Credit Augmented Taylor Rules in a Small Open Economy with Financial Frictions*

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Abstract

In this paper, we study the effectiveness of a credit growth augmented Taylor rule in a New Keynesian small open economy model with banking sector. The model displays financial frictions as in Gertler and Kiyotaki (2011) with the modification that in this model, banks are solely responsible for the foreign borrowing of the small open economy. The model is successful in generating capital outflows and real depreciation of the domestic currency in response to country borrowing premium shocks. Our preliminary results indicate that a credit growth augmented Taylor rule that suggests an increase in short term policy rate in response to increased credit growth, is able to partly contain the adverse implications of TFP, risk premium and monetary policy shocks as opposed to a conventional Taylor rule.

Keywords: Banking sector, domestic- or foreign-currency reserve requirements, reserve options mechanism, macroeconomic and financial shocks.

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1 Model Economy

We analyze the countercyclical reserve requirements in a model of a small open economy with New Keynesian features and a banking sector. The model economy is inhabited by (i) households that are composed of consumers and bankers, (ii) final, intermediate, and capital goods producers, and (iii) a government that is responsible for fiscal and monetary policy. Unless otherwise stated, variables denoted by upper (lower) case characters represent nominal (real) values in domestic currency.

1.1 Households

There is a large number of infinitely-lived identical households, who derive utility from consumption, c_t, leisure, $(1-h_t)$, and real money balances, $\frac{M_t}{P_t}$. The consumption good is a constant-elasticity-of-substitution (CES) aggregate of domestically produced and imported tradable goods as in Galí and Monacelli (2005) and Gertler et al. (2007),

$$c_t = \left[\omega^{\frac{1}{\gamma}}(c_t^H)^{\frac{\gamma-1}{\gamma}} + (1-\omega)^{\frac{1}{\gamma}}(c_t^F)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}, \tag{1}$$

where $\gamma > 0$ is the elasticity of substitution between *home* and *foreign* goods, and $0 < \omega < 1$ is the relative weight of home goods in the consumption basket, capturing the degree of home bias in household preferences. Let P_t^H and P_t^F represent domestic currency denominated prices of home and foreign goods, respectively. If home and foreign goods are aggregated according to (1), then the expenditure minimization problem of households

$$\min_{c_t^H, c_t^F} P_t c_t - P_t^H c_t^H - P_t^F c_t^F$$

yields the demand curves $c_t^H = \omega\left(\frac{P_t^H}{P_t}\right)^{-\gamma} c_t$ and $c_t^F = (1-\omega)\left(\frac{P_t^F}{P_t}\right)^{-\gamma} c_t$, for home and foreign goods, respectively. These demand curves and the consumption aggregator in turn imply that the domestic consumer price index (CPI) of this economy is

$$P_t = \left[\omega(P_t^H)^{1-\gamma} + (1-\omega)(P_t^F)^{1-\gamma}\right]^{\frac{1}{1-\gamma}}. \tag{2}$$

The final demand for home consumption good, c_t^H, is an aggregate of a continuum of varieties of intermediate home goods along the [0,1] interval. That is, $c_t^H = \left[\int_0^1 (c_{it}^H)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}$, where each variety is indexed by i, and ϵ is the elasticity of substitution between these varieties. For any given level of demand for the composite home good c_t^H, the demand for each variety i solves the problem of minimizing total home goods expenditures, $\int_0^1 P_{it}^H c_{it}^H di$ subject to the aggregation constraint, where P_{it}^H is the nominal price of variety i. The solution to this problem yields the optimal demand for c_{it}^H which satisfies

$$c_{it}^H = \left(\frac{P_{it}^H}{P_t^H} \right)^{-\epsilon} c_t^H, \tag{3}$$

with the aggregate home good price index P_t^H being

$$P_t^H = \left[\int_0^1 (P_{it}^H)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}. \tag{4}$$

We assume that each household is composed of a worker and a banker who perfectly insure each other. Workers consume the consumption bundle and supply labor (h_t). They also save in local currency assets which are *deposited* within financial intermediaries owned by the banker members of *other* households.[1] The balance of these deposits are denoted by B_{t+1}, which promises to pay a net nominal risk-free rate, i_t. By assumption, households cannot directly save in the form of physical capital production, and only banker members of households are able to borrow in foreign currency.

Preferences of households over consumption, leisure, and real balances are represented by the lifetime utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t U \left(c_t, h_t, \frac{M_t}{P_t} \right), \tag{5}$$

where U is a CRRA type period utility function given by

$$U \left(c_t, h_t, \frac{M_t}{P_t} \right) = \left[\frac{(c_t - h_c c_{t-1})^{1-\sigma} - 1}{1-\sigma} - \frac{\chi}{1+\xi} h_t^{1+\xi} + \upsilon \, \log \left(\frac{M_t}{P_t} \right) \right]. \tag{6}$$

where c_t is a composite consumption good in period t, h_t is hours worked in period t, E_t is the mathematical expectation operator conditional on the information set available at t, $\beta \in (0,1)$ is the subjective discount rate, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution, $h_c \in [0,1)$ governs the degree of habit formation, χ is the utility weight of labor, and $\xi > 0$ determines the Frisch elasticity of labor supply. We assume Greenwood-Hercowitz-Huffman (1988) (GHH hereafter) preferences in order to abstract from wealth effect of real wages on labor supply.[2] Finally, we assume that the natural logarithm of real money balances provides utility in an additively separable fashion, and υ governs the utility weight of real money balances.

Households face the flow budget constraint,

[1] This assumption is useful in making the agency problem that we introduce in Section 1.2 more realistic.

[2] This type of preferences (GHH in short) provide realistic business cycle dynamics for small open economies, and are commonly used in the literature. See Mendoza (1991), Correira, Neves, and Rebello (1995), Schmitt-Grohe and Uribe (2003), Jaimovich and Rebelo (2008), among others.

$$c_t + \frac{B_{t+1}}{P_t} + \frac{M_t}{P_t} \;=\; \frac{W_t}{P_t}h_t + \frac{(1+r_{nt-1})B_t}{P_t} + \frac{M_{t-1}}{P_t} + \Pi_t - \frac{T_t}{P_t}. \tag{7}$$

On the right hand side are the real wage income, $\frac{W_t}{P_t}h_t$, real balances of the domestic currency interest bearing assets at the beginning of period t, $\frac{B_t}{P_t}$, and real money balances at the beginning of period t, $\frac{M_{t-1}}{P_t}$. Π_t denotes real profits remitted from sectors owned by the household (banks, intermediate home goods producers, and capital goods producers). T_t represents nominal lump-sum taxes collected by the government. On the left hand side are the outlays of consumption expenditures and asset demands.

Households choose c_t, h_t, B_{t+1}, and M_t to maximize preferences in (6) subject to (7) and standard transversality conditions imposed on asset demands, B_{t+1}, and M_t. The first order conditions of the utility maximization problem of the households are given by

$$\varphi_t = (c_t - h_c c_{t-1})^{-\sigma} - \beta b E_t \left(c_{t+1} - h_c c_t\right)^{-\sigma}, \tag{8}$$

$$\frac{W_t}{P_t} = \frac{\chi h_t^{\xi}}{\varphi_t} \tag{9}$$

$$\varphi_t = \beta E_t \left[\varphi_{t+1}(1+r_{nt})\frac{P_t}{P_{t+1}}\right], \tag{10}$$

$$\frac{\upsilon}{M_t/P_t} = \beta E_t \left[\varphi_{t+1} r_{nt} \frac{P_t}{P_{t+1}}\right]. \tag{11}$$

Equation (8) equates marginal utility of consuming an additional unit of income to the Lagrange multiplier, φ_t. Equation (9) equates marginal disutility of labor to real wages. Finally, equations (10) and (11) represent the Euler equations for bonds, the consumption-savings margin, and money demand, respectively.

Combining equations (8) and (10) yields the consumption-savings optimality condition,

$$\left(c_t - bc_{t-1} - \frac{\chi}{1+\xi}h_t^{1+\xi}\right)^{-\sigma} - \beta b E_t \left(c_{t+1} - bc_t - \frac{\chi}{1+\xi}h_{t+1}^{1+\xi}\right)^{-\sigma}$$

$$= \beta E_t \left[\left\{\left(c_{t+1} - bc_t - \frac{\chi}{1+\xi}h_{t+1}^{1+\xi}\right)^{-\sigma} - \beta b \left(c_{t+2} - bc_{t+1} - \frac{\chi}{1+\xi}h_{t+2}^{1+\xi}\right)^{-\sigma}\right\}(1+r_{nt+1})\frac{P_t}{P_{t+1}}\right]. \tag{12}$$

Combining equations (10) and (11) implies the consumption-money optimality condition,

$$\frac{\upsilon / m_t}{\varphi_t} = \frac{r_{nt}}{1 + r_{nt}}. \tag{13}$$

with m_t denoting real balances held by consumers.

The CES aggregator for c_t and the price index of final consumption goods imply that optimal relative demands for home and foreign goods are determined by the condition,

$$\frac{c_t^H}{c_t^F} = \frac{\omega}{1 - \omega} \left(\frac{P_t^H}{P_t^F} \right)^{-\gamma}. \tag{14}$$

The nominal exchange rate of the foreign currency in domestic currency units is denoted by S_t. Therefore, the real exchange rate of the foreign currency in terms of real home goods becomes $s_t = \frac{S_t P_t^*}{P_t}$, where foreign currency denominated CPI, P_t^*, is taken exogenously.

We assume that foreign goods are produced in a symmetric setup as in home goods. That is, there is a continuum of foreign intermediate goods that are bundled into a composite foreign good, whose consumption by the home country is denoted by c_t^F. We assume that the law of one price holds for the import prices of intermediate goods, that is, $MC_t^F = S_t P_t^{F*}$, where MC_t^F is the marginal cost for intermediate good importers and P_t^{F*} is the foreign currency denominated price of such goods. Foreign intermediate goods producers put a markup over the marginal cost, MC_t^F while choosing the domestic currency denominated price of foreign goods. The small open economy also takes P_t^{F*} as given. In Section 1.4, we elaborate how the domestic currency denominated prices of home and foreign goods, P_t^H and P_t^F, are determined.

1.2 Banks

The modeling of banks closely follows Gertler and Kiyotaki (2011) except that banks in this paper collect domestic and foreign deposits. They borrow in local currency from domestic households and in foreign currency from international lenders. Banks combine these funds with their net worth, and finance capital expenditures of home based tradable goods producers. For tractability, we assume that banks only lend to home based production unit.

The main financial friction in this economy originates in the form of a a moral hazard problem between bankers and their funders and leads to an endogenous borrowing constraint on the former. The agency problem is such that depositors (both domestic and foreign) believe that bankers might divert certain fraction of their assets for their own benefit. Additionally, we formulate the diversion assumption in a particular way to ensure that in equilibrium, an endogeneous positive spread between the cost of domestic deposits and the cost of borrowing from abroad emerges, as in the data. Ultimately, in equilibrium, the diversion friction restrains funds raised by bankers and limit the credit extended to nonfinancial firms.

Banks are also subject to a reserve requirement on domestic deposits, i.e. they are obliged to hold a certain fraction of domestic deposits, rr_t, at the central bank.[3] In the benchmark specification of the model, we retain this assumption to construct a measure of the monetary base.

We now proceed to the bankers' problem. For ease of notation, we denote nominal (real) variables in the balance sheet of banks in capital (lower case) letters.

Bank's Balance Sheet. The period-t balance sheet of a banker j denominated in domestic currency units is,

$$Q_t l_{jt} = B_{jt+1}(1 - rr_t) + S_t B^*_{jt+1} + N_{jt}, \tag{15}$$

where B_{jt+1} and B^*_{jt+1} denote domestic deposits and foreign debt (in nominal foreign currency units), respectively, N_{jt} denotes banker's net worth, Q_{jt} is the nominal price of claims purchased from nonfinancial firms and l_{jt} is the quantity of such claims. rr_t is the required reserves ratio on domestic deposits. It is useful to divide equation (15) by the aggregate price index, P_t, and re-arrange terms to obtain banker j's balance sheet in real terms. Those manipulations imply

$$q_t l_{jt} = b_{jt+1}(1 - rr_t) + b^*_{jt+1} + n_{jt}, \tag{16}$$

where q_t is the relative price of the security claims purchased by bankers and $b^*_{jt+1} = \frac{S_t B^*_{jt+1}}{P_t}$ is the foreign borrowing in real domestic units. Notice that if the exogenous foreign price index, P^*_t is assumed to be equal to 1 at all times, then b^*_{jt+1} incorporates the impact of the real exchange rate, $s_t = \frac{S_t}{P_t}$ on the balance sheet.

Next period's real net worth, n_{jt+1}, is determined by the difference between the return earned on assets (i.e., loans and reserves) and the cost of borrowing. Therefore we have,

$$n_{jt+1} = R_{kt+1} q_t l_{jt} + rr_t b_{jt+1} - R_{t+1} b_{jt+1} - R^*_{t+1} b^*_{jt+1}, \tag{17}$$

where R_{kt+1} denotes the state-contingent real returns earned on the claims against the securities issued by domestic final goods producers. R_{t+1} is the real risk-free deposits rate offered to domestic workers, and R^*_{t+1} is the international real borrowing rate for foreign debt. R_t and R^*_t both satisfy Fisher equations,

$$R_t = E_t \left\{ (1 + r_{nt}) \frac{P_t}{P_{t+1}} \right\}$$

$$R^*_t = E_t \left\{ \Psi_t (1 + r^*_{nt}) \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \right\} \quad \forall t, \tag{18}$$

[3]For simplicity, we assume no reserve requirement on foreign deposits. Nevertheless, the framework is easy to extend in that direction.

where r_n denotes the net nominal deposit rate as in equation (7) and r_n^* denotes the net nominal international borrowing rate. Bankers face a premium over this rate while borrowing from abroad. Specifically, the premium is an increasing function of foreign borrowing; $\Psi_t = F(b_{t+1}^*)\psi_t$ with $F'(.) > 0$, where b_{t+1}^* represents the aggregate foreign borrowing of bankers from international capital markets and ψ_t is a random disturbance to this premium.[4] Introducing ψ_t enables us to study the domestic business cycle responses to exogenous cycles in global capital flows.

Solving for b_{jt+1} in equation (16) and substituting it in equation (17), and re-arranging terms imply that bank's net worth evolves as,

$$n_{jt+1} = \left[R_{kt+1} - \frac{R_{t+1} - rr_t}{1 - rr_t}\right] q_t l_{jt} + \left[\left(\frac{R_{t+1} - rr_t}{1 - rr_t} - R_{t+1}^*\right)\right] b_{jt+1}^*$$

$$+ \frac{R_{t+1} - rr_t}{1 - rr_t} n_{jt}, \tag{19}$$

Note that $\frac{R_{t+1} - rr_t}{1 - rr_t}$ can be thought as reserves adjusted domestic deposit rate. Denoting this term by $\hat{R}_{t+1}$, equation (19) can be re-written as

$$n_{jt+1} = \left[R_{kt+1} - \hat{R}_{t+1}\right] q_t l_{jt} + \left[\left(\hat{R}_{t+1} - R_{t+1}^*\right)\right] b_{jt+1}^* + \hat{R}_{t+1} n_{jt}. \tag{20}$$

This equation illustrates that individual bankers' net worth depends positively on the premium of the return earned on assets over the reserves adjusted cost of borrowing, $\left[R_{kt+1} - \hat{R}_{t+1}\right]$. The second term on the right-hand side shows the benefit of raising foreign debt as opposed to domestic debt. Finally, the last term highlights the contribution of internal funds, that are multiplied by, $\hat{R}_{t+1}$, the opportunity cost of raising one unit of external funds via domestic borrowing.

For banks to lend to nonfinancial firms, the following condition must hold:

$$E_t \left\{\Lambda_{t,t+i+1} \left[R_{kt+i+1} - \hat{R}_{t+i+1}\right]\right\} \geq 0 \quad \forall t, \tag{21}$$

where $\Lambda_{t,t+i+1} = \beta E_t \left[\frac{U_c(t+i+1)}{U_c(t)}\right]$ denotes the $i+1$-periods-ahead stochastic discount factor of households, whose banker members operate as financial intermediaries. This condition ensures that bankers find it profitable to purchase securities issued by nonfinancial firms. In the absence of financial frictions, this premium would converge to zero and financial intermediation would only be a veil. In the following, we also establish that

$$E_t \left\{\Lambda_{t,t+i+1} \left[\hat{R}_{t+i+1} - R_{t+i+1}^*\right]\right\} > 0 \quad \forall t, \tag{22}$$

[4] By assuming that the cost of borrowing from international capital markets increases in the net foreign indebtedness of the aggregate economy, we ensure the stationarity of the foreign assets dynamics as in Schmitt-Grohe and Uribe (2003).

so that the cost of domestic debt entails a positive premium over cost of foreign debt at all times.

In order to rule out any possibility of complete self-financing, we assume that bankers have a finite life and survive to the next period only with probability $0 < \theta < 1$. At the end of each period, $1-\theta$ measure of new bankers are born and are remitted $\frac{\epsilon}{1-\theta}$ fraction of the loans owned by exiting bankers, in the form of start-up funds.

Maximization Problem. Bankers maximize expected discounted value of the terminal net worth of their financial firm, V_{jt}, by choosing the amount of security claims purchased, l_{jt}, and the amount of foreign debt, b^*_{jt+1}. For a given level of net worth, the optimal amount of domestic deposits can be solved for by using the balance sheet.

Bankers solve the following value maximization problem,

$$\begin{aligned} V_{jt} &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\ n_{jt+1+i} \\ &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i} \Big\{ \Big[R_{kt+1+i} - \hat{R}_{t+1+i} \Big] q_{t+i} l_{jt+i} \\ &\quad + \Big[\Big(\hat{R}_{t+1+i} - R^*_{t+1+i} \Big) \Big] b^*_{jt+1+i} + \hat{R}_{t+1+i} n_{jt+i} \Big\}. \end{aligned} \tag{23}$$

Given a non-negative premium on credit, the solution to the value maximization problem of banks would lead to an unbounded magnitude of assets. In order to rule out such a scenario, we follow Gertler and Kiyotaki (2011) and introduce an agency problem between depositors and the bankers. Specifically, lenders believe that banks might divert λ fraction of their total divertable assets, where divertable assets constitute total assets minus a fraction, ω_l, of domestic deposits. This feature reflects the idea that domestic depositors would have comparative advantage over foreign depositors in monitoring domestic bankers. This assumption is instrumental in creating a trade-off for bankers while deciding their liability structure. Specifically, bankers face an elastic supply of funds in the international markets at an exogenous borrowing rate, whereas funds provided by domestic depositors are bounded by the size of the small open economy. This, in equilibrium shall create a premium in the cost of domestic debt over the cost of foreign borrowing, as we elaborate in greater detail below.

When lenders become aware of the potential confiscation of assets, they would initiate a bank run and lead to the liquidation of the bank altogether. In order to rule out bank runs in equilibrium, in any state of nature, bankers' optimal choice of l_{jt} should be incentive compatible. Therefore, the following constraint is imposed on bankers,

$$V_{jt} \geq \lambda \Big(q_t l_{jt} - \omega_l b_{jt+1} \Big), \tag{24}$$

where λ is a constant between zero and one. This inequality suggests that the liquidation cost of bankers, V_{jt}, from diverting funds should be greater than or equal to the diverted portion of the assets. When this constraint binds, bankers would never choose to divert funds and lenders adjust their position and restrain their lending to bankers accordingly.

Given this institutional setup, we follow the solution strategy adopted by Gertler and Kiyotaki (2011) and represent the value function of bankers in recursive form. Since,

$$\begin{aligned} V_{jt} &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\ n_{jt+1+i} \\ &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \left[(1-\theta)\Lambda_{t,t+1} n_{jt+1} + \sum_{i=1}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\ n_{jt+1+i} \right], \end{aligned} \tag{25}$$

we have

$$V_{jt} = \max_{l_{jt}, b^*_{jt+1}} E_t \Big\{ \Lambda_{t,t+1} [(1-\theta) n_{jt+1} + \theta V_{jt+1}] \Big\}. \tag{26}$$

Now we conjecture the optimal value of financial intermediaries to be a linear function of bank loans, foreign debt, and bank capital, that is,

$$V_{jt} = \nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt}, \tag{27}$$

where ν^l_t is the marginal value of assets, ν^*_t is the excess value of borrowing from abroad, and ν_t is the marginal value of bank capital at the end of period t. The Lagrangian which solves the bankers' profit maximization problem reads,

$$\begin{aligned} \max_{l_{jt}, b^*_{jt+1}} L &= \nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} \\ &\quad + \mu_t \left[\nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} - \lambda \Big(q_t l_{jt} - \frac{\omega_l}{1 - rr_t} [q_t l_{jt} - b^*_{jt+1} - n_{jt}] \Big) \right], \end{aligned} \tag{28}$$

where the term in square brackets represents the incentive compatibility constraint, (24) combined with the balance sheet, (16), to eliminate b_{jt+1}. The first-order conditions for l_{jt}, b^*_{jt+1}, and the Lagrange multiplier μ_t are:

$$\nu^l_t (1 + \mu_t) = \lambda \mu_t \Big(1 - \frac{w_l}{1 - rr_t} \Big), \tag{29}$$

$$\nu^*_t (1 + \mu_t) = \lambda \mu_t \frac{w_l}{1 - rr_t}, \tag{30}$$

and

$$\nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} - \lambda \Big(q_t l_{jt} - \frac{\omega_l}{1 - rr_t} [q_t l_{jt} - b^*_{jt+1} - n_{jt}] \Big) \geq 0, \tag{31}$$

respectively. We are interested in cases in which the incentive constraint of banks is always binding, which implies that $\mu_t > 0$ and (31) holds with equality.[5] This is the case in which the loss of bankers in the event of liquidation is just equal to the amount of loans that they can divert.

From (30), $\lambda, \mu > 0$, and $rr_t < 1$, we find $\nu_t^* > 0$. This establishes that the excess value of borrowing from abroad should be positive. Therefore, in equilibrium, domestic depositors are expected to charge more compared to international lenders. From the perspective of global financial markets efficiency, this finding also suggests that uncovered interest parity does not hold due to financial frictions. On the other hand, the necessary condition for a positive value of making loans, i.e, $\nu_t^l > 0$ requires $\omega_l < 1 - rr_t$, i.e. the fraction of nondiverted domestic deposits has to be smaller than one minus the reserve requirement ratio, as implied by (29).

Combining (29) and (30) yields,

$$\frac{\nu_t^*}{\nu_t^l + \nu_t^*} = \frac{\omega_l}{1 - rr_t}. \tag{32}$$

Re-arranging the binding version of (31) implies,

$$q_t l_{jt} - \omega_l b_{jt+1} = \frac{\nu_t - \nu_t^*}{\lambda - \zeta_t} n_{jt} = \kappa_{jt} n_{jt}, \tag{33}$$

where $\zeta_t = \nu_t^l + \nu_t^*$. This endogenous constraint, which emerges from the costly enforcement problem described above, ensures that banks' leverage of risky assets is always equal to κ_{jt} and is decreasing with the fraction of divertable funds, λ.

Following Gertler and Kiyotaki (2011), we replace V_{jt+1} in equation (26) by imposing our linear conjecture in equation (27) and the borrowing constraint, (33) to obtain,

$$V_{jt}^* = E_t\Big\{\Xi_{t,t+1} n_{jt+1}\Big\}, \tag{34}$$

where V_{jt}^* stands for the optimized value and $\Xi_{t,t+1} = \Lambda_{t,t+1}[1 - \theta + \theta(\zeta_{t+1}\kappa_{t+1} + \nu_{t+1} - \nu_{t+1}^*)]$ is the augmented stochastic discount factor of bankers, which is a weighted average governed by the likelihood of survival.

Replacing the left-hand side to verify our linear conjecture on bankers' value, (27), and using equation (20), we find that ν_t^l, ν_t, and ν_t^* should satisfy,

$$\nu_t^l = E_t\Big\{\Xi_{t,t+1}\Big[R_{kt+1} - \hat{R}_{t+1}\Big]\Big\}, \tag{35}$$

$$\nu_t = E_t\Big\{\Xi_{t,t+1}\hat{R}_{t+1}\Big\}, \tag{36}$$

[5] Our methodological approach is to linearly approximate the stochastic equilibrium around the deterministic steady state.

and

$$\nu_t^* = E_t\Big\{\Xi_{t,t+1}\left[\hat{R}_{t+1} - R^*_{t+1}\right]\Big\}, \tag{37}$$

respectively.

Equation (35) suggests that bankers' marginal valuation of total assets is the premium between the expected discounted total return to loans and the benchmark cost of domestic funds. Equation (36) shows that marginal value of net worth should be equal to the expected discounted opportunity cost of domestic funds, and lastly, equation (37) demonstrates that the excess value of raising foreign debt is equal to the expected discounted value of the premium in the cost of raising domestic debt over the cost of raising foreign debt. Recall that this expression is strictly positive, as we have established that $\nu_t^* > 0$ in the solution to the Lagrangian. Absent financial frictions, one would have $\Xi_{t,t+1} = \Lambda_{t,t+1}$ and $\nu_t^* = 0$, leading equation (37) to represent the uncovered interest parity. Note also that banks' augmented stochastic discount factor takes into account the probabilistic survival of bankers and the implication of the borrowing constraint on the size their balance sheet.

We confine our interest to equilibria in which all households behave symmetrically so that we can aggregate equation (33) over j and obtain the following aggregate relationship:

$$q_t l_t - \omega_l b_{t+1} = \kappa_t n_t, \tag{38}$$

where $q_t l_t$, b_{t+1} and n_t represent aggregate levels of bank assets, domestic deposits, and net worth, respectively. Equation (38) shows that aggregate credit net of undivertable domestic deposits can only be up to an endogenous multiple of aggregate bank capital. Furthermore, fluctuations in asset prices, q_t, would feed back into fluctuations in bank capital via this relationship. This would be the source of the financial accelerator mechanism in our model.

The evolution of the aggregate net worth depends on that of the surviving bankers (n_{et+1}) and the start-up funds of the new entrants (n_{nt+1}). Surviving bankers' net worth might be obtained by substituting the aggregate bank capital constraint, (38) into the net worth evolution equation, (20),

$$n_{et+1} = \theta\Big\{\left[R_{kt+1} - R^*_{t+1}\right]\kappa_t + R^*_{t+1}\Big\}n_t. \tag{39}$$

The start-up funds for new entrants, on the other hand, are equal to $\frac{\epsilon}{1-\theta}$ fraction of exiting banks' loans, $(1-\theta)q_t l_t$. Therefore,

$$n_{nt+1} = \epsilon q_t l_t. \tag{40}$$

As result, the transition for the aggregate bank capital becomes,

$$n_{t+1} = n_{et+1} + n_{nt+1}. \tag{41}$$

1.3 Capital Producers

Perfectly competitive capital producers purchase investment goods and transform them into new capital. They also repair the depreciated capital that they buy from the intermediate goods producing firms. At the end of period t, they sell both newly produced and repaired capital to the intermediate goods firms at the unit price of q_t. Intermediate goods firms use this new capital for production at time $t+1$. Capital producers take prices as given and they are owned by households. We would like to note here that capital producers are crucial in order to obtain variation in the price of capital. We also assume that capital producers incur investment adjustment costs while producing new capital, which are given by the following function:

$$\Phi\left(\frac{i_t}{i_{t-1}}\right) = \frac{\Psi}{2}\left[\frac{i_t}{i_{t-1}} - 1\right]^2 \tag{42}$$

Capital producers use an investment good that is composed of home and foreign final goods in order to repair the depreciated capital and to produce new capital goods:

$$i_t = \left[\omega_i^{\frac{1}{\gamma_i}}(i_t^H)^{\frac{\gamma_i-1}{\gamma_i}} + (1-\omega_i)^{\frac{1}{\gamma_i}}(i_t^F)^{\frac{\gamma_i-1}{\gamma_i}}\right]^{\frac{\gamma_i}{\gamma_i-1}} \tag{43}$$

where ω_i governs the relative weight of home input in the investment composite good and γ_i measures the elasticity of substitution between home and foreign inputs. Capital producers choose the optimal mix of home and foreign inputs according to the intra-temporal first order condition:

$$\frac{i_t^H}{i_t^F} = \frac{\omega_i}{1-\omega_i}\left(\frac{P_t^H}{P_t^F}\right)^{-\gamma_i} \tag{44}$$

The aggregate investment price index, $P_{I,t}$, is given by

$$P_{I,t} = \left[\omega_i(P_t^H)^{1-\gamma_i} + (1-\omega_i)(P_t^F)^{1-\gamma_i}\right]^{\frac{1}{1-\gamma_i}}. \tag{45}$$

Capital producers require i_t units of investment good at a unit price of $\frac{P_{I,t}}{P_t}$ and incur investment adjustment costs, $\Phi\left(\frac{i_t}{i_{t-1}}\right)$ per unit of investment to produce new capital goods, i_t, and repair the depreciated capital, which will be sold at the price q_t. Therefore, a capital producer maximize its discounted profits by choosing investment as follows

$$\max_{i_t} \sum_{t=0}^{\infty} E_0\Big\{\beta^t \Lambda_{t,t+1}\Big[q_t i_t - \Phi\left(\frac{i_t}{i_{t-1}}\right) q_t i_t - \frac{P_{I,t}}{P_t} i_t\Big]\Big\} \tag{46}$$

The optimality condition with respect to i_t gives the following *Q-investment* relation for capital goods:

$$\frac{P_{I,t}}{P_t} = q_t\Big[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right) - \Phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\Big] + \beta E_t\Big[\Lambda_{t,t+1}q_{t+1}\Phi'\left(\frac{i_{t+1}}{i_t}\right)\frac{i_{t+1}}{i_t}\Big] \tag{47}$$

$$k_{t+1} = (1-\delta_t)k_t + \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right]i_t \tag{48}$$

1.4 Firms

Final and intermediate goods in this economy are produced by a representative final good producer and a continuum of intermediate goods producers that are indexed by $i \in [0,1]$, respectively. Among these, the former repackage the differentiated varieties produced by the latter and sell in the domestic market. The latter on the other hand, acquires capital and labor and operate in a monopolistically competitive market. In order to assume rigidity in price setting, we assume that intermediate goods firms face menu costs.

1.4.1 Final Goods Producers

Finished goods producers combine different varieties $y_t(i)$, that sell at the monopolistically determined price, $P_t^H(i)$, into a final good that sell at the competitive price P_t^H, according to the constant-returns-to-scale technology,

$$y_t^H = \left[\int_0^1 y_t^H(i)^{1-\frac{1}{\epsilon}}di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}. \tag{49}$$

The zero profit condition for the finished goods producers imply that the solution to the problem,

$$\max_{y_t^H(i)} \; P_t^H\left[\int_0^1 y_t^H(i)^{1-\frac{1}{\epsilon}}di\right]^{\frac{1}{1-\frac{1}{\epsilon}}} - \left[\int_0^1 P_t^H(i)y_t^H(i)di\right] \tag{50}$$

implies that the optimal variety demand is,

$$y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H, \tag{51}$$

with, $P_t^H(i)$, P_t^H satisfying,

$$P_t^H = \left[\int_0^1 P_t^H(i)^{1-\epsilon}di\right]^{\frac{1}{1-\epsilon}}. \tag{52}$$

Similar conditions apply for finished goods producers that repackage imported intermediate goods, so that $y_t^F(i) = \left(\frac{P_t^F(i)}{P_t^F}\right)^{-\epsilon} y_t^F$ and $P_t^F = \left[\int_0^1 P_t^F(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$ holds.

1.4.2 Intermediate Goods Producers

There is a large number of intermediate goods producers indexed by i, who produce variety $y_t(i)$ using the constant-returns-to-scale production technology,

$$y_t(i) = A_t \Big(u_t(i) k_t(i)\Big)^{\alpha} h_t(i)^{1-\alpha}. \tag{53}$$

As shown in the production function, firms choose the level of capital and labor used in production, and the utilization rate of the capital stock. A_t represents the aggregate productivity level and follows an autoregressive process given by

$$\ln(A_{t+1}) = \rho^A \ln(A_t) + \epsilon_{t+1}^A, \tag{54}$$

with zero mean and constant variance innovations, ϵ_{t+1}^A.

Part of $y_t(i)$ is sold in the domestic market, as $y_t^H(i)$, in which the producer i operates as a monopolistically competitor. Accordingly, the nominal sales price $P_t^H(i)$ is chosen by the firm to meet the aggregate domestic demand for its variety,

$$y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H, \tag{55}$$

which depends on the the aggregate home output, y_t^H. Apart from incurring nominal marginal costs of production, MC_t, these firms additionally face Rotemberg (1982)-type quadratic menu costs of price adjustment, in the form of

$$P_t \frac{\varphi^H}{2} \left[\frac{P_t^H(i)}{P_{t-1}^H(i)} - 1\right]^2. \tag{56}$$

These costs are denoted in nominal terms with φ^H capturing the intensity of the price rigidity.

Domestic intermediate goods producers choose their nominal price level to maximize the present discounted real profits

$$\max_{P_t^H(i)} E_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} \left[\frac{D_{t+j}^H(i)}{P_{t+j}}\right] \tag{57}$$

subject to the nominal profit function

$$D^H_{t+j}(i) = P^H_{t+j}(i)y^H_{t+j}(i) + S_{t+j}P^{H*}_{t+j}c^{H*}_{t+j}(i) - MC_{t+j}y_{t+j}(i) - P_{t+j}\frac{\varphi^H}{2}\left[\frac{P^H_{t+j}(i)}{P^H_{t+j-1}(i)} - 1\right]^2, \tag{58}$$

and the demand function $y^H_t(i) = \left(\frac{P^H_t(i)}{P^H_t}\right)^{-\epsilon} y^H_t$. Since households own these firms, any profits are remitted to consumers and future streams of real profits are discounted by the stochastic discount factor of consumers, accordingly. Notice that the sequences of the nominal exchange rate and export prices in foreign currency $\{S_{t+j}, P^{H*}_{t+j}\}^{\infty}_{j=0}$ are taken exogenously by the firm, since it acts as a price taker in the export market. The first-order condition to this problem becomes

$$(\epsilon - 1)\left(\frac{P^H_t(i)}{P^H_t}\right)^{-\epsilon}\frac{y^H_t}{P_t} = \epsilon\left(\frac{P^H_t(i)}{P^H_t}\right)^{-\epsilon-1}MC_t\frac{y^H_t}{P_tP^H_t} - \varphi^H\left[\frac{P^H_t(i)}{P^H_{t-1}(i)} - 1\right]\frac{1}{P^H_{t-1}(i)} \tag{59}$$

$$+\varphi^H E_t\left\{\Lambda_{t,t+1}\left[\frac{P^H_{t+1}(i)}{P^H_t(i)} - 1\right]\frac{P^H_{t+1}(i)}{P^H_t(i)^2}\right\}. \tag{60}$$

We confine our interest to symmetric equilibrium, in which all intermediate producers choose the same price level, that is $P^H_t(i) = P^H_t \;\; \forall i$. Imposing this condition to (60) and using the definitions, $rmc_t = \frac{MC_t}{P_t}$, $\pi^H_t = \frac{P^H_t}{P^H_{t-1}}$, and $p^H_t = \frac{P^H_t}{P_t}$, yields

$$p^H_t = \frac{\epsilon}{\epsilon - 1}rmc_t - \frac{\varphi^H}{\epsilon - 1}\frac{\pi^H_t(\pi^H_t - 1)}{y^H_t} + \frac{\varphi^H}{\epsilon - 1}E_t\left\{\Lambda_{t,t+1}\frac{\pi^H_{t+1}(\pi^H_{t+1} - 1)}{y^H_t}\right\}. \tag{61}$$

Notice that even if prices are flexible, that is $\varphi^H = 0$, the monopolistic nature of the intermediate goods market implies that the optimal sales price reflects a markup over the marginal cost, that is $P^H_t = \frac{\epsilon}{\epsilon-1}MC_t$.

The remaining part of the intermediate goods is exported as $c^{H*}_t(i)$ in the foreign market, where the producer is a price taker. To capture the foreign demand, we follow Gertler et al. (2007) and impose an autoregressive exogenous function in the form of

$$c^{H*}_t = \left[\left(\frac{P^{H*}_t}{P^*_t}\right)^{-\Gamma} y^*_t\right]^{\nu^H}(c^{H*}_{t-1})^{1-\nu^H}, \tag{62}$$

which positively depends on foreign output. We further assume that the small open economy takes $P^{H*}_t = P^*_t = 1$, and y^*_t as given.

Imported intermediate goods are purchased by a continuum of producers that are analogous to the domestic producers except that these firms face exogenous import prices as their marginal cost. In other words, the law of one price holds for the import prices, so that $MC_t^F = S_t P_t^{F*}$. Since these firms also face quadratic price adjustment costs, the domestic price of imported intermediate goods is determined as,

$$p_t^F = \frac{\epsilon}{\epsilon - 1} s_t - \frac{\varphi^F}{\epsilon - 1} \frac{\pi_t^F(\pi_t^F - 1)}{y_t^F} + \frac{\varphi^F}{\epsilon - 1} E_t \left\{ \Lambda_{t,t+1} \frac{\pi_{t+1}^F(\pi_{t+1}^F - 1)}{y_t^F} \right\}, \tag{63}$$

with $p_t^F = \frac{P_t^F}{P_t}$, $s_t = \frac{S_t P_t^{F*}}{P_t}$, and $P_t^{F*} = 1 \; \forall t$ is taken exogenously by the small open economy.

For a given sales price, optimal factor demands and utilization of capital are determined by the solution to a symmetric cost minimization problem, where the cost function shall reflect the capital gains from market valuation of firm capital and resources that are devoted to the repair of the worn out part of it. Consequently, firms minimize

$$\min_{u_t, k_t, h_t} q_{t-1} r_{kt} k_t - (q_t - q_{t-1}) k_t + p_{I,t} \delta(u_t) k_t + w_t h_t + rmc_t \Big[y_t - A_t \Big(u_t k_t \Big)^{\alpha} h_t^{1-\alpha} \Big] \tag{64}$$

subject to the endogeneous depreciation rate function,

$$\delta(u_t) = \delta + \frac{d}{1+\varrho} u_t^{1+\varrho}, \tag{65}$$

with $\delta, d, \varrho > 0$. The first order conditions to this problem govern factor demands and the optimal utilization choice as,

$$p_{I,t} \delta'(u_t) k_t = \alpha \Big(\frac{y_t}{u_t} \Big) rmc_t, \tag{66}$$

$$R_{kt} = \frac{\alpha \Big(\frac{y_t}{k_t} \Big) rmc_t - p_{i,t} \delta(u_t) + q_t}{q_{t-1}}, \tag{67}$$

and

$$w_t = (1 - \alpha) \Big(\frac{y_t}{h_t} \Big) rmc_t. \tag{68}$$

1.5 Monetary Authority and the Government

The monetary authority sets the short-term nominal interest rate *via* a simple monetary policy rule that includes only a few observable macroeconomic variables and ensures a unique rational expectations equilibrium (and hence implementable).[6] The rule prescribes potential reactions to domestic inflation, $\pi_t = \frac{P_t}{P_{t-1}} - 1$ and output, y_t^H. Given the home goods inflation and relative

[6]For further discussion, see Schmitt-Grohe and Uribe (2006).

prices, the definition of the CPI in equation (2) governs the evolution of the aggregate inflation of the model economy,

$$(1+\pi_t)^{1-\gamma} = \omega(1+\pi_t^H)^{1-\gamma}(p_t^H)^{1-\gamma} + (1-\omega)(1+\pi_t)^{1-\gamma}(s_t)^{1-\gamma}. \tag{69}$$

At the steady state, aggregate inflation is fixed to a value consistent with the data. Consequently, the monetary policy rule satisfies,

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n}\log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi \log\left(\frac{1+\pi_t}{1+\overline{\pi}}\right) + \varphi_y \log\left(\frac{y_t^H}{\overline{y}}\right)\right], \tag{70}$$

where variables with bars denote respective steady-state values that are targeted by the central bank.

In the benchmark specification, we assume that the required reserves ratio is fixed at $rr_t = rr\ \forall t$, with rr denoting a steady state level. Money supply in this economy will be demand determined and it compensates for the cash demand of workers and the required reserves demand of bankers. Consequently, the money market clearing condition is given by

$$M_{0t} = M_t + rrB_t, \tag{71}$$

where M_{0t} denotes the supply of monetary base at period t.

Government consumes an exogenous flow of nontradable goods, g_t^H, which follows and autoregressive process in natural logarithm. Hence,

$$\log g_{t+1}^H = (1-\rho^{g^H})\log \bar{g^H} + \rho^{g^H}\log g_t^H + \epsilon_{t+1}^{g^H}, \tag{72}$$

where $\bar{g^H}$ is the steady state value of government expenditures and $\epsilon_{t+1}^{g_H}$ is a disturbance term.

The fiscal and monetary policy arrangements lead to the consolidated government budget constraint,

$$p_t^H g_t^H = \frac{M_t - M_{t-1}}{P_t} + rr\Big(b_t - b_{t-1}\Big) + \frac{T_t}{P_t}. \tag{73}$$

Lump sum taxes $\tau_t = \frac{T_t}{P_t}$ are determined endogenously to satisfy the consolidated government budget constraint at any date t.

1.6 Resource Constraints

The resource constraint for home goods equates the domestic production to domestic demand and the real price adjustment cost, so that

$$y_t^H = c_t^H + i_t^H + g_t^H + \left(p_t^H\right)^{-1} \frac{\varphi^H}{2} \left(\pi_t^H - 1\right)^2. \tag{74}$$

A similar market clearing condition holds for the domestic consumption of the imported goods, where

$$y_t^F = c_t^F + i_t^F + \left(p_t^F\right)^{-1} \frac{\varphi^F}{2} \left(\pi_t^F - 1\right)^2. \tag{75}$$

The balance of payments vis-a-vis the rest of the world equates the current account balance to the summation of income balance and the trade balance,

$$b_{t+1}^* - b_t^* = (R_t^* - 1)b_t^* + s_t(c_t^{H*} - y_t^F). \tag{76}$$

Finally, the national income account that follows the expenditures approach and reflects the investment adjustment costs would read

$$y_t = p_t^H y_t^H + \frac{\Psi}{2} \left(\frac{i_t}{i_{t-1}} - 1\right)^2 + b_{t+1}^* - R_t^* b_t^*. \tag{77}$$

2 Calibration

We parameterize the model by using conventional estimates reported in the literature. For the ROM-related parameters, which are absent in the literature, we follow a joint calibration strategy, as will be discussed below. Table 1 presents the parameter values.

The subjective discount factor, β, is set at 0.9885, in line with the observed 4.73% annualized real deposit rate in Turkey. The relative risk aversion, ρ, and the labor supply elasticity, δ_h, parameters are taken as 2 following Benigno *et al.* (2013). Weight of real money balances in the utility function, υ, is calibrated at 0.02 to match the M1 to GDP ratio. We calibrate χ at 3.7 to have households spending $\frac{1}{3}$ of their time working at the deterministic steady state. Finally, we follow Gertler *et al.* (2003) and set $\omega = 0.5$, and $\gamma = 0.99$.

Share of capital in producing tradable and non-tradable goods are assumed equal and set at 0.3, following Benigno *et al.* (2013). Quarterly depreciation rate, δ^f, is taken as .035 to have average annual ratio of investment to capital of 14.8%. We calibrate capital adjustment cost parameters at, $\Psi^N = 1.4$ and $\Psi^T = 0.95$, to have an elasticity of price of capital with respect to investment-capital ratio of 0.25 for each sector (non-tradable and tradable firms, respectively). Non-tradable firms are able to change their prices at an average frequency of four quarters, implying a Calvo stickiness parameter, $\theta^f = 0.75$.

Share of non-tradable firms in total bank credit, ϕ_N, is taken as 0.58, following Gumus and

Bahadir (2013). We calibrate the diversion parameters at, $\lambda_0 = 0.615$ (the level parameter), $\lambda_1 = -1.2$ (the slope parameter), and $\lambda_2 = 3.50$ (the curvature parameter), to match a leverage ratio of 5.96 for financial intermediaries, foreign funding to assets ratio of 0.59, and lending spread from foreign funds of approximately 80 basis points.

We take rr as 11.5%, the weighted average of domestic required reserve ratio implemented by the CBRT. The ROC level parameter, roc_1, is set at 1.275, to match the minimum ROC in practice; the slope parameter, roc_2, at 2.85 to resemble the observed ROC schedule, and roc_3, at 0.6, to match the maximum fraction of domestic required reserves to be held at the ROM (which is 60% in practice). We assume that the central bank follows a simple Taylor-type rule, with $\varphi_\pi = 1.5$, and $\varphi_y = 0.5$, with inertia, $\rho_r = 0.90$. Productivity shock processes are taken from Gumus and Bahadir (2013), and risk premium shock from Gertler et al. (2003).

3 Dynamics of the Model Economy

In this section, we explore the workings of the model in response to shocks to TFP, borrowing premium on foreign debt, and policy rate. Among these, arguably the most interesting case is the response to the risk premium shocks, since the hampered ability of the small open economy to borrow from abroad brings additional constraints on the monetary policy authority. Figures 1 to 6 display responses of selected real, financial, and monetary variables of the model to the relevant shock. In each plot, straight (dashed) plots represent of the impulse response functions of model variables in the benchmark economy (economy with the augmented Taylor rule). The model suggests that operationalizing the short term rates as a macroprudential instrument is very effective in stabilizing macroeconomic, financial and monetary variables in the absence of financial frictions.

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Table 1: Model Parameters

Description	Parameter	Value	Target
Households			
Quarterly discount factor	β	0.9885	Annualized real deposit rate (4.73%)
Relative risk aversion	ρ	2	Benigno *et al.* (2013)
Labor supply elasticity	δ	2	Benigno *et al.* (2013)
Relative utility weight of money	υ	0.04	M1 to GDP ratio.
Relative utility weight of leisure	χ	3.7	1/3 working time
Elasticity of substitution between tradable and nontradable goods	γ	0.99	Gertler *et al.* (2003)
Relative weight of nontradable goods in consumption basket	ω	0.5	Gertler *et al.* (2003)
Financial Intermediaries			
Share of total bank credit to nontradable firms	ϕ^N	0.58	Gumus & Bahadir (2013)
Diversion function level parameter	λ_0	0.667	Annual commercial & industrial loan spread
Diversion function slope parameter	λ_1	-1.20	Leverage ratio of financial intermediaries (5.97)
Diversion function curvature parameter	λ_2	3.50	Foreign funding to assets (0.589)
Prop. transfer to the entering bankers	ϵ^b	0.0005	1.33% of aggregate net worth
Survival probability of the bankers	θ^b	0.9625	Capital adequacy ratio of 16% for commercial banks
Firms			
Share of capital in output in nontradable sector	α^N	0.3	Labor share of output (0.70)
Share of capital in output in tradable sector	α^T	0.3	Labor share of output (0.70)
nontradable capital adjustment cost parameter	Ψ^N	1.4	Elasticity of price of nontradable capital w.r.t. investment-capital ratio of 0.25
Tradable capital adjustment cost parameter	Ψ^T	0.95	Elasticity of price of tradable capital w.r.t. investment-capital ratio of 0.25
Depreciation rate of capital	δ^f	0.035	Average annual ratio of investment to capital (14.8%)
Fraction of nontradable firms with unchanged prices	θ^f	0.75	Frequency of price change per quarter
Monetary Authority and Government			
Domestic currency required reserve ratio	rr	0.115	TL required reserve ratio for 2010:Q4 - 2013:Q3
Reserve option coefficient level parameter	roc_1	1.275	Minimum reserve option coefficient imposed by the CBRT
Reserve option coefficient slope parameter	roc_2	2.85	Slope of ROC schedule implemented by the CBRT
Reserve option coefficient fucntion parameter	roc_3	0.6	Maximum ROM utilization rate imposed by the CBRT
Reaction parameter to domestic inflation	φ_π	1.5	-
Reaction parameter to output gap	φ_y	0.5	-
Shock Processes			
Persistence of TFP process in nontradable sector	ρ_{A^N}	0.652	Gumus & Bahadir (2013)
Std. deviation of productivity shocks in nontradable sector	σ_{A^N}	0.0152	Gumus & Bahadir (2013)
Persistence of TFP process in tradable sector	ρ_{A^T}	0.77	Gumus & Bahadir (2013)
Std. deviation of productivity shocks in tradable sector	σ_{A^T}	0.029	Gumus & Bahadir (2013)
Persistence of risk premium process	ρ_ψ	0.95	Gertler *et al.* (2003)
Std. deviation of risk premium shocks	σ_ψ	0.0015	Gertler *et al.* (2003)

Figure 1: Impact of TFP Shocks on Real and Financial Variables

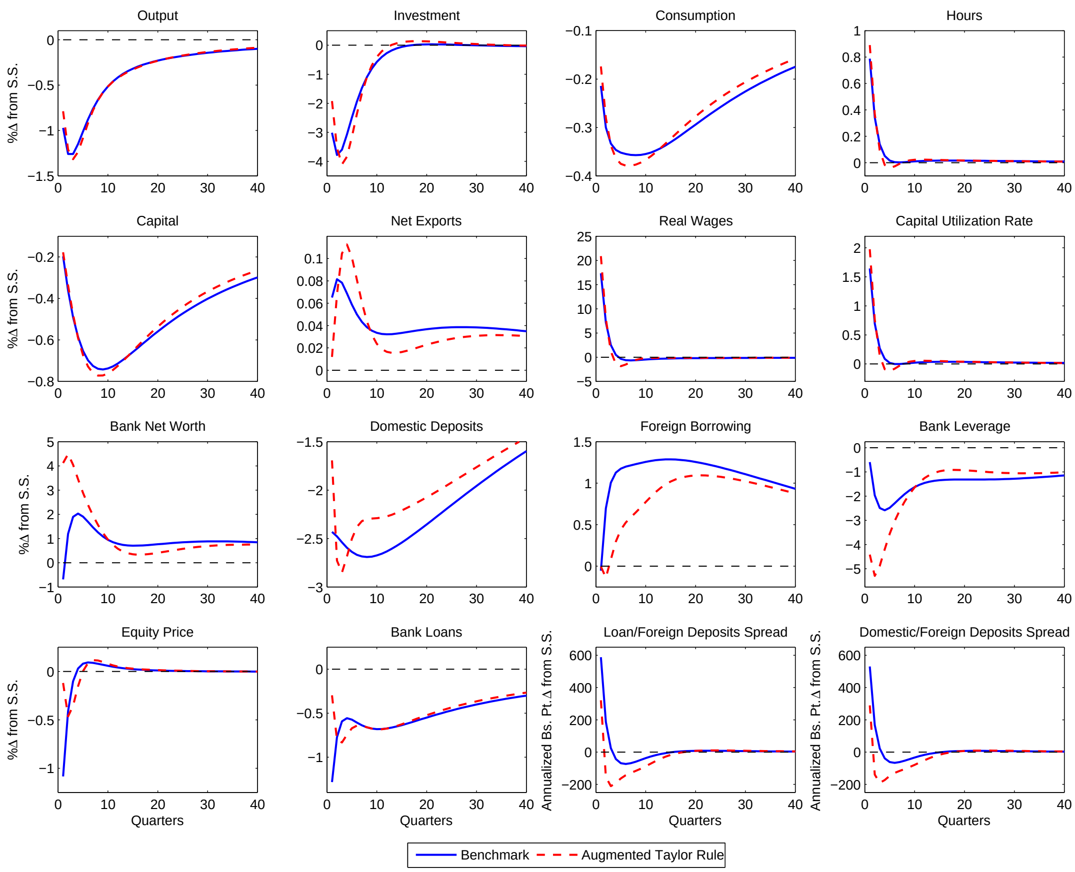

Figure 2: Impact of TFP Shocks on Monetary Variables

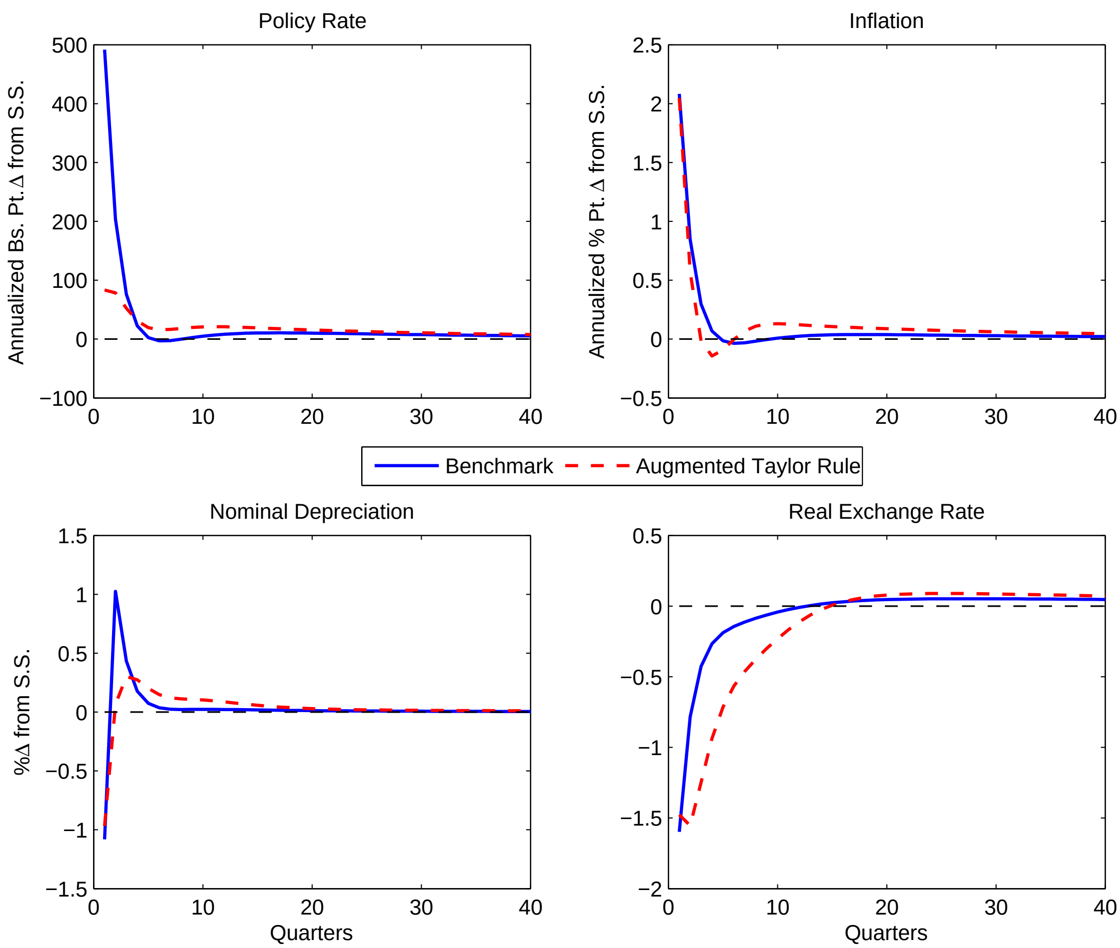

Figure 3: Impact of Country Borrowing Premium Shocks on Real and Financial Variables

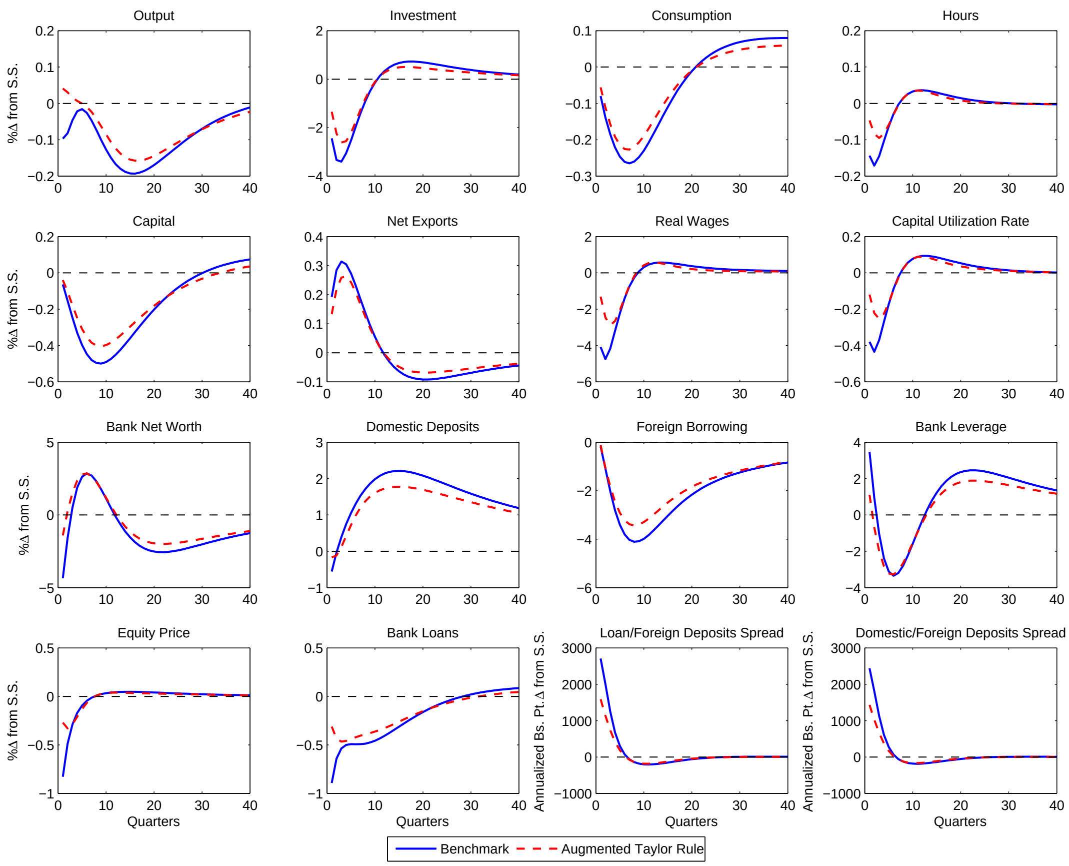

Figure 4: Impact of Country Borrowing Premium Shocks on Monetary Variables

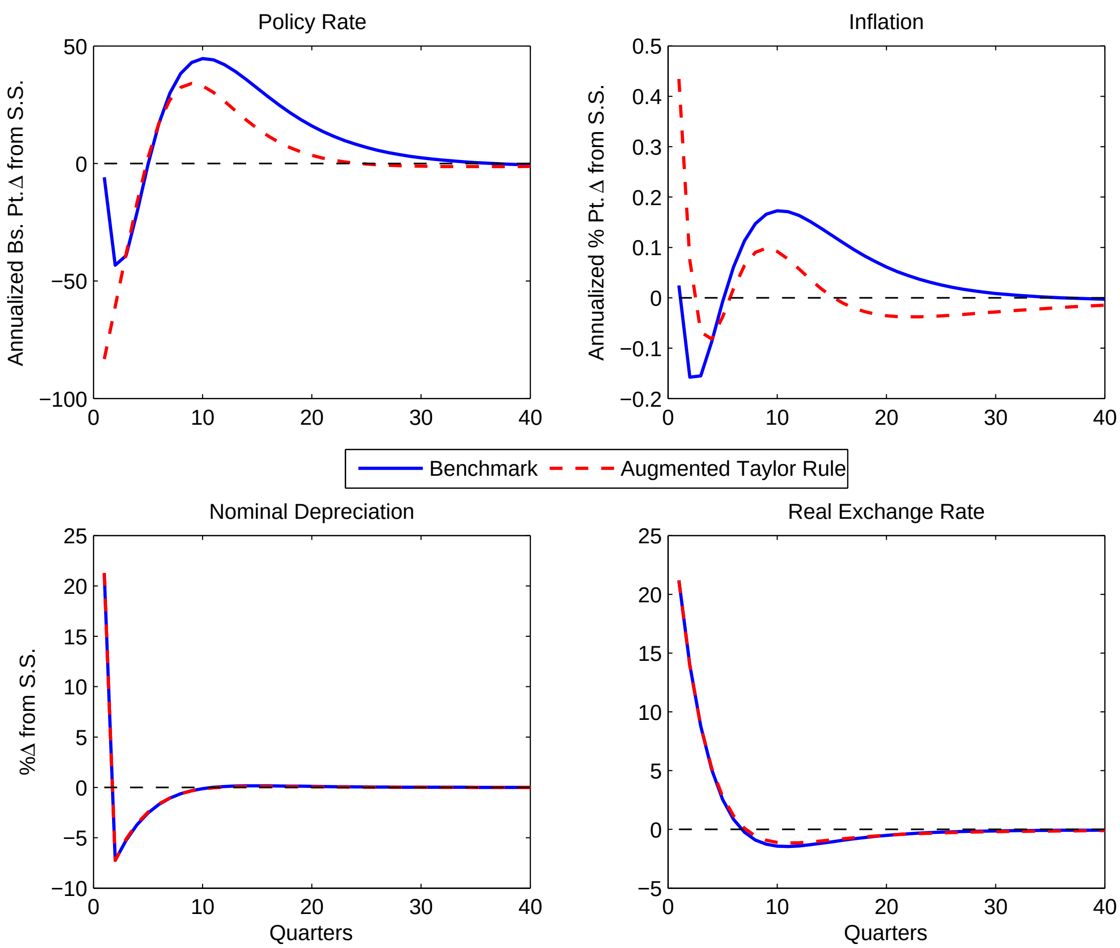

Figure 5: Impact of Monetary Policy Shocks on Real and Financial Variables

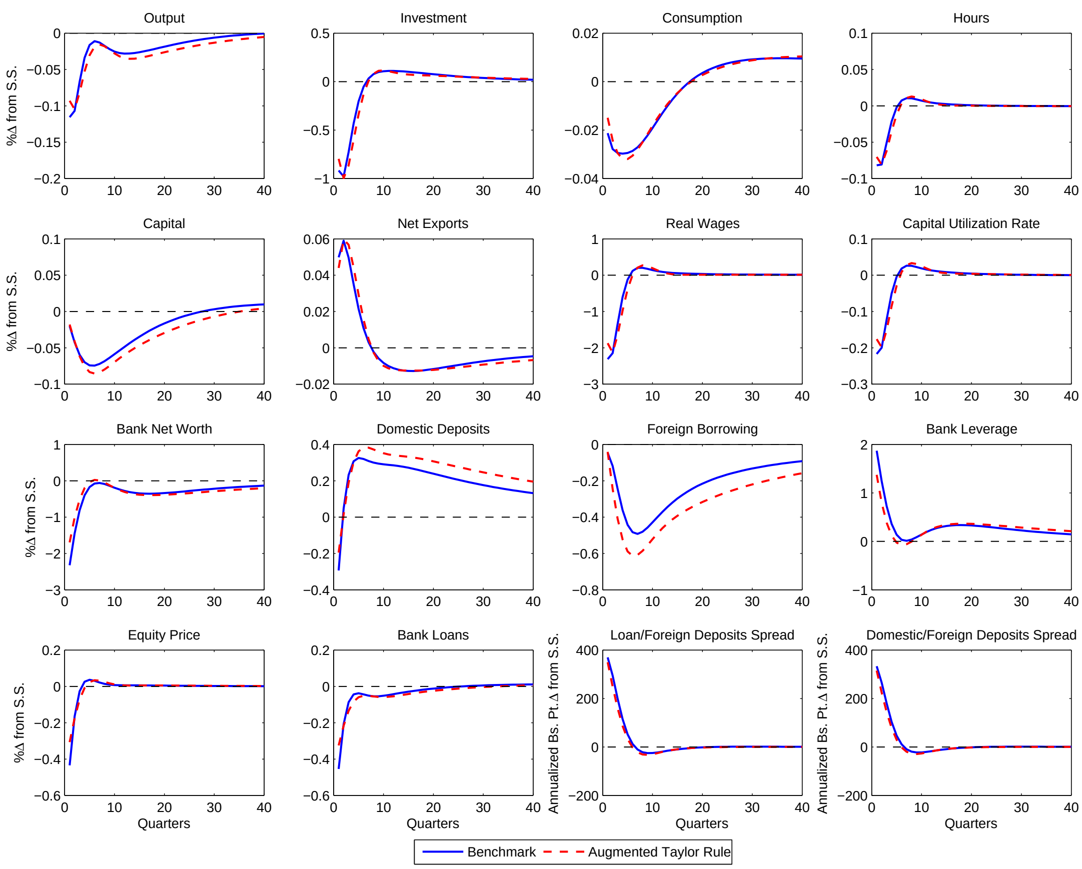

Figure 6: Impact of Monetary Policy Shocks on Monetary Variables