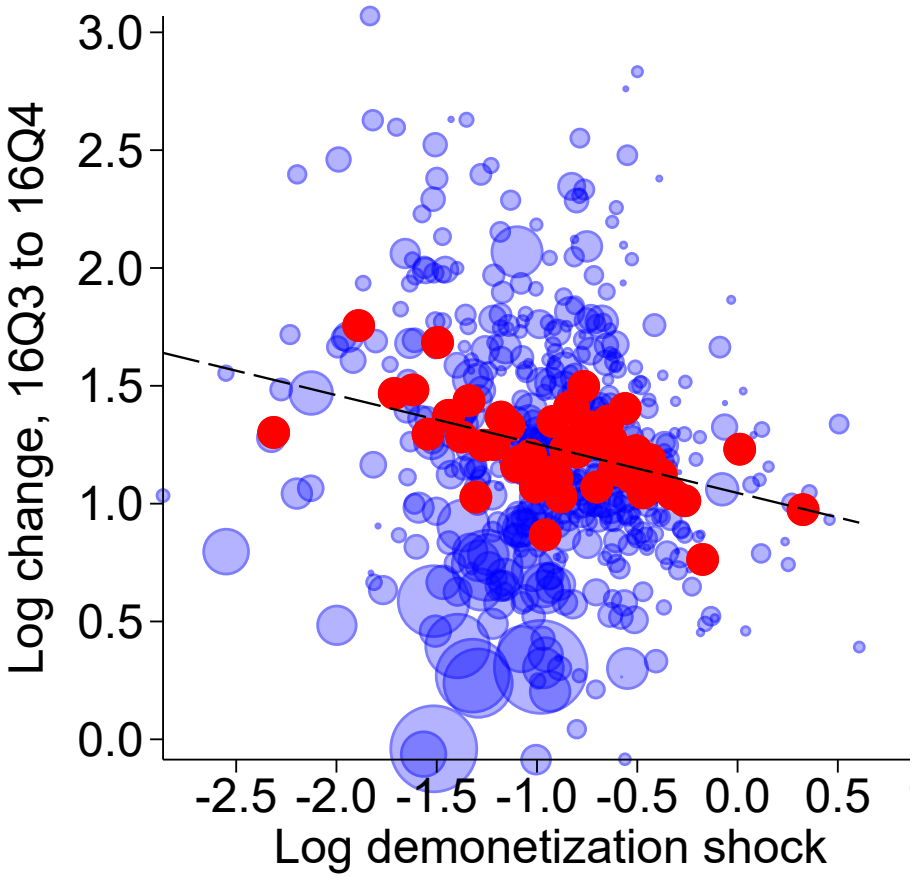
- POS: credit card payments routed through NCPI.

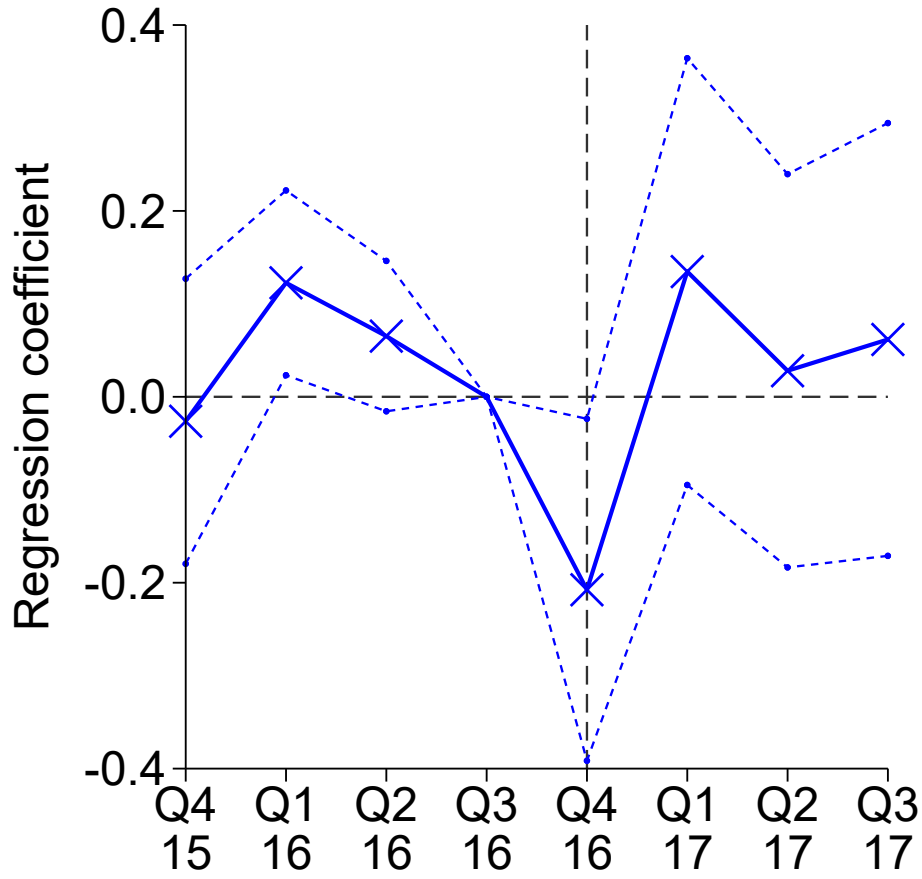
ALTERNATIVE FORMS OF PAYMENT: ROBUSTNESS

Dep. var.: log change in	E-Wallet			POS		
	(1)	(2)	(3)	(4)	(5)	(6)
Demonetization shock	−2.78**	−2.99**	−3.41**	−3.46*	−4.24**	−3.50+
	(0.53)	(0.47)	(0.69)	(1.31)	(1.38)	(1.71)
Log GDP per capita		−0.74	−0.41		−2.57**	−3.23**
		(0.57)	(0.50)		(0.80)	(0.72)
Agriculture share of GDP		0.01	0.02		0.14**	0.19**
		(0.02)	(0.02)		(0.02)	(0.03)
Log population density		0.12	0.14		−1.53*	−1.16
		(0.32)	(0.23)		(0.55)	(0.90)
Control lagged outcomes	No	Yes	Yes	No	Yes	Yes
Weight	No	No	Yes	No	No	Yes
Fitted 90-10 differential	-32.2	-34.7	-39.6	-40.2	-49.3	-40.6
R^2	0.20	0.24	0.23	0.05	0.31	0.40
Clusters	30	29	29	33	31	31
Observations	512	503	503	522	499	499

BANK DEPOSITS

▸ ROBUSTNESS

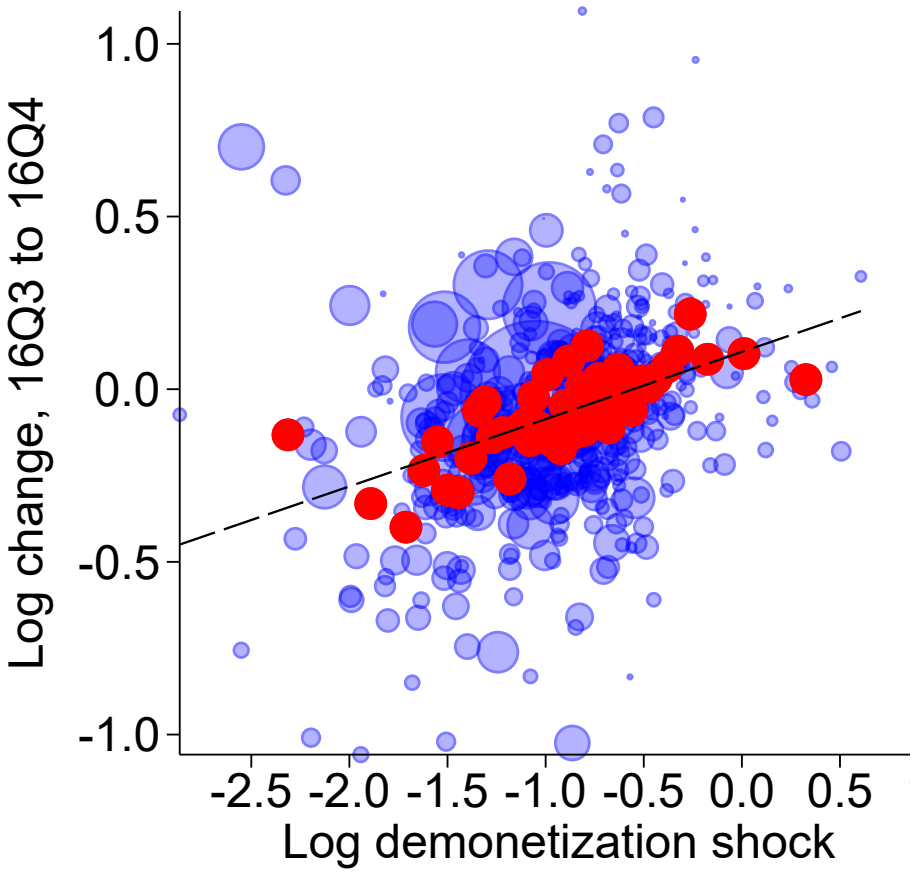


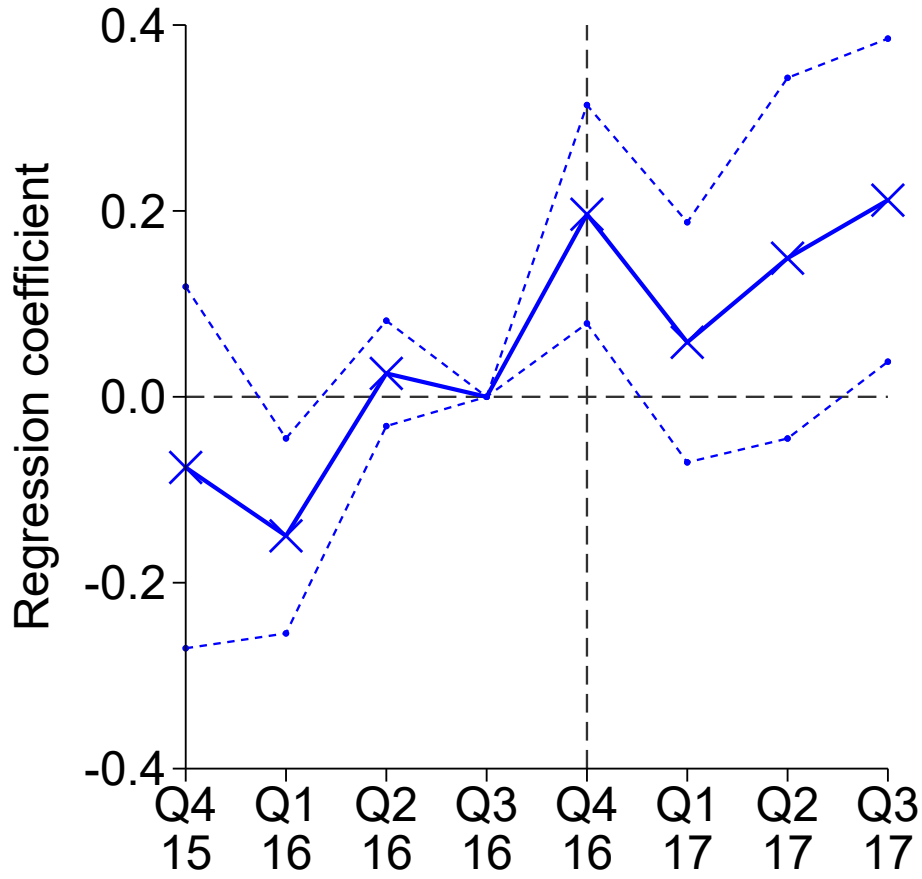


Source for dependent variable: RBI Quarterly Statistics on Deposits and Credit of Scheduled Commercial Banks.

- Deposits at branches in district.

BANK CREDIT ▸ ROBUSTNESS





Source for dependent variable: RBI Quarterly Statistics on Deposits and Credit of Scheduled Commercial Banks.

- Credit made by branches in district.

Summary

Districts experiencing more severe demonetization had:

1. Sharper declines in ATM withdrawals.
2. Reduced economic activity as measured by night lights and survey employment.
3. Faster adoption of alternative payment technologies.
4. Higher deposit growth.
5. Lower bank credit growth.

Outline

Aggregation

- Partial equilibrium aggregation formula:

$$\frac{\sum_{i:Z_{i,t}\leq 1}\left(e^{\beta_{1,t}z_{i,t}}-1\right)Y_{i,baseline}}{\sum_i Y_{i,baseline}} \approx \frac{\beta_{1,t}\sum_{i:Z_{i,t}\leq 1} z_{i,t}Y_{i,baseline}}{\sum_i Y_{i,baseline}}.$$

  - Nightlights decline: 3.6% in December 2016.
  - Employment decline: 3.3% in December 2016.

Aggregation

- Partial equilibrium aggregation formula:

$$\frac{\sum_{i:Z_{i,t}\leq 1}\left(e^{\beta_{1,t}z_{i,t}}-1\right)Y_{i,baseline}}{\sum_i Y_{i,baseline}} \approx \frac{\beta_{1,t}\sum_{i:Z_{i,t}\leq 1} z_{i,t}Y_{i,baseline}}{\sum_i Y_{i,baseline}}.$$

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  - Employment decline: 3.3% in December 2016.

- Model: sharp lower bound for aggregate decline because of tradeable industries (similar to cross-sectional fiscal multipliers).

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  - Nightlights decline: 3.6% in December 2016.
  - Employment decline: 3.3% in December 2016.

- Model: sharp lower bound for aggregate decline because of tradeable industries (similar to cross-sectional fiscal multipliers).
- Output decline similar to effect of 200 basis point tightening.
- Output decline an order of magnitude smaller than cash decline because of substitution to alternative methods of payment.

Comparison to GDP

- Night lights: 3% decline in output in November-December 2016 $\Rightarrow$ 2 p.p. decline in quarterly GDP growth rate.
- No-demonetization trend growth rate 1.5% implies absolute decline in GDP of 0.5% in 2016Q4.
- Compare to "official" quarterly growth rate of 1.4%.
- Difference due to coverage of informal sector (81% of employment and 44% of output) or confounding aggregate shocks.

Take Aways

1. Districts experiencing more severe demonetization had larger reductions in economic activity, faster adoption of alternative payment technologies, higher deposit and lower bank credit growth.

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Take Aways

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3. Decline in output smaller than decline in $M \Rightarrow$ endogenous adoption of alternative payment methods.

4. Effects on output not permanent. Agnostic on longer term effects (tax collection, better saving technology, digital payments).

APPENDIX

Ramey (home 2016) ▸ Back

I would argue that the most likely reason for the breakdown of many specifications in the later sample is simply that we can no longer identify monetary policy shocks well. Monetary policy is being conducted more systematically, so true monetary policy shocks are now rare. It is likely that what we now identify as monetary policy shocks are really mostly the effects of superior information on the part of the Fed, foresight by agents, and noise...

What, then, are we to conclude about the output effects of monetary shocks? I would argue that the best evidence still remains the historical case studies, such as Friedman and Schwarz, and the times series models estimated on samples that exclude recent decades. Of course, one worries that the structure of the economy may have changed in the last few decades, but we simply do not have enough information to produce estimates with any great certainty.

HOUSEHOLDS

- Hold cash for transaction (Lucas, 1982; Svensson, 1985) *and* tax evasion purposes.

$$\max_{C_{it}^T, C_{it}^N, D_{it}, M_{it}} \sum_{t=0}^{\infty} \beta^t U(C_{i,t})$$

s.t.,

$$P_{i,t}C_{i,t} + D_{i,t} + M_{i,t} \leq R_{t-1}D_{i,t-1} + M_{i,t-1} + (1 - \tau(\eta_{i,t}))W_{i,t}N_{i,t} + T_{i,t},$$

$$\kappa P_{i,t}C_{i,t} \leq M_{i,t-1} + T_{it}^M$$

$$C_{i,t} = (C_{i,t}^T)^{\alpha}(C_{i,t}^N)^{1-\alpha}, C_{i,t}^T = \left(\int_0^1 C_{i,t}^T(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}}$$

$\eta_{it} = \frac{M_{it}}{W_{it}N_{it}}$, $-1 < \tau'(\eta_{it}) < 0$, $0 < \kappa \leq 1$.

▸ Return

BANKS/FIRMS

- (Perfectly competitive) Banks take deposits and lend to firms and government.

$$\int_i A_{it}^f di + A_t^g = \int_i D_{it} di$$

- (Perfectly competitive) Firms: Hire workers and take working capital loans, $Y_t = N_t$

$$P_t^T(\omega) = P_{i,t}^N = (1 + \varphi(R_t - 1))W_{i,t}.$$

- Downward wage rigidity

$$W_{it} \geq \gamma W_{it-1}$$

$0 < \gamma \leq 1$

Government

- Budget constraint

$$\int_0^1 \left(M_{i,t}^s + B_{i,t}^g + \tau(\eta_{i,t}) W_{i,t} N_{i,t} \right) di =$$
$$\int_0^1 \left(T_{i,t}^M + T_{i,t}^g + M_{i,t-1}^s + R_{t-1} B_{i,t-1}^g \right) di$$

$$T_{i,t}^M = M_{i,t}^s - M_{i,t-1}^s$$

Government

- Budget constraint

$$\int_0^1 \left(M_{i,t}^s + B_{i,t}^g + \tau(\eta_{i,t}) W_{i,t} N_{i,t} \right) di =$$
$$\int_0^1 \left(T_{i,t}^M + T_{i,t}^g + M_{i,t-1}^s + R_{t-1} B_{i,t-1}^g \right) di$$

$$T_{i,t}^M = M_{i,t}^s - M_{i,t-1}^s$$

- Timeline of shock
  - Period -1: Pre-demonetization; in steady state with no binding CIA
  - Period 0: Demonetization, $T^M < 0$, $Z = \frac{M_0^s}{M_{-1}^s}$
  - Period 1 onwards: Post-demonetization; back to steady state with no binding CIA

▸ Return

Proposition

Pre-demonetization steady state

In period -1 all regions are in a symmetric zero inflation steady state with $M^s = M_{-1}$, *and*

1. *The economy is in full employment:*

$$N_{-1} = \bar{N}, \qquad Y^T_{-1} = N^T_{-1} = \alpha\bar{N}, \quad Y^N_{-1} = N^N_{-1} = (1-\alpha)\bar{N}.$$

2. *Real money balances increase in the consumption* C *and in labor income tax* $\bar{\tau}$, *and decrease in the interest rate* $R_{-1} = 1/\beta$:

$$\frac{M_{-1}}{P_{-1}} = \frac{\eta_{-1} C_{-1}}{(1+\varphi(R_{-1}-1))}, \qquad \eta_{-1} = \frac{1}{\nu}\ln\left(\frac{\nu\bar{\tau}}{1-(1/R_{-1})}\right).$$

3. *Nominal wages and prices are given by:*

$$W_{-1} = \frac{M_{-1}}{\bar{N}\eta_{-1}}, \quad P^T_{-1} = P^N_{-1} = (1+\varphi(\beta^{-1}-1))\frac{M_{-1}}{\bar{N}\eta_{-1}}.$$

Proposition

Uniform demonetization

Let $Z = M_0^s/M_{-1}^s = M_0/M_{-1}$ *where* $0 < Z < 1$ *so that the CIA binds and the wage constraint binds, that is* $\kappa P_0 C_0 = M_0$ *and* $W_0 = \gamma W_{-1}$. *If* Z *is sufficiently low relative to the downward rigidity of wages,*[a] $Z \cdot \frac{\eta_{-1}}{\kappa(1+\varphi(\beta^{-1}-1))} < \gamma$, *then:*

1. *Output and employment declines:*

$$\frac{Y_0}{Y_{-1}} = \frac{Z}{\gamma} \cdot \frac{\eta_{-1}}{\kappa(1+\varphi(\beta^{-1}-1))}.$$

2. *Lending by banks to firms decline:*

$$\frac{B_0^f}{P_0} = \frac{\varphi N_0}{(1+\varphi(R_{-1}-1))} < \frac{B_{-1}^f}{P_{-1}}.$$

3. *Nominal wages and prices:*

PROPOSITION

Non-uniform demonetization

If the drop in each region is sufficient to make the CIA constraint and wage constraint bind in all regions, that is, $\kappa P_{i0} C_{i0} = M_{i0}$ *and* $W_{i0} = \gamma W_{-1}\ \forall i$*, then:*

1. *Regions with higher* Z_i *have smaller declines in output. The differential is increasing in the size of the non-traded sector:*

$$\frac{Y_{i0}}{Y_{i,-1}} = \frac{Y_{T0}(\omega) + Y_{Ni0}}{Y_{i,-1}} = \frac{\alpha Z + (1-\alpha) Z_i}{\gamma} \cdot \frac{\eta_{-1}}{\kappa(1+\varphi(\beta^{-1}-1))}.$$

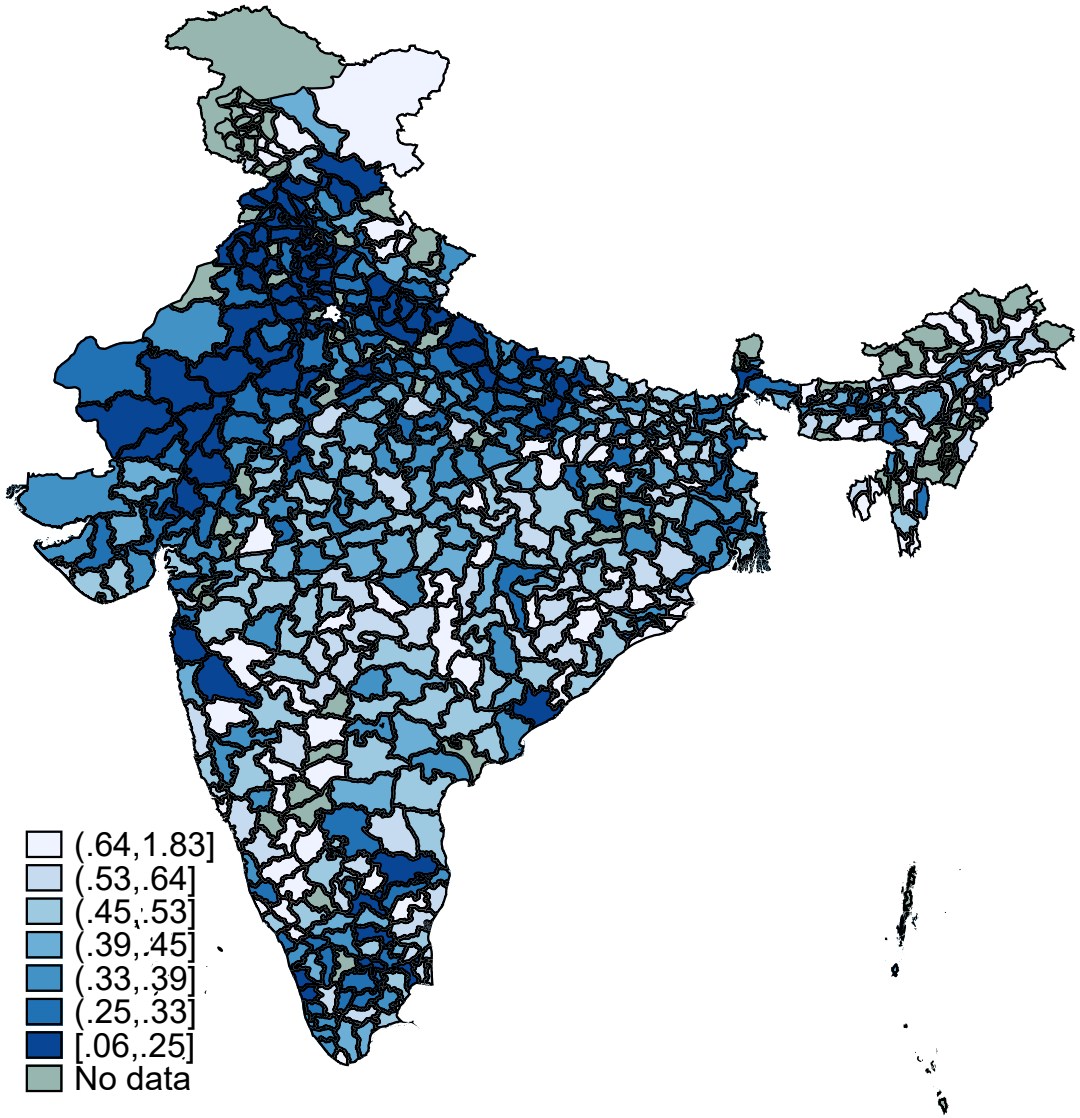
2. *Borrowing by firms falls by less in regions with higher* Z_i*:*

$$\frac{B^f_{i0}}{P_0} = \frac{\varphi Y_{i0}}{(1+\varphi(\beta^{-1}-1))}.$$

3. *Nominal wages and prices are given by:*

GEOGRAPHY OF DEMONETIZATION SHOCK

BACK



Mean=0.36, SD=0.24, Median=0.31, P10=0.13, P90=0.64.

STATISTICAL CORRELATES OF SHOCK

BACK

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log GDP per capita	−0.21						0.02
	(0.15)						(0.22)
Ag. share of GDP		0.00					−0.13^{+}
		(0.07)					(0.07)
Log distance			0.13*				−0.11
to RBI office			(0.06)				(0.06)
Log bank branches p.c.				−0.21			−0.12
				(0.12)			(0.17)
Log pop. density					−0.32**		−0.39**
					(0.10)		(0.12)
Log demon. notes p.c.						−0.33**	−0.32**
						(0.08)	(0.09)
BM df	13.0	9.8	19.7	18.6	16.9	13.9	
R^2	0.04	0.00	0.02	0.04	0.10	0.11	0.22
Clusters	31	31	33	31	31	31	31
Observations	540	532	542	540	539	540	531

ATM WITHDRAWALS: ROBUSTNESS

	(1)	(2)	(3)
Demonetization shock	3.04**	2.86**	3.08*
	(0.85)	(0.92)	(1.12)
Log GDP per capita		0.04	0.17
		(0.85)	(0.76)
Agriculture share of GDP		0.02	−0.01
		(0.03)	(0.03)
Log population density		−0.39	−0.04
		(0.43)	(0.29)
Control lagged outcomes	No	Yes	Yes
Weight	No	No	Yes
Fitted 90-10 differential	35.3	33.2	35.8
Treatment BM df	12.8	14.6	12.8
R^2	0.13	0.18	0.17
Clusters	33	31	31
Observations	531	521	521

REAL ACTIVITY: ROBUSTNESS

Dep. var.: log change in	Employment			Nightlights			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Demonetization shock	0.34**	0.47**	0.22	1.20**	1.15**	1.44*	1.19**
	(0.09)	(0.08)	(0.16)	(0.37)	(0.34)	(0.46)	(0.31)
Log GDP per capita		0.22+	0.04		−0.25	0.22	
		(0.11)	(0.25)		(0.20)	(0.30)	
Agriculture share of GDP		0.00	0.00		0.01	−0.00	
		(0.00)	(0.00)		(0.01)	(0.01)	
Lop population density		0.11+	0.03		0.03	−0.18	
		(0.05)	(0.07)		(0.10)	(0.23)	
Control lagged outcomes	No	Yes	Yes	No	Yes	Yes	No
Month span FE	No	Yes	Yes	No	No	No	No
Weight	Yes	Yes	No	No	No	Yes	No
Fitted 90-10 differential	4.0	5.6	2.6	14.0	13.3	16.7	13.9
R^2	0.03	0.30	0.21	0.11	0.50	0.49	0.10
Clusters	22	22	22	32	30	30	33
Observations	407	396	396	473	464	464	537

ALTERNATIVE FORMS OF PAYMENT: ROBUSTNESS

BACK

Dep. var.: log change in	E-Wallet			POS		
	(1)	(2)	(3)	(4)	(5)	(6)
Demonetization shock	−2.78**	−2.99**	−3.41**	−3.46*	−4.24**	−3.50+
	(0.53)	(0.47)	(0.69)	(1.31)	(1.38)	(1.71)
Log GDP per capita		−0.74	−0.41		−2.57**	−3.23**
		(0.57)	(0.50)		(0.80)	(0.72)
Agriculture share of GDP		0.01	0.02		0.14**	0.19**
		(0.02)	(0.02)		(0.02)	(0.03)
Log population density		0.12	0.14		−1.53*	−1.16
		(0.32)	(0.23)		(0.55)	(0.90)
Control lagged outcomes	No	Yes	Yes	No	Yes	Yes
Weight	No	No	Yes	No	No	Yes
Fitted 90-10 differential	-32.2	-34.7	-39.6	-40.2	-49.3	-40.6
R^2	0.20	0.24	0.23	0.05	0.31	0.40
Clusters	30	29	29	33	31	31
Observations	512	503	503	522	499	499

BANK DEPOSITS AND CREDIT, 2016Q4

BACK

Dep. var.: log change in	Deposits			Credit		
	(1)	(2)	(3)	(4)	(5)	(6)
Demonetization shock	−0.21*	−0.35**	−0.30*	0.20**	0.14**	0.09+
	(0.09)	(0.10)	(0.11)	(0.05)	(0.04)	(0.05)
Log GDP per capita		−0.25**	−0.28**		−0.00	0.07+
		(0.06)	(0.05)		(0.03)	(0.04)
Agriculture share of GDP		0.01**	0.01**		−0.00**	−0.00*
		(0.00)	(0.00)		(0.00)	(0.00)
Log population density		−0.10+	−0.15**		−0.06*	−0.01
		(0.05)	(0.04)		(0.02)	(0.03)
Control lagged outcomes	No	Yes	Yes	No	Yes	Yes
Weight	No	No	Yes	No	No	Yes
Fitted 90-10 differential	-2.4	-4.0	-3.5	2.3	1.6	1.1
R^2	0.04	0.29	0.43	0.11	0.25	0.24
Clusters	32	30	30	32	30	30
Observations	531	521	521	531	520	520

NIGHTLIGHTS VERSUS ELECTRICITY

BACK

	Dep. var.: log change in nightlight intensity			
Aggregation:	District	State		
	(1)	(2)	(3)	(4)
Demonetization shock	1.20**	0.87+		0.01
	(0.37)	(0.41)		(0.47)
Growth of electricity use			3.38**	3.38**
			(0.83)	(1.03)
Weight	None	Districts	Districts	Districts
R^2	0.11	0.11	0.35	0.35
Observations	473	33	33	33