A Practitioner's Guide to Macroprudential and Monetary Policies in India

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Abstract

We build a dynamic stochastic general equilibrium model to analyze the interaction between monetary policy and several macroprudential policies: LTV ratios, prior provisioning of standard assets, risk weights, and capital requirement regulations. In our model households could borrow from both banks and non-banks and a portion of households save with returns the same as the risk-free rate; entrepreneurs could borrow only from banks. Calibrating the model to India, we find that provisioning norms are the most efficient in mitigating either a consumption demand shock, a TFP shock, or a housing boom if calibrated correctly. The results for risk weights and capital requirements are at best an attenuated version of provisioning norms, and LTV ratios being demand-side policies result in a sharper reallocation of loans toward the less-regulated non-banks compared to other policies. Monetary policy is potent but could be unnecessarily costly in terms of its effect on output and inflation.

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1 Introduction

Macroprudential policies (MPP) refer to a broad class of policies that ensure the stability of the financial system *as a whole* to prevent unwanted disruptions in the flow of credit or other financial services necessary to sustain stable economic growth. Although the global financial crisis in 2008 renewed interest in the use of MPPs across economies, it has been implemented in India at least since 2004 (Table 1). The range of tools available to Indian policymakers is also larger than most advanced economies; it includes loan-to-value (LTV ratios) mostly in the case of mortgage loans, preemptive provisioning requirements for standard assets, risk-weights on sectoral exposures, and minimum capital requirements. However, most of the tightening or loosening of such measures has been accompanied by a similar response from monetary policy. During the monetary tightening phases (2004-08, 2009-11, and 2013-14), most of the macroprudential norms were tightened, and vice versa in periods of loose monetary policy, making their individual effects ambiguous. Preliminary evidence (Verma (2018)) suggests that MPPs have been effective, but limited attempts have been made in the Indian context to identify the true effect of MPPs by eliminating the confounding effects of monetary policy. The primary objective of this project is to disentangle the effects of both types of policies in general and assess the differential impacts of each type of MPP, and monetary policy on credit and real economic activity in particular.

The end objective is what distinguishes a microprudential from a macroprudential policy. MPPs take into account the interconnectedness and feedback across financial intermediaries that may magnify the effect of a negative externality. Microprudential policies are designed to preserve the health of an individual financial institution. Promoting higher capital ratios will make a financial institution more resilient to negative shocks, but at the same time, if it is *too big to fail*, minimum capital requirements are also macroprudential. The same is true for the other policy instruments described above. Even financial institution-specific stress tests (formally known as Comprehensive Capital Analysis and Review in the US), which are mainly targeted toward single financial institutions have macroprudential elements that take into account systemic risk. In our framework, we use lender-side policies as macroprudential since we are mostly interested in their macro feedback effects. The borrower-side policies (limits on LTV ratios) are mostly used to restrict aggregate credit growth or house prices. These are macroprudential even in the narrowest sense of the term.

In a dynamic stochastic general equilibrium framework, we use this motivation to evaluate the interplay of MPPs and monetary policy. The model features two types of households – patient (savers) and impatient (borrowers), entrepreneurs who produce intermediate goods, final goods producers, banks, shadow lenders (NBFCs in Indian parlance), capital and housing stock producers, a central bank, and a government. The patient households deposit their savings in the banks, using them to finance loans to the impatient households and entrepreneurs. The non-banks borrow from the banks and loan out to the households in the economy. The main difference between the banks and the non-banks is that NBFCs cannot accept deposits. The banks are subject to all the supply-side MPPs mentioned above. However, the NBFCs are not subject to any regulation. The MPPs and monetary policy are expected to contain unnecessary credit growth. We use our calibrated model to study three shocks and a simultaneous response of different classes of macroprudential policies and an incremental monetary policy. In our first experiment, we consider a positive shock to consumption demand. We use prior provisioning policy, increased risk weights, and LTVs separately to mitigate the effect of the shock. In each of these cases we also simultaneously introduce a monetary tightening shock. We conduct the same exercise for TFP and housing supply shocks. The main policy implications of these exercises are as follows:

1. Sector-specific prior provisioning measures are the best macroprudential instruments that can be used to reduce the growth in loans.
2. Risk weights and capital regulations are attenuated versions of prior provisioning measures. A small change in the desired direction is ineffective. This is especially true if the banking system is well-capitalized.
3. Monetary policy is a potent measure to reduce loans in the case of all the shocks. However, it may have undesired side effects in terms of inflation and output.
4. LTV ratios do not reduce loans in general. They mostly reallocate loans from the regulated banking sector to relatively less regulated NBFCs.
5. Any policy, including monetary policy shocks reallocates loans from banks to NBFCs or vice-versa, depending on the direction of the policy. Therefore the presence of a less regulated sector makes all policies less effective in reducing the private sector's exposure to loans.

Our model also features an informal labor market. Since capital is not required in informal production, it is expected to act as a cushion to both macroeconomic shocks and policy slippages. In the model, if MPP regulations are tightened, we expect three simultaneous effects each with different magnitudes. First, higher collateral requirements may shift production towards the informal sector. Second, NBFC credit may partially offset the reduction in bank credit, but this comes with a loss in formal output as the entrepreneurs do not borrow from the NBFCs. Finally, they are expected to squeeze demand and overall output creating a tradeoff between real growth and loan growth. In our model, the shadow lenders depend entirely on banks for funds. This feature of the model may rationalize why MPPs are mostly used in emerging market economies. The shadow lending sector is deeper in advanced economies with multiple sources of funding, while EMEs are still mostly dependent on regulated bank credit.

The rest of the paper is organized as follows. Section 2 spells out the entire model; section 3 describes the data used, calibration, the estimation technique, and the fit of the model; section 4 describes the policy experiments about the interaction between macroprudential policies and monetary policy, and section 5 concludes.

2 Model

The model economy comprises three types of agents: patient households, impatient households, and entrepreneurs, with mass Γ_P, Γ_I, and Γ_E respectively such that $\Gamma_P + \Gamma_I + \Gamma_E = 1$. There is a representative final goods producer, and housing and capital goods producers. There are two types of financial intermediaries: Banks and non-bank financial companies (NBFCs). There is a central bank that targets inflation and sets the risk-free rate of the economy[1], and a government that taxes the households and the entrepreneurs, and

[1] The central bank also sets the regulation in this economy. That is not explicitly modeled, and assumed to be discretionary.

Table 1: Coordination between Monetary and Macroprudential Policies

	Monetary tightening phase (September 2004-August 2008)	Monetary easing phase (October 2008-April 2009)	Monetary tightening phase (October 2009-October 2011)	Monetary easing phase (January 2012-May 2013)	Monetary tightening phase (July 2013-January 2014)	Monetary easing phase January 2015-CoViD
Monetary Measures						
Repo rate	300	-425	375	-125	75	-260
Reserve repo rate	125	-275	425	-125	75	-210
Cash reserve ratio	450	-400	100	-150	0	0
Provisioning Norms						
Capital market exposures	175	-160	0	-	-	-
Housing loans	75	-60	160*	-	-	15-175 reduction
Other retail loans	175	-160	-	-	-	-
Commercial real estate loans	175	-160	60	-	-	-
Non-deposit taking systemically important non-financial companies	175	-160	0	-	-	-
Risk Weights						
Capital market exposures	25	0	0	-	-	-
Housing loans	-25-25@	0	0-25#	0-50 reduction	-	15-15 reduction
Other retail loans	25	0	0	-	-	-
Commercial real estate loans	50	-50	0	-	-	-
Non-deposit taking systemically important non-financial companies	25	-25	0	-	-	-

Provisioning requirement for housing loans with teaser interest rates was increased to 2.0% in Dec 2010.
@:Risk wrights on housing loans of relatively smaller size classified priority sector was reduced from 75% to 50% in May 2007, which was not a countercyclical measure but rather an attempt to align the risk weights on secured mortgages with the provisions of Basel II which was to be implemented with effects from 2008. On the larger loans and those with LTV Radio exceeding 75% the risk weight was increased from 75% to 100%.
#: The risk weight on loans above Rs. 7.5 million was increased to 125%.

Source: Reserve Bank of India and Sinha (2011) transfers the proceeds to the households to balance its budget every period.

In addition to monetary policy, the economy is subject to four different types of macroprudential policies: i. Loan-to-value ratio (LTV), ii. minimum capital requirements on banks, iii. provisioning requirements on standard assets, and iv. risk-weights on bank assets. In the baseline environment, we assume that the NBFCs are not subject to any regulatory supervision.

The patient households buy demand deposits from banks and invest in housing services. They supply labor in formal and informal labor markets and consume. They own the banks and enjoy dividends, but do not participate in their day-to-day operations. Impatient households borrow from banks and NBFCs to finance their housing investment subject to a collateral constraint through which LTV regulation operates, participates in both types of labor markets, and consumes. Entrepreneurs have access to formal and informal labor used in two different production technologies; the technology using formal labor contracts is assumed to be capital intensive. Entrepreneurs can only borrow from banks, while the NBFCs are assumed to specialize in retail consumer lending. They are also subject to collateral constraints, similar to that faced by households. Entrepreneurs care about their consumption and importantly, they also own the NBFCs. Similar to patient households and banks they also do not participate in daily operations. The model economy is similar to Gerali et al. (2010) and Angelini et al. (2011). Our model is modified to include formal and informal labor market, and shadow credit which has grown enormously in significance over the last decade[2]

In the following sub-sections, we spell out the decision problems of each of the agents and institutions in detail.

2.1 Patient Households

Patient households maximize the following objective function:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_P^t \left\{ (1-a^P)\epsilon_t^c log(c_t^P - a^P \overline{c_{t-1}^P}) + \epsilon_t^h log(h_t^P) - \frac{(n_t^{PF})^{1+\gamma^{lF}}}{1+\gamma^{lF}} - \frac{(n_t^{PX})^{1+\gamma^{lX}}}{1+\gamma^{lX}} \right\} \tag{1}$$

Here $\overline{c_{t-1}^P}$ is the aggregate group-specific consumption habit of the patient households in period $t-1$, h_t^P is their stock of housing. n_t^P is the total labor supply of patient households. We assume there is a free movement across formal and informal sectors as in Restrepo-Echavarria (2014), implying $n_t^P = n_t^{P,F} + n_t^{P,X}$, where X and F indicate informal and formal employment respectively. γ^{lF} and γ^{lX} are Frisch-elasticity of labor supply for formal and informal sectors respectively. ϵ_t^c and ϵ_t^h are shocks to consumption and housing demand respectively. Both these shocks follow an AR(1) process of the form:

$$\epsilon_t^i = (1-\rho_i)\bar{\epsilon}_i + \rho_i \epsilon_{t-1}^i + \zeta_t \tag{2}$$

where $i = \{c, h\}$. $\bar{\epsilon}_i$ is the steady state value of both the shocks. ζ_t is an IID normal random variable with zero mean and standard deviation σ_ζ. The patient households' choices must satisfy the following real budget constraints for each period t.

[2]See India Finance Report (2023) – *Connecting the Last Mile*

$$c_t^P + q_t^h \Delta h_t^P + \frac{d_t^P}{\Gamma_P} \leq (1-\tau_t) w_t^F n_t^{P,F} + w_t^X n_t^{P,X} + (1+r_{t-1}) \frac{d_{t-1}^P}{\pi_t \Gamma_P} + \frac{\Pi_t^b}{\Gamma_P} + \frac{T_t}{\Gamma_P + \Gamma_I} + \frac{\Pi_t^n}{\Gamma_P} \tag{3}$$

where q_t^h is the real price of housing in terms of final goods, and c_t^P is the real consumption of the representative household. $\Delta h_t^P = h_t^P - (1-\delta_h) h_{t-1}^P$, where δ_h is the depreciation rate on the existing housing stock. d_t^P is the deposits by the entire group of patient households in period t. We specify deposit per capita in the budget constraint. Deposits in period $t-1$ earn a safe interest rate r_{t-1}. Formal and informal wages are given by w_t^F and w_t^X respectively. Formal employment is subject to labor income taxes at the rate τ_t [3]. π_t is the inflation rate in period t. Π_t^b and Π_t^n are the dividends from profits earned by the banks and NBFCs and distributed to the entire group of patient households. T_t denotes government transfers, distributed to both the patient and impatient households equally.

2.2 Impatient Households

The impatient households have a subjective discount factor $\beta^I < \beta^P$[4]. The impatient households maximize the following expected utility.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_I^t \left\{ (1-a^I)\epsilon_t^c log(c_t^I - a^I \overline{c_{t-1}^I}) + \epsilon_t^h log(h_t^I) - \frac{(n_t^{IF})^{1+\gamma^{lF}}}{1+\gamma^{lF}} - \frac{(n_t^{IX})^{1+\gamma^{lX}}}{1+\gamma^{lX}} \right\} \tag{4}$$

Similar to the patient households, the impatient households also derive utility from consumption, housing stock and dislike labor. Their maximization problem is subject to the following budget constraints.

$$c_t^I + q_t^h \Delta h_t^I + (1+r_{t-1}^{bI}) \frac{b_{t-1}^{bI}}{\pi_t \Gamma_I} + (1+r_{t-1}^{nI}) \frac{b_{t-1}^{nI}}{\pi_t \Gamma_I} \leq$$
$$(1-\tau_t) w_t^F n_t^{I,F} + w_t^X n_t^{I,X} + \frac{b_t^{bI}}{\Gamma_I} + \frac{b_t^{nI}}{\Gamma_I} + \frac{T_t}{\Gamma_P + \Gamma_I} \tag{5}$$

Impatient households borrow from both banks and NBFCs, denoted by b_t^{bI} and b_t^{bn} respectively. Impatient households do not have deposits. Similar to patient households, we set the labor income tax constant.

$$(1+r_t^{bI}) \frac{b_t^{bI}}{\Gamma_I} \leq m_t^I \mathbb{E}_t (q_{t+1}^h h_t^I \pi_{t+1} (1-\delta^h)) \tag{6}$$

This constraint states that the total bank loan amount including the interest charged is lower than m_t^I proportion of the expected nominal value of the depreciated housing stock next period. m_t^I is the exogenous stochastic LTV ratio assumed to follow an AR(1) process similar in structure to (2). In the baseline model, NBFC loans do not require posting collateral. However, we have another borrowing constraint on impatient

[3] We set the value of the tax rate constant when we solve it.

[4] We also assume that entrepreneurs have the same discount factor as the impatient households.

households.

$$(1+r_t^{bI})\frac{b_t^{bI}}{\Gamma_I} + (1+r_t^{nI})\frac{b_t^{nI}}{\Gamma_I} \leq \theta_{limit} \cdot \{(1-\tau_l)w_t^F n_t^{I,F} + w_t^X n_t^{I,X}\} \tag{7}$$

The second borrowing constraint highlights that an impatient household's total borrowing from both financial intermediaries is θ_{limit} times their total labor income in period t[5]. Here θ_{limit} is a parameter defining the threshold on total impatient household borrowing.

2.3 Entrepreneurs

Entrepreneurs care about the deviation of their consumption from group-specific lagged habits. They maximize the following expected utility function.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_E^t \epsilon_t^c (1-a^E) log(c_t^E - a^E \overline{c_{t-1}^E}) \tag{8}$$

Entrepreneurs have access to two different production functions: formal, which utilizes both capital and labor, and informal which uses only labor. This assumption captures the fact that most of the formal employment is capital-intensive. Entrepreneurs choose capital for the following period, consumption, both types of labor, price of their differentiated output, and borrow only banks[6]. The formal production function for the entrepreneurs is given as follows.

$$y_t^F = z_t k_{t-1}^{E(\alpha)} n_t^{F(1-\alpha)} \tag{9}$$

where $n_t^F = n_t^{P,F} + n_t^{I,F}$, implying that labor from patient and impatient households are perfect substitutes. z_t is the economy-wide productivity shock that follows an AR(1) process similar to (2) with mean $\bar{z}$ and standard deviation σ_z. α is the Cobb-Douglas parameter indicating the share of capital in the formal production process. The informal production function is given as follows.

$$y_t^X = z_t n_t^{X(1-\alpha)} \tag{10}$$

The entrepreneurs are free to use any of the two available production technologies. However, formal production requires costly capital investment, which can only be financed by collateralized bank borrowing. Formal wages are also subject to payroll taxes. Informal production involves a probability $\theta_t^s = f(n_t^X)$[7] of government audit and an associated penalty on the entire sales of the firm. The entrepreneur's budget constraint in period t is given as follows.

[5]Given the uncertainty of income in the following period, the NBFCs typically calculate the *free* income of the households and set limits of current debt based on such a threshold.

[6]This can be generalized to include NBFC borrowing.

[7]Intuitively, higher informal employment makes it easier for the government to locate and punish tax evasion.

$$c_t^E + (1+\tau_t^P) w_t^F n_t^F + w_t^X n_t^X + (1+r_{t-1}^{bE}) \frac{b_{t-1}^{bE}}{\pi_t \Gamma_E} \leq$$

$$P_t^E (1-\theta_t^s \tau_t^s) y_t + \frac{b_t^{bE}}{\Gamma_E} - q_t^k (k_t - (1-\delta^k) k_{t-1}) \quad (11)$$

where $y_t = y_t^F + y_t^X$, and $\tilde{y}_t$ is aggregate real output given by $\Gamma_E y_t$. We assume that after production formal and informal goods are indistinguishable and are sold at the same relative price P_t^E. Entrepreneurs are assumed to operate in a perfectly competitive market. τ_t^P is the payroll taxes, q_t^k is the relative price of capital and, τ_t^s denote penalty taxes resulting from audit of informal production. Similar to impatient households, the entrepreneurs' repayment is independent of default. The entrepreneurs' bank borrowing is subject to the following collateral constraint.

$$(1+r_t^{bE}) \frac{b_t^{bE}}{\Gamma_E} \leq m_t^E \mathbb{E}_t (q_{t+1}^k k_t^E \pi_{t+1} (1-\delta^k)) \quad (12)$$

Equation (11) states that the expected value of depreciated capital in nominal terms should be enough to pay back the entire principal and interest accrued on the current bank borrowing. Entrepreneurs are also subject to a stochastic LTV ratio m_t^E.

2.4 Final Goods Producers

The final goods producers operate in a monopolistically competitive market. They are of measure 1. They buy intermediate goods from entrepreneurs, relabel them, and then sell them as differentiated products to the households at price P_t. The final good aggregator has the following form.

$$Y_t = \left[\int_0^1 \tilde{y}_t(j)^{\frac{\eta-1}{\eta}} dj \right]^{\frac{\eta}{\eta-1}} \quad (13)$$

where η is the elasticity of substitution among the differentiated final goods used for consumption and investment. Each final good producer produces $\tilde{y}_t(j)$[8]. The final goods producer's optimization problem yields the following demand function for each intermediate good j.

$$\tilde{y}_t(j) = \left(\frac{P_t^E(j)}{P_t} \right)^{-\eta} Y_t \quad (14)$$

where P_t is the price of final goods defined as $P_t = [\int_0^1 P_t^E(j)^{1-\eta} dj]^{\frac{1}{1-\eta}}$. In this model, we assume P_0 to be the numeraire. These producers face price-setting frictions as in Rotemberg (1982). Given the above demand schedule, their optimization problem results in the following new Keynesian Philips curve:

$$p_E = \frac{\epsilon_f - 1}{\epsilon_f} + \frac{\chi_P}{\epsilon_f} \left\{ (\pi_t - \pi_{t-1}^{\eta} \overline{\pi}^{1-\eta}) \pi_t - \beta_E \frac{\lambda_{t+1}^E}{\lambda_t^E} \frac{\tilde{y}_{t+1}}{\tilde{y}_t} (\pi_{t+1} - \pi_t^{\eta} \overline{\pi}^{1-\eta}) \pi_{t+1} \right\} \quad (15)$$

[8]Notice that it is the j only that differentiates the homogeneous good sold by the entrepreneur and the final good sold by the final-good producers. They are just re-labeled.

The above equation depicts an inertia for the price change. If inflation π_t deviates from the weighted average of past inflation π_{t-1} and steady state inflation $\overline{\pi}$ then the final goods producer bears a cost, whose sensitivity is given by χ_p. This makes the price-setting by the final goods producers a dynamic choice and lowers its variability over time. If price change costs are not present for the final goods producer, they charge a constant markup over the price charged on the intermediate inputs. Then, final goods track the prices of the intermediate inputs perfectly.

2.5 Banks

There is a measure 1 of banks, $j \in [0,1]$. Banks extend loans to entrepreneurs, impatient households, and the NBFCs, and accept deposits from the patient households. The loan advances market is monopolistically competitive while there is perfect competition in the deposit market[9]. Banks have to abide by the following balance sheet identity.

$$B_t^b(j) = D_t(j) + K_t^b(j) \tag{16}$$

Total loan advances are defined as $B_t^b(j) = P_t b_t^{bE}(j) + P_t b_t^{bI}(j) + P_t b_t^{bn}$[10] must equal bank capital K_t^b and deposits D_t. Banks are further subject to leverage regulations in the form of capital-to-risk-weighted asset ratios and loan provisioning. To highlight all the features of the banking sector properly, we model the bank as a combination of two units: the *wholesale* branch extends wholesale loans to the *retail* branch and accepts deposits from the patient households. The wholesale branch is responsible for implementing the capital regulations set by the central bank. They take prices on the loans as given and choose loans and deposits to maximize the following cash flow[11].

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,0}^P \Big\{ (1+R_t^{bI}) b_t^{bI} - b_{t+1}^{bI}\pi_{t+1} + (1+R_t^{bE}) b_t^{bE} - b_{t+1}^{bE}\pi_{t+1} + (1+R_t^{bn}) b_t^{bn} - b_{t+1}^{bn}\pi_{t+1} - (1+r_t) d_t$$
$$+ \pi_{t+1} d_{t+1} + \Delta k_{t+1}^b - \frac{\chi_{k^b}}{2}\left(\frac{k_t^b}{rwa_t} - \nu_t\right)^2 k_t^b \Big\} \tag{17}$$

subject to the identity given in (14). Here, rwa_t is the bank's risk-weighted assets, defined as $rwa_t = \Omega_t^I b_t^{bI} + \Omega_t^E b_t^{bE} + \Omega_t^n b_t^{bn}$, where Ω_t^i, for $i = \{I, E, n\}$ signify the stochastic risk-weights on exposure of banks to the households, firms, and NBFCs respectively. ν_t is the stochastic regulatory requirement of capital to risk-weighted assets imposed by the central bank. $\Delta k_{t+1} = \pi_{t+1}k_{t+1} - k_t$ is the additional capital available in period $t+1$.The regulatory processes Ω_t^i, and ν_t are exogenously given and follow an AR(1) process like (2), each with a different mean and standard deviation. All the real variables are defined in lower caps. The nominal law of motion for bank capital, K_t^b is defined as follows.

[9] Here we assume that the central bank offers an elastic flow of deposits to the banks at the safe interest rate r_t in period t

[10] Nominal value of loans, deposits, and capital are expressed in capital letters.

[11] This is the problem of the j^{th} bank. We drop the j notation in certain contexts for ease of notation.

$$K_t^b = (1-\delta^b)K_{t-1}^b + \Upsilon^b \kappa_{t-1}^b \tag{18}$$

The banks replenish their capital with retained profits. κ_t^b is the nominal profit of the bank from its intermediation activities[12]. The banks retain a fraction Υ^b of their profits to add to their capital. The banks have to bear an intermediation cost of δ^b proportion of capital each period it operates.

The retail branch operates in a monopolistically competitive loan market. They borrow sectoral loans from the wholesale branch and sell them as differentiated products to each sector. They use their market power to charge a markup on the rates charged by the wholesale branch to earn profits. The retail branch of bank j chooses interest rates on new advances to each of the sectors and maximizes their cash flow given as follows.

$$\begin{aligned}\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,0}^P \Big\{ & (1+r_t^{bI}(j)-\psi_I)b_t^{bI}(j) - (1+R_t^{bI})b_t^{bI} + (1+r_t^{bE}(j)-\psi_E)b_t^{bE}(j) \\ & - (1+R_t^{bE})b_t^{bE} + (1+r_t^{bn}(j)-\psi_n)b_t^{bn}(j) - (1+R_t^{bn})b_t^{bn} - \frac{\chi_{r^{bI}}}{2}\left(\frac{r_t^{bI}(j)}{r_{t-1}^{bI}(j)}-1\right)^2 r_t^{bI} b_t^{bI} - \\ & \frac{\chi_{r^{bE}}}{2}\left(\frac{r_t^{bE}(j)}{r_{t-1}^{bE}(j)}-1\right)^2 r_t^{bE} b_t^{bE} - \frac{\chi_{r^{bn}}}{2}\left(\frac{r_t^{bn}(j)}{r_{t-1}^{bn}(j)}-1\right)^2 r_t^{bn} b_t^{bn} \Big\}\end{aligned} \tag{19}$$

Their maximization problem is subject to the demand function for each type of loan faced by the bank[13]. The retail branch faces a cost of changing interest rates similar to the price change frictions faced by the final goods producers. The cash flow for both units of the bank is discounted by $\Lambda_{t,0}^P$, which is the stochastic discount factor of the patient households, defined as $\beta_P^t \frac{u_{c,t}^P}{u_{c_0}^P}$. This is because the patient households in this economy own the banks. The profits earned by both branches give the banks consolidated profits; this equals intermediation margins minus other associated costs, including provisions for standard assets that are added back to the profits, cost of deviation from capital regulation, and the costs from changing interest rates by the retail arm. The nominal profit expression for bank j, after accounting for all the intra-bank transactions[14], are given as follows.

$$\kappa_t^b(j) = \sum_i r_t^{bi}(j)B_t^{bi}(j) - r_t D_t - \frac{\chi_{k^b}}{2}\left(\frac{k_t^b}{rwa_t} - \nu_{t-1}\right)^2 K_t^b - \sum_i Adj_t(i) \tag{20}$$

for $i = \{I, E, n\}$. $Adj(i)$ are the interest rate adjustment costs incurred by the retail unit. Note that the mandatory (ex-ante) provisioning requirements are added to the bank profits. The banks do not take this into account while deciding on the current advances[15]. Ex-ante provisioning thus creates a buffer from unanticipated shocks to bank capital, once they are recognized.

[12] Note that the wholesale arm is perfectly competitive. Hence all the bank profits are made by the retail arm of the banks.

[13] Here j represents the j^{th} bank.

[14] Intermediation costs $\delta^b K_{t-1}$ are assumed to affect capital next period. They are paid after the current profits are realized.

[15] This essentially captures the provision for losses from default on loans. In this version of the paper, we do not model default explicitly

2.6 NBFCs

Similar to the banks, there is a unit measure of non-bank financial companies, $m \in [0,1]$. They cannot accept deposits. They borrow from banks[16] and in turn, lend to impatient households. NBFCs are not subject to any regulation. NBFC m is subject to the following balance sheet constraint,

$$B_t^n(m) = K_t^n(m) + B_t^{bn}(m) \tag{21}$$

This implies that total NBFC loans to all sectors cannot exceed its capital and total bank borrowing. Its law of motion for nominal capital is similar to that of banks. We further assume that the Υ^n proportion of profits of NBFCs are paid out as dividends to the entrepreneurs[17]. Similar to the commercial banks, we assume that the NBFCs have a wholesale and a retail arm. The wholesale arm gives competitive loans to the retail arm and borrows from banks. They are responsible for maintaining the capital position of the NBFCs. The wholesale arm maximizes profits subject to their balance sheet constraint. Their optimization problem is given as follows.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,0}^E \left\{ (1+R_t^n) b_t^n - \pi_t b_{t+1}^n + \pi_t b_{t+1}^{bn}(m) - (1+r_t^{bn}) b_t^{bn} + \Delta k_{t+1}^n \right\} \tag{22}$$

subject to the identity given in (21). The retail arm accepts homogeneous loans from the perfectly competitive wholesale branch, differentiates them, and sells them to entrepreneurs and impatient households in a monopolistically competitive loan market. The problem of the retail arm is given as follows.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,0}^E \left\{ (1+r_t^{nI}(m)) b_t^{nI}(m) - \pi_{t+1} b_{t+1}^{nI}(m) - (1+R_t^n) b_t^n + \pi_{t+1} b_{t+1}^n - \frac{\chi_{r^n I}}{2} \left(\frac{r_t^{nI}(m)}{r_{t-1}^{nI}} - 1 \right)^2 r_t^{nI} b_t^{nI} \right\} \tag{23}$$

The retail branch is subject to a quadratic cost that results from rate change frictions. Since the retail arm lends out the entire amount of wholesale loans, we must have $b_t^n = B_t^{nI}(m)$. NBFC profits, after accounting for intra-group transactions are given as follows.

$$\kappa_t^n(m) = \sum_i r_t^{ni}(m) B_t^{ni}(m) - r_t^{bn} B_t^{bn} - \sum_i Adj(I) \tag{24}$$

where $Adj(I)$ is the interest adjustment cost for impatient households. The assumption of a lack of regulation for NBFCs is reminiscent of the loosely regulated NBFC sector in India. It is easy to incorporate lighter regulations on the sector to be more realistic. In this stylized model, we choose not to take that route. Intuitively, banks are more regulated to protect the interests of the depositors. Regulators aim to capitalize

[16] We assume this because in India most of the funding for the NBFCs comes from banks. The model can be extended to include mutual funds/ other funding vehicles used by the NBFC

[17] This proportion also determines the relative size of the NBFCs to that of banks in this model

banks to the extent that there is never a chance of default on deposits. However, in the case of NBFCs, as also evident from our model, capital is free to become negative, in which case it is equivalent to assuming a partial default on bank loans if raising capital is prohibitively expensive.

2.7 Central Bank and The Government

The central bank has the twin objectives of inflation targeting and output stabilization. It uses the following Taylor rule to set deposit interest rates, which in turn influence demand.

$$\frac{1+r_t}{1+r} = \left(\frac{1+r_{t-1}}{1+r}\right)^{\rho_r} \left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{\tilde{y_y}}{\tilde{y_{t-1}}}\right)^{\rho_Y} \exp(\epsilon_t^m) \tag{25}$$

Here $\rho_r \in (0,1)$, and $\rho_\pi > 0$, $\rho_Y > 0$ are the sensitivity of the central bank towards deviation of previous period's safe rate from steady state, deviation of inflation from target, and deviation of real GDP from previous period's GDP respectively. ϵ_t^m is a monetary policy shock.

The government collects labor income taxes, payroll taxes, and, penalties from audits. It transfers the proceeds to the patient and impatient households as lumpsum subsidies. Its period budget is balanced and is given as follows (in real terms).

$$(\Gamma_P + \Gamma_I)\tau_t w_t^F n_t^F + \Gamma_E \tau_t^P w_t^F n_t^F + \theta_t P_t^E \tau_t^s \tilde{y}_t = T_t \tag{26}$$

The first expression on the left-hand side is the government's revenue from labor income taxes. Note that labor income taxes can only be levied on formal employment from the household sector. The second expression is the revenue from payroll taxes levied on the entrepreneurs. The third term is the revenue from penalties levied on entrepreneurs.

2.8 Capital and Housing Stock Producers and the Resource Constraint

Capital producers buy i_t^k of final goods from the final goods producers and depreciated capital $\Gamma_E(1-\delta^k)k_{t-1}$ from the entrepreneurs at price q_t^k. They then convert it to new capital $\Gamma_E k_t$ and sell it again at the same price q_t^k to the entrepreneurs. We assume that these producers operate in a perfectly competitive market for tractability. The problem of the capital goods producer is given as follows.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,0}^E \left\{ q_t^k \Gamma_E (k_t - (1-\delta^k)k_{t-1}) - i_t^k \right\} \tag{27}$$

subject to the constraint

$$\Gamma_E k_t = \Gamma_E(1-\delta^k)k_{t-1} + \left(1 - \frac{\chi_{ik}}{2}\left(\frac{i_t^k}{i_{t-1}^k} - 1\right)^2\right) i_t^k$$

The housing stock producers behave in a similar way as the capital producers. They buy i_t^h of final goods and the stock of old housing from the patient and impatient households and convert it to a new housing stock. This new stock is sold at the same price q_t^h. The housing market is competitive. We further assume that entrepreneurs own the housing market production. The problem of the housing stock producers is as follows.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,0}^E \Big\{ q_t^h (h_t - (1-\delta^h) h_{t-1}) - i_t^h \Big\} \tag{28}$$

subject to the constraint

$$h_t = (1-\delta^h) h_{t-1} + \left(1 - \frac{\chi_{ih}}{2}\left(\frac{i_t^h}{i_{t-1}^h} - 1\right)^2\right) i_t^h$$

Here $h_t = \Gamma_P h_t^P + \Gamma_I h_t^I$. Both the housing and capital goods producers face an adjustment cost for changing their investment from the previous level. χ_{ij}, $j = \{k, h\}$ is the sensitivity of the cost to an adjustment in investment for both the producers. In the case of housing and capital goods producers, the stochastic discount factor is defined as $\Lambda_{t,0}^E = \beta_E^t \frac{u_{c,t}^E}{u_{c,0}^E}$. Finally, the resource constraint in this economy is given as follows.

$$c_t + i_t^k + i_t^h + \delta^b k_t^b + \delta^n k_t^n + Adj_t = Y_t \tag{29}$$

where c_t is the total real consumption in the economy and Adj_t consists of adjustment costs for prices and interest rates. The adjustment costs associated with capital and housing investment are already included in the i_t^k and i_t^h terms.

3 Estimation

We estimate our DSGE model using Bayesian methods. We describe the data used in the estimation first, then describe the calibrated parameters with their priors. We report the estimated parameters with their posterior mean, median, and standard deviation. In this version, we use limited data to calibrate our model. More granular data availability could help shed light on the dynamics of the model even better and bring the model closer to the data[18]. We use 4 variables for the Indian economy that are available at quarterly frequency: real total bank credit, real GDP, inflation, and policy rate. We detrend all the variables using the HP filter and convert them to real variables. We show the deviations for all 4 observations from 2015 Q1 to 2024 Q1 in figure 1 from their trend. Real bank credit and real GDP are expressed as log deviations from the trend, while inflation and policy rates are not logged. They are demeaned and expressed as deviations from their mean.

3.1 Calibration and Prior Distribution

Calibrated Parameters: Table 2, reports the values of calibrated parameters. We set the discount factor for patient households at 0.9943. We set the β_I and β_E for the impatient households and entrepreneurs respectively to 0.945. We set these subjective discount factors such that the patient households want to save and the others

[18]More specifically, data on total NBFC loans, bank loans, consumption, and bank deposits can further improve the calibration. We intend to take that up in the next version of this paper.

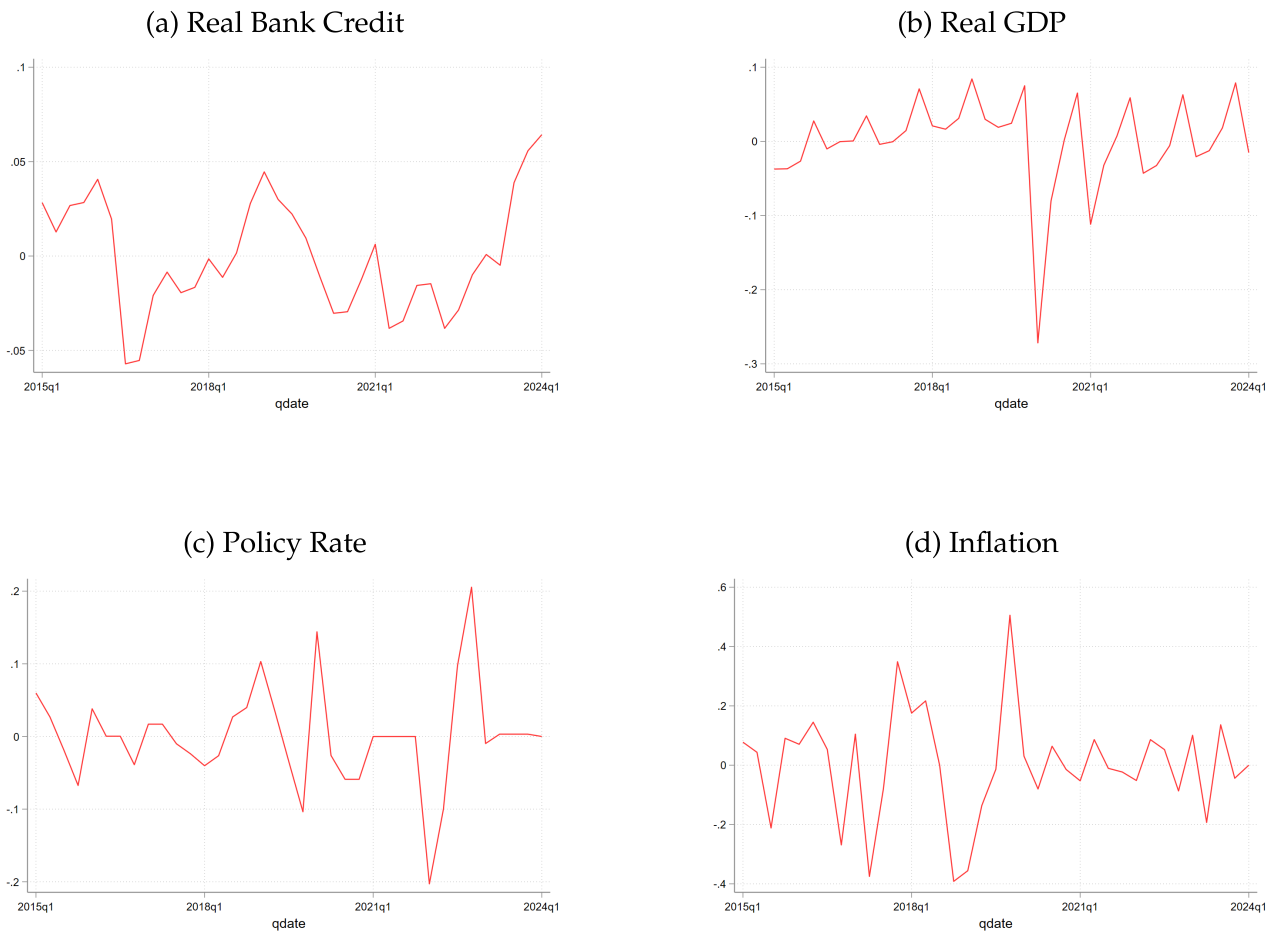

Figure 1: Observable Variables for Indian Economy used in the Model Estimation

Note: Cyclical components of Real GDP and Real Bank Credit are expressed as log deviations from trend. Policy rate and inflation are expressed as absolute deviations from their mean.

optimally wish to borrow in a steady state. We set the steady-state risk-free rate r_bar to 0.4, in line with the steady-state inflation target in India[19]. We set Γ_P to 0.6 to take into account the fact that the majority of the households in India do not borrow[20]; we set Γ_I to 0.1, as approximately 10 pp of households borrow in India. The inverse of the Frisch elasticities of labor supply for formal and informal sectors are set to 0.5 and 0.3 respectively. This is in the range of the macroeconomic estimates for emerging market economies. We assume the formal sectors' elasticity of labor supply to be lower because of the higher separation cost associated with formal employment contracts compared to informal ones. We set the steady-state value of weight on housing in households' utility function $\overline{\epsilon_h}$ is 1. Loan-to-value steady-state ratios are set to 0.5 for both households and entrepreneurs. Compared to developed economies such as Canada (see Christensen et al. (2016)) India has an average loan-to-value ratio higher, enabling higher bank credit. The consumption stickiness parameter for all the agents in the model has been assigned the same value of 0.5. We keep the average capital-to-risk-weighted assets ratio in a steady state to equal to 9%. This is the same as the Basel III norms adopted by the RBI. The elasticity of demand for all types of retail loans is assigned a value of 6, except for the elasticity of demand for loans from households to banks. We set it to 4. This makes household loans from banks more expensive

[19]The inflation target in India set by the RBI is 4 percent with a positive and negative 2 percent room for deviation from the target.

[20]Source: CPHS data

relative to other bank loans and discourages bank borrowing. This encourages non-bank loans allowing our model to capture the unprecedented NBFC sector growth of the last decade.

Table 2: Calibrated Parameters

Parameter	Description	Value
β_P	Discount Factor for Patient Households	0.9943
β_E	Discount Factor for Entrepreneurs	0.945
β_I	Discount Factor for Impatient Households	0.945
Γ_P	Proportion of patient households	0.6
Γ_I	Proportion of impatient households	0.3
Γ_E	Proportion of entrepreneurs	0.1
γ_{lF}	Inverse of Frisch Elasticity for Formal Sector	2
γ_{lX}	Inverse of Frisch Elasticity for Informal Sector	3.3
$\epsilon_{\bar{h}}$	Weight of housing in the households' utility function in steady state	1
a_E	Consumption Stickiness for Entrepreneurs	0.5
a_P	Consumption Stickiness for Patient Households	0.5
a_I	Consumption Stickiness for Impatient Households	0.5
δ_k	Capital Depreciation	0.1
δ_h	Housing Depreciation	0.1
$\bar{\nu}$	Target Capital to Loans Ratio	0.09
$\bar{m}_E$	Entrepreneurs' Loan to Value Ratio	0.5
$\bar{m}_I$	Households' Loan to value Ratio	0.5
ϵ_{bI}	Elasticity of Demand for Loan to Households from Banks	4
ϵ_{bE}	Elasticity of Demand for Loan to Entrepreneurs from Banks	6
ϵ_{nI}	Elasticity of Demand for Loan to Households from NBFCs	6
ϵ_{bn}	Elasticity of Demand for Loan to NBFCs from Banks	6
r	Steady-state risk-free rate	0.04

Capital and housing depreciation are set at 10 percent. We keep these numbers higher than the literature on advanced economies to account for imperfect institutions in emerging-market economies. We report the priors of structural estimable parameters in Table 3. These parameter priors are consistent with the previous literature and Gerali et al. (2010). The prior means for rate adjustment cost parameters are kept between 6 to 10, except for the cost of changing prices. This simply captures the higher values of the price adjustment parameter found in the literature. The last 11 parameters in 3 are the standard deviation of the policy shocks, as well as the shocks on productivity z. We keep the persistence parameter the same for all the policy shocks in our model. With more granular data it would be possible to estimate them separately.

3.2 Posterior Estimates

Table 3 reports the summary statistics of posterior distributions of the estimated parameters. We draw the posterior distribution of the parameters using the Metropolis-Hastings algorithm. We run 10 chains, each with 100000 draws per chain. We also assess the convergence of the estimated parameters using convergence stats proposed by Brooks and Gelman (1998). We report the marginal densities of select structural parameters in the figure 2[21]. While running the estimation the algorithm identifies some parameters that could not be estimated

[21] The rest of the estimated parameters with their marginal densities are added in the appendix M

Table 3: Model Parameters and Their Statistics

Parameter	Prior		Posterior		
	Mean	Std. Dev.	Mean	Median	Std. Dev.
χ_P	50	20.0000	9.3315	9.1301	2.4839
χ_{rE}	3	2.5000	2.2207	1.8055	1.7318
χ_{rn}	3	2.5000	3.0217	2.3971	2.4443
χ_{rI}	3	2.5000	3.4933	2.1452	3.6256
χ_{Kb}	6	5.0000	2.7669	2.7339	0.6131
χ_{rnI}	3	2.5000	3.4383	2.7075	2.8182
ρ_r	0.7500	0.1000	0.9317	0.9348	0.0209
ρ_y	0.1000	0.1500	-0.0692	-0.0702	0.1427
ρ_π	2	0.5000	2.1236	2.0743	0.3787
ρ	0.6000	0.1000	0.4552	0.4553	0.0682
σ_m	0.0100	0.0500	0.0280	0.0270	0.0072
σ_z	0.0100	0.0500	0.2199	0.2090	0.0668
σ_{mI}	0.0100	0.0500	0.0118	0.0068	0.0188
σ_{mE}	0.0100	0.0500	0.0089	0.0067	0.0082
σ_{cap}	0.0100	0.0500	0.0114	0.0070	0.0139
σ_{oI}	0.0100	0.0500	0.0089	0.0067	0.0072
σ_{oE}	0.0100	0.0500	0.0090	0.0068	0.0068
σ_{on}	0.0100	0.0500	0.0094	0.0066	0.0099
σ_{pI}	0.0100	0.0500	2.5908	2.3999	0.8700
σ_{pE}	0.0100	0.0500	0.2745	0.2669	0.0567
σ_{pn}	0.0100	0.0500	0.0087	0.0067	0.0066

given the data. These are the parameters whose values diverge by a significant amount from the properties of the prior distribution. There are 3 such parameters: χ_p, σ_{pI}, and $\sigma_p E$. For these parameters, in the experiments that follow, we use the mean of their prior distributions.

The posterior median for policy rate ρ_r and sensitivity of policy rate to output ρ_y are weakly identified and within the bounds of prior. However, the ability of the model to fit data on all the shocks and adjustment parameters for interest rates is highly sensitive to observables. We would require more variables for the Indian economy to identify the adjustment parameters correctly. However, experimenting with higher or lower values of adjustment parameters does not change the model behavior.

4 Policy Experiments

In this section we consider three policy experiments using our calibrated model to study the interplay between monetary policy and macroprudential policies. The first one involves a positive consumption shock that generates high demand. We try to mitigate the effects of this shock using individual policy instruments, added one by one, and finally adding a contractionary monetary policy to the mix. The second policy experiment involves studying a similar interplay using a TFP shock, and the third one is an experiment with a housing demand shock. We do not mix the available macroprudential policy variables in our experiments. For example, in a typical exercise with a consumption demand shock where we use L-T-Vs as our macroprudential

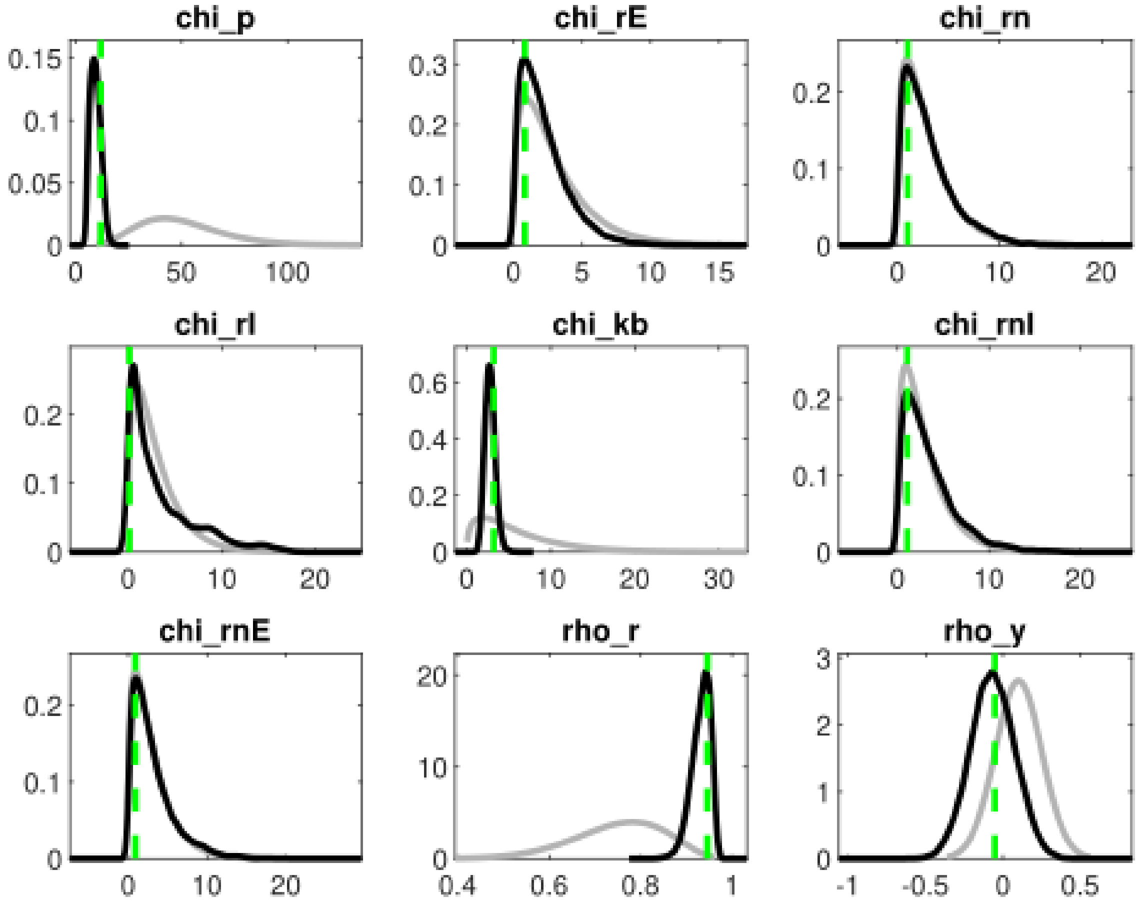

Figure 2: Marginal Distributions: Prior(Gray Line) and Posterior(Black Line)
The variables shown in the figure are expressed symbolically as follows in the order: χ_P, χ_{rE}, χ_{rn}, χ_{rI}, χ_{Kb}, χ_{rnI}, ρ_r, ρ_y, ρ_π. *The marginal densities are based on 10 chains, each chain with 100,000 draws based on Metropolis-Hastings Algorithm.*

policy of choice, we never impose stricter capital regulations on the banks simultaneously. After incrementally adding a stricter L-T-V on all the sectors, we finally add a monetary policy shock. We are more interested in the differential impact of each policy in the situations we concoct.

4.1 A Positive Shock to Consumption Demand

Prior-provisioning

Figures 3 and 4 plot the combined effects of a consumption shock with prior provisioning of bank loans as the choice for macroprudential policies and a monetary policy shock. A positive shock to consumption demand increases the total demand for NBFC loans on impact and shifts away demand from bank loans. The response of bank loans due to the shock is muted by fewer loans advanced to the entrepreneurs. A positive consumption shock results in lower investment demand and hence lower capital in the following periods. This leads to a lower value of collateralizable assets for entrepreneurs. However, household loans from banks increase on impact as expected. Output increases due to the increased consumption demand, with most of the increase coming from the informal sector (not shown in the figures). Since patient households prefer consumption over savings, demand for deposits goes down and deposit rates rise on the impact of the consumption shock. The demand shock also leads to higher inflation.

An increase in prior provisioning on NBFC loans from banks reduces both household loans from banks and NBFC loans from banks. The loan reduction from NBFCs follows from the significantly higher interest rates charged to the NBFCs by the banks, and its pass through to the retail consumers by the NBFCs. Entrepreneur loans remain unchanged. A marginal drop in output because of NBFC provisioning results in lowering deposits even further. This results in lower consumer loans from banks as well, given that bank capital only responds with a lag. Adding a higher prior provisioning shock for loans to the entrepreneurs strengthens this channel even further since entrepreneur loans from banks take a hit and output drops even more. Adding a positive prior provisioning shock to consumer loans has a first-order effect on bank loans to consumers. It raises retail interest rates charged by the banks to the consumers resulting in a reduction in bank borrowing from households.

Prior provisioning affects the loan advances in the margin. Bank profits increase because we add back the provisioned capital to the profits at the end of the period. This results in increased bank capital, and a reduced dependence on deposits by the banks. Adding prior provisioning on consumer loans successively after adding the same for NBFCs and entrepreneurs leads to regulatory arbitrage. Banks start lending disproportionately larger amounts to the NBFCs (even more than the consumption shock alone would have done). This is because of the forthcoming support from higher bank capital, elevated consumption demand, and relatively better deals provided by the NBFCs (see figure 4 where the retail interest rates charged by the NBFCs do not increase as much as those by the banks). Although NBFC capital drops initially because of the higher cost of funds from banks, it starts to increase because of the increased volume of loans, allowing them to depend less on expensive bank loans and more on capital. The reduction in bank loans and deposits is not fully mitigated by a shift towards the NBFCs. This shows up as a marginally lower inflation with all the macroprudential policies added.

Monetary policy has a first-order impact on deposit rates and inflation. It lowers output, and deposits demand and worsens the regulatory arbitrage by shifting the demand toward NBFC loans even further. Since it cuts back deposits, its initial impact on lowering loans is significantly large. However, unless inflation is above target, the model shows that increasing the prior provisioning on the desired sector can bring about the desired magnitude of effect, at the cost of lower output loss and inflation.

Risk Weights

Increasing risk weights and increasing prior provisioning have similar effects on all the variables of interest, as shown in the figures 5 and 6. In our study, we allow a 20 pp incremental increase in the risk weights. We find that increasing risk weights have an attenuated impact on bank loans and NBFC loans. The demand shock increases the deposit rates, but the policy variables do not increase it further because of a much smaller effect on output compared to the effect of prior provisioning norms. Interest rates charged by the banks also change by an order of magnitude smaller than that with prior provisioning. Since loans are not severely impacted, neither is there a case of regulatory arbitrage.

Intuitively, risk weights are not a tax on the loan interest rates charged by the banks. It impacts loan interest rates only through the regulatory capital to risk-weighted-assets ratio. If the banking system is not severely under-capitalized or over-capitalized, risk weights fail to have a considerable impact. However, if the magnitude of the risk weights is increased by a much larger amount for a given level of bank capital, the magnitude of the impact can be much higher. Note that, this effect also depends on the capital position of the banks. If the banking system is well capitalized, as is the case in India, risk weights may not be the most desired macroprudential instrument of choice.

The incremental effect of an increase in monetary policy is the strongest in this case. Similar to the case with prior provisioning, it brings down loans, deposits, and inflation. However, the incremental effect of monetary policy in the case of prior provisioning might not be the strongest. Sector-specific provisioning works better than a blunt monetary policy.

Loan-to-Value Ratios

Figures 7 and 8 plot the impact of a reduction in the LTVs and a contractionary monetary policy incrementally as a response to a positive shock to consumption demand. The effects of LTVs are different from the previous two policy experiments. This is because it is a demand-side policy that only modestly affects the supply side of loans. Since supply remains more or less intact, a reduction of the LTV on the consumer loans leaves the total loans unchanged. However, it reallocates household loans from the banks to the NBFCs. When an incremental LTV shock for the entrepreneurs is added to the mix, total loans drop. This is because, in our benchmark model, NBFCs do not advance loans to entrepreneurs.

Entrepreneur LTVs severely impact output and hence they are responsible for a higher inflation than the consumption shock alone. Although output drops with a negative entrepreneur LTV, it creates incentives for the entrepreneurs to preserve capital. This is because the collateral value of the capital increases as more capital implies more bank loans. Output drop mainly comes from the drop in labor demand, as entrepreneurs cut back on the wage bill to accommodate the consumption shock and shortage of loans from the banks[22].

An incremental monetary policy tightening has only minimal effect. Since income plummets and inflation peaks with the lower entrepreneur LTV, the economy becomes less sensitive to rate hikes. Monetary tightening affects the rates but not the quantities of the loans. This way it successfully reduces the spike in inflation by reducing demand in a supply-constrained due to the entrepreneur LTV reduction. Note that the reallocation of loans from banks to NBFCs implies a rise in the economy's unsecured or less secured credit. However, rate hikes increase bank and NBFC capital, making them more resilient and mitigating some of the risk from higher unsecured outstanding loans in the economy.

Capital Requirements

Figures 9 and 10 plot the effect of increasing the capital requirements (from 9 to 12 pp) to contain the consumption shock. Like the previous policy experiments, we also add a 10 bps contractionary shock to monetary policy. Similar to our experiment on risk weights, we find that increasing capital requirements only marginally affects sectoral loans. The reason for this is also similar to our risk weights experiment. Since the target variable is the capital-to-risk-weighted-assets ratio, increasing capital requirements can change the behavior of banks

[22]The model can be easily extended to include NBFC loans to the entrepreneurs. We do not add that to our benchmark specification because NBFCs in India mainly specialize in retail loans in India.

that were severely undercapitalized[23]. Well-capitalized banks have less incentive to respond to this change. Also, note that a 3 pp increase is a significantly high increase. For lower changes, the effect is smaller. From our IRFs, we see that bank capital increases marginally as a result of the marginally higher interest rates charged by the banks. The loan reallocation from banks to NBFCs also happens but on a much smaller magnitude than our experiment with LTVs or prior provisioning.

As always, monetary policy dominates. It raises deposit rates, lowers total deposits, and favors the less regulated NBFC sector because of the lower sensitivity of NBFC loans to interest rate changes. Monetary tightening reduces inflation and output, making it a costly policy to be used for leaning against the wind of higher sectoral borrowing.

4.2 Other Shocks: TFP and Housing

Figures 11 to 26 plot similar counterfactual policy exercises concerning a positive TFP shock and a positive housing demand shock. Since the qualitative results of a sequential introduction of macroprudential and monetary policies are the same for those shocks as well, we do not elaborate on them here. However, there are a few things to note. Unlike a consumption demand shock, a TFP shock is deflationary. An increase in prior provisioning by 1 pp could successfully reduce sectoral loans and be much more effective than the other policy instruments. An incremental monetary tightening over-tightens, intensifying the deflationary effect. Unlike a consumption demand shock, economy-wide capital increases and keeps increasing over the foreseeable horizon for a positive TFP shock. This is because a TFP shock increases the marginal productivity of capital. As a result, most of the associated expansion in output comes from the expansion of the formal sector.

Expansion in housing demand has a snowball effect. Since housing is a stock, an expansion in demand creates over-accumulation and supports over-consumption by acting as a collateralizable asset. If macroprudential shocks are introduced in the impact period of the housing demand shock, it reduces loans below steady state, leading to a drop in output and an undesired deflation. Because of the drop in output, household savings drop and a larger proportion of household income goes into housing investment. Eventually, bank advances increase along with the housing stock (not shown) which mitigates some of the positive effects of the policy and shows up as increased consumption. Apart from this, a housing policy shock reacts to monetary and macroprudential policies similarly to the other shocks.

[23] In the steady state we find that banks' capital exceeds the 9 pp capital regulation.

5 Conclusion

We build a dynamic stochastic general equilibrium model to study the interaction between monetary policy and several macroprudential policy instruments: LTV ratios, prior provisioning measures, risk weights on assets, and capital regulations. We analyze the best possible mix of policies in situations characterized by a consumption boom, a housing boom, or a positive productivity shock. We find that a consumption boom or a productivity boom is best contained by an increase in prior provisioning of sectoral loan advances from banks. Risk weights and capital regulations are weaker instruments and require large doses of change to show any tangible impact on loans. LTVs are demand-side instruments. Using them results in a sharp reallocation of loans from banks to the lightly regulated NBFC sector. We also find that monetary policy is a very potent instrument. A monetary tightening almost always reduces inflation and causes output to shrink along with the shrinking of loans across all sectors in the economy. However, the inflation and output costs are unnecessary unless they deviate from the pre-decided targets set forth by the central bank and the fiscal authorities. The same applies to housing booms. However, both macroprudential and monetary policies may be a bit less effective in this case because of the *snowball* effect. If housing growth is not fully contained, it supports higher consumer loans in the future mitigating some of the positive impacts of policy. In such cases, fiscal interference along with a well-calibrated policy mix is warranted.

This paper has several limitations. The calibration could be improved by using granular data on sectoral loans flowing from both banks and NBFCs. This would help the estimation of more parameters. We do not explicitly model default in this version. Exogenous default, if estimated using sectoral NPAs for both banks and NBFCs could reduce the dependence of the results on exogenously fixed parameter values and bring more credibility to the results. However, the results are robust to a sensitivity check on the parameter values and we expect the qualitative nature of the results to remain intact in a better calibrated version. Finally, the efficacy of monetary policy shocks is overestimated in this model. It is well understood that fiscal and monetary coordination determines the price level and other fundamentals in an economy. In our model, there is no strategic decision-making by the fiscal authorities. Incorporating this feature may result in a modest effect of monetary policy shocks, as seen in many emerging markets and developing economies with less developed financial markets.

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A Shocks to Consumption, Prior Provisioning, and Monetary Policy

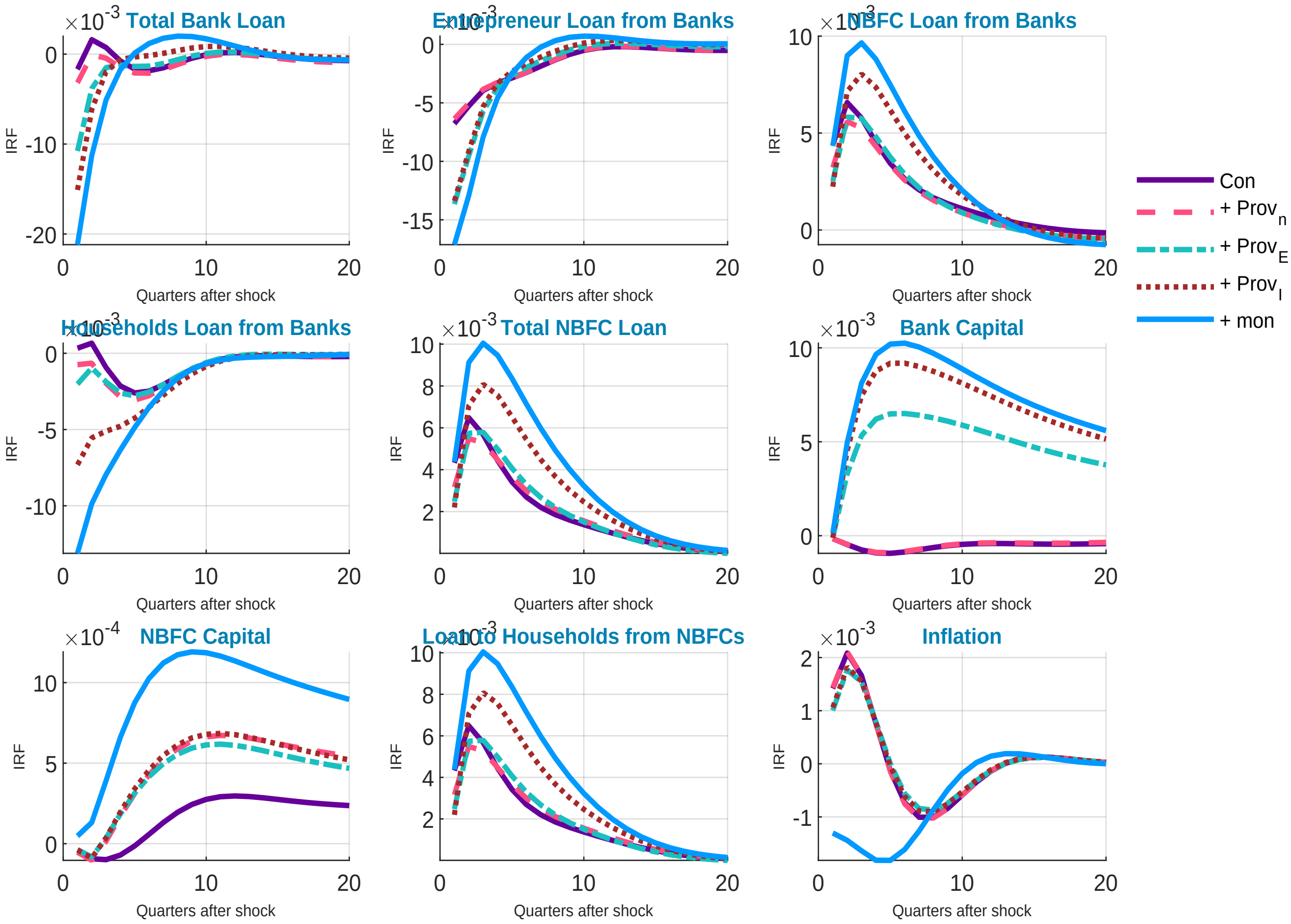

Figure 3: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in prior provisioning measures on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 *percent shock to the consumption demand shock because of its low standard deviation. Then, we add sector-wise prior provisioning. The dashed line in red represents the impulse responses of variables due to an increase in prior provisioning for NBFCs. Similarly, we add prior provisioning for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a* 1% *increase in all prior provisioning for sectoral loans. We study a* 10 *bps increase in monetary policy.*

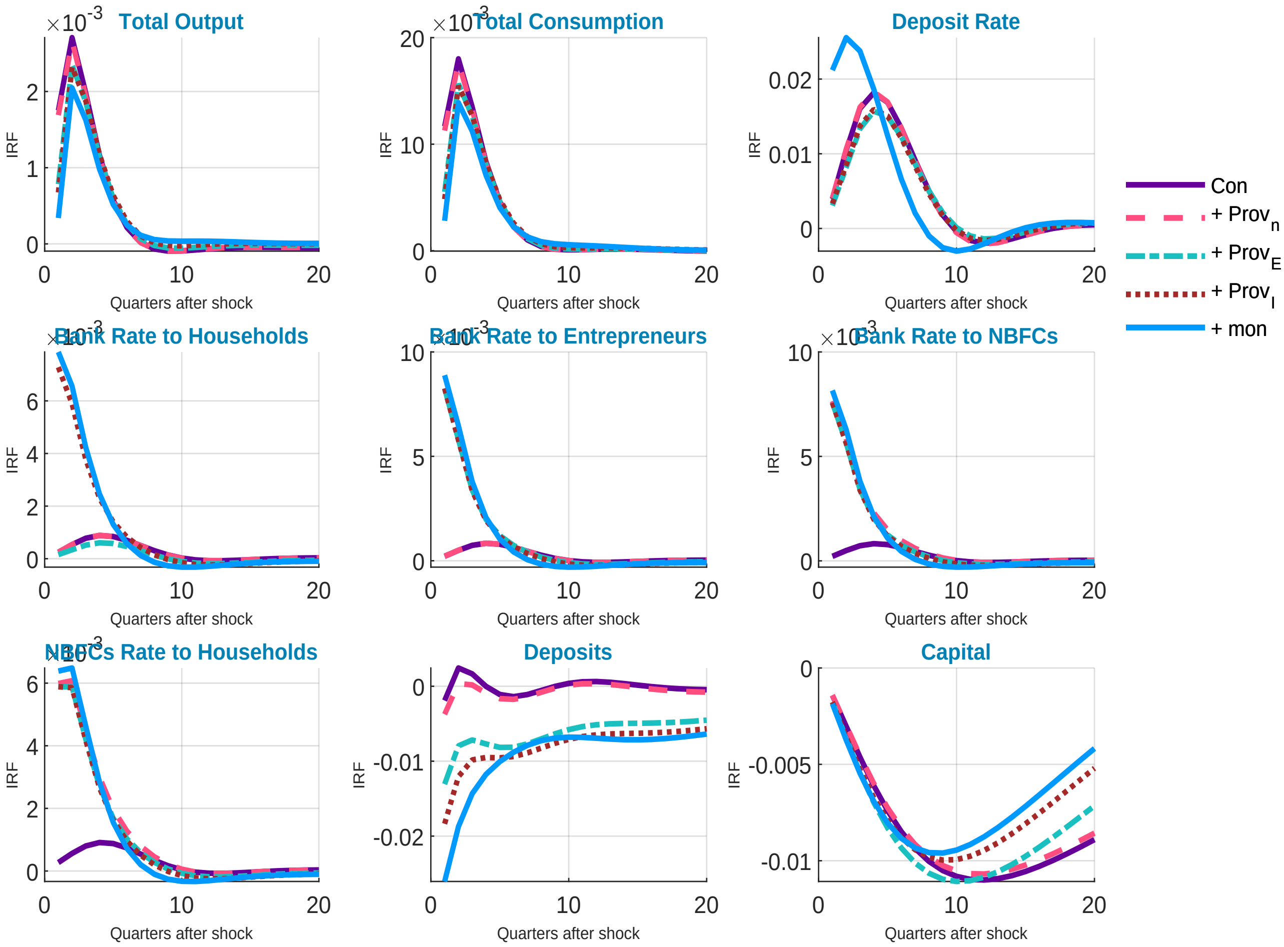

Figure 4: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in prior provisioning measures on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 percent shock to the consumption demand shock because of its low standard deviation. Then, we add sector-wise prior provisioning. The dashed line in red represents the impulse responses of variables due to an increase in prior provisioning for NBFCs. Similarly, we add prior provisioning for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 1% increase in all prior provisioning for sectoral loans. We study a 10 bps increase in monetary policy.

B Shocks to Consumption, Risk Weights, and Monetary Policy

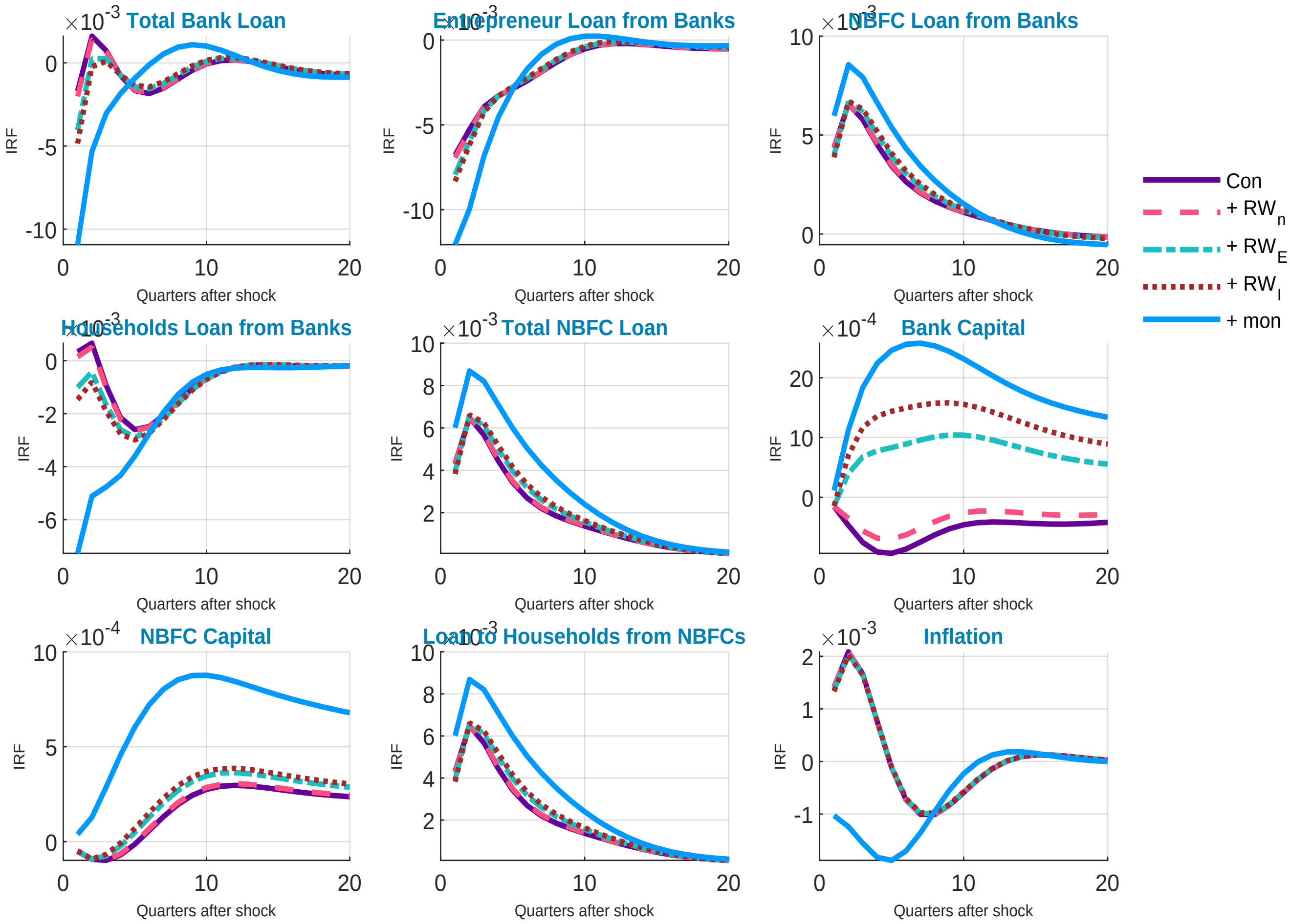

Figure 5: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in risk-weights on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 *percent shock to the consumption demand shock because of its low standard deviation. Then, we increase sector-wise risk weights, each by* 20 *pp. The dashed line in red represents the impulse responses of variables due to an increase in risk weights for NBFCs. Similarly, we increase risk weights for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a* 20% *increase in all the risk weights. We study a* 10 *bps increase in monetary policy.*

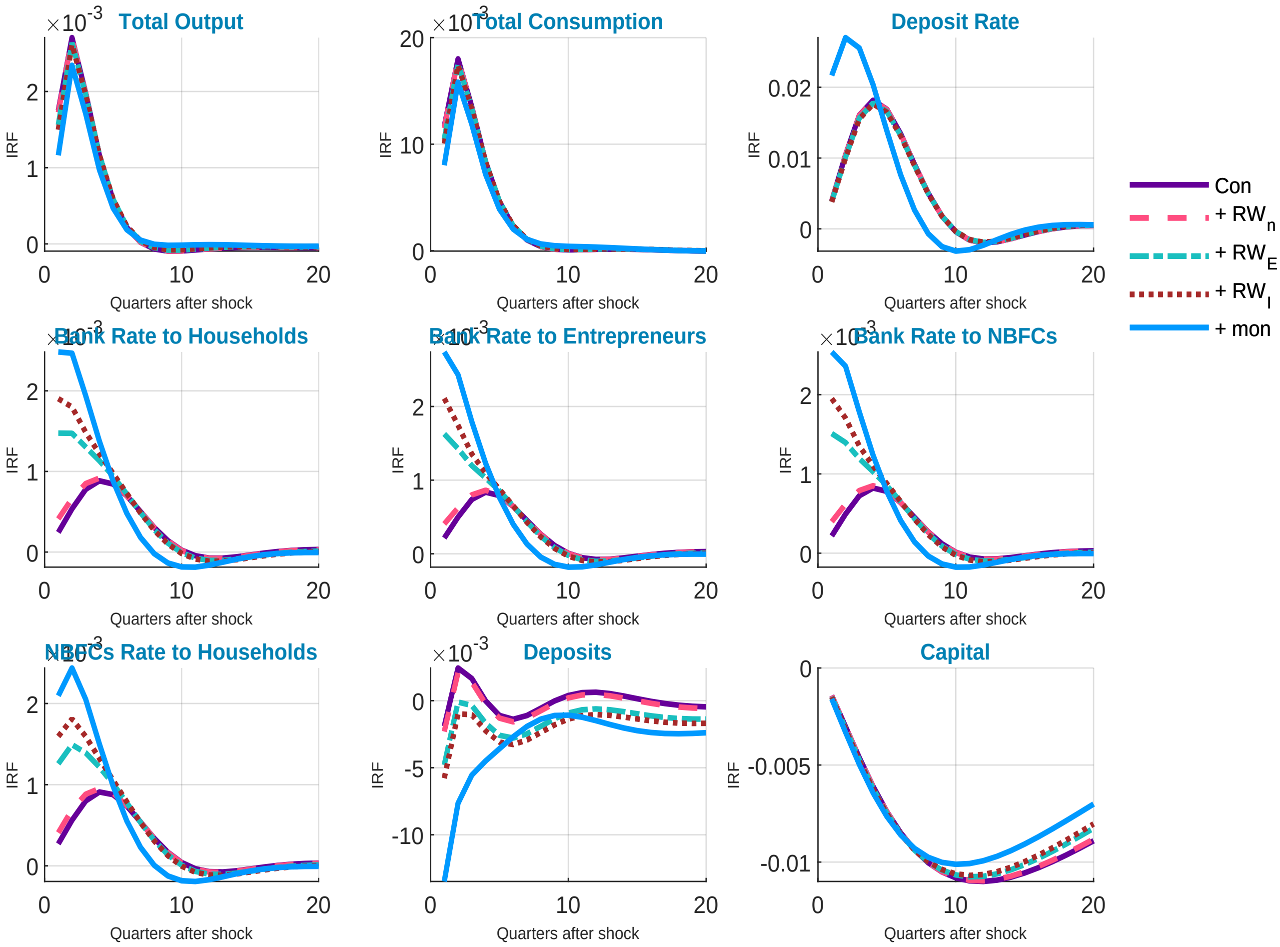

Figure 6: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in risk-weights on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 *percent shock to the consumption demand shock because of its low standard deviation. Then, we increase sector-wise risk weights, each by* 20 *pp. The dashed line in red represents the impulse responses of variables due to an increase in risk weights for NBFCs. Similarly, we increase risk weights for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a* 20% *increase in all the risk weights. We study a* 10 *bps increase in monetary policy.*

C Shocks to Consumption, LTVs, and Monetary Policy

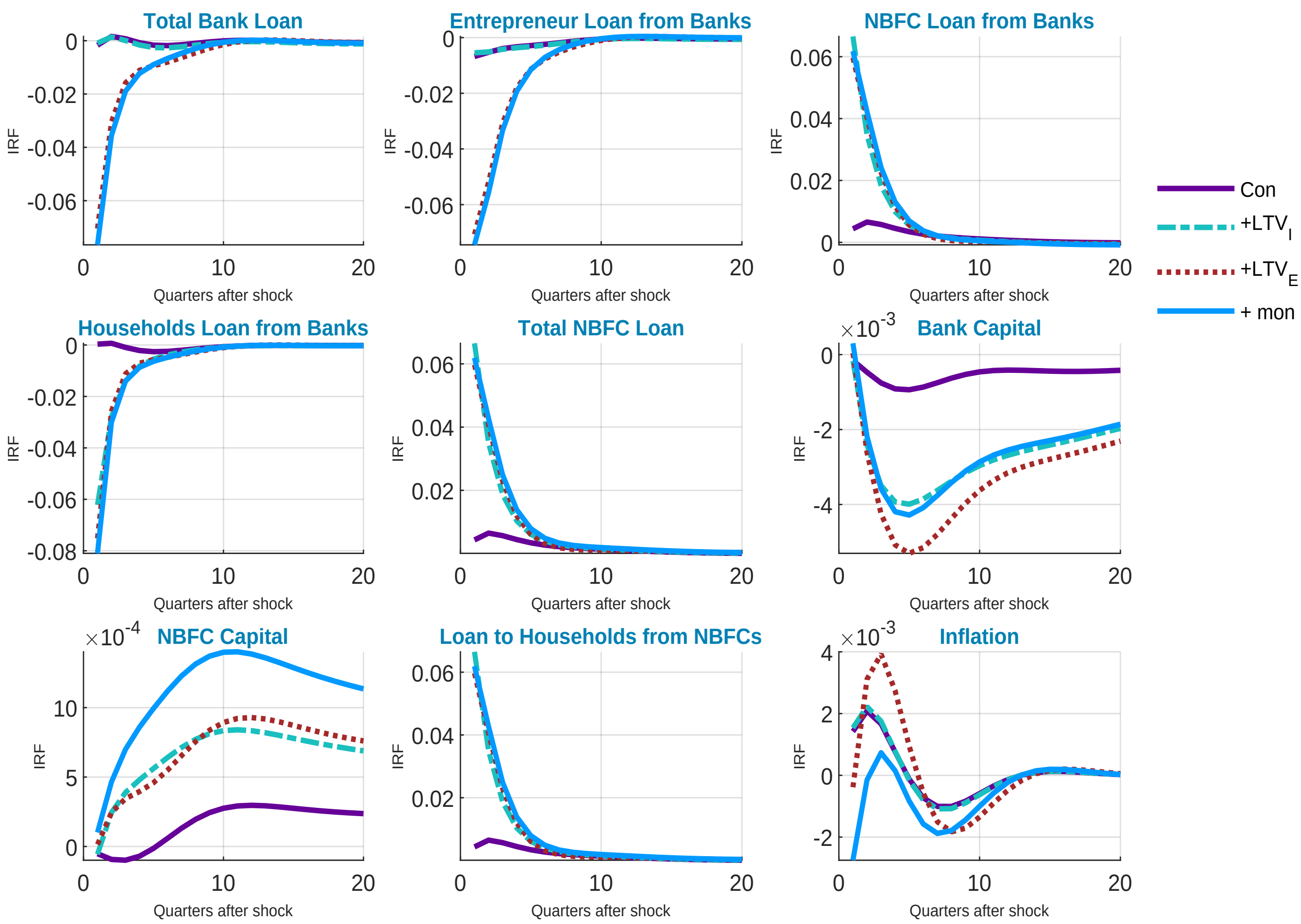

Figure 7: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in loan-to-value ratios on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 *percent shock to the consumption demand shock because of its low standard deviation. Then, we reduce the sectoral loan-to-value ratios by* 10 *pp incrementally. The dashed line in turquoise represents the impulse responses of variables due to a reduction in LTV for the households. The brown dotted line adds a reduction in the LTV ratio of similar magnitude to the entrepreneurs. The monetary policy shock is the blue line which is incremental over both the LTV reductions. We study a* 10 *bps increase in monetary policy.*

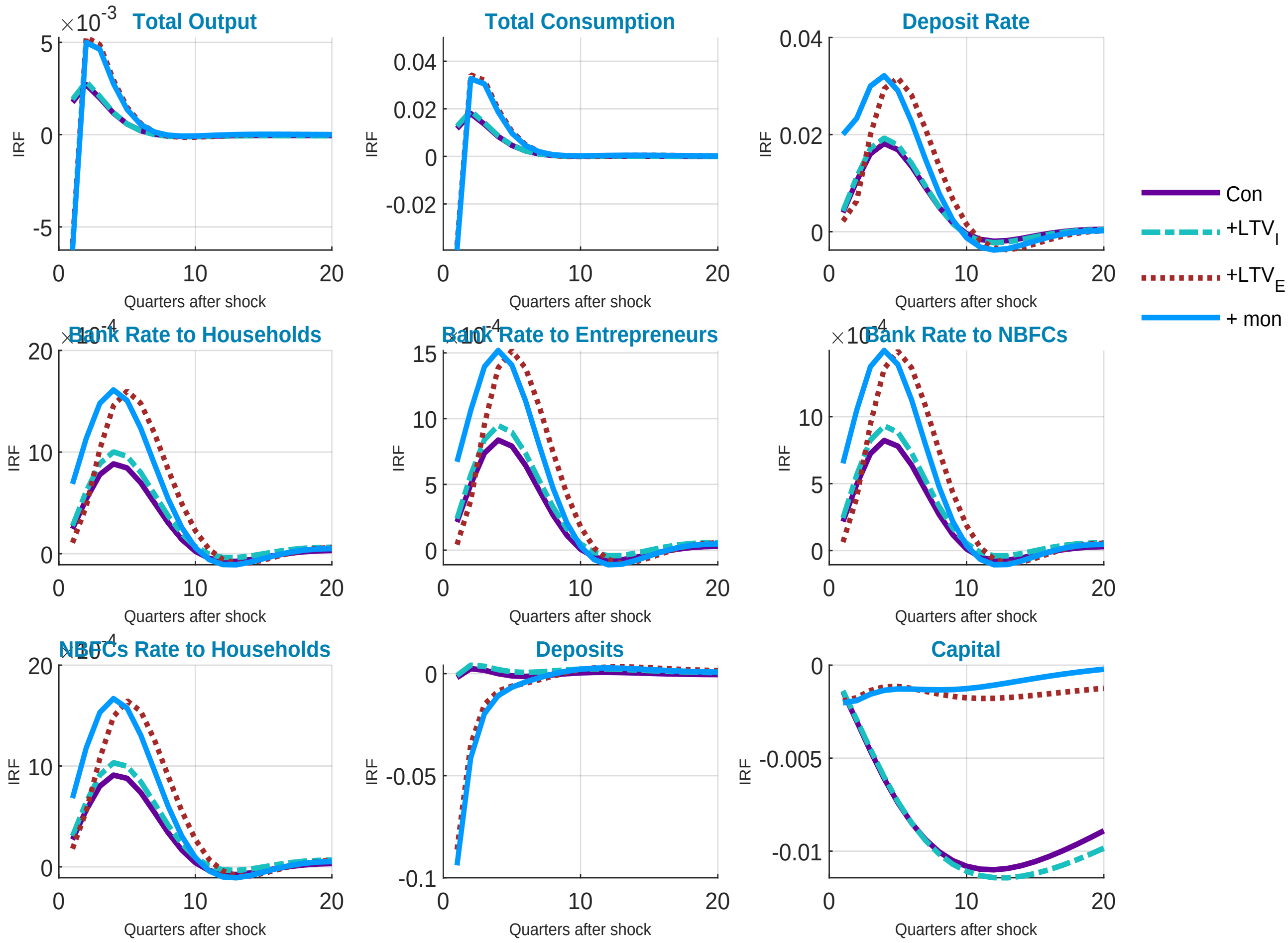

Figure 8: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in loan-to-value ratios on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 *percent shock to the consumption demand shock because of its low standard deviation. Then, we reduce the sectoral loan-to-value ratios by* 10 *pp incrementally. The dashed line in turquoise represents the impulse responses of variables due to a reduction in LTV for the households. The brown dotted line adds a reduction in the LTV ratio of similar magnitude to the entrepreneurs. The monetary policy shock is the blue line which is incremental over both the LTV reductions. We study a* 10 *bps increase in monetary policy.*

D Shocks to Consumption, Capital Regulation, and Monetary Policy

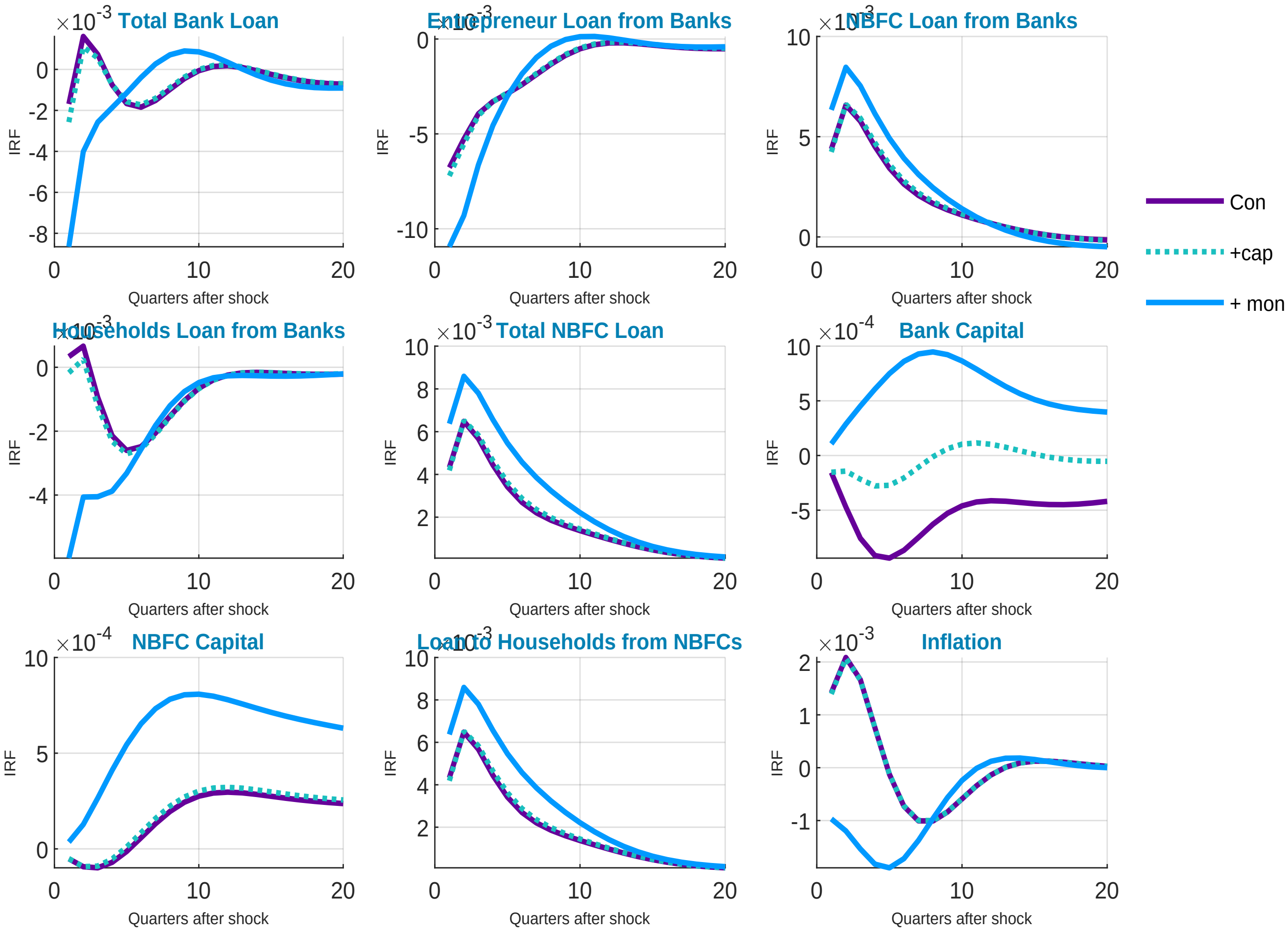

Figure 9: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in capital regulations and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 percent shock to the consumption demand shock because of its low standard deviation. Then, we increase the capital regulation for banks from 9 pp to 12 pp, as shown by the turquoise line. We study a 10 bps increase in monetary policy.

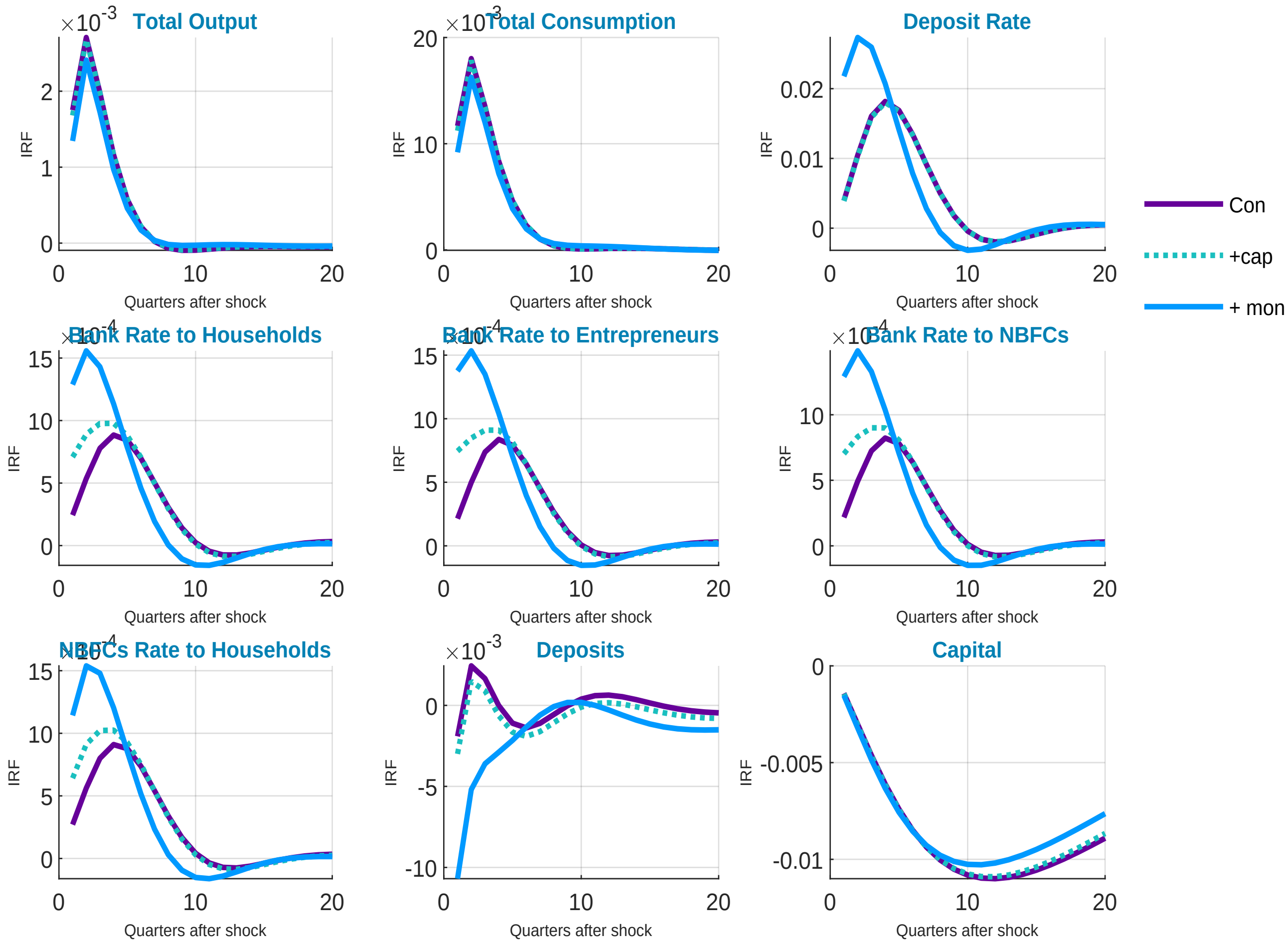

Figure 10: Effect of a positive consumption shock and the associated mitigation efforts of incremental changes in capital regulations and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 10 percent shock to the consumption demand shock because of its low standard deviation. Then, we increase the capital regulation for banks from 9 pp to 12 pp, as shown by the turquoise line. We study a 10 bps increase in monetary policy.

E Shocks to Productivity, Prior Provisioning, and Monetary Policy

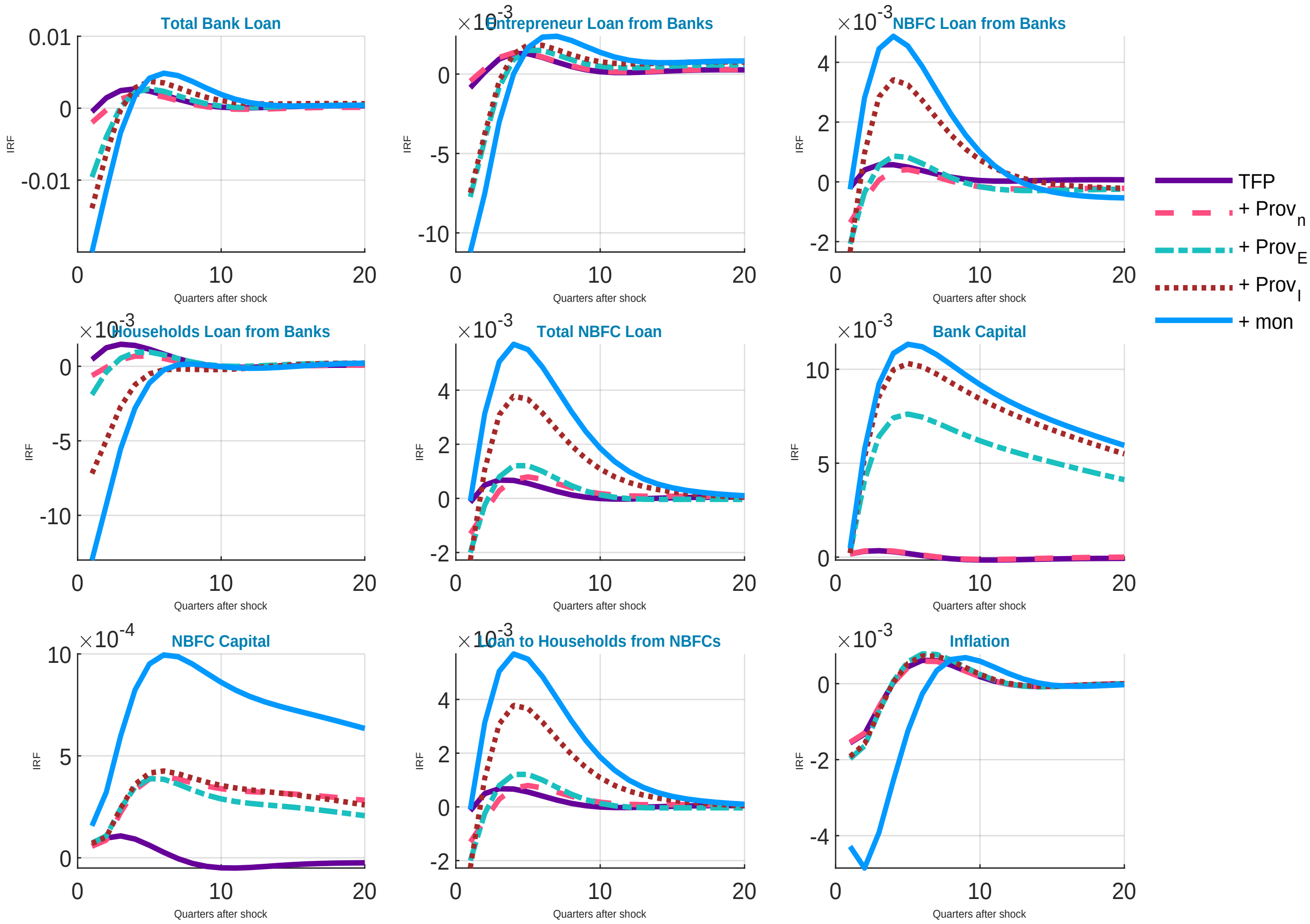

Figure 11: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in prior provisioning and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 percent shock to the TFP shock. Then, we add sector-wise prior provisioning. The dashed line in red represents the impulse responses of variables due to an increase in prior provisioning for NBFCs. Similarly, we add prior provisioning for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 1% increase in all prior provisioning for sectoral loans. We study a 10 bps increase in monetary policy.

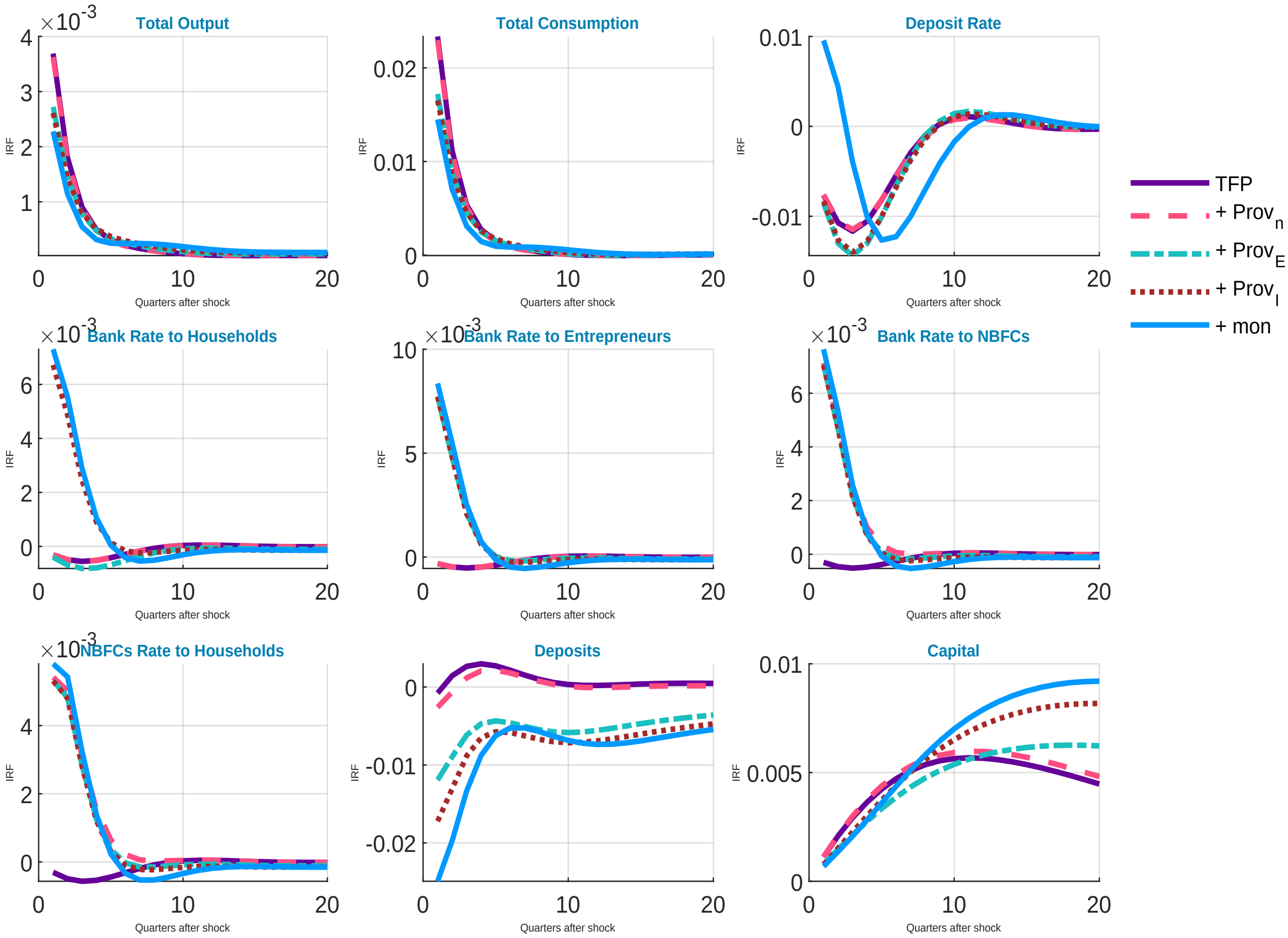

Figure 12: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in prior provisioning and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 percent shock to the TFP shock. Then, we add sector-wise prior provisioning. The dashed line in red represents the impulse responses of variables due to an increase in prior provisioning for NBFCs. Similarly, we add prior provisioning for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 1% increase in all prior provisioning for sectoral loans. We study a 10 bps increase in monetary policy.

F Shocks to Productivity, Risk Weights, and Monetary Policy

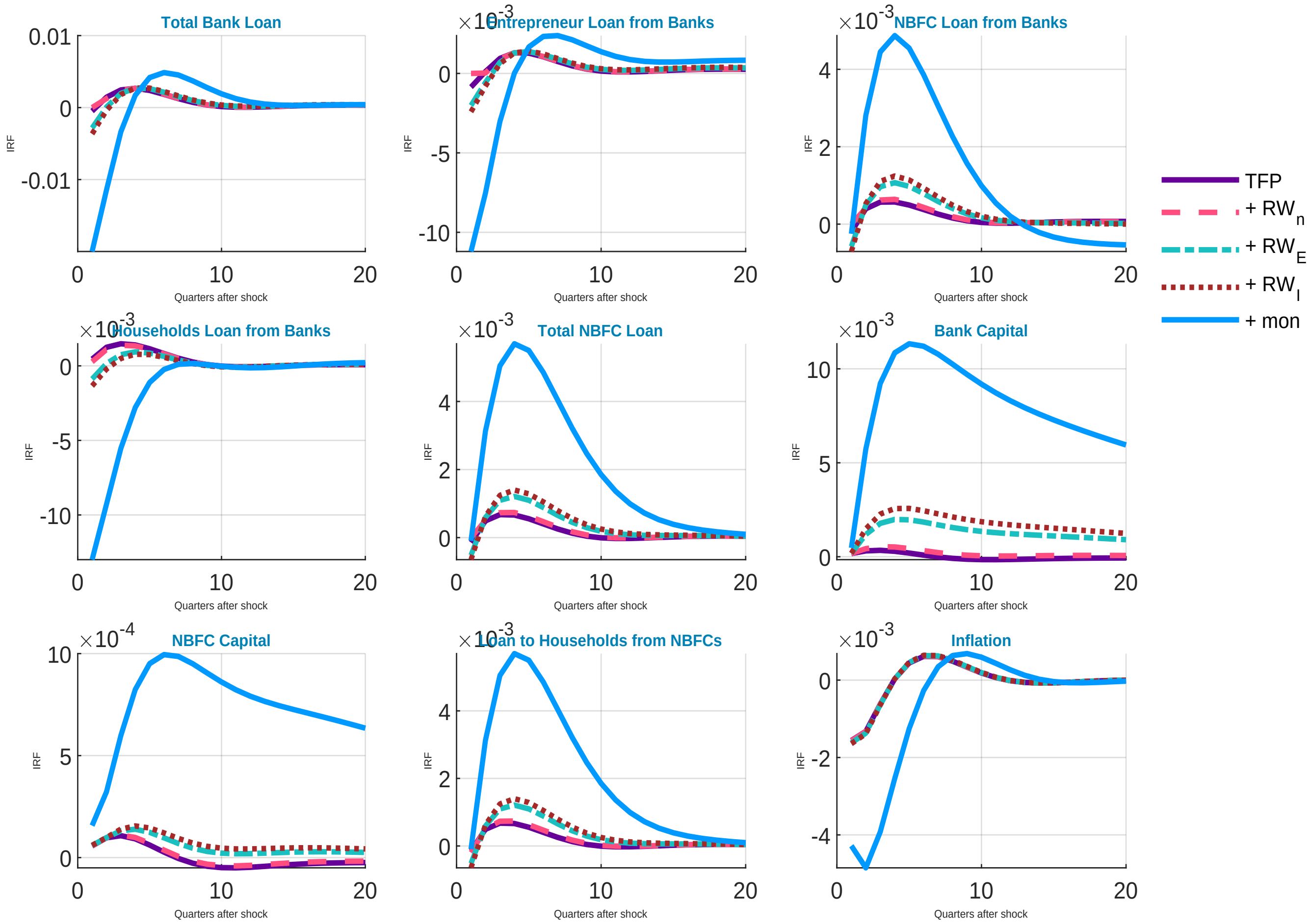

Figure 13: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in risk-weights on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 percent TFP shock. Then, we increase sector-wise risk weights, each by 20 pp. The dashed line in red represents the impulse responses of variables due to an increase in risk weights for NBFCs. Similarly, we increase risk weights for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 20% increase in all the risk weights. We study a 10 bps increase in monetary policy.

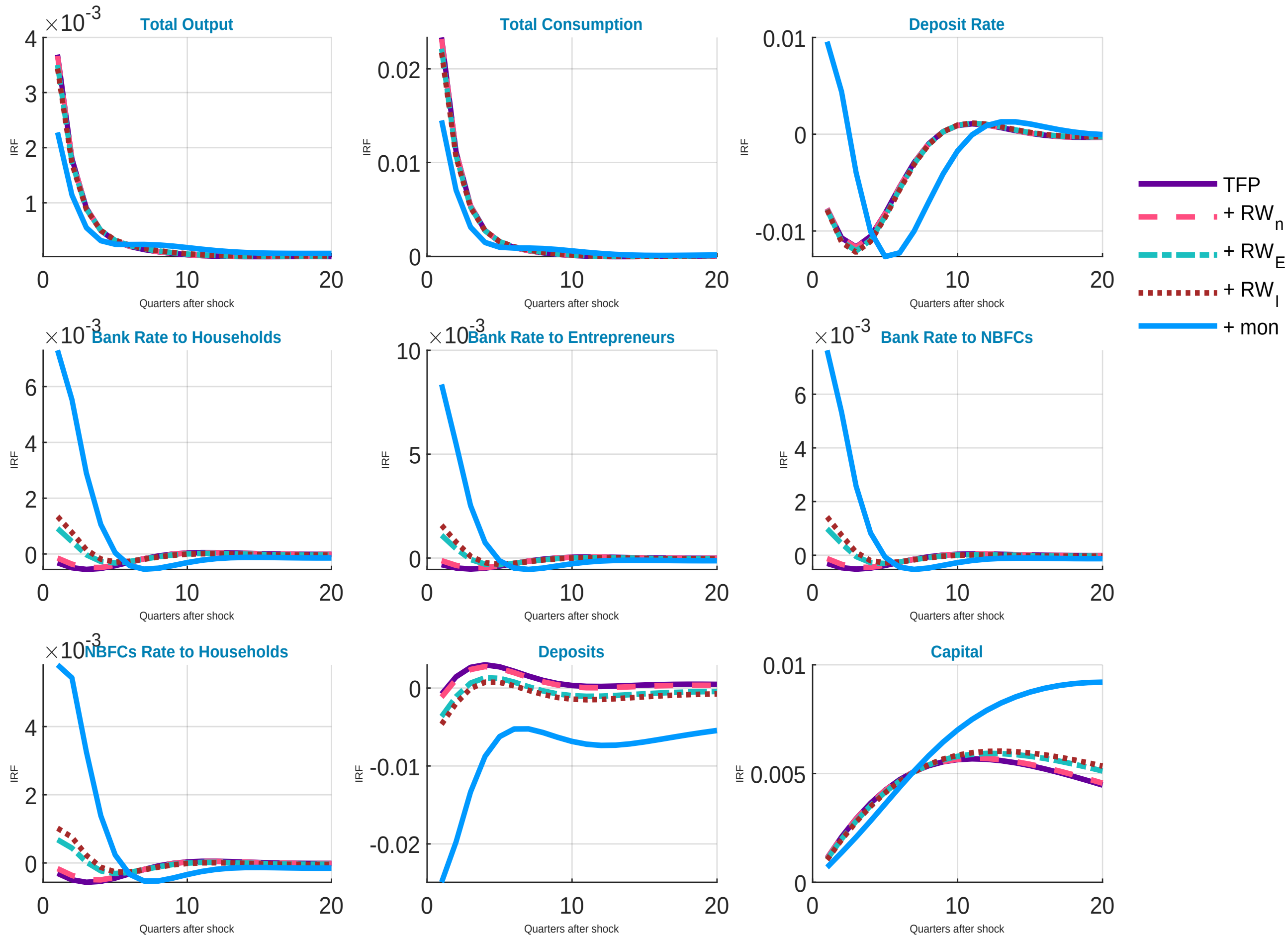

Figure 14: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in risk-weights on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 percent TFP shock. Then, we increase sector-wise risk weights, each by 20 pp. The dashed line in red represents the impulse responses of variables due to an increase in risk weights for NBFCs. Similarly, we increase risk weights for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 20% increase in all the risk weights. We study a 10 bps increase in monetary policy.

G Shocks to Productivity, LTVs, and Monetary Policy

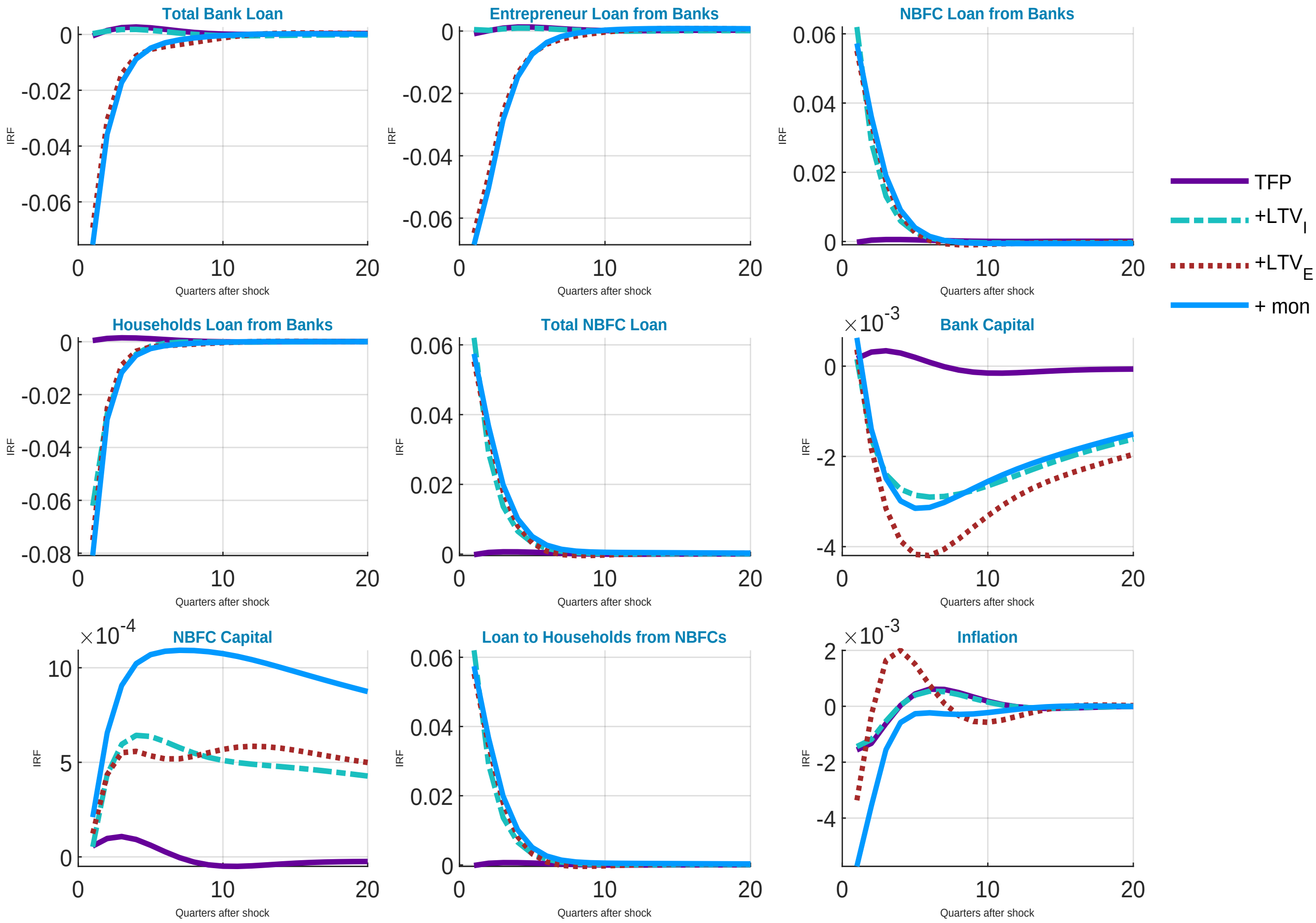

Figure 15: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in loan-to-value ratios on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 percent TFP shock. Then, we reduce the sectoral loan-to-value ratios by 10 pp incrementally. The dashed line in turquoise represents the impulse responses of variables due to a reduction in LTV for the households. The brown dotted line adds a reduction in the LTV ratio of similar magnitude to the entrepreneurs. The monetary policy shock is the blue line which is incremental over both the LTV reductions. We study a 10 bps increase in monetary policy.

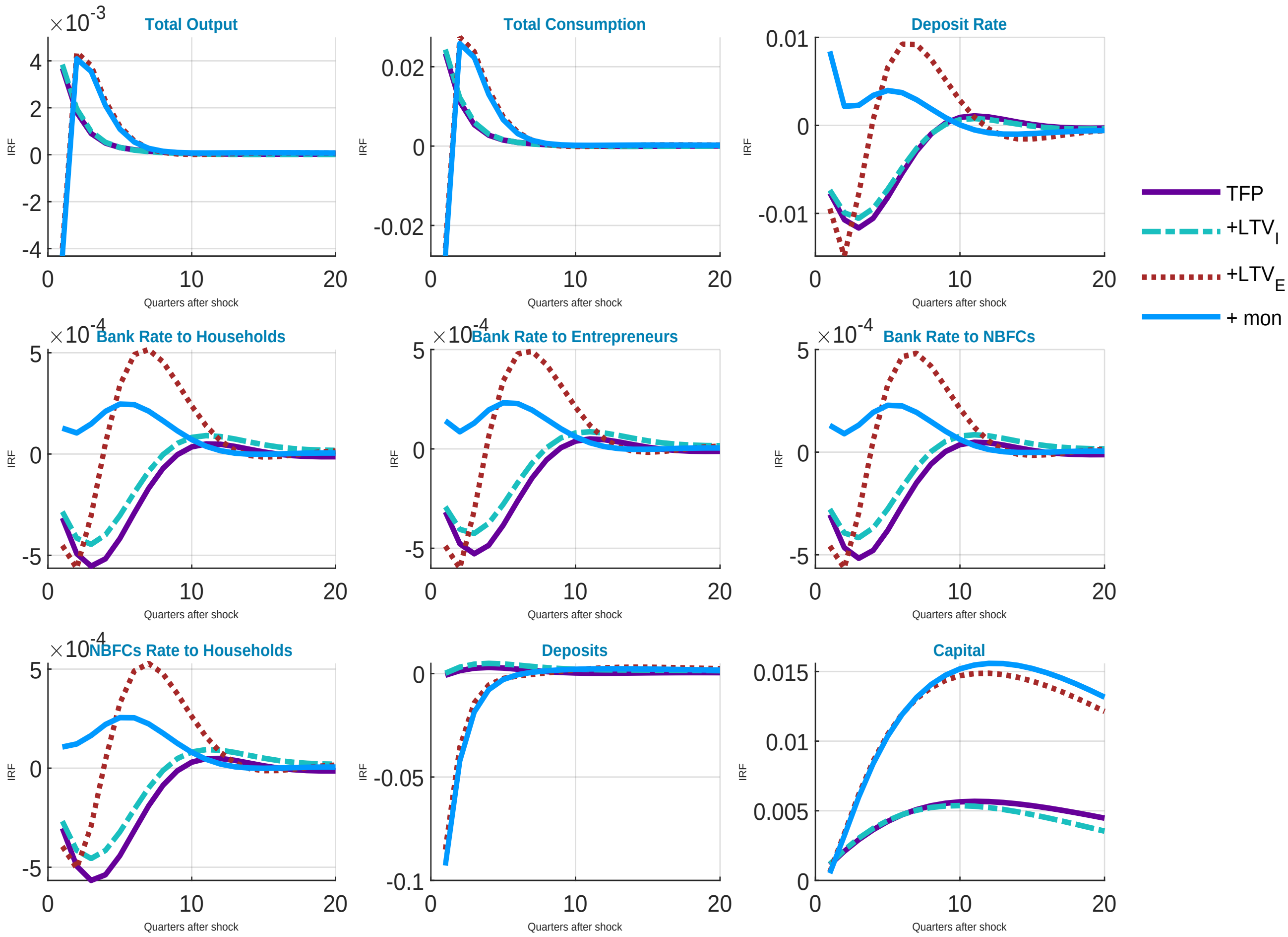

Figure 16: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in loan-to-value ratios on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 *percent TFP shock. Then, we reduce the sectoral loan-to-value ratios by* 10 *pp incrementally. The dashed line in turquoise represents the impulse responses of variables due to a reduction in LTV for the households. The brown dotted line adds a reduction in the LTV ratio of similar magnitude to the entrepreneurs. The monetary policy shock is the blue line which is incremental over both the LTV reductions. We study a* 10 *bps increase in monetary policy.*

H Shocks to Productivity, Capital Regulation, and Monetary Policy

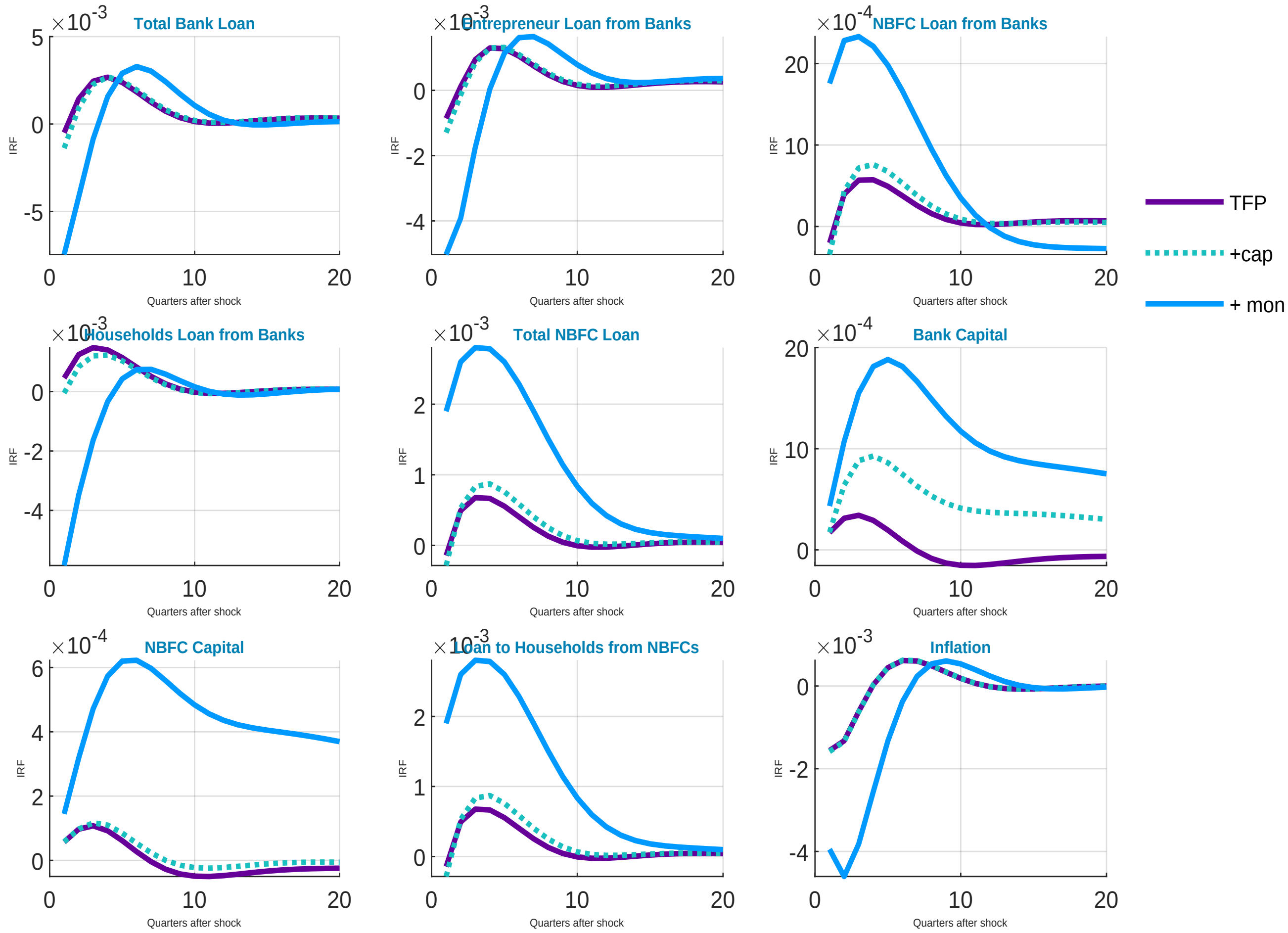

Figure 17: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in capital regulations and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 percent shock to TFP. Then, we increase the capital regulation for banks from 9 pp to 12 pp, as shown by the turquoise line. We study a 10 bps increase in monetary policy.

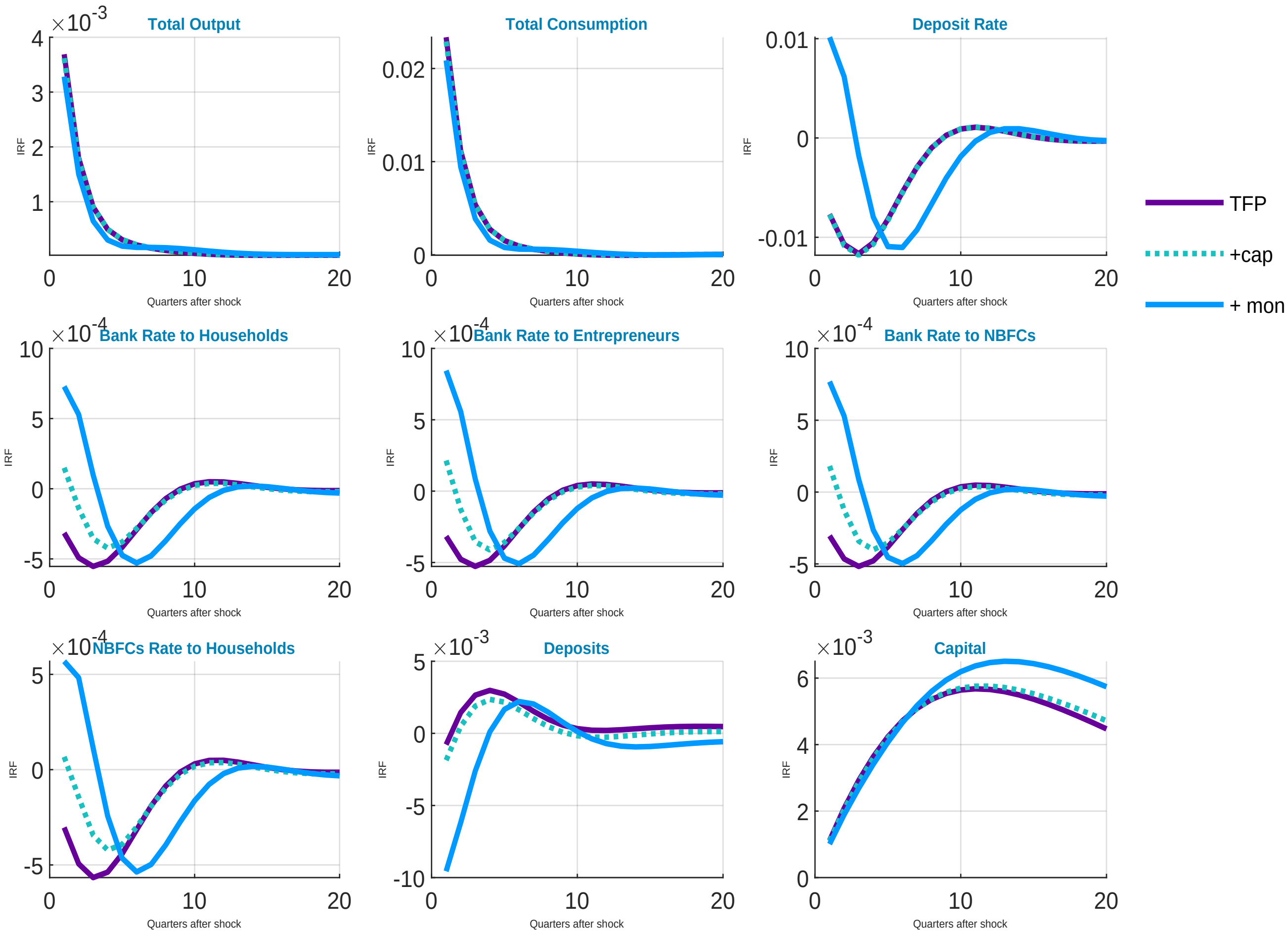

Figure 18: Effect of a positive TFP shock and the associated mitigation efforts of incremental changes in capital regulations and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 2 percent shock to TFP. Then, we increase the capital regulation for banks from 9 pp to 12 pp, as shown by the turquoise line. We study a 10 bps increase in monetary policy.

I Shocks to Housing Demand, Prior Provisioning, and Monetary Policy

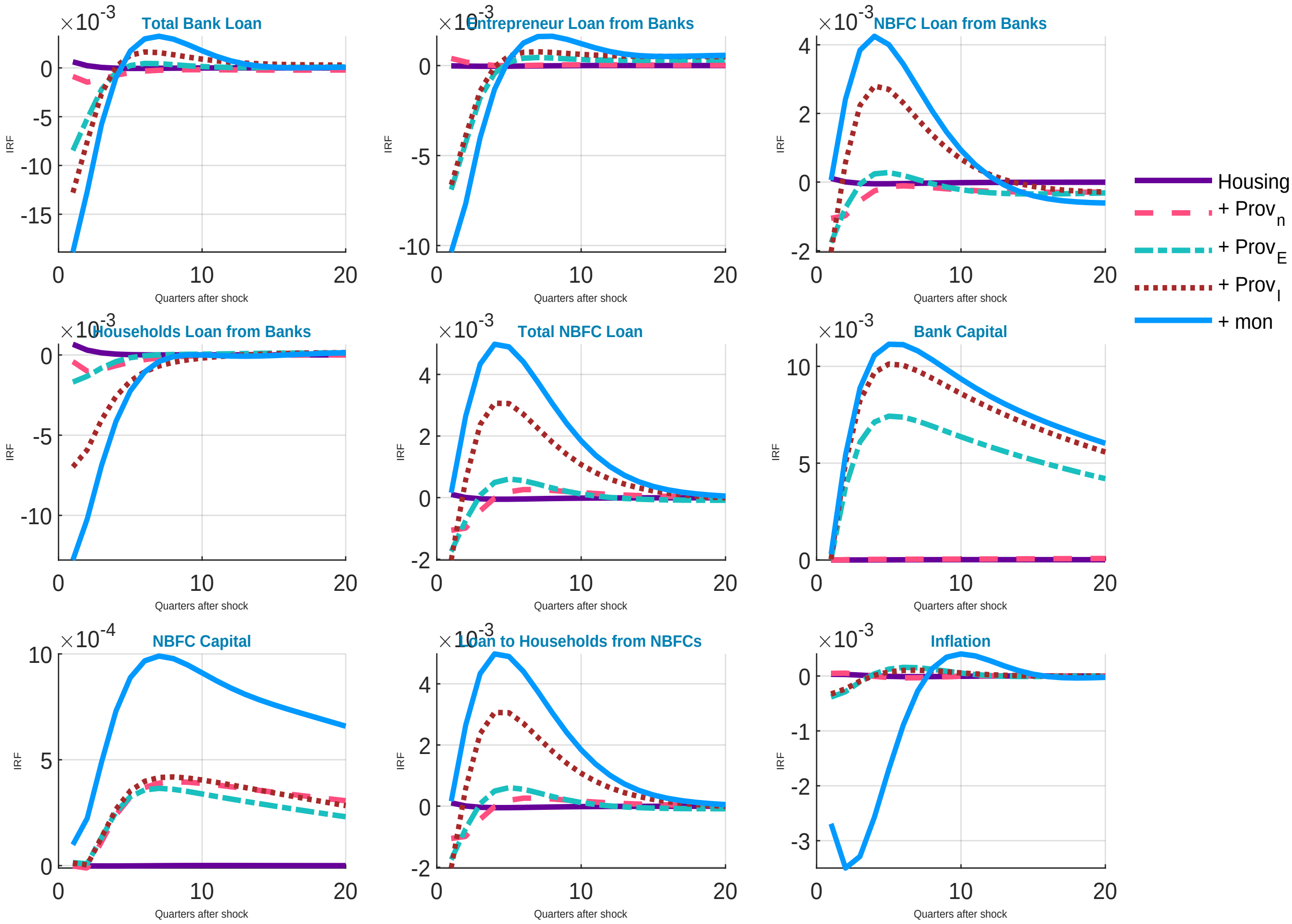

Figure 19: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in prior provisioning measures on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 *percent shock to the housing demand shock. Then, we add sector-wise prior provisioning. The dashed line in red represents the impulse responses of variables due to an increase in prior provisioning for NBFCs. Similarly, we add prior provisioning for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 1% increase in all prior provisioning for sectoral loans. We study a* 10 *bps increase in monetary policy.*

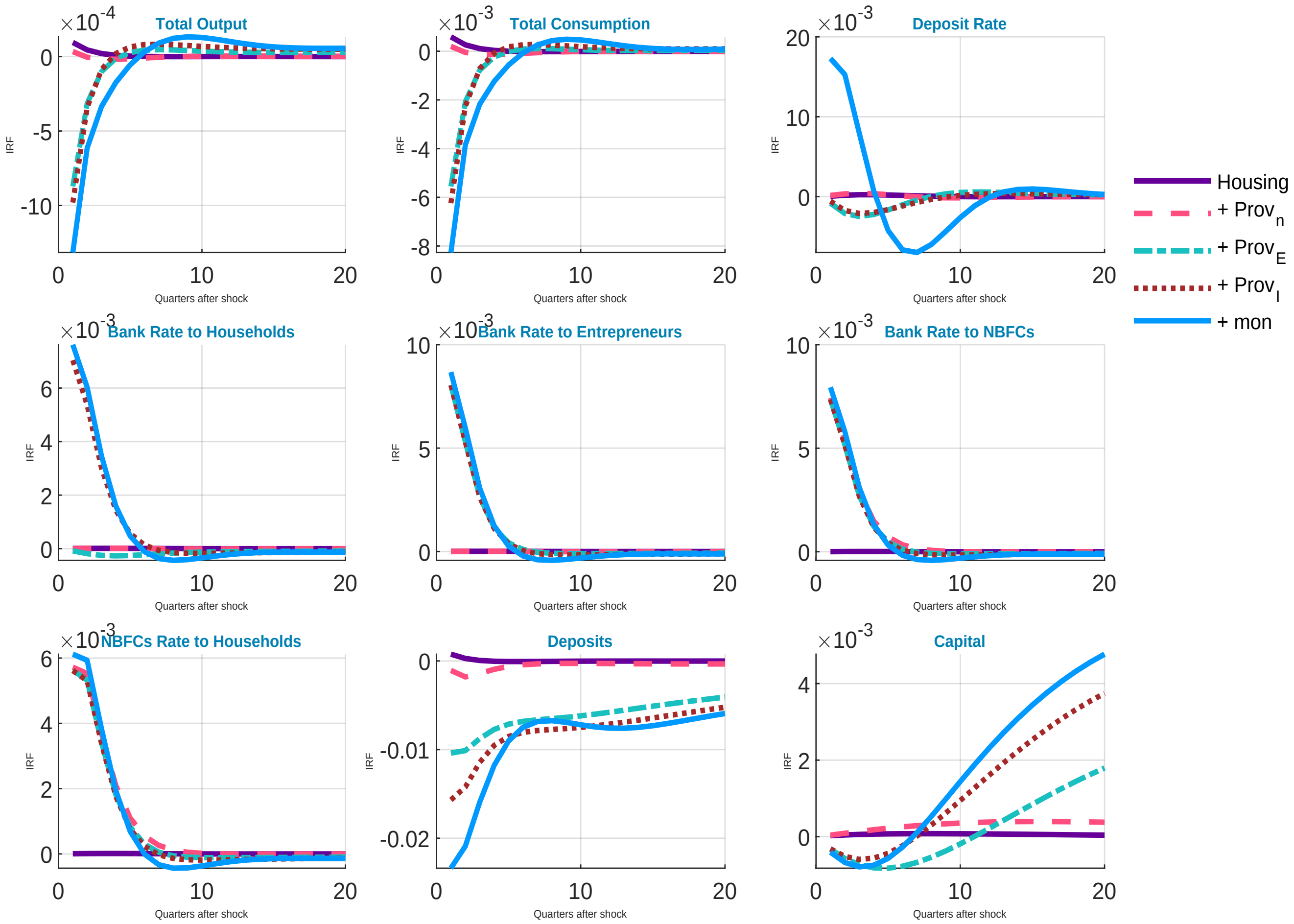

Figure 20: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in prior provisioning measures on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 percent shock to the housing demand shock. Then, we add sector-wise prior provisioning. The dashed line in red represents the impulse responses of variables due to an increase in prior provisioning for NBFCs. Similarly, we add prior provisioning for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 1% increase in all prior provisioning for sectoral loans. We study a 10 bps increase in monetary policy.

J Shocks to Housing Demand, Risk Weights, and Monetary Policy

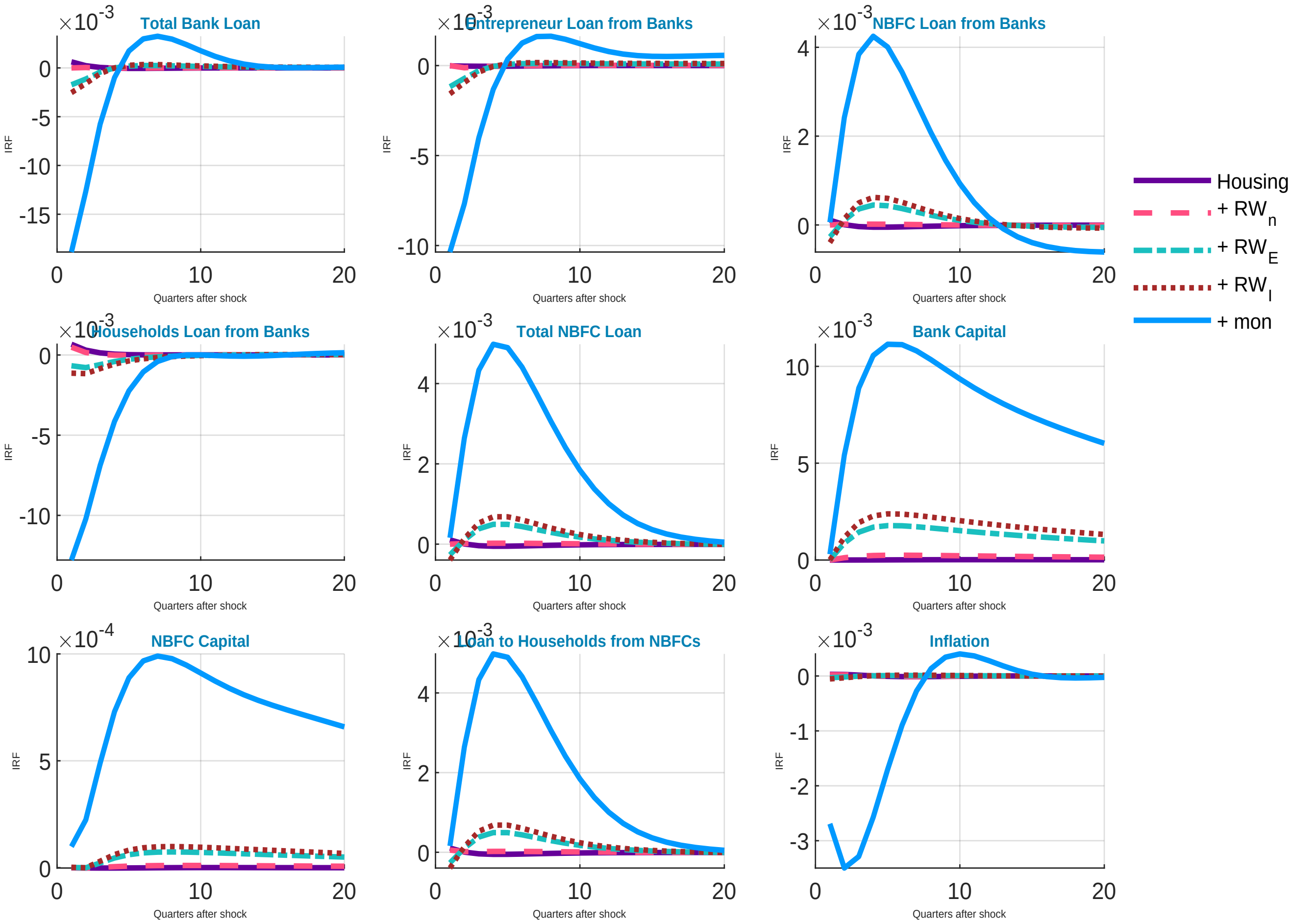

Figure 21: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in risk-weights on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 percent housing demand shock. Then, we increase sector-wise risk weights, each by 20 pp. The dashed line in red represents the impulse responses of variables due to an increase in risk weights for NBFCs. Similarly, we increase risk weights for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a 20% increase in all the risk weights. We study a 10 bps increase in monetary policy.

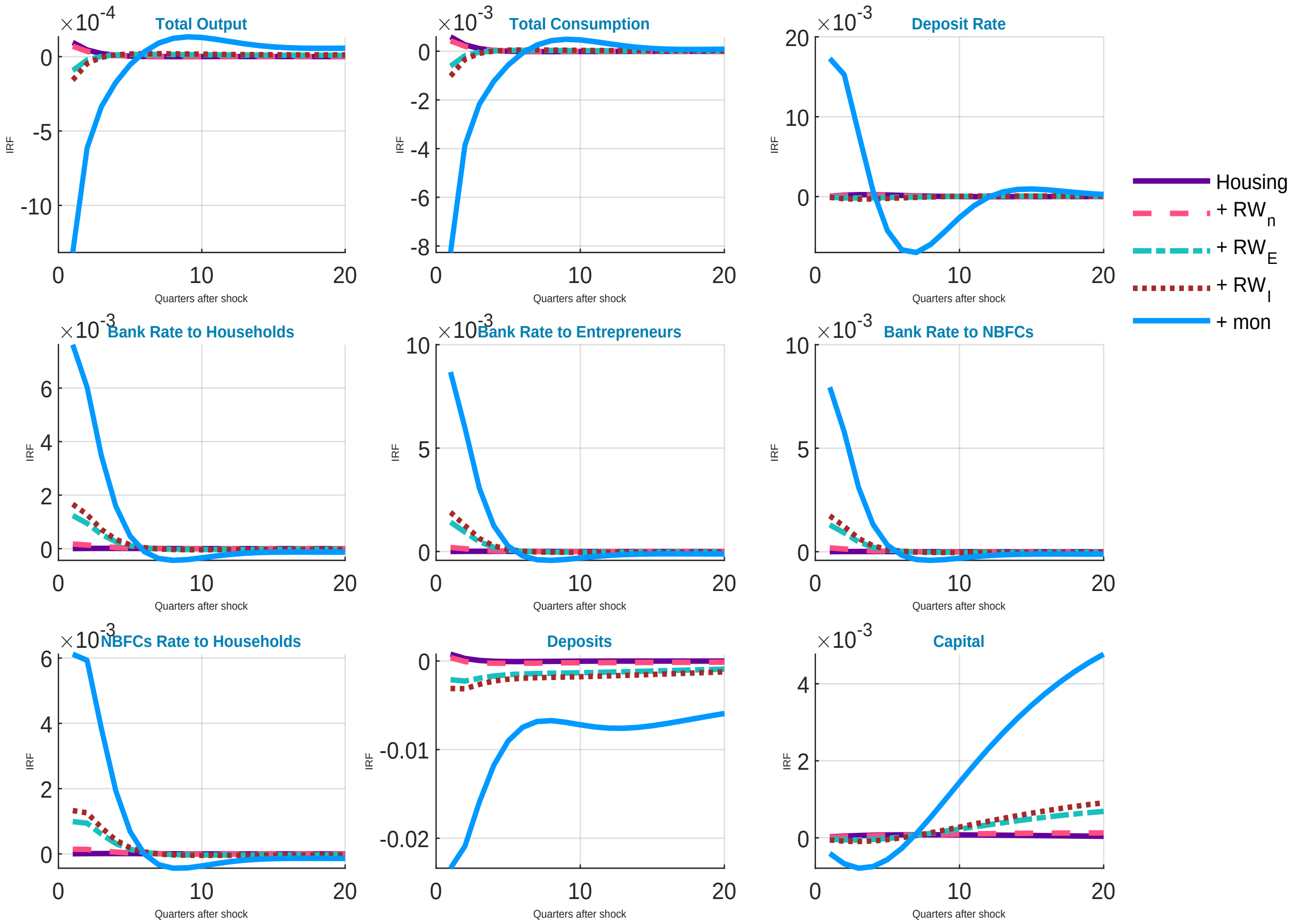

Figure 22: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in risk-weights on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 *percent housing demand shock. Then, we increase sector-wise risk weights, each by* 20 *pp. The dashed line in red represents the impulse responses of variables due to an increase in risk weights for NBFCs. Similarly, we increase risk weights for Entrepreneur loans (light turquoise), and consumer loans (light brown). The monetary policy shock is the blue line which is incremental over a* 20% *increase in all the risk weights. We study a* 10 *bps increase in monetary policy.*

K Shocks to Housing Demand, LTVs, and Monetary Policy

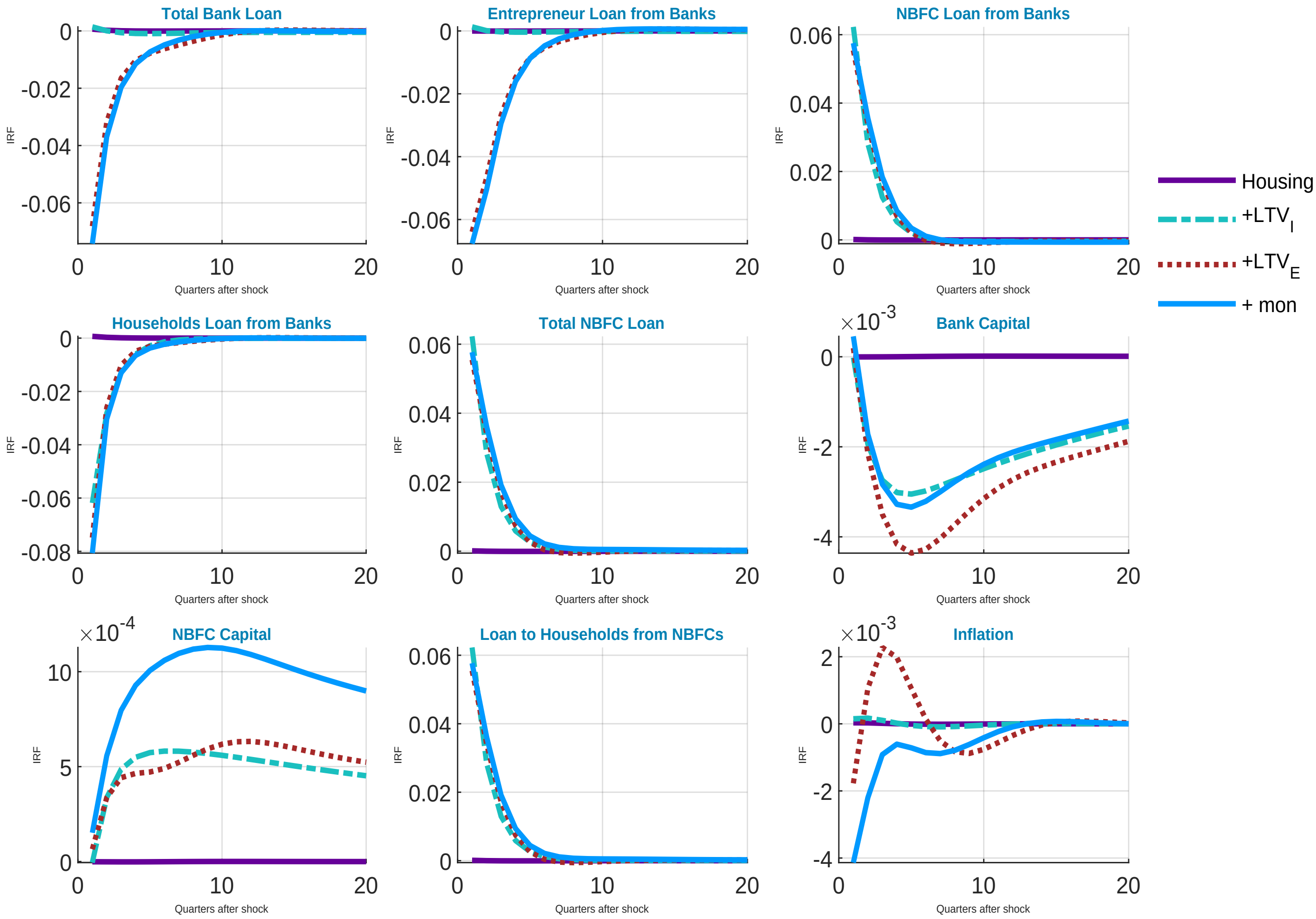

Figure 23: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in loan-to-value ratios on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 *percent shock to housing demand. Then, we reduce the sectoral loan-to-value ratios by* 10 *pp incrementally. The dashed line in turquoise represents the impulse responses of variables due to a reduction in LTV for the households. The brown dotted line adds a reduction in the LTV ratio of similar magnitude to the entrepreneurs. The monetary policy shock is the blue line which is incremental over both the LTV reductions. We study a* 10 *bps increase in monetary policy.*

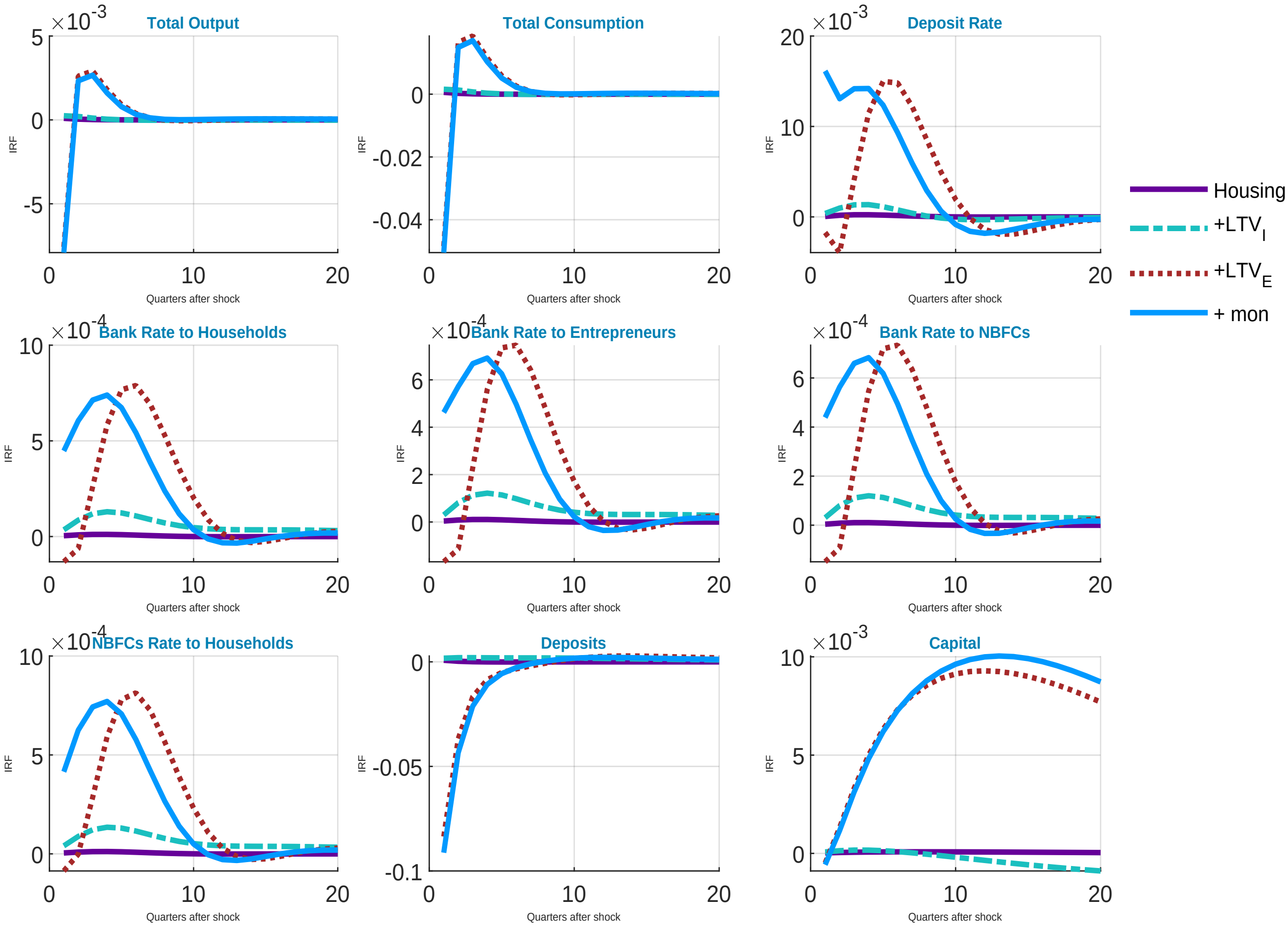

Figure 24: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in loan-to-value ratios on bank loans and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 *percent shock to housing demand. Then, we reduce the sectoral loan-to-value ratios by* 10 *pp incrementally. The dashed line in turquoise represents the impulse responses of variables due to a reduction in LTV for the households. The brown dotted line adds a reduction in the LTV ratio of similar magnitude to the entrepreneurs. The monetary policy shock is the blue line which is incremental over both the LTV reductions. We study a* 10 *bps increase in monetary policy.*

L Shocks to Housing Demand, Capital Regulation, and Monetary Policy

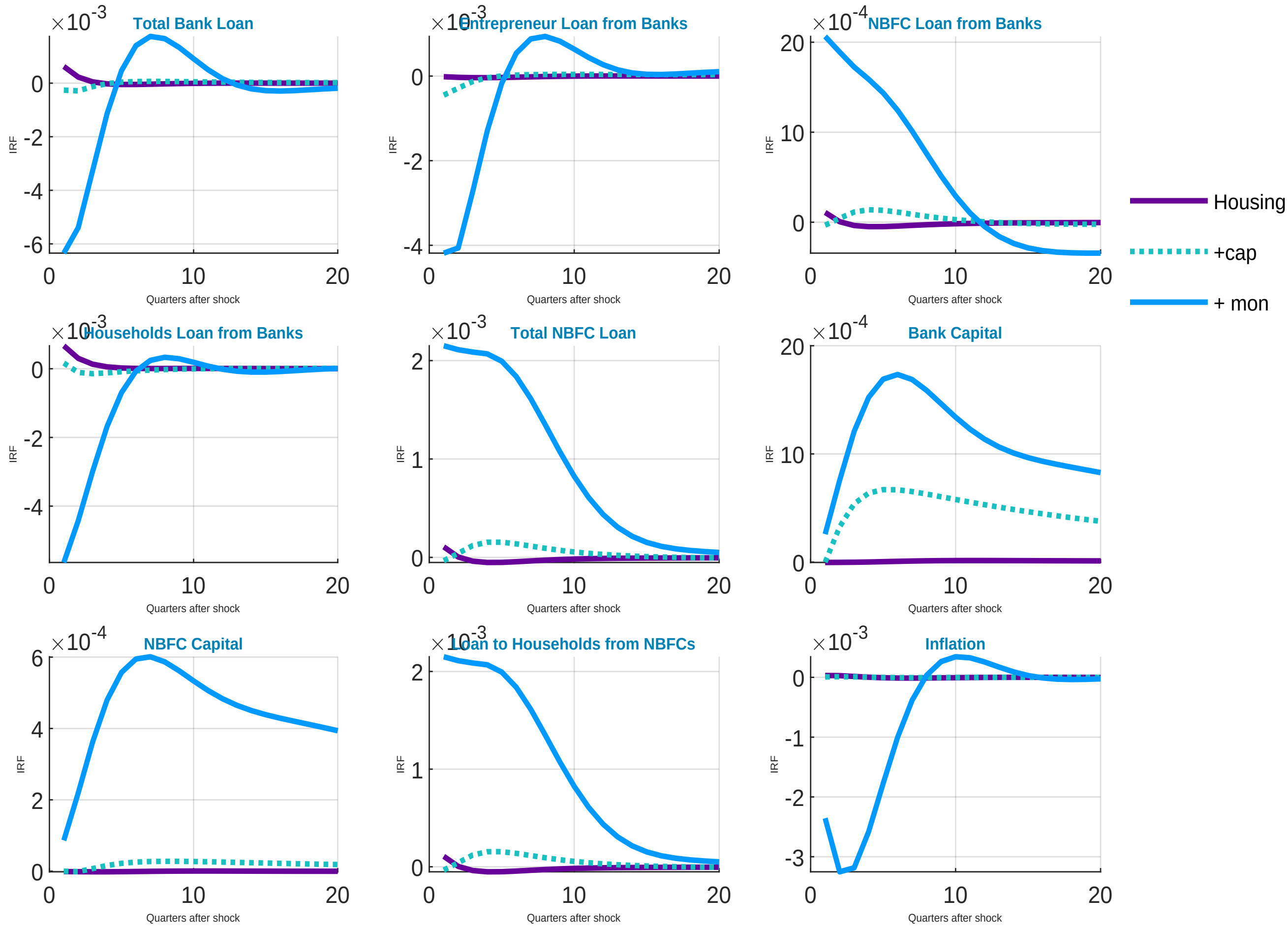

Figure 25: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in capital regulations and monetary policy.
Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 *percent shock to housing demand. Then, we increase the capital regulation for banks from* 9 *pp to* 12 *pp, as shown by the turquoise line. We study a* 10 *bps increase in monetary policy.*

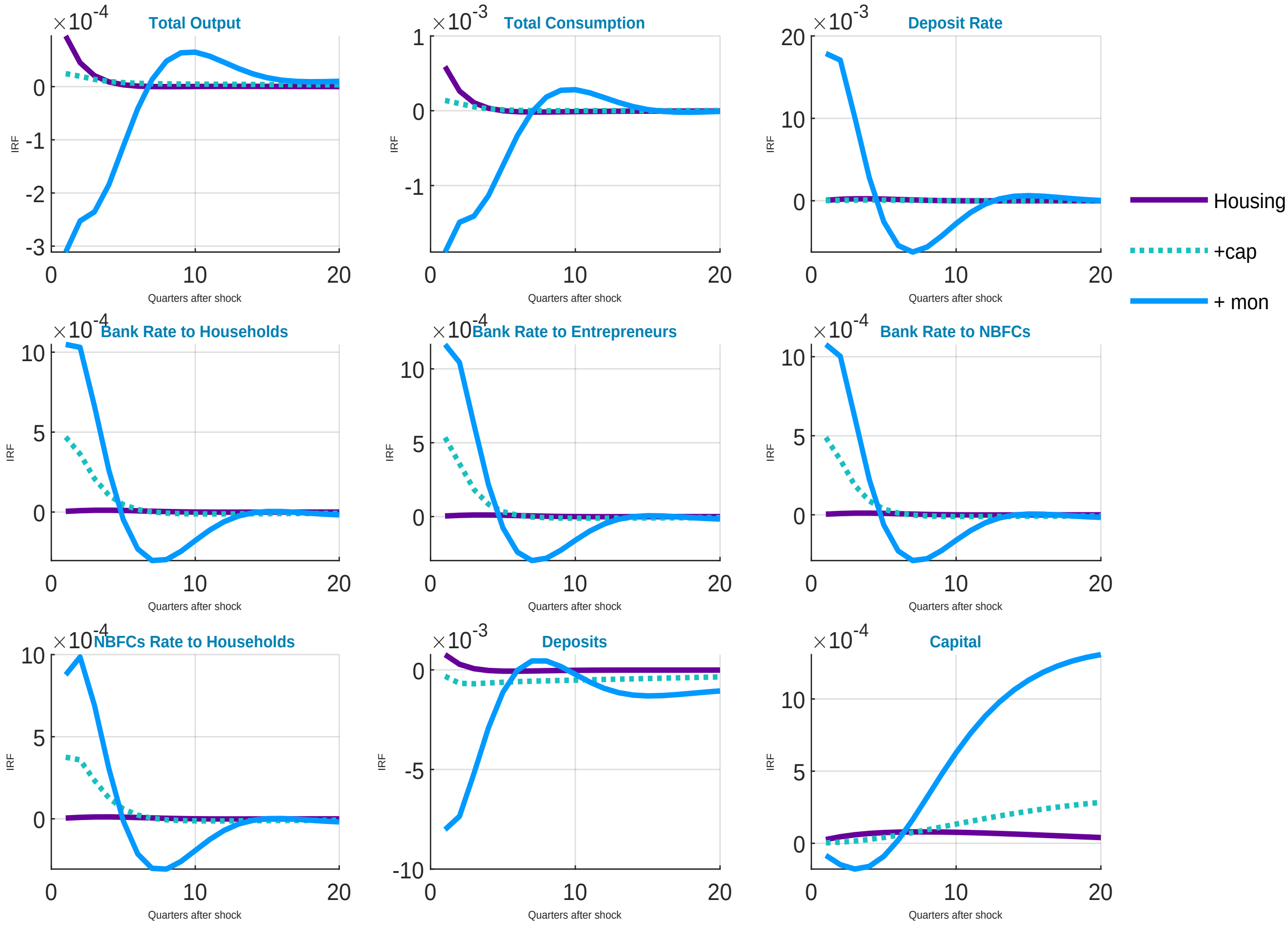

Figure 26: Effect of a positive housing shock and the associated mitigation efforts of incremental changes in capital regulations and monetary policy.

Note: Total Bank Loan and Inflation are expressed in percentage deviations from steady state. All the other variables are expressed in absolute deviations from steady state. The purple line in the figure shows the path of consumption shock. We study a 1 *percent shock to housing demand. Then, we increase the capital regulation for banks from* 9 *pp to* 12 *pp, as shown by the turquoise line. We study a* 10 *bps increase in monetary policy.*

M Marginal Densities of Structural Parameters

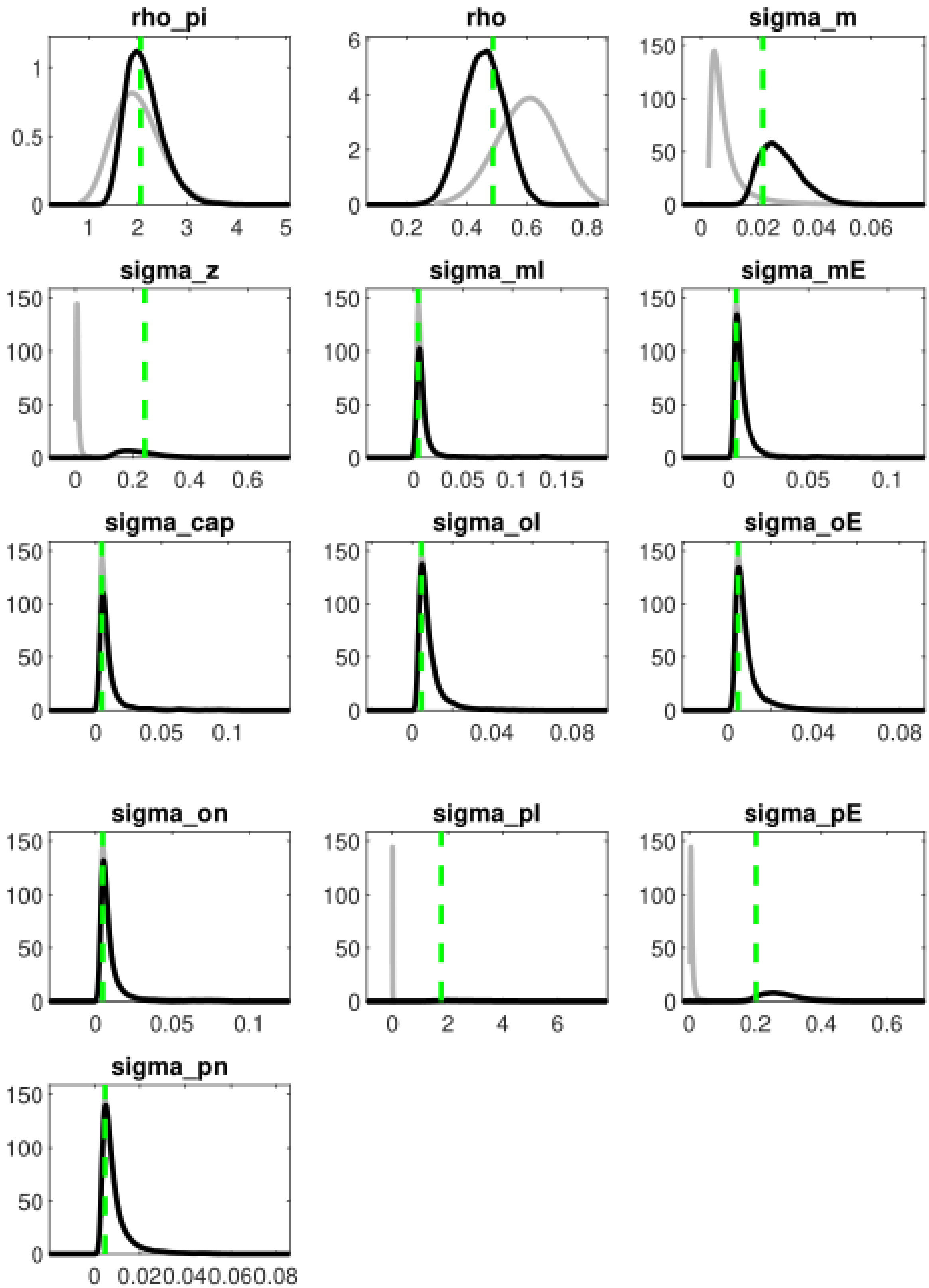

Figure 27: We use 10 chains and each chain with 100,000 draws to estimate the structural parameters. Here we use the Metropolis Hastings algorithm for Bayesian estimation. The solid black line represents the posterior distribution.