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Abstract

This paper explores how best a small open economy can defend against a foreign interest rate rise, such as the impending Fed lift-off. We find that a broad based macroprudential policy is the most effective tool in containing fluctuations arising from the interest rate shock, hence yielding the lowest loss in welfare.

Keywords: Foreign interest rates; emerging markets; monetary policy; macroprudential measures; capital controls.

JEL Classification: E5, F3, F4, G1.

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1 Introduction

The US Federal Reserve (Fed) has played a leading role in shaping the global monetary responses to the 2007-08 financial crisis through both conventional and unconventional monetary policy. This has taken the form of, respectively, cutting interest rate to near zero levels and enacting a large scale asset purchasing program, widely known as quantitative easing (QE), with clear implications for the global economy. The emerging market countries (EMs) have greatly benefited from the lax US monetary policy. Excess liquidity created by QE led to substantial capital flows into these economies at the back of the very low US interest rates. Bank of International Settlements estimates suggest that EMs dollar denominated borrowing has doubled since 2009.

It is, therefore, not surprising that the reaction of EMs to the announcements of Fed's unwinding QE has been dramatic. Major fluctuations in both the stock and currency markets across EMs were observed throughout May 2013-October 2014 over which the Fed first cut back and then ended its asset purchases. Similarly, the signal from the Fed in September 2015, to raise interest rates sooner than expected, resulted in sharp reversal of capital flows.[1] Given the scale of foreign currency exposure, as mentioned above, it is clear that these risks are real not just for the indebted countries but also for the global economy.

Although the significance of the Fed lift-off is well-understood in policy circles, there is, as yet, no systematic analysis of how best a country can respond to an external shock of the kind presented by a US move towards contractionary monetary policy. The growing literature on the spill-overs of US post-crisis monetary policy on other economies is currently of empirical nature and focusses on main drivers of the resulting capital inflows to other countries (Chen *et al.*, 2011 and Ahmed and Zlate, 2014); the impact of interest rate setting in other countries (Takats and Vela, 2014); and the impact of announcements regarding exit from QE (Eichengreen and Gupta, 2014 and Aizenman *et al.*, 2014).

This paper examines how a small open economy can respond to a foreign interest rate rise by presenting a comparative analysis of monetary, macroprudential and capital control policies which are widely adopted across the world since the global financial crisis. We find that a broad based macroprudential policy is the most effective tool in dampening fluctuations following

[1] In its Global Financial Stability Reports, the International Monetary Fund (IMF) have repeatedly warned countries with substantial dollar denominated debts of severe risks from higher US interest rates.

a foreign interest rate rise. We also present a welfare analysis reaffirming this finding.

2 The model

2.1 The basic model structure

Our framework is an open economy New Keynesian dynamic stochastic general equilibrium (DSGE) model of an emerging economy that shares many features with Bernanke *et al.* (1999), Kanan *et al.*, (2012) and particularly Ozkan and Unsal (2012 and 2014). The economy is populated by households, firms, entrepreneurs, financial intermediaries and a monetary authority. Following Gali and Monacelli (2002) and De Paoli (2009) among many others, we derive the dynamics of small open economy (SOE) as a limiting case of a two country model where the size of the SOE is negligible relative to the size of the rest of the world (ROW). The economy is populated by households, firms, entrepreneurs, financial intermediaries and a monetary authority.

In what follows we present the key features of the basic model structure. Table 1 in the Appendix presents the full list of model equations.

Households

Households receive utility from consumption and provide labor to the production firms. They participate in domestic and (incomplete) international financial markets. The households own the firms in the economy and therefore receive profits from these firms.

Firms

There are three types of firms in the model. Production firms produce a differentiated final consumption good using both capital and labor as inputs. These firms engage in local currency pricing and face price adjustment costs. As a result, final goods' prices are sticky in terms of the local currency of the markets in which they are sold. Importing firms also have some market power and face adjustment costs in changing prices. Price stickiness in export and import prices causes the law of one price to fail such that exchange rate pass through is incomplete in the short run. Finally, there are competitive firms that combine investment with rented capital to produce unfinished capital goods that are then sold to entrepreneurs.

Entrepreneurs

As is the case in this class of models, entrepreneurs are key players. They transform unfinished capital goods that are then rented to the production firms. Each entrepreneur has access to a stochastic technology in transforming unfinished capital into finished capital goods.

Entrepreneurs finance their investment by external borrowing channeled through perfectly competitive financial intermediaries. Productivity is observed by the entrepreneur, but lenders can only observe it at a monitoring cost which is assumed to be a certain fraction of the return (costly state verification). As is shown by Carlstrom and Fuerst (1997) and Bernanke *et al.* (1999), the optimal contract between the enterpreneurs and the lenders ensures that the entrepreneur maximizes their expected return subject to the participation constraints of the lender, leading to the following conditions

$$E_t[R_{t+1}] = E_t[(1 + i_t^*)(1 + \Phi_{t+1})], \tag{1}$$

where R_{t+1} is the cost of borrowing to the enterpreneur, i_t^* is foreign interest rates and $(1 + \Phi_{t+1})$ is the external finance premium. Clearly, the greater the perceived risk of default, the greater the external finance premium the enterpreneur needs to pay to secure funding. A greater use of external financing generates an incentive for entrepreneurs to take on more risky projects, which raises the probability of default. This, in turn, will increase the external finance premium, Φ. Similarly, a fall in the entrepreneurs' net worth increases their leverage, leading to an upward adjustment in Φ.

Financial intermediaries and macroprudential policy

There exists a continuum of perfectly competitive financial intermediaries that channel funds from lenders to entrepreneurs. The zero profit condition implies that the lending rates are equal to $E_t[(1 + i_t^*)(1 + \Phi_{t+1})]$ in the absence of macroprudential measures.

In contrast to the widely unregulated financial markets prior to the global financial crisis, policymakers across the globe now have a wide range of macroprudential instruments at their disposal towards ensuring the stability of the financial system. These include countercyclical capital requirements, time-varying margins on certain financial transactions, limits on interbank exposure, size dependent leverage limits and caps on loan-to-value ratios (see, for example, IMF, 2011).

Following Kannan *et al.* (2012), Unsal (2013), and Quint and Rabanal (2014), we maintain that macroprudential measures raise the cost of financial intermediation. These costs are then passed onto borrowers in the form of higher interest rates.[2] We refer to the increase in lending rates brought by macroprudential measures as the "regulation premium" and maintain that it is positively linked to nominal credit growth, making macroprudential policy countercyclical by design. Hence macroprudential measures would be tightened in good times and loosened in the face of perceived risk in bad times.

It, therefore, follows that, when there are macroprudential regulations, the spread between the lending rate and the policy rate will be affected by both the external finance and the regulation premium. Hence, the cost of borrowing, $E_t[R_{t+1}]$ becomes:

$$E_t[R_{t+1}] = E_t[(1 + i_t^*)(1 + \Phi_{t+1})(1 + RP_t)], \tag{2}$$

where RP_t is the regulation premium.

Given the key role of excessive credit growth on output losses during the 2008-09 global financial crisis and the fact that restrictions on credit growth have been among the most widely used macroprudential measures since 2008, we set the regulation premium as a function of the credit growth in the economy (see, for example, Lim *et al.* 2011 and Feldkircher, 2014):

$$RP_t = \Psi(\frac{S_t D_t^F}{S_{t-1} D_{t-1}^F} - 1) \tag{3}$$

where S_t denotes the nominal exchange rate in period t, defined as the price of foreign currency in terms of domestic currency and D_t^F denotes the level of external borrowing in foreign currency terms.

We consider two types of macroprudential policy (*MP). The first is* targeted *MP* where policy is set in such a way that borrowing costs rise as a function of the evolution of foreign debt ($\frac{S_t D_t}{S_{t-1} D_{t-1}}$), as in (3). The second type of MP we examine is a broad one where the borrowing costs respond to the changes in total debt ($\frac{S_t D_t^F + D_t^D}{S_{t-1} D_{t-1}^F + D_{t-1}^D}$), where D_t^D level of domestic borrowing.

In sum, the targeted *MP* is geared towards keeping capital flows in check and can thus be seen as capital controls (CC) while the broad *MP* targets the overall financial stability responding to movements in total credit.

Monetary policy

[2]See, for example, Angeloni *et al.* (2015) for empirical evidence on the role of macroprudential measures on the cost of borrowing.

As standard in the literature, we model monetary policy in terms of simple implementable rules in which the central bank sets the policy rate in response to some observable variables:

$$1 + i_t = [(1 + i)\ (\pi_t)^{\epsilon_\pi} (Y_t/Y)^{\epsilon_Y} (\mathit{credit\ growth})^{\epsilon_D}]^{\varpi} [1 + i_{t-1}]^{1-\varpi}, \qquad (4)$$

where i_t denotes policy rate, π_t is CPI inflation, Y_t is aggregate output, *credit growth* denotes nominal credit growth in the economy in domestic currency terms and ϖ is the interest rate smoothing parameter and i and Y denote the steady-state levels of nominal interest rate and output.

2.2 Solution and calibration

We calibrate the model for a generic emerging market economy, using established values in the literature, as listed in Table 1. The discount factor, β is set at 0.99, implying a riskless annual return of approximately 4 per cent in the steady state (time is measured in quarters). We set the inverse of the elasticity of intertemporal substitution, σ at 1, in line with much of the literature. The inverse of the elasticity of labour supply φ is set at 2. The degree of openness, $(1 - \alpha)$, and the share of capital in production, η, are set at 0.35, consistent with other studies (See, for example, Gertler *et al.*, 2007.) Following Devereux *et al.* (2006), the elasticity of substitution between differentiated goods of the same origin, λ, is taken to be 11, implying a flexible price equilibrium mark-up of 1.1, and price adjustment cost is assumed to be 120 for all sectors. The quarterly depreciation rate δ is taken to be 0.025, a conventional value used in the literature. The share of entrepreneurs' labour, Ω, is set at 0.01, implying that 1 per cent of the total wage bill goes to the entrepreneurs. With respect to monetary policy, we use the original Taylor estimates and set $\epsilon_\pi = 1.5$ and $\epsilon_Y = 0.5$ in the baseline calibration. The degree of interest rate smoothing parameter (ϖ) is chosen as 0.5. ρ_ϱ is taken to be 0.5, so that it takes 9 quarters for the shock to die away. The steady state leverage ratio and the value of quarterly external risk premium in the domestic economy are set at 0.3 and 200 basis points. We set the monitoring cost parameter, μ, at 0.2 as in Devereux *et al.* (2006). These parameter values imply a survival rate, ϑ, of approximately 99.33 per cent.

We solve the model numerically up to a second-order approximation around the non-stochastic steady state.

2.3 Fed lift-off and the domestic economy

We examine the impact of a foreign interest rate rise in two alternative scenarios; in the first the interest rate shock only affects the cost of borrowing from abroad; and in the second borrowing conditions both at home and abroad are unfavorably affected, where the foreign interest rate rise impacts upon global risk appetite and global credit conditions. We argue that this is a better representation of how US monetary policy in general, and interest rate changes in particular are transmitted onto other countries in practice. As is documented by Rey (2013), a rise is Federal Funds rate is strongly associated with an increase in VIX (measuring market volatility arising from uncertainty and market risk aversion), a fall in global capital inflows and a fall in global domestic credit. The first scenario, a much narrower interpretation of the interest rate shock transmission across countries, is included to enable us to trace the differences between the two cases and their consequences. These two scenarios are depicted in Fig.1 and 2, respectively.

Fig.1 portrays the response of the small open economy to a rise in foreign interest rates in the first scenario under three separate policy options; the standard Taylor rule; a broad *MP;* and a targeted *MP,* seen as capital controls (CC), as argued above.

Insert Fig.1 here

As is clear from Fig.1, a rise in foreign interest rate raises the cost of foreign borrowing, leading to a fall in capital inflows. Lower borrowing, in turn, decreases the future supply of capital and hence brings about a decrease in investment. The fall in the inflow of capital also lowers the demand for domestic currency, leading to its depreciation. Since the entrepreneurs' borrowing is denominated in foreign currency, this unanticipated change in the exchange rate also creates balance sheet effects through a rise in the real debt burden. Due to the expansionary impact of the depreciation, domestic debt also rises, yet not sufficiently to compensate for the fall in foreign debt, resulting in a fall in total credit hence in consumption, investment and output.

Fig.1 reveals that both the broad and the targeted macroprudential policy, MP and CC respectively, dampen the responses of real and financial variables relative to the standard Taylor rule. This is due to the countercyclical nature of MP allowing borrowing costs to fall following the unfavorable interest rate shock, which helps contain the fluctuations in the economy. It can also be seen that CC does a better job by directly countering the shock at its source - note that interest rate shock only affects the cost of foreign borrowing in this scenario. Monetary policy response creates greatest fluctuations in both financial and real variables; responding to the foreign interest rate shock by varying the policy rate magnifies the impact by exposing the other parts of the economy, such as household borrowing, to the unfavourable consequences of the foreign interest rate shock. Hence, the reduction in capital inflows is the greatest under monetary policy - in the absence of macroprudential policy- leading to the sharpest response in output.

We now turn to the second scenario. Fig.2 portrays the domestic economy's response to the foreign interest rate rise which also influences the perceived risk associated with domestic borrowers, thereby leading to an additional rise in the cost of borrowing. As a result, entrepreneurs reduce their use of external borrowing, setting in motion the process described above resulting in reductions in real activity. Furthermore, as the foreign interest rate shock also affects borrowing conditions at home now domestic debt also falls, magnifying the extent of the fall in asset prices, investment and output. Similarly, depreciation of the domestic currency is almost twice as large.

Insert Fig.2 here

Interestingly, the ranking between the broad MP and targeted MP (CC) is now reversed; CC brings about the smallest drop in foreign debt while leading to greatest fluctuations in domestic borrowing; pre-emptive policy exclusively geared towards foreign debt when the whole financial sector is impacted can only shelter the domestic economy partially. The broad MP is now the most effective shock absorber; fluctuations in both investment and output are lower with the broad MP than under CC. This result points to a limited domestic impact of capital controls, as is widely documented (see, for example, Pasricha *et al.*, 2015, for recent evidence).

Overall, MP is still more effective than monetary policy in reducing fluctuations following the foreign interest rate shock; preemptive policy works. Both broad MP and CC produce smaller reductions in the real activity as compared with those under the Taylor rule. Also note that, a key difference between the use of MP and monetary policy is in their impact on the exchange rate, where the exchange rate response is greater in the latter, as is evident from both Fig.1 and 2. This effect mirrors the impact of policy on capital inflows the sharpest fall in which arises from the monetary policy response. Given that exchange rate changes have important implications for largely open EMs, this finding provides additional support for the use of *MP* as a preemptive device against financial shocks in these economies.

2.4 Welfare evaluation

As in Faia and Monacelli (2007), and Gertler and Karadi (2010), our welfare analysis is based on household utility, which can be expressed recursively:

$$V_t = U(C_t, H_t) + \beta E_t V_{t+1}^{HH} \tag{5}$$

where $V_t \equiv E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, H_t)$ denotes the utility function of households. Using the second order solution of the model, we calculate V_t in each of the separate cases of monetary and macroprudential policies. Our metric Υ, is the fraction of consumption required to equate welfare under any given monetary and macroprudential policies, V_t, to the one under the optimal Taylor rule, V_t^{opt} - a higher Υ implies a higher welfare loss. In our specification of the utility function, and under $\sigma = 2, \Upsilon$ is given by

$$\Upsilon = (\frac{(V_t^{opt} - V_t)(1-\beta)(C - \frac{\chi}{1+\varphi} H^{1+\varphi})^2}{C(1 - (V_t^{opt} - V_t)(1-\beta)(C - \frac{\chi}{1+\varphi} H^{1+\varphi}))} \tag{6}$$

where the variables without subscripts are the steady state values of the corresponding variables.

Table 3 presents Υ under the three policy regimes, for both interpretations of the foreign interest rate shock. Clearly, *MP* dominates monetary policy in both scenarios. In the case of foreign interest rate only impacting the cost of foreign borrowing, *CC* provides the best policy option, in line with the impulse responses in the previous section. In contrast, the broad *MP* yields lowest welfare losses in the second scenario. In all cases, *MP* dominates monetary policy.

Such a ranking confirms our results in the previous section; in the face of foreign interest rate shocks both types of macroprudential policy are superior to the Taylor rule. That is, monetary policy is too blunt an instrument when the source of the shock is external, leading to the highest welfare losses. Regarding the form of macroprudential policy, it all depends on how foreign interest rate changes are transmitted onto the financial conditions in the domestic economy. In the more realistic second scenario, when the conditions for both the domestic and foreign borrowing are affected capital controls are not as effective as the broad macroprudential policy and hence yield higher welfare losses.

3 Concluding remarks

The impending Fed lift-off is widely expected to be a major blow to countries that are reliant on external borrowing. We examined the effectiveness of monetary, macroprudential and capital control policies as alternative measures against the spill-overs from such a potential interest rate rise. We find that a broad based macroprudential policy anchored towards system-wide financial stability measures such as credit growth delivers the best defense against spill-overs from foreign interest rate shocks, in the form of lowest fluctuations in financial and real variables as well as the highest welfare. This provides a testament for the proliferation of macroprudential measures in recent years particularly in emerging economies.

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Table 1. Model Equations

Households

$C_{H,t}= (1-\alpha)(\frac{P_{H,t}}{P_t})^{-\gamma}C_t,\ C_{M,t} = \alpha(\frac{P_{M,t}}{P_t})^{-\gamma}C_t$	Home and imported goods demand
$P_t= [(1-\alpha)P_{H,t}^{1-\gamma} + \alpha P_{M,t}^{1-\gamma}]^{1/(1-\gamma)}$	Consumer price index
$\chi H_t^{\varphi} = W_t$	Labor demand
$(C_t - \frac{\chi}{1+\varphi}H_t^{1+\varphi})^{-\sigma} = \beta(1+i_t)E_t[(C_{t+1} - \frac{\chi}{1+\varphi}H_{t+1}^{1+\varphi})^{-\sigma}\frac{P_t}{P_{t+1}}]$	Domestic bond demand
$(C_t - \frac{\chi}{1+\varphi}H_t^{1+\varphi})^{-\sigma} = \beta(1+i_t^*)\Psi_{D,t}E_t[(C_{t+1} - \frac{\chi}{1+\varphi}H_{t+1}^{1+\varphi})^{-\sigma}\frac{P_t}{P_{t+1}}\frac{S_{t+1}}{S_t}]$	Foreign bond demand

where C_t is a composite consumption index, H_t is hours of work, W_t is the wage rate, $P_{H,t}$ and $P_{M,t}$ are the prices for domestic and imported goods, i_t is domestic interest rate, i_t^* is foreign interest rate, S_t is the nominal exchange rate, $\Psi_{D,t} = \frac{\Psi_D}{2}[\exp(\frac{S_t D_{t+1}^H}{P_t GDP_t} - \frac{SD^H}{PGDP}) - 1]^2$ external borrowing premium.

Production Firms

$Y_t = A_t N_t^{1-\eta} K_t^{\eta}$	Production function
$N_t = H_t^{1-\Omega} H_t^{E\Omega}$	Labor input
$W_t = \frac{(1-\eta)(1-\Omega)Y_t MC_t}{N_t}$	Wage rate
$W_t^E = (1-\eta)\Omega Y_t MC_t$	Entrepreneurial wage rate
$R_t = \frac{\eta Y_t MC_t}{K_t}$	Rental rate of capital
$P_{H,t} = \frac{\lambda}{\lambda-1}MC_t - \frac{\Psi_H}{\lambda-1}\frac{P_t}{Y_{H,t}}\frac{P_{H,t}}{P_{H,t-1}}(\frac{P_{H,t}}{P_{H,t-1}} - 1) + \frac{\Psi_H}{\lambda-1}E_t[\Theta_t\frac{P_{t+1}}{Y_{H,t}}\frac{P_{H,t+1}}{P_{H,t}}(\frac{P_{H,t+1}}{P_{H,t}} - 1)]$	Price of domestic goods
$S_t P_{X,t} = \frac{\lambda}{\lambda-1}MC_t - \frac{\Psi_X}{\lambda-1}\frac{P_t}{Y_{X,t}}\frac{P_{X,t}}{P_{X,t-1}}(\frac{P_{X,t}}{P_{X,t-1}} - 1) + \frac{\Psi_X}{\lambda-1}E_t[\Theta_t\frac{P_{t+1}}{Y_{X,t}}\frac{P_{X,t+1}}{P_{X,t}}(\frac{P_{X,t+1}}{P_{X,t}} - 1)]$	Price of exports

where H_t^E is entrepreneurial labor, K_t denotes capital provided by the entrepreneur, W_t^E is the entrepreneurial wage rate, R_t is the rental rate of capital and MC_t is the marginal cost, $\frac{\Psi_i}{2}(\frac{P_{i,t}(j)}{P_{i,t-1}(j)} - 1)^2$ for $i = H, X$ is the quadratic menu cost for price adjustments, and $\Theta_t = \beta\frac{(C_{t+1} - \frac{\chi}{1+\varphi}H_{t+1}^{1+\varphi})^{-\sigma}}{(C_t - \frac{\chi}{1+\varphi}H_t^{1+\varphi})^{-\sigma}}\frac{P_t}{P_{t+1}}$.

Importing Firms

$P_{M,t}= \frac{\lambda}{\lambda-1}S_t P_t^* - \frac{\Psi_M}{\lambda-1}\frac{P_t}{Y_{M,t}}\frac{P_{M,t}}{P_{M,t-1}}(\frac{P_{M,t}}{P_{M,t-1}} - 1) + \frac{\Psi_M}{\lambda-1}E_t[\Theta_t\frac{P_{t+1}}{Y_{M,t}}\frac{P_{M,t+1}}{P_{M,t}}(\frac{P_{M,t+1}}{P_{M,t}} - 1)]$	Price index for imported goods

where $Y_{M,t}$ denote the aggregate import demand of the domestic economy.

Unfinished capital goods producers

$I_{H,t} = (1-\alpha)(\frac{P_{H,t}}{P_t})^{-\gamma} I_t,\ \ I_{M,t} = \alpha(\frac{P_{M,t}}{P_t})^{-\gamma} I_t$	Domestic and imported investment goods
$K_{t+1} = [\frac{I_t}{K_t} - \frac{\Psi_I}{2}(\frac{I_t}{K_t} - \delta)^2]K_t + (1-\delta)K_t$	Law of motion for capital
$\frac{Q_t}{P_t} = [1 - \Psi_I(\frac{I_t}{K_t} - \delta)]^{-1}$	Price of a unit of capital

where I_t, is composed of domestic and imported investment goods, which are priced at $P_{H,t}$ and $P_{M,t}$, $\frac{\Psi_I}{2}(\frac{I_t}{K_t} - \delta)^2$ is the adjustment cost, δ is the depreciation rate.

Entrepreneurs

$\omega^{v}_{t+1} K^{v}_{t+1}$	Production function for $v = F, D$
$P_t NW^F_t = Q_t K^F_{t+1} - S_t D^F_{t+1}$	Budget constraint for entrep. F
$P_t NW^D_t(k) = Q_t K^D_{t+1}(k) - D^D_{t+1}(k)$	Budget constraint for entrep. D
$\omega^{v*}_{t+1}(k) = \omega^{v}_{t+1}(k)\varrho_t$	Lenders' perception of $\omega^{v}_{t+1}(k)$
$\ln(\varrho_t) = \rho_\varrho \ln(\varrho_{t-1}) + \varepsilon_\varrho$	Misperception factor
$E_t[R^K_{t+1} Q_t K^{v}_{t+1}(\int_{\overline{\omega}^{v}_{t+1}}^{\infty} \omega^{v} f(\omega^{v}) d\omega^{v} - \overline{\omega}^{v}_{t+1} \int_{\overline{\omega}_{t+1}}^{\infty} f(\omega^{v}) d\omega^{v})]$ $= E_t[R^K_{t+1} Q_t K^{v}_{t+1} z^{v}(\overline{\omega}^{v}_{t+1})]$	Expected return to entrep. $v = F, D$
$E_t[R^K_{t+1} Q_t K^{v}_{t+1}(\overline{\omega}^{v*}_{t+1} \int_{\overline{\omega}^{v}_{t+1}}^{\infty} f(\omega^{v*}) d\omega^{v*}$ $+(1-\mu)\int_0^{\overline{\omega^{v}}_{t+1}} \omega^{v*}_{t+1} f(\omega^{v*}) d\omega^{v*})]$ $= E_t[R^K_{t+1} Q_t K^{v}_{t+1} g^{v}(\overline{\omega}^{v}_{t+1}; \varrho^{v}_t)]$	Expected return to lenders
$E_t[\frac{R^K_{t+1} Q_t K^F_{t+1}}{S_{t+1}} g^F(\overline{\omega}^F_{t+1}; \varrho^F_t)] = (1+i^*_t) D^F_{t+1}$	Participation constraint (F)
$E_t[R^K_{t+1} Q_t K^D_{t+1} g^D(\overline{\omega}^D_{t+1}; \varrho^D_t)] = (1+i_t) D^D_{t+1}$	Participation constraint (D)
$E_t[R^K_{t+1}] = E_t[(1+i^*_t)(1+\Phi^F_{t+1})]$	Return to capital (F)
$E_t[R^K_{t+1}] = E_t[(1+i_t)(1+\Phi^D_{t+1})]$	Return to capital (D)
$1 + \Phi^F_{t+1}(k) = [\frac{z^{F'}(\overline{\omega}^F_{t+1}(k))}{g^F(\overline{\omega}^F_{t+1}(k); \varrho_t) z^{F'}(\overline{\omega}^F_{t+1}(k)) - z^F(\overline{\omega}^F_{t+1}(k)) g^{F'}(\overline{\omega}^F_{t+1}(k); \varrho_t)}] E_t\{\frac{S_{t+1}}{S_t}\}$	Risk premium on F debt
$1 + \Phi^D_{t+1}(k) = [\frac{z^{D'}(\overline{\omega}^D_{t+1}(k))}{g^D(\overline{\omega}^D_{t+1}(k); \varrho_t) z^{D'}(\overline{\omega}^D_{t+1}(k)) - z^D(\overline{\omega}^D_{t+1}(k)) g^{D'}(\overline{\omega}^D_{t+1}(k); \varrho_t)}]$	Risk premium on D debt
$K_t = K^F_t + K^D_t$	Total capital
$P_t C^{FE}_t = (1-\vartheta)[R^K_t Q_{t-1} K^F_t (1 - \nu^F_t) - (1+i^*_{t-1}) S_t D^F_t]$	Consumption of entrep F
$P_t C^{DE}_t = (1-\vartheta)[R^K_t Q_{t-1} K^D_t (1 - \nu^D_t) - (1+i_{t-1}) D^D_t]$	Consumption of entrep D
$z^{v}(\overline{\omega}^{v}_t) = 1 - \Theta(z^{v}_{1t} - \sigma^{v}_{\omega}) - \overline{\omega}^{v}_t (1 - \Theta(z^{v}_{1t}))$	Borrowers' share of return
$g^{v}(\overline{\omega}^{v}_t; \varrho_t) = \varrho_t[\frac{\overline{\omega}^{v}_t}{\varrho_t}(1 - \Theta(z^{v}_{2t})) + (1-\mu)\Theta(z^{v}_{2t} - \sigma^{v}_{\omega})]$	Lenders' share of return

where $v = F, D$ is the lenders' type, $\log(\omega_t(k)) \sim N(\frac{-1}{2}\sigma^2_\omega, \sigma^2_\omega)$, D^F_{t+1} and D^D_{t+1} denote foreign currency denominated debt and domestic currency denominated debt, $z^{v}(\overline{\omega}^{v}_t) + g^{v}(\overline{\omega}^{v}_t, \varrho^{v}_t) = 1 - \nu^{v}_t$ and ν^{v}_t is the cost of monitoring, the functions $\mathrm{erf}(.)$ and $\mathrm{erf}c(.)$ and the c.d.f. of a standard normal distribution $\Theta(.)$ are $\mathrm{erf}(x) = 2\Theta(x\sqrt{2}) - 1$ and $\mathrm{erf}c(x) = 2(1 - \Theta(x\sqrt{2}))$, and $z^{v}_{1t} = \frac{\ln\omega^{v}_t + 0.5\sigma^{v2}_\omega}{\sigma^{v}_\omega}$ and $z^{v}_{2t} = \frac{\ln(\frac{\omega^{v}_t}{\varrho_t}) + 0.5\sigma^{v2}_\omega}{\sigma^{v}_\omega}$.

Financial Intermediaries and Macroprudential Policy
Broad macroprudential policy

$E_t[R^K_{t+1}] \; = E_t[(1+i^*_t)(1+\Phi^F_{t+1})(1+RP^{MP}_t)]$	Lending rate for F
$E_t[R^K_{t+1}] \; = E_t[(1+i_t)(1+\Phi^D_{t+1})(1+RP^{MP}_t)]$	Lending rate for D
$RP^{MP}_t = \Psi(\frac{D_t}{D_{t-1}} - 1)$	Regulation premium
$D_t = S_t D^F_t + D^D_t$	Total credit

Targeted macroprudential policy (capital controls)

$E_t[R^K_{t+1}] \; = E_t[(1+i^*_t)(1+\Phi^F_{t+1})(1+RP^{TMP}_t)]$	Lending rate for F
$E_t[R^K_{t+1}] \; = E_t[(1+i_t)(1+\Phi^D_{t+1})]$	Lending rate for D
$RP^{TMP}_t = \Psi(\frac{S_t D^F_t}{S_{t-1} D^F_{t-1}} - 1)$	Regulation premium

Monetary Policy

$$1 + i_t = [(1+i)\ (\pi_t)^{\epsilon_\pi} (Y_t/Y)^{\epsilon_Y}]^{\varpi} [1 + i_{t-1}]^{1-\varpi} \quad \text{Taylor rule}$$

where π_t is inflation and Y_t is output.

General Equilibrium

$Y_t = Y_{H,t} + Y_{X,t}$	Aggregate output
$Y_{H,t} = C_{H,t} + C^E_{H,t} + I_{H,t} + (1-\alpha)(\frac{P_{H,t}}{P_t})^{-\gamma}[\sum_{i=H,X} \frac{\Psi_i}{2}(\frac{P_{i,t}}{P_{i,t-1}} - 1)^2$ $+ \frac{\Psi_M}{2}(\frac{P_{M,t}}{P_{M,t-1}} - 1)^2 + \sum_{j=F,D} v^j_t \frac{R^K_t}{P_t} Q_{t-1} K^j_t]$.	Domestic goods equi.
$Y_{X,t} = C^*_{M,t} + C^{E*}_{M,t} + I^*_{M,t} + (\alpha^*)(\frac{P^*_{M,t}}{P^*_t})^{-\gamma}[\sum_{i=H,X} \frac{\Psi_i}{2}(\frac{P^*_{i,t}}{P^*_{i,t-1}} - 1)^2$ $+ \frac{\Psi_M}{2}(\frac{P^*_{M,t}}{P^*_{M,t-1}} - 1)^2 + v^*_t \frac{R^{K*}_t}{P^*_t} Q^*_{t-1} K^*_t]$.	Exported goods equi.
$S_t P_{X,t} Y_{X,t} - S_t P^*_t Y^*_{X,t} = S_t(1 + i^*_{t-1})(D^H_t \Psi_{D,t-1} + D^F_t) - S_t(D^H_{t+1} + D^F_{t+1})$,	Balance of Payments

where $Y_{X,t}$ is the foreign aggregate export demand for domestic goods and is determined endogenously in the foreign country block.

Table 2: Parameter Values for Consumption, Production, and Entrepreneur Sectors

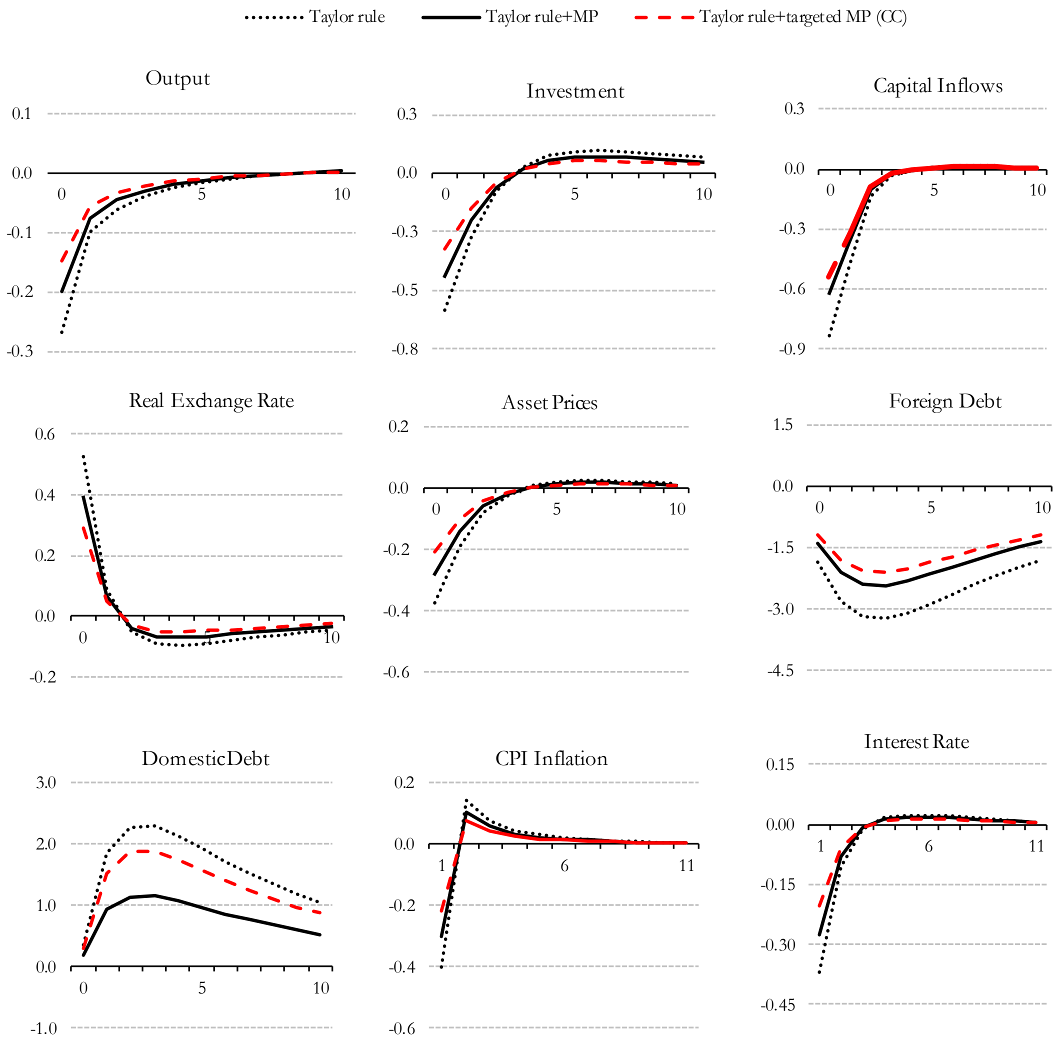
$\beta = 0.99$	Discount factor
$\sigma = 2$	Inverse of the intertemporal elasticity of substitution
$\gamma = 1$	Elasticity of substitution between domestic and foreign goods
$\varphi = 2$	Frisch elasticity of labour supply
$(1-\alpha) = 0.35$	Degree of openness
$\eta = 0.35$	Share of capital in production
$\lambda = 11$	Elasticity of substitution between domestic goods
$\delta = 0.025$	Quarterly rate of depreciation
$\Omega = 0.01$	Share of entrepreneurial labor
$\Psi_I = 12$	Investment adjustment cost
$\Psi_D = 0.0075$	Responsiveness of household risk premium to debt/GDP
$\Psi_i, \Psi_M = 120$	Price adjustment costs for $i = H, X$
$\varpi = 0.5$	Inertia in the policy rule
$\rho_{\varrho} = 0.5$	Persistence of the domestic perception shock
$\Phi_t = 0.02$	External risk premium
$\mu = 0.2$	Monitoring cost
$\vartheta = 0.9933$	Survival rate

Table 3: Welfare results

Policy regimes	Υ	Υ'
Taylor rule (TR)	0.73	1.19
Taylor rule with broad macroprudential policy (MP)	0.51	0.43
Taylor rule with targeted macroprudential policy (CC)	0.33	1.06
Optimal Taylor rule	-	-

Note: Υ and Υ' denote welfare losses in units of steady state consumption in the face of foreign interest rate shock only affecting the cost of foreign borrowing (Scenario 1) and both foreign and domestic borrowing (Scenario 2), respectively. Regarding policy coefficients, the coefficient of inflation is taken to be 1.5 and output gap 0.5 following the original Taylor estimates. Regarding *MP*, the coefficient of the relevant credit growth is set at 0.75.

Figure 1. A Positive Foreign Interest Rate Shock: Emerging Market Economy:
Taylor Rule, Taylor Rule+MP, Taylor Rule+targeted MP (CC)†
(percent deviations from the steady state)



Note: The figures show the impact of a 1% positive shock to foreign interest rate. The variables are presented as log deviations from the steady-state (except for interest rate), multiplied by 100 to have an interpretation of percentage deviations.

Figure 2. A Positive Foreign Interest Shock Scenario 2:
Taylor Rule, Taylor Rule+MP, TayloRule+targeted MP (CC)†
(percent deviations from the steady state)