A Monetary Business Cycle Model for India

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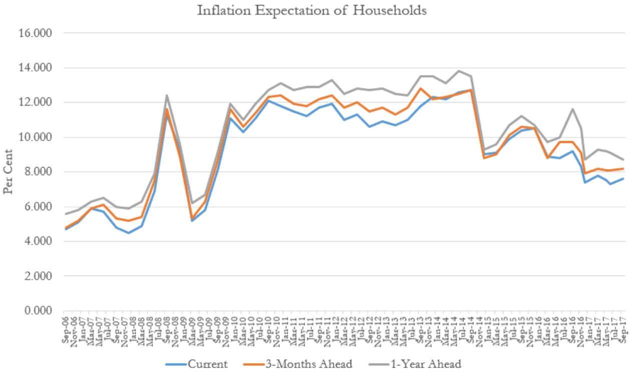
Introduction

- Monetary policy in India has undergone a major overhaul
  - Flexible inflation targeting with a clearly defined nominal anchor (de facto adoption in April 2014)
    - Requires the RBI to publicly hit announced inflation targets
    - Monetary policy transmission crucial to the success of this regime
  - Clearly defined mandate
  - Formation of a monetary policy committee (since September 2016)
- Expert Committee to Revise and the Strengthen the Monetary Policy Committee Framework (January 2014)

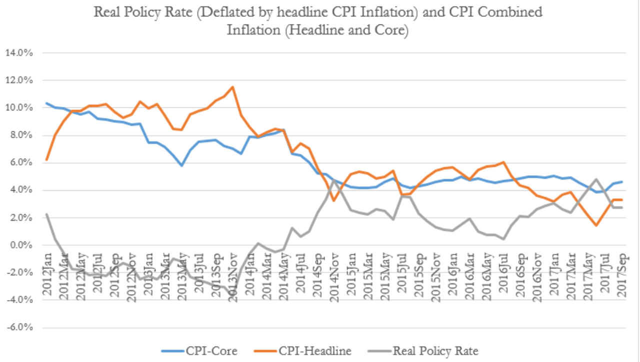
Background

- Survey based inflation expectations of households



Background

- Real policy rates



Introduction

- Despite major changes in monetary policy, monetary transmission has been partial, asymmetric, and slow
  - See Das (2015), Mishra, Montiel and Sengupta (2016), and Mohanty and Rishab (2016)
- To quote from Mishra, Montiel, and Sengupta (2016, p. 60-61)

"While the pass through from the policy rate to bank lending rates is in the right direction, pass through is incomplete...Unable to uncover evidence for any effect of monetary policy shocks on aggregate demand either in the IIP gap or the inflation rate"

- Expert Committee (January 2014) also lists other factors hindering monetary transmission
  - small savings schemes / administered interest rates; presence of large informal sector

A key stylized fact

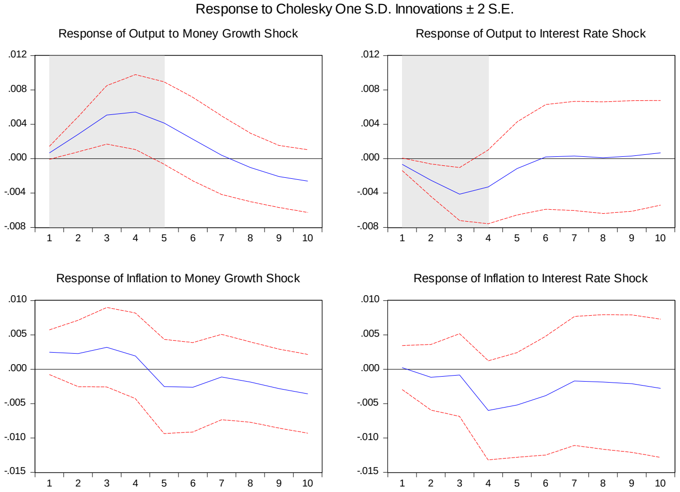


Figure 1: Impulse Responses under Cholesky-type Identification

A key stylized fact

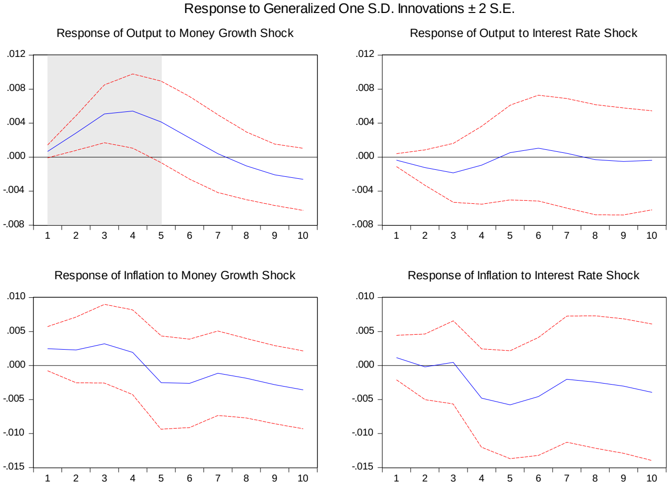


Figure 2: Impulse Responses under Pesaran-type Identification

Goals

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- Key research question: *what explains weak monetary policy transmission mechanism in India?*
- Very few studies use DSGE style frameworks to address this question
  - See Levine et al. (2012), and Banerjee and Basu (2017)
- Build and calibrate/estimate a baseline New Keynesian monetary business cycle model to understand weak monetary transmission in India
  - Embed financial repression in the form of (i) SLR and (ii) administered interest rates
- We focus on the aggregate demand channel/interest rate channel of monetary transmission and try and replicate the impact of
  - Money base shocks on real GDP and inflation
  - Policy rate shocks on real GDP and inflation
- We then extend the model to add an informal sector and do model comparisons

Model extension

- Keep the baseline entrepreneur, but allow for heterogenous consumers (Ricardian, and Rule of Thumb) who both supply labor. Rationale is to allow for an "unbanked" population.
    - Entrepreneurs now have two sources of labor
    - CIA constraint is now on wage payments of RT consumers
    - Role of fiscal policy shocks improves, but base money shocks becomes less important because of the presence of RT consumers.
    - However, horse race on shocks preserved again
    - Monetary transmission affects real wages of RT households thereby affecting their consumption.

Main results

- Relative importance of technological versus non-technological shocks. Horse race between several contenders shows
  - Roughly half of the variance in output are explained by TFP shocks
  - One-third by fiscal shocks;
  - Monetary policy in terms of interest rate shocks and base money shocks only explain a negligible amount (about 17%). Base money shocks dominate.
- Comparison of output impulse responses of monetary base versus policy rate shocks reveals that the output response is much more prolonged for a positive shock to monetary base as opposed to the interest rate.
- Neither administered interest rates or SLR weaken monetary transmission as is widely believed. Financial repression does not affect monetary transmission.
- Presence of informal sector hinders monetary transmission

Theoretical Model

Theoretical model

- Households
- Capital producers
  - Perfectly competitive firms invest to produce new capital and supply capital to wholesale producers
  - Face a cost to adjusting investments.
- Wholesale producers
  - Perfectly competitive firms produce intermediate goods for final good producing retailers
  - Hire labor from households and debt-finance (from banks) new capital purchases from capital good firms.
- Final good retail firms
  - Monopolistically competitive firms buy intermediate goods and package them into final goods.
  - Retailer prices are sticky and indexed to past and steady state inflation as in Gerali et al. (2010)

Theoretical model

- Banks
  - Perfectly competitive
  - Maximize cash flows. Take household deposit sequence as given. Offer loans.
  - Keep reserves at the central bank
  - Constrained to buy government debt (SLR)
  - Deposits subject to withdrawal uncertainty
- Combined government entity sets monetary and fiscal policy
  - Twin monetary policy
  - Fiscal Policy
- Extension of model
  - Add transaction demand for money
  - Allow for an unbanked population

Households

- Household and production side, model is similar to Gerali et al. (2010). Economy populated by households and entrepreneurs, each group has unit mass. Infinitely lived households consume (C), work (H), accumulate savings in i) risk free deposits (D), and ii) postal/administered deposits(D^a). Representative household maximizes

$$\max_{C_t, H_t, D_t, D_t^a} E_0 \sum_{s=0}^{\infty} \beta^{t+s} [U(C_{t+s}) - \Phi(H_{t+s}) + \underbrace{V(D_{t+s}/P_{t+s}, D^a_{t+s}/P_{t+s})}_{\text{Convenience Utility}}] \quad (1)$$

subject to

$$\underbrace{P_t\left(C_t + T_t\right) + D_t + D_t^a}_{\text{Flow of Expenses}} \leq \underbrace{\begin{array}{c} W_t H_t + (1 + i_t^D) D_{t-1} + \\ (1 + i^a)\, D^a_{t-1} + \Pi_t^k + \Pi_t^r + \Pi_t^b \end{array}}_{\text{Resources}}$$

where P_t is the aggregate price index.

- $i_t^D > 0$ fixed deposit rate on one period deposits; $i^a > 0$ fixed administered rate

Households

- Using $D_t/P_t = d_t$ and $D_t^a/P_t = d_t^a$, and substituting out for $U'(C_t) = \lambda_t P_t$, household's optimality conditions become:

$$D_t: \; U'(C_t) = V_1'(d_t, d_t^a) + \beta E_t \left\{ U'(C_{t+1})(1 + i_{t+1}^D)(P_t/P_{t+1}) \right\}, \tag{2}$$

$$D_t^a: \; U'(C_t) = V_2'(d_t, d_t^a) + \beta E_t \left\{ U'(C_{t+1})(1 + i^a)(P_t/P_{t+1}) \right\} \tag{3}$$

and

$$\Phi'(H_t) = (W_t/P_t)\, U'(C_t). \tag{4}$$

  - Equation (2) is the standard Euler equation for deposits.
  - Equation (3) is the Euler equation for postal deposits which attract the administered interest rate, i^a.
  - Equation (4) is the standard intra-temporal optimality condition for labor supply.

Capital producers

- Competitive firms buy last period's undepreciated capital, $(1-\delta_k)K_{t-1}$, at real price Q_t from wholesale-entrepreneurs, and I_t units of the final good from retailers at price P_t.
- Convert I_t units of output into $[1-S(\cdot)]I_t$ units of new capital
- Capital goods producing firms maximize

$$\max_{I_t} E_t \sum_{s=0}^{\infty} \Omega_{t,t+s} P_{t+s} \left[Q_{t+s} I_{t+s} - \left\{ 1 + S\left(\frac{I_{t+s}}{I_{t+s-1}} \right) \right\} I_{t+s} \right] \quad (5)$$

s.t. $\quad K_t = (1-\delta_k)K_{t-1} + Z_{x,t} I_t$

$\Rightarrow$ capital good pricing equation

$$Q_t = 1 + S\left(\frac{I_t}{I_{t-1}}\right) + S'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}} - \beta E_t \frac{U'(C_{t+1})}{U'(C_t)}\left[S'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2 \right]$$

- In the steady state $Q = 1$

Wholesale producers

- Risk neutral firms produce intermediate goods for final good producing retailers
- Hire labor from households, and purchase new capital from capital good producing firms, at (the real price) Q_t
- Purchase of new capital debt-financed by $L_t > 0$ loans from banks
- Balance sheet of firms

$$\underbrace{Q_t K_t}_{\text{Amount of New Capital Purchased}} = \left(\frac{L_t}{P_t}\right). \tag{6}$$

- Production function

$$Y_t^W = \xi_t^a K_{t-1}^{\alpha} H_t^{1-\alpha} \tag{7}$$

where with $0 < \alpha < 1$. ξ_t^a denotes stochastic total factor productivity,

Wholesale producers

- Real wage rate and rate of return to capital given by

$$W_t/P_t = \underbrace{(P_t^W/P_t)}_{\text{Real MC=Real Price of } Y_t^W} \quad MPH_t = (1-\alpha)\frac{(P_t^W/P_t)Y_t^W}{H_t} \tag{8}$$

$$\underbrace{1+r_{t+1}^k}_{\text{Gross Return to 1 unit of K}} = \frac{(P_{t+1}^W/P_{t+1})MPK_{t+1} + (1-\delta_k)Q_{t+1}}{Q_t} \tag{9}$$

- Demand for capital given by the following arbitrage condition

$$1+r_{t+1}^k = \left(1+i_{t+1}^L\right)\frac{P_t}{P_{t+1}}$$

$$1+i_{t+1}^L = \left[\left(\frac{P_{t+1}^w}{P_{t+1}}\right)\frac{MPK_{t+1}}{Q_{t+1}} + 1 - \delta_k\right]\left[\frac{P_{t+1}Q_{t+1}}{P_tQ_t}\right].$$

Final good retail firms

- Buy intermediate goods at P_t^W and package them into final goods
- Retail prices are sticky and indexed to combination of past and steady state inflation⇒If retailers want to change their prices beyond what indexation allows, they face a quadratic adjustment cost
- Choose $\{P_{t+j}(i)\}_{j=0}^{\infty}$ to the maximize present value of their expected profit.

$$\max_{P_t(i)} E_t \sum_{s=0}^{\infty} \Omega_{t,t+s} \left\{ \Pi_{t+s|t}^{r} \right\} \tag{10}$$

subject to demand constraint

$$y_{t+s|t}(i) = \left(\frac{P_{t+s}(i)}{P_{t+s}} \right)^{-\varepsilon^Y} y_{t+s}$$

Final good retail firms

- Profit function of the i^{th} retailer

$$\Pi^{r}_{t+s}(i) = P_{t+s}(i)\, y_{t+s}(i) - P^{W}_{t+s}(i)\, y^{W}_{t+s}(i) - \frac{\phi_p}{2}\left[\left\{\frac{P_{t+s}(i)}{P_{t+s-1}(i)} - \underbrace{(1+\pi_{t+s-1})^{\theta_p}(1+\bar{\pi})^{1-\theta_p}}_{\text{Costly Price Adjustment in Goods Markets}}\right\}^{2} P_{t+s}\right.$$

Final good retail firms

- Note $\phi_p > 0$, $0 < \theta_p < 1$, and

$$y_t = \left[\int_0^1 y_t(i)^{\frac{\varepsilon^Y - 1}{\varepsilon^Y}} \, di \right]^{\frac{\varepsilon^Y}{\varepsilon^Y - 1}}; \qquad \varepsilon^Y > 1.$$

θ_p is an indexation parameter.

- FOC

$$1 - \varepsilon^Y + \varepsilon^Y \left(\frac{P_t}{P_t^W}\right)^{-1} - \phi_p \left\{ 1 + \pi_t - (1 + \pi_{t-1})^{\theta_p} (1 + \bar{\pi})^{1-\theta_p} \right\} = 0. \tag{11}$$

As $\pi_t \uparrow \Rightarrow \frac{P_t^W}{P_t} \uparrow$ (real MC $\uparrow$). When $\pi_{t+1} = \pi_t = \pi$, steady state mark-up is,

$$\frac{P}{P^W} = \frac{\varepsilon^Y}{\varepsilon^Y - 1}. \tag{12}$$

Banks

- Maximize cash flows by taking deposits and making loans. Take $\{D_t\}_{t=0}^{\infty}$ as given.
- Keep reserves at the central bank (CB), and constrained to buy public debt (SLR) against deposit inflows
- Following Chang et al. (2014), banks face a stochastic withdrawal of deposits (reserve loss): if withdrawals exceed bank reserves, banks borrow from the central bank at the penalty rate, i^p.
- Banks pay back the emergency borrowing to the central bank (CB) at the end of the period. Withdrawal uncertainty $\rightarrow$banks desire excess reserves
- Let i_t^L to be interest rate on loans, L_{t-1}
- i^R the interest rate on reserves, M_t^R, mandated by the central bank,
- $\widetilde{W}_t$ is the stochastic withdrawal (Uniform dist.)
- Assume government bonds and deposits are perfects substitutes $\rightarrow i_t^D = i_t^G = i_t^S$ (say)

Banks

- Bank's cash flow at t

$$
\begin{aligned}
\Pi_t^b = & (1+i_t^L)L_{t-1} + (1+i^R)M_{t-1}^R + \underbrace{\alpha_q(1+i_t^G)D_{t-1}}_{SLR \text{ on last period's deposits}} \\
& - \underbrace{(1+i_t^D)D_{t-1}}_{\text{Cost of Funds of Last period's Deposits}} \\
& - (1+i^p)\max(\widetilde{W_{t-1}} - M_{t-1}^R, 0) + \underbrace{D_t}_{\text{Current Deposits}} \\
& - \underbrace{\alpha_q D_t}_{SLR \text{ this period}} - L_t - M_t^R
\end{aligned}
$$

Banks

- Banks maximizes discounted cash flows in two stages. Banks first solve for optimal reserves, M_t^R. Next, choose the loan amount, L_t. Given $\left\{i_t^D\right\}_{t=0}^{\infty}, \left\{i_t^L\right\}_{t=0}^{\infty}, \left\{D_t\right\}_{t=0}^{\infty}$, banks solve

$$\underset{M_t^R,,L_t}{Max} \; E_t \sum_{s=0}^{\infty} \Omega_{t,t+s} \left\{\Pi_{t+s}^b\right\}$$

subject to the statutory reserve requirement:

$$M_t^R \geqq \alpha_r D_t \tag{13}$$

where $\Omega_{t,t+s} = \frac{\beta^s U'(c_{t+s})}{U'(c_t)}.\frac{P_t}{P_{t+s}}$ is the inflation adjusted stochastic discount factor.

- We assume (13) never binds (banks always hold excess reserves)

Banks

- FOC for reserves

$$E_t\Omega_{t,t+1}\left[\underbrace{(1+i^R)}_{\text{Banks Interest Income from Reserves}} + \underbrace{(1+i^p)\int_{M_t^R}^{D_t} f(\widetilde{W}_t)\,d\widetilde{W}_t}_{\text{Expected saving of penalty because of the holding of more reserves}}\right] + \lambda_t = 1 \quad (14)$$

- Since reserve requirement not binding, KT condition $\Rightarrow \lambda_t = 0$. Assume $\widetilde{W}_t \sim U[0, D_t]$. Equation (14)$\Rightarrow$

$$\frac{x_t}{d_t} = 1 - \frac{1-(1+i^R)E_t\Omega_{t,t+1}}{(1+i^p)E_t\Omega_{t,t+1}} \quad (15)$$

where $x_t = M_t^R/P_t$ and $d_t = D_t/P_t$.

Banks

- FOC for loans

$$L_t : \; 1 = E_t \Omega_{t,t+1}(1 + i^L_{t+1}) \tag{16}$$

- In the steady state, equations (16) and (2) yield the spread

$$i^L - i^D = \frac{(1+\pi)}{\beta} \frac{V_1^{'}(d, d^p)}{U'(c)} > 0$$

- Spread appears even though banks are not monopolistic because deposits provide a liquidity service (convenience utility) to households. Credit rationing $\Rightarrow$ positive spread in the steady state.

Monetary policy

- CB follows a money supply growth rule: It lets the monetary base (M_t^B), or the supply of reserves, M_t^R (since currency is zero), increase by the following rule:

$$\frac{M_t^B / M_{t-1}^B}{1+\bar{\pi}} = \left(\frac{M_{t-1}^B / M_{t-2}^B}{1+\bar{\pi}} \right)^{\rho_\mu} \exp(\xi_t^\mu) \tag{17}$$

where ρ_μ is the policy smoothing coefficient and ξ_t^μ is the money supply shock, which follows an AR (1) process.

$$M_t^B = M_t^R$$

Monetary policy

- The short term interest rate on government bonds (i_t^G) is the policy rate given by an inflation targeting Taylor rule as follows:

$$\frac{(1+i_t^G)}{(1+\bar{i}^G)} = \left(\frac{(1+i_{t-1}^G)}{(1+\bar{i}^G)}\right)^{\rho_{i^G}} \left[\left(\frac{1+\pi_{t-1}}{1+\pi}\right)^{\varphi_\pi}\left(\frac{Y_t}{Y}\right)^{\varphi_Y}\right]^{(1-\rho_{i^G})} \exp\left(\xi_t^G\right) \tag{18}$$

The parameters $\phi_p > 0$, and $\phi_y > 0$ are the inflation, and output gap sensitivity parameters in the Taylor Rule. Y_t denotes GDP, and therefore $\frac{Y_t}{Y}$ denotes the output gap. ρ_{i^G} is the interest rate smoothing term and ξ_t^G is the policy rate shock.

Fiscal policy

- GBC

$$\begin{aligned} & P_t G_t + \left(1 + i_t^G\right) B_{t-1} + (1 + i^R) M_{t-1}^R + (1 + i^a) D_{t-1}^a \\ = \quad & P_t T_t + B_t + M_t^R + D_t^a + (1 + i^p) E_t \max(\widetilde{W}_t - M_t^R, 0) \end{aligned}$$

- Government spending (government purchases) evolves stochastically:

$$G_t - \bar{G} = \rho_G \left(G_{t-1} - \bar{G}\right) + \xi_t^G.$$

ξ_t^G denotes the shock to government spending.

- Goods, loans, and money markets clear.

Steady State

Recursive Steady State

Short run system has 19 endogenous variables. These can be written as a recursive system

1. $(1 + i^L) = (1 + \pi)/\beta$
2. $(1 + i^L) = \left[\left(\frac{\varepsilon^Y - 1}{\varepsilon^Y}\right)\alpha\left(\frac{K}{H}\right)^{\alpha-1} + 1 - \delta_K\right](1 + \pi)$
3. $W/P = (1 - \alpha)\left(\frac{\varepsilon^Y - 1}{\varepsilon^Y}\right)(\Lambda)^{\alpha}$ where $\Lambda = K/H$ solved from the preceding equation
4. $C = W/P$
5. $G = \bar{G}$
6. Using $C + G = \left[\Lambda^{-(1-\alpha)} - \delta_K\right]K$, and steady state G, Solve K
7. Using $K/H = \Lambda$, solve H
8. Using $d\left[1 + \pi - \beta\left(1 + i^D\right)\right] = \eta C(1 + \pi)$, and (5) above solve for d.
9. $d^a\left[1 + \pi - \beta\left(1 + i^a\right)\right] = (1 - \eta)\,C(1 + \pi)$, solve for d^a

Recursive Steady State

10. $\frac{x}{d} = 1 - \frac{1-(1+i^R)\ \Omega}{(1+i^p)\Omega}$
11. $\frac{P_t}{P_t^W} = \frac{\varepsilon^Y}{\varepsilon^Y - 1}$.
12. $I = \delta K$
13. $\pi =$ *long run* inflation target ($\bar{\pi}$) (Note that this is pinned down by the money supply rule (17))
14. T solved from the steady state government budget constraint
15. (Stochastic Discount Factor) $\Omega = \beta/(1+\pi)$
16. $Y = AK^\alpha H^{1-\alpha}$
17. $A = \bar{A}$
18. $i^G = \overline{i^G}$
19. $1 + i^D = \zeta(1 + i^G)$

Quantitative Analysis

Model validation

- We first calibrate the model on Indian macroeconomic data
  - After baseline model validation, we explain the IRFs and variance decompositions
- Focus on standard instruments of monetary policy in an inflation targeting central bank
  - Money base
  - Short term interest rate
- Also look at the magnitude of cross correlations between policy instruments and policy targets as indicators of pass through of policy shocks.

Baseline parametrization

Table 1: Structural and Policy Parameters of Baseline Models

Parameters	Description	Value	Source
α	Share of capital	0.30	Banerjee & Basu, 2017
β	Discount rate	0.98	Gabriel et al., 2011
η	Preference for holding bank deposit	0.84	RBI database
δ_k	Depreciation rate of capital	0.025	Banerjee & Basu, 2017
κ	Investment adjustment cost	2	Banerjee & Basu, 2017
ζ	Mark-down factor for Deposit rate	0.97	Set to match Savings A/C rate
ε^Y	Price elasticity of demand	7	Gabriel et al., 2011
ϕ_p	Price adjustment cost	118	Anand et al., 2010
θ_p	Past inflation indexation	0.58	Sahu J. P., 2013

Baseline parametrization

Table 1: Continued

Parameters	Description	Value	Source
ρ_{i^G}	Interest rate smoothing parameter	0.80	Banerjee & Basu, 2017
φ_{π}	Inflation Stabilizing Coefficient	1.20	Gabriel et al., 2011
φ_{y}	Output Stabilizing Coefficient	0.50	Banerjee & Basu, 2017
α_s	Statutory Liquidity Ratio	21.5%	RBI Website
π	Long-run inflation target	4%	Urjit Patel Committee Report, 2013
i^G	Steady state policy rate	7%	RBI Database
i^a	Steady state administered rate	4%	Indian Postal Service Website
i^p	Steady state penalty rate	6.5%	RBI Database

Baseline parametrization

Table 2: Baseline Parameterization of Shock Processes

Parameters	Description	Values
ρ_a	Persistence coefficient of TFP shock	0.82
ρ_{Z_x}	Persistence coefficient of IST shock	0.63
ρ_G	Persistence coefficient of Fiscal shock	0.59
ρ_μ	Persistence coefficient of Money base shock	0.48
σ_a	Standard error of TFP shock	0.016
σ_{Z_x}	Standard error of IST shock	0.133
σ_G	Standard error of Fiscal shock	0.026
σ_μ	Standard error of Money base shock	0.021
σ_{iG}	Standard error of Interest rate shock	0.002

Model validation

Table 3: Results of Moment Matching between Data (1996Q4 to 2017Q1) and Model

Targeted Moments	Data	Model
std. dev (y)	0.02	0.02
std. dev (π)	0.03	0.01
std. dev (i^L)	0.02	0.02
correl $[y, c]$	0.38	0.39
correl $[y, i]$	0.79	0.53
correl $[i^L, \pi]$	0.59	0.65
correl $[y, d]$	0.69	0.54
correl $[d^a, i]$	0.26	0.18
correl $[d^a, i^L]$	-0.30	-0.47

Model validation

Table 3: Results of Moment Matching between Data (1996Q4 to 2017Q1) and Model

Non-targeted Moments	Data	Model
correl $\left[y, (x_t/x_{t-1})\right]$	0.38	0.25
correl $\left[y, i^G\right]$	0.34	0.12
correl $\left[i^G, i^L\right]$	0.68	0.37
correl $\left[d^a, \pi\right]$	-0.60	-0.84
correl $\left[d, (x_t/x_{t-1})\right]$	0.38	0.22
correl $\left[d, i\right]$	0.49	0.33
correl $\left[i, (x_t/x_{t-1})\right]$	0.32	0.13
AR(1) coefficient of y	0.87	0.79
AR(1) coefficient of π	0.84	0.92

Impulse response analysis of monetary transmission

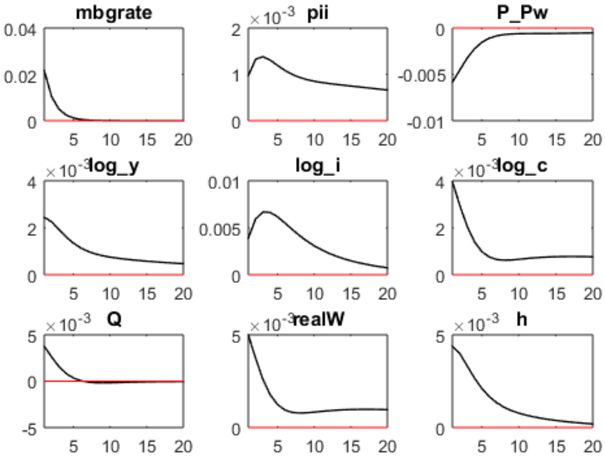


Figure 3: Effects of Shock to Monetary Base

Impulse response analysis of monetary transmission

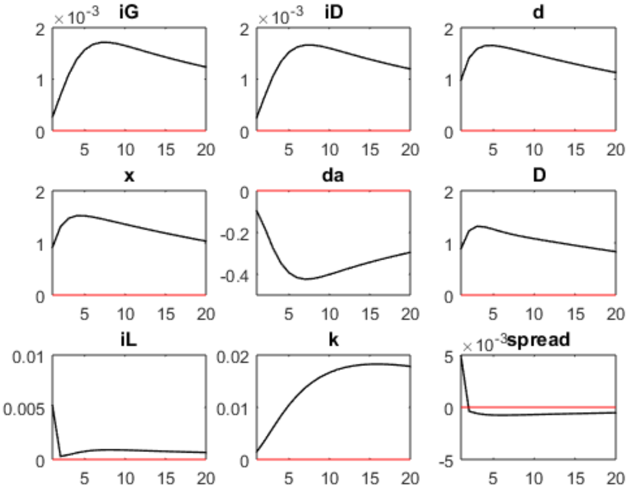


Figure 4: Effects of Shock to Monetary Base

Intuition

- Money Base $\uparrow \Rightarrow \pi \uparrow \Rightarrow$ Real MC $(\frac{P^W}{P}) \uparrow$
- Real MC$\uparrow \Rightarrow$VMP$_K \uparrow$,VMP$_L \uparrow \Rightarrow K, L \uparrow \Rightarrow$ Firms increase their supply of output
- Nominal markup falls $(\frac{P}{P^W}) \downarrow$
- Higher inflation promotes investment (Tobin effect)
- $i^L \uparrow$ because of the Fisher effect
- Higher $\frac{W}{P} \Rightarrow C \uparrow$
- Higher $\pi \Rightarrow i^G \uparrow$ (acts like a built in stabilizer via the Taylor Rule)
- Since $i^G \propto i^D \Rightarrow d \uparrow \Rightarrow x \uparrow$, but $\frac{x}{d} \downarrow \Rightarrow \frac{d}{x} \uparrow$ (money multiplier)
- $\frac{x}{d} \downarrow \Rightarrow$Bank Lending $\uparrow \Rightarrow Inv \uparrow$
- When $i^D \uparrow \Rightarrow d \uparrow \Rightarrow d^a \downarrow$, but total deposits $d + d^a \uparrow$
- Spread $=(i^L - i^D) \uparrow$

Impulse response analysis of monetary transmission

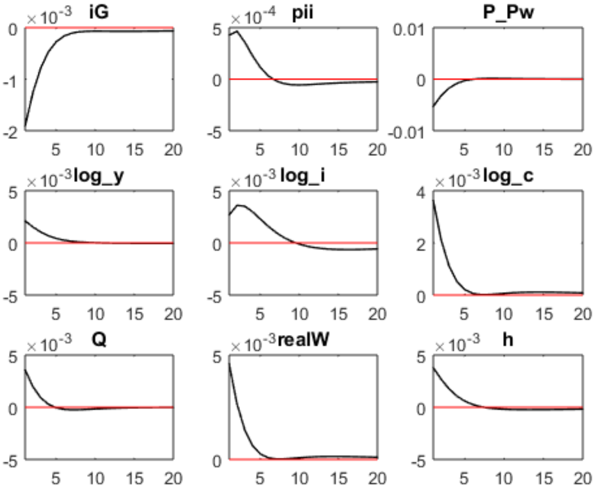


Figure 5: Effects of Interest Rate Shock

Impulse response analysis of monetary transmission

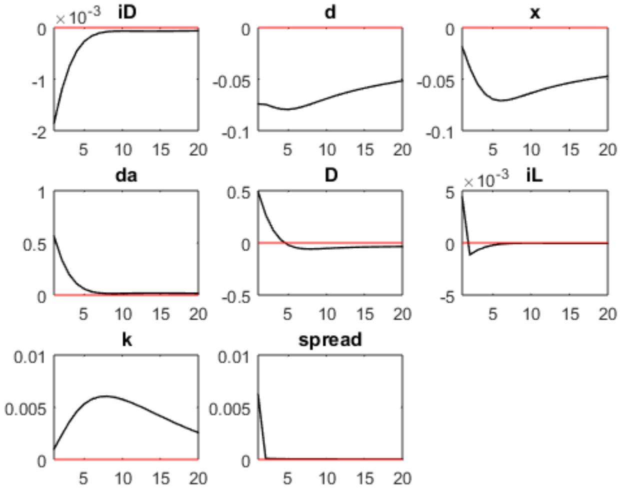


Figure 6: Effects of Interest Rate Shock

Intuition

- When $i^G \downarrow \Rightarrow i^D \downarrow \Rightarrow$ consumption $\uparrow$ $\Rightarrow$ aggregate demand $\uparrow \Rightarrow \pi \uparrow$ (via real marginal costs $\uparrow$)
- $\Rightarrow$ $\text{VMP}_L \uparrow \Rightarrow L \uparrow$ and Investment $\uparrow$ (via the Tobin Effect)
- But $i^G \propto i^D \downarrow \Rightarrow d \downarrow$ and $d^a \uparrow$.
- Higher $\pi \Rightarrow i^L \uparrow$
- Rise of i^L does not last long. i^G also falls over time $\Rightarrow i^D$ falls over time. Bank deposits fall over time, and administered deposits $\uparrow$
- Since $d \downarrow \Rightarrow x$ (real reserves) also fall.

Variance decomposition results

Table 4: Variance Decomposition Results for Major Macroeconomic Variables

List of Variables	ξ^a	ξ^{Z_x}	ξ^G	ξ^μ	ξ^{i^G}
y	50.78	2.36	30.05	13.08	3.72
c	43.37	28.09	9.75	13.74	5.05
i	32.69	55.41	3.71	6.91	1.29
π	71.76	0.21	0.47	26.91	0.66
i^L	63.48	1.19	5.96	20.06	9.31
i^G	31.11	0.68	2.87	59.67	5.68
$\left(i^L - i^D\right)$	55.88	1.26	8.08	16.91	17.87
d	32.23	0.25	0.14	67.23	0.16
d^a	53.94	0.85	4.40	36.19	4.62
TD	49.71	0.13	0.47	49.15	0.54
x	33.38	0.24	0.12	66.12	0.14

- Lion's share of fluctuations in y, π, and i^L explained by shock to TFP

Sensitivity analysis

Table 5: Sensitivity Experiments for Monetary Transmission to Output

Sensitivity Experiments	Share of ξ^{μ} in FEVD of y	Share of ξ^{i^G} in FEVD of y	correl of $[y, (x_t/x_{t-1})]$	correl of $[y, i^G]$
Baseline	13.08	3.72	0.247	0.116
$\eta = 0.756$	13.08	3.72	0.247	0.116
$i^a = 0.036$	13.08	3.72	0.247	0.116
$\alpha_s = 0.194$	13.08	3.72	0.247	0.116
$\zeta = 0.873$	44.25	0.84	0.499	0.554
$\phi_p = 106$	11.57	3.44	0.241	0.081
$\theta_p = 0.522$	14.53	3.94	0.248	0.153
$\varphi_\pi = 1.08$	15.93	3.90	0.273	0.176
$\varphi_y = 0.45$	13.37	3.72	0.252	0.108
$\rho_{i^G} = 0.90$	16.79	11.75	0.3175	0.0556

Main takeaways

- Sensitivity experiment with respect to the preference parameter for administered deposits versus regular deposits, suggests no change in the baseline values of the monetary transmission indicators.
- Fiscal dominance parameters α_s (the SLR requirement) and i^a (the administered interest rate) have no effect on monetary transmission indicators.
- With low price adjustment costs (low ϕ_p) and higher degree of past inflation indexation (high θ_p) in the retail sector, monetary transmission becomes weaker. Lower values of the nominal friction and forward looking price setting behavior limits the real effects of a monetary policy shock via the expectation channel.

Main takeaways

- Less aggressive inflation targeting (lower φ_π) and less output stabilization (lower φ_y) raises the pass through of monetary base shock to output, inflation and the nominal loan rate.
- In terms of the mark-down factor (ζ), the transmission of monetary base shock becomes *higher* as seen by the error variance decomposition and money-output correlation while the transmission of interest rate shock is *diminished*.
  - Intuition: Lower $\zeta \Rightarrow$ deposit rates $\downarrow \Rightarrow$ households deposit less $\Rightarrow$ Reserve demand $\downarrow \Rightarrow$ Loans $\uparrow \Rightarrow$ Contribution to money growth shock $\uparrow$
  - If $\zeta \downarrow \Rightarrow (i^L - i^D) \downarrow \Rightarrow$ pass through from a policy rate shock to i^L weakens $\Rightarrow$ policy rate has a lower correlation with output.

Model extension

- Risk neutral entrepreneurs now hire from two groups of workers: households who supply labor as a credit good (F) and households who supply labor as a cash good (RT)
- Production function is given by

$$Y_t^W = \xi_t^a K_{t-1}^{\alpha} [H_t^{RT} + H^F]^{1-\alpha}$$

- Entrepreneurs are subject to a borrowing constraint

$$P_t Q_t K_t \leq L_t \tag{19}$$

which we assume binds.

- RT consumers have to be paid in cash. Assume a CIA constraint

$$W_t^{RT} H_t^{RT} \leq M_{t-1}^T \tag{20}$$

- Because of the payment friction, wages of the two groups is not the same.

Model extension

- Basic return equation continues to hold

$$1 + i^L_{t+1} = \left[\left(\frac{P^w_{t+1}}{P_{t+1}} \right) \frac{MPK'_{t+1}}{Q_{t+1}} + 1 - \delta_k \right] \left[\frac{P_{t+1} Q_{t+1}}{P_t Q_t} \right]. \qquad (21)$$

- New labour demand equation for the RT consumer

$$\frac{W^{RT}_t}{P_t} = \frac{\beta U'(C_t)}{U'(C_{t-1})} \left(\frac{P_{t-1}}{P_t} \right) \left(\frac{P^w_t}{P_t} \right) MPH_t \qquad (22)$$

- Labour demand equation for the F consumer

$$\left(\frac{P^w_t}{P_t} \right) MPH^F_t - \frac{W^F_t}{P_t} = 0 \qquad (23)$$

- In the steady state, higher inflation depresses the RT wage and creates more wage inequality.

Comparing results of model 2 with model 1

Table 6: Results of Moment Matching between Data (1996Q4 to 2017Q1) and Model 1 & 2

Targeted Moments	Data	Model 1	Model 2
std. dev (y)	0.02	0.02	0.02
std. dev (π)	0.03	0.01	0.01
std. dev (i^L)	0.02	0.02	0.02
correl $[y, c]$	0.38	0.39	0.40
correl $[y, i]$	0.79	0.53	0.52
correl $[i^L, \pi]$	0.59	0.65	0.64
correl $[y, d]$	0.69	0.54	0.52
correl $[d^a, i]$	0.26	0.18	0.15
correl $[d^a, i^L]$	-0.30	-0.47	-0.45

Comparing results of model 2 with model 1

Table 7: Results of Moment Matching between
Data (1996Q4 to 2017Q1) and Model 1 & 2

Non-Targeted Moments	Data	Model 1	Model 2
correl $[y, (x_t/x_{t-1})]$	0.38	0.25	0.21
correl $[y, i^G]$	0.34	0.12	0.11
correl $[i^G, i^L]$	0.68	0.37	0.36
correl $[d^a, \pi]$	-0.60	-0.84	-0.84
correl $[d, (x_t/x_{t-1})]$	0.38	0.22	0.23
correl $[d, i]$	0.49	0.33	0.34
correl $[i, (x_t/x_{t-1})]$	0.32	0.13	0.14
AR(1) coefficient of y	0.87	0.79	0.78
AR(1) coefficient of π	0.84	0.92	0.92

Comparing results of model 2 with model 1

Table 8: Variance Decomposition Results for Major Macroeconomic Variables

List of Variables	ξ^{a}		ξ^{Z_x}		ξ^{G}		ξ^{μ}		ξ^{i^G}	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
y	50.78	50.11	2.36	2.10	30.05	33.87	13.08	10.91	3.72	3.01
c	43.37	48.53	28.09	28.77	9.75	8.59	13.74	10.29	5.05	3.82
i	32.69	31.12	55.41	55.91	3.71	3.88	6.91	7.77	1.29	1.32
π	71.76	70.04	0.21	0.19	0.47	0.46	26.91	28.67	0.66	0.64
i^L	63.48	62.26	1.19	1.05	5.96	6.01	20.06	21.61	9.31	9.06
i^G	31.11	30.06	0.68	0.68	2.87	3.21	59.67	60.00	5.68	6.05
$(i^L - i^D)$	55.88	55.44	1.26	1.05	8.08	8.25	16.91	17.85	17.87	17.42
d	32.23	32.60	0.25	0.24	0.14	0.15	67.23	66.85	0.16	0.16
d^a	53.94	51.38	0.85	0.86	4.40	4.79	36.19	38.12	4.62	4.84
TD	49.71	50.65	0.13	0.11	0.47	0.53	49.15	48.13	0.54	0.58
x	33.38	33.81	0.24	0.23	0.12	0.13	66.12	65.69	0.14	0.14

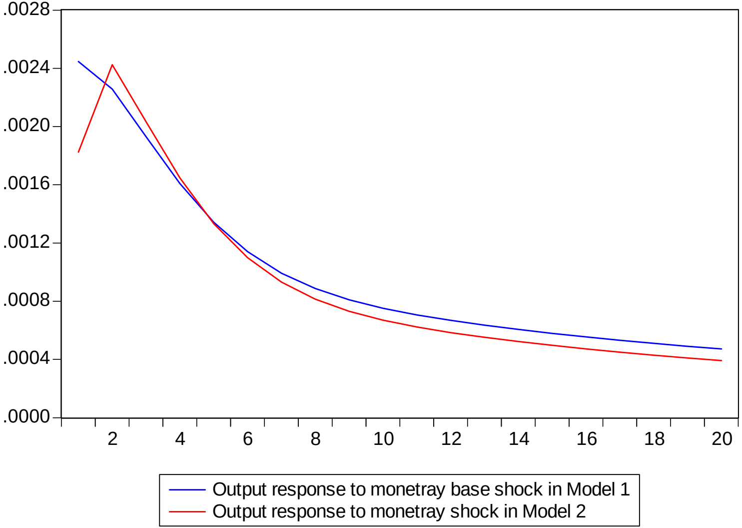
Comparing results of model 2 with model 1

Table 9: Sensitivity Experiments for Monetary Transmission to Output

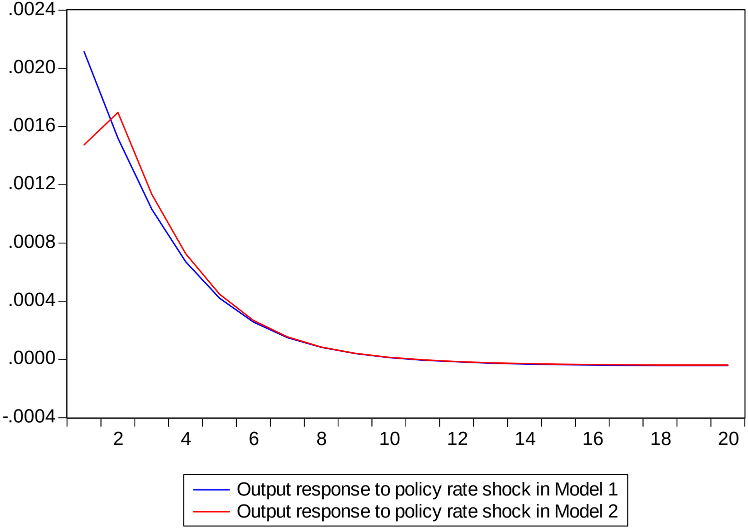
Sensitivity Experiments	Share of ξ^{μ} in FEVD in y		Share of ξ^{i^G} in FEVD in y		correl $[y, (x_t/x_{t-1})]$		correl $[y, i^G]$	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Baseline	13.08	10.91	3.72	3.01	0.247	0.213	0.116	0.105
$\eta = 0.756$	13.08	10.95	3.72	3.01	0.247	0.214	0.116	0.106
$i^a = 0.036$	13.08	10.91	3.72	3.01	0.247	0.213	0.116	0.105
$\alpha_s = 0.194$	13.08	10.91	3.72	3.01	0.247	0.213	0.116	0.105
$\zeta = 0.873$	44.25	42.00	0.84	0.65	0.499	0.441	0.554	0.561
$\phi_p = 106$	11.57	9.52	3.44	2.75	0.241	0.207	0.081	0.072
$\theta_p = 0.522$	14.53	12.16	3.94	3.20	0.248	0.214	0.153	0.143
$\varphi_\pi = 1.08$	15.93	13.62	3.90	3.18	0.273	0.238	0.176	0.167
$\varphi_y = 0.45$	13.37	11.17	3.72	3.03	0.252	0.218	0.108	0.097
$\rho_{i^G} = 0.90$	16.79	15.25	11.75	10.19	0.3175	0.2780	0.0556	0.0504

Monetary transmission indicated by comparative statics on parameters

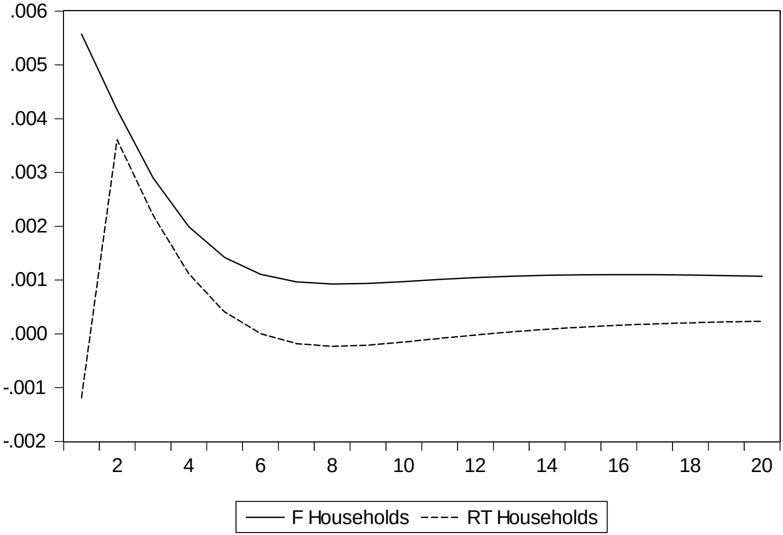
Comparing results of model 2 with model 1: output



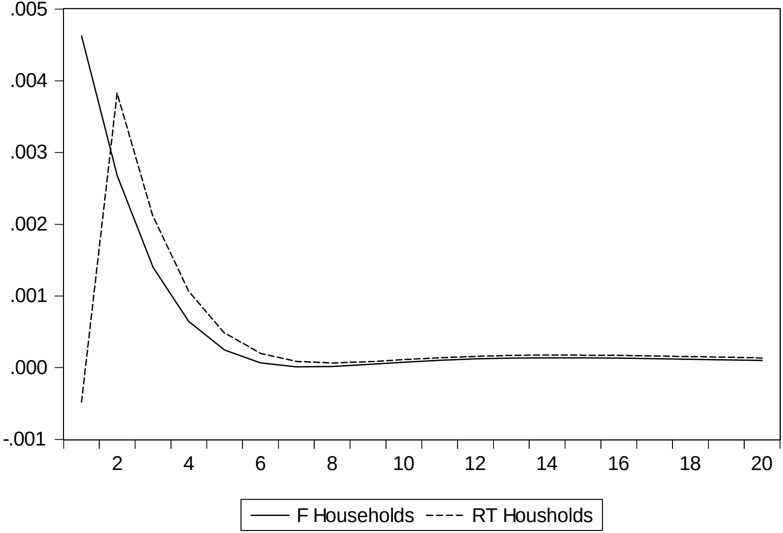
Comparing results of model 2 with model 1: output



Comparing results of model 2 with model 1: consumption



Comparing results of model 2 with model 1: consumption



Conclusion

- We started by asking: *what explains weak monetary policy transmission mechanism in India?*
- One of the first DSGE models to focus on monetary transmission in the Indian context. Our paper focuses on the aggregate demand channel.
- We find that
    - Financial repression does not weaken monetary transmission
    - Comparison of output impulse responses of monetary base versus policy rate shocks reveals that the output response is much more prolonged for a positive shock to monetary base as opposed to the interest rate.
    - Informal sector hinders monetary transmission.

Thank you