



IMF Working Paper

Capital Flows and Financial Stability: Monetary Policy and Macroprudential Responses

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Research Department

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Abstract

The resumption of capital flows to emerging market economies since mid 2009 has posed two sets of interrelated challenges for policymakers: (i) to prevent capital flows from exacerbating overheating pressures and consequent inflation, and (ii) to minimize the risk that prolonged periods of easy financing conditions will undermine financial stability. While conventional monetary policy maintains its role in counteracting the former, there are doubts that it is sufficient to guard against the risks of financial instability. In this context, there have been increased calls for the development of macroprudential measures, with an explicit focus on systemwide financial risks. Against this background, this paper analyses the interplay between monetary policy and macroprudential regulations in an open economy DSGE model with nominal and real frictions. The key result is that macroprudential measures can usefully complement monetary policy. Even under the “optimal policy,” which calls for a rather aggressive monetary policy reaction to inflation, introducing macroprudential measures is found to be welfare improving. Broad macroprudential measures are shown to be more effective than those that discriminate against foreign liabilities (prudential capital controls). However, these measures are not a substitute for an appropriate monetary policy reaction. Moreover, macroprudential measures are less useful in helping economic stability under a technology shock.

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1 Introduction

Unusually strong cyclical and policy differences between advanced and emerging economies, and a gradual shift in portfolio allocation towards emerging markets, have led to capital flows into emerging market economies since mid-2009 (GFSR, 2010, WEO, 2011). This rapid resumption of capital inflows, which are large in historical context, has posed risks to macroeconomic and financial stability. To address these risks, policy makers have turned their attention to the use of macroprudential measures, in addition to monetary policy.

Past experience has shown that macroeconomic stability is not sufficient condition for financial stability. For example, prior to the crisis, financial imbalances built up in advanced economies despite stable growth and low inflation.¹ Moreover, microprudential regulation and supervision, which focus on ensuring safety and soundness of individual financial institutions, turned out to be inadequate as system-wide risks could not be contained. Hence, a different approach based on macroprudential supervision has started to be implemented in several emerging market economies.

Macroprudential measures are defined as regulatory policies that aim to reduce systemic risks, ensure stability of the financial system as whole against domestic and external shocks, and ensure that it continues to function effectively (BIS, 2010). During boom times, perceived risk declines; asset prices increase; and lending and leverage become mutually reinforcing. The opposite happens during a bust phase: a vicious cycle can arise between deleveraging, asset sales, and the real economy. This amplifying role of financial systems in propagating shocks—the so called “financial accelerator mechanism”, implies procyclicality of financial conditions.² In principle, macroprudential measures could address procyclicality of financial markets by making it harder to borrow during the boom times, and therefore make the subsequent reversal less dramatic, thus reducing the amplitude of the boom-bust cycles by design.

One initial question, however, is how a policy intervention to private borrowing decisions is justified in economic terms. This question can be answered in two main ways: first, by reference to negative externalities that arise because agents do not internalize the effect of their individual decisions, which are distorted towards excessive borrowing, on financial instability; and, second, by reference to the potential role of macroprudential regulations in mitigating standard Keynesian impacts of financial crisis that can not be ruled out by monetary and/or fiscal policies alone. There is a rapidly growing literature on both fronts. On the first, Jeanne and Korinek (2009), Korinek (2009), Bianchi (2009), and Bianchi and Mendoza (2011) focus on “overborrowing” and consequent externalities. In these papers, regulations induce agents to internalize their externalities and thereby increase macroeconomic stability. However, “overborrowing” is a model-specific feature. For example, Benigno et al. (2011) find that in normal times, “underborrowing” is much more likely to emerge rather than “overborrowing”.

This paper fits into the latter strand of research. Only recently have several studies started analyzing interactions between monetary policy and macropruden-

¹The environment of low interest rates may also be conducive to an increase in the risk appetite of financial intermediaries and investors—recently referred to as the “risk taking channel” of monetary policy—, and thus may favor build up of imbalances. See Borio and Zhu (2008), Altumbas et al. (2010), Dell’Ariccia et al. (2010) and Himenez et al. (2010) for a more in-depth discussion on the issue.

²See Craig et al. (2006) for evidence on the procyclicality of emerging financial markets.

tial measures. Angeloni and Faia (2009), Kannan et al. (2009), N'Diaye (2009), and Angelini et al. (2010) incorporate macroprudential instruments into general equilibrium models where monetary policy has a non-trivial role in stabilizing economy after a shock. However, all of these papers feature either a closed economy or do not explicitly model the financial sector. This paper complements the existing literature by adding an open economy dimension with a fully articulated financial sector from first principles. The analysis allows a quantitative assessment of alternative monetary and macroprudential responses to capital inflow surges. Also, we can assess the stabilization performance of macroprudential measures that discriminate against foreign liabilities - capital controls- as in the model entrepreneurs borrow from both domestic and foreign resources.

Both changes in policy interest rates and macroprudential measures are able to affect aggregate demand and supply as well as financial conditions in similar ways. On the one hand, monetary policy affects asset prices and financial markets in general. Indeed, asset prices are one channel via which monetary policy operates. On the other hand, macroprudential policies can have macroeconomic spillovers, through cushioning or amplifying the economic cycle, for example by directly affecting the provision of credit.

However, the two instruments are not perfect substitutes, and can usefully complement each other, especially in the presence of large capital inflows that tend to increase vulnerabilities of the financial system. First, the policy rate may be “too blunt” an instrument, as it impacts all lending activities regardless of whether they represent a risk to stability of the economy.³ The interest rate increase required to deleverage specific sectors might be so large as to result into unduly large aggregate economic volatility. By contrast, macroprudential regulations can be aimed specifically at markets in which the risk of financial stability is believed to be excessive.⁴ Second, in economies with open financial accounts, an increase in the interest rate might have only a limited impact on credit expansion if firms can borrow at a lower rate abroad. Moreover, although monetary transmission works well through the asset price channel in “normal” times, in “abnormal” times sizeable rapid changes in risk premiums could offset or diminish the impact of policy rate changes on credit growth and asset prices (Kohn, 2006; Bank of England, 2009). Third, and perhaps more importantly, interest rate movements aiming to ensure financial stability could be inconsistent with those required to achieve macroeconomic stability, and that discrepancy could risk de-anchoring inflation expectations (Borio and Lowe, 2002; Mishkin, 2007). For example, under an inflation targeting framework, if the inflation outlook is consistent with the target, a response to asset price fluctuations to maintain financial stability may damage the credibility of the policy framework.

We analyze the tradeoffs and complementarities between monetary policy and macroprudential measures in an open economy, New Keynesian DSGE model. The model features the financial accelerator mechanism developed by Bernanke et al. (1999), and draws on elements of models by Gertler et al. (2007), Kannan et al. (2009), and particularly Ozkan and Unsal (2010). The corporate sector plays a key role in the model - they decide the production and investment of capital which is an asset and a way of accumulating wealth. In order to finance their investments,

³See, among many others, Ostry et al (2010).

⁴The bluntness of the policy rate could also be its advantage over macroprudential measures as it is difficult to circumvent a rise in borrowing costs brought by policy rates in the same way as regulations can be avoided. See BIS (2010) and Ingves et al (2010).

corporations partially use internal funds. However, they also use external financing which is more costly, with the difference termed “the risk premium”, linking the terms of credit and balance sheet conditions. Macroprudential policy entails higher costs for financial intermediaries that are passed onto borrowers in the form of higher lending rates. Therefore, in the model, macroprudential ensures are defined as an additional “*regulation premium*” to the cost of borrowing that rises with nominal credit growth. This set up captures the notion that such measures make it harder for firms to borrow during boom times, and hence make the subsequent bust less dramatic.

The initial shock is modeled as a decline in investors’ perception of risk, which triggers capital inflows through the establishment of easier credit conditions. As financing costs decline, firms borrow and invest more. Stronger demand for goods and higher asset prices boost firms’ balance sheet and reduce the risk premium further. As capital inflows surge, the currency appreciates which helps limit overheating and inflation pressures. Eventually, higher leverage triggers an increase in risk premium, capital inflows slow and financial conditions normalize. But both monetary and macroprudential policies have a non-trivial role in mitigating the impact of the shocks.

The remainder of the paper is organized as follows. Section 2 sets-out the structure of our two-country DSGE model by describing household, firm and entrepreneurial behavior with a special emphasis on financial intermediaries and macroprudential policies. Section 3 describes the solution and the calibration of the model. Section 4 presents impulse responses to a financial shock and analyzes welfare performances of alternative policy responses. Finally, Section 5 provides the concluding remarks.

2 The Model

We develop a two-country sticky price DSGE model where both the trade and financial linkages between the two countries are fully specified. Three important modifications are introduced here. First, we incorporate macroprudential measures into the monetary policy framework in a relatively traceable manner. Second, we allow entrepreneurs to borrow both from domestic and foreign resources. As will be explained later, this is a crucial departure in order to differentiate macroprudential measures that discriminate against foreign liabilities (capital controls) from more broad-based measures. Third, capital inflows are modeled as a favorable change in the perception of lenders. As they become “overoptimistic” about the economy, financing conditions becomes easier. This is an intuitive, and likely realistic, representation of what is going on financial markets during sudden swings of capital across countries.

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 that sell the goods produced in the foreign economy 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.⁵ Finally, there are competitive firms that combine investment with rented capital to produce unfinished capital goods that are then sold to entrepreneurs.

Entrepreneurs play a major role in the model. They produce capital which is rented to production firms and finance their investment in capital through internal funds as well as external borrowing; however, agency costs make the latter more expensive than the former. As monitoring the business activity of borrowers is a costly activity, lenders must be compensated by an external finance premium in addition to the international interest rate. The magnitude of this premium varies with the leverage of the entrepreneurs, linking the terms of credit to balance sheet conditions.

The model for the small open economy (SOE) is presented in this section and we use a simplified version of the model for the rest of the world (ROW). In what follows, variables without superscripts refer to the home economy, while variables with a star indicate the foreign economy variables (unless indicated otherwise).

2.1 Households

A representative household is infinitely-lived and seeks to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{H_t^{1+\varphi}}{1+\varphi} \right), \quad (1)$$

where C_t is a composite consumption index, H_t is hours of work, E_t is the mathematical expectation conditional upon information available at t , β is the representative consumer's subjective discount factor where $0 < \beta < 1$, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution and $\varphi > 0$ is the inverse elasticity of labour supply.

The composite consumption index, C_t , is given by:

$$C_t = \left[\alpha^{\frac{1}{\gamma}} C_{H,t}^{(\gamma-1)/\gamma} + (1-\alpha)^{\frac{1}{\gamma}} C_{M,t}^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-1)}, \quad (2)$$

where $C_{H,t}$ and $C_{M,t}$ are CES indices of consumption of domestic and foreign goods, represented by:

$$C_{H,t} = \left[\int_0^1 C_{H,t}(j)^{(\lambda-1)/\lambda} dj \right]^{\lambda/(\lambda-1)} ; C_{M,t} = \left[\int_0^1 C_{M,t}(j)^{(\lambda-1)/\lambda} dj \right]^{\lambda/(\lambda-1)},$$

where $j \in [0, 1]$ indicates the goods varieties and $\lambda > 1$ is the elasticity of substitution among goods produced within a country. Equation (2) suggests that the expenditure share of the domestically produced goods in the consumption basket of households is given by α and $0 < \alpha < 1$.⁶

The real exchange rate REX_t is defined as $REX_t = \frac{S_t P_t^*}{P_t}$, where S_t is the nominal exchange rate, domestic currency price of foreign currency, and $P_t^* \equiv$

⁵This is motivated by the considerable empirical evidence of pricing-to-market and incomplete exchange rate pass-through for small open economies as analyzed by Naug and Nymoen (1996) and Campa and Goldberg (2005). See Golberg and Knetter (1997) for a detailed survey.

⁶Demand for home and foreign goods is derived from the household's minimization of expenditure, conditional on total composite demand, and is as follows:

$$C_{H,t} = \alpha \left(\frac{P_{H,t}}{P_t} \right)^{-\gamma} C_t,$$

$\left[\int_0^1 P_t^*(j)^{1-\lambda} dj\right]^{1/(1-\lambda)}$ is the aggregate price index for foreign country's consumption goods in foreign currency. In contrast to standard open economy models, our two-country framework enables us to determine P_t^* endogenously in the ROW block.

Households participate in domestic and foreign financial markets: they deposit their savings in domestic currency, D_t^D , or they can borrow from international financial markets in foreign currency, D_t^H , with a nominal interest rate of i_t and $i_t^* \Psi_{D,t}$. Due to imperfect capital mobility, households need to pay a premium, $\Psi_{D,t}$, given by $\Psi_{D,t} = \frac{\Psi_D}{2} [\exp(\frac{S_t D_{t+1}^H}{P_t GDP_t} - \frac{S D^H}{PGDP}) - 1]^2$ when they borrow from the rest of the world.⁷ Households own all home production and the importing firms and thus are recipients of profits, Π_t . Other sources of income for the representative household are wages W_t , and new borrowing net of interest payments on outstanding debts, both in domestic and foreign currency. Then, the representative household's budget constraint in period t can be written as follows:

$$P_t C_t + (1 + i_{t-1})B_t + (1 + i_{t-1}^*)\Psi_{D,t-1}S_t D_t^H = W_t H_t + B_{t+1} + S_t D_{t+1}^H + \Pi_t. \quad (3)$$

The representative household chooses the paths for $\{C_t, H_t, B_{t+1}, D_{t+1}^H\}_{t=0}^{\infty}$ in order to maximize its expected lifetime utility in (1) subject to the budget constraint in (3).⁸

2.2 Firms

2.2.1 Production Firms

Each firm produces a differentiated good indexed by $j \in [0, 1]$ using the production function:

$$Y_t(j) = A_t N_t(j)^{1-\eta} K_t(j)^\eta, \quad (4)$$

where A_t denotes labor productivity, common to all the production firms and $N_t(j)$ is the labor input which is a composite of household, $H_t(j)$, and entrepreneurial labor,

$$C_{M,t} = (1 - \alpha) \left(\frac{P_{M,t}}{P_t}\right)^{-\gamma} C_t,$$

and the corresponding price index is given by:

$$P_t = [\alpha P_{H,t}^{1-\gamma} + (1 - \alpha) P_{M,t}^{1-\gamma}]^{1/(1-\gamma)},$$

where $P_{H,t}$ and $P_{M,t}$ represent the prices for domestic and imported goods and P_t denotes the consumer price index (CPI).

⁷Following Schmitt-Grohe and Uribe (2003), this premium is introduced for technical reasons to maintain the stationarity in the economy's net foreign assets. As in Schmidt-Grohe and Uribe, we assume that the elasticity of the premium with respect to the debt is very close to zero ($\Psi_D = 0.0075$) so that the dynamics of the model are not affected by this friction.

⁸The first order conditions for this optimization problem are given by:

$$\frac{H_t^\varphi}{C_t^{-\sigma}} = \frac{W_t}{P_t},$$

$$C_t^{-\sigma} = \beta(1 + i_t)E_t[C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}}],$$

$$C_t^{-\sigma} = \beta(1 + i_t^*)\Psi_{D,t}E_t[C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \frac{S_{t+1}}{S_t}].$$

In the absence of financial frictions, last two equations would yield the standard uncovered interest rate parity condition.

$H_t^E(j)$; defined as $N_t(j) = H_t(j)^{1-\Omega} H_t^E(j)^\Omega$. $K_t(j)$ denotes capital provided by the entrepreneur, as is explored in the following subsection.

Assuming that the price of each input is taken as given, the production firms minimize their costs subject to (4).⁹

Firms have some market power and they segment domestic and foreign markets with local currency pricing, where $P_{H,t}(j)$ and $P_{X,t}(j)$ denote price in domestic market (in domestic currency) and price in foreign market (in foreign currency). Firms also face quadratic menu costs in changing prices expressed in the units of consumption basket given by $\frac{\Psi_i}{2} \left(\frac{P_{i,t}(j)}{P_{i,t-1}(j)} - 1 \right)^2$ for different market destinations $i = H, X$. This generates a gradual adjustment in the prices of goods in both markets, as suggested by Rotemberg (1982). The combination of local currency pricing together with nominal price rigidities implies that fluctuations in the nominal exchange rate have a smaller impact on export prices so that exchange rate pass-through to export prices is incomplete in the short run.

As firms are owned by domestic households, the individual firm maximizes its expected value of future profits using the household's intertemporal rate of substitution in consumption, given by $\beta^t U_{c,t}$. The objective function of firm j can thus be written as:

$$E_o \sum_{t=0}^{\infty} \frac{\beta^t U_{c,t}}{P_t} [P_{H,t}(j) Y_{H,t}(j) + S_t P_{X,t}(j) Y_{X,t}(j) - MC_t Y_t(j) - P_t \sum_{i=H,X} \frac{\Psi_i}{2} \left(\frac{P_{i,t}(j)}{P_{i,t-1}(j)} - 1 \right)^2], \quad (5)$$

where $Y_{H,t}(j)$ and $Y_{X,t}(j)$ represent domestic and foreign demand for the domestically produced good j . We assume that different varieties have the same elasticities in both markets, so that the demand for good j can be written as,

$$Y_{i,t}(j) = \left(\frac{P_{i,t}(j)}{P_{i,t}} \right)^{-\lambda} Y_{i,t}, \quad \text{for } i = H, X, \quad (6)$$

where $P_{H,t}$ is the aggregate price index for goods sold in domestic market, as is defined earlier and $P_{X,t}$ is the export price index given by $P_{X,t} \equiv [\int_0^1 P_{X,t}(j)^{1-\lambda} dj]^{1/(1-\lambda)}$.

$Y_{X,t}$ denotes the foreign aggregate export demand for domestic goods and is given by:

$$Y_{X,t} = \alpha^* \left(\frac{P_{X,t}}{P_t^*} \right)^{-\gamma^*} Y_t^*, \quad (7)$$

where α^* denotes the fraction of world demand for domestic country's exports, γ^* is the price elasticity of global demand for domestic output and P_t^* is the foreign price level expressed in terms of the foreign currency.¹⁰

⁹Omitting the firm-specific indices for notational simplicity, cost minimizing behavior implies the following first order conditions:

$$R_t = \frac{\eta Y_t MC_t}{K_t},$$

where W_t^E is the entrepreneurial wage rate, R_t is the rental rate of capital and MC_t is the (nominal) marginal cost given by $MC_t = \frac{R_t^\eta W_t^{1-\eta}}{A_t \eta^\eta (1-\eta)^{1-\eta}}$.

¹⁰Since the profit maximization condition is symmetric among firms, the optimal price setting

2.2.2 Importing Firms

There is a set of monopolistically competitive importing firms, owned by domestic households, who buy foreign goods at prices $S_t P_t^*$ and then sell to the domestic market. They are also subject to a price adjustment cost with $\Psi_M \succeq 0$, the cost of price adjustment parameter, analogous to the production firms. This implies that there is some delay between exchange rates changes and the import price adjustments so that the short run exchange rate pass through to import prices is also incomplete. The price index for the imported goods is then given by:

$$P_{M,t} = \frac{\lambda}{\lambda-1} S_t P_t^* - \frac{\Psi_M}{\lambda-1} \frac{P_t}{Y_{M,t}} \frac{P_{M,t}}{P_{M,t-1}} \left(\frac{P_{M,t}}{P_{M,t-1}} - 1 \right) + \frac{\Psi_M}{\lambda-1} E_t \left[\Theta_t \frac{P_{t+1}}{Y_{M,t}} \frac{P_{M,t+1}}{P_{M,t}} \left(\frac{P_{M,t+1}}{P_{M,t}} - 1 \right) \right], \quad (8)$$

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

2.2.3 Unfinished Capital Producing Firms

Let I_t denote aggregate investment in period t , which is composed of domestic and final goods:

$$I_t = \left[\alpha^{\frac{1}{\gamma}} I_{H,t}^{(\gamma-1)/\gamma} + (1-\alpha)^{\frac{1}{\gamma}} I_{M,t}^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-1)}, \quad (9)$$

where the domestic and imported investment goods' prices are assumed to be the same as the domestic and import consumer goods prices, $P_{H,t}$ and $P_{M,t}$. The new capital stock requires the same combination of domestic and foreign goods so that the nominal price of a unit of investment equals the price level, P_t . This implies that $I_{H,t} = \alpha \left(\frac{P_{H,t}}{P_t} \right)^{-\gamma} I_t$ and $I_{M,t} = (1-\alpha) \left(\frac{P_{M,t}}{P_t} \right)^{-\gamma} I_t$.

Competitive firms use investment as an input, I_t and combine it with rented capital K_t to produce unfinished capital goods. Following Kiyotaki and Moore (1997), we assume that the marginal return to investment in terms of capital goods is decreasing in the amount of investment undertaken (relative to the current capital stock) due to the existence of adjustment costs, represented by $\frac{\Psi_I}{2} \left(\frac{I_t}{K_t} - \delta \right)^2$ where δ is the depreciation rate. Then, the production technology of the firms producing unfinished capital can be represented by $\Xi_t(I_t, K_t) = \left[\frac{I_t}{K_t} - \frac{\Psi_I}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 \right] K_t$ which exhibits constant returns to scale so that the unfinished capital producing firms earn

equations can be written in aggregate terms as follows

$$P_{H,t} = \frac{\lambda}{\lambda-1} MC_t - \frac{\Psi_H}{\lambda-1} \frac{P_t}{Y_{H,t}} \frac{P_{H,t}}{P_{H,t-1}} \left(\frac{P_{H,t}}{P_{H,t-1}} - 1 \right) + \frac{\Psi_H}{\lambda-1} E_t \left[\Theta_t \frac{P_{t+1}}{Y_{H,t}} \frac{P_{H,t+1}}{P_{H,t}} \left(\frac{P_{H,t+1}}{P_{H,t}} - 1 \right) \right],$$

$$S_t P_{X,t} = \frac{\lambda}{\lambda-1} MC_t - \frac{\Psi_X}{\lambda-1} \frac{P_t}{Y_{X,t}} \frac{P_{X,t}}{P_{X,t-1}} \left(\frac{P_{X,t}}{P_{X,t-1}} - 1 \right) + \frac{\Psi_X}{\lambda-1} E_t \left[\Theta_t \frac{P_{t+1}}{Y_{X,t}} \frac{P_{X,t+1}}{P_{X,t}} \left(\frac{P_{X,t+1}}{P_{X,t}} - 1 \right) \right],$$

where $\Theta_t = \beta \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}}$.

zero profit in equilibrium. The stock of capital used by the firms in the economy evolves according to:

$$K_{t+1} = \left[\frac{I_t}{K_t} - \frac{\Psi_I}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 \right] K_t + (1 - \delta) K_t. \quad (10)$$

The optimality condition for the unfinished capital producing firms with respect to the choice of I_t yields the following nominal price of a unit of capital Q_t :

$$\frac{Q_t}{P_t} = [1 - \Psi_I \left(\frac{I_t}{K_t} - \delta \right)]^{-1}. \quad (11)$$

2.3 Entrepreneurs

The key players of the model are entrepreneurs. They transform unfinished capital goods and sell them to the production firms. They finance their investment by borrowing from domestic lenders and foreign lenders, channeled through perfectly competitive financial intermediaries. We denote variables for entrepreneurs borrowing from domestic resources with superscript D , and entrepreneurs borrowing from foreign resources with superscript F . In the absence of cost differences, entrepreneurs would be indifferent between borrowing from domestic and foreign resources, and therefore the amount borrowed from domestic and foreign resources would be equal.

There is a continuum of entrepreneurs indexed by k in the interval $[0,1]$. Each entrepreneur has access to a stochastic technology in transforming $K_{t+1}^v(k)$ units of unfinished capital into $\omega_{t+1}^v(k)K_{t+1}^v(k)$ units of finished capital goods, where v is either F or D . The idiosyncratic productivity $\omega_t(k)$ is assumed to be *i.i.d.* (across time and across firms), drawn from a distribution $F(\cdot)$, with p.d.f of $f(\cdot)$ and $E(\cdot) = 1$.¹¹

At the end of period t , each entrepreneur k of type v has net worth denominated in domestic currency, $NW_t^v(k)$. The budget constraints of the entrepreneurs for two different types are defined as follows:

$$P_t NW_t^F(k) = Q_t K_{t+1}^F(k) - S_t D_{t+1}^F(k), \quad (12)$$

$$P_t NW_t^D(k) = Q_t K_{t+1}^D(k) - D_{t+1}^D(k), \quad (13)$$

where D_{t+1}^F and D_{t+1}^D denote foreign currency denominated debt and domestic currency denominated debt respectively. Equations (12 and 13) simply state that capital financing is divided between net worth and debt.

Productivity is observed by the entrepreneur, but not by the lenders who have imperfect knowledge of the distribution of $\omega_{t+1}^v(k)$. Following Curdia (2007, 2008) we specify the lenders' perception of $\omega_{t+1}^v(k)$ as given by $\omega_{t+1}^{v*}(k) = \omega_{t+1}^v(k) \varrho_t^v$ where ϱ_t^v is the misperception factor over a given interval $[0,1]$. Further, the misperception factor, ϱ_t^v , is assumed to follow $\ln(\varrho_t^v) = \rho_\varrho \ln(\varrho_{t-1}^v) + \varepsilon_\varrho^v$ where ρ_ϱ denotes the persistence parameter. We take the origin of the capital inflows as a change in lenders' perception regarding idiosyncratic productivity (ε_ϱ^v).¹²

¹¹The idiosyncratic productivity is assumed to be distributed log-normally; $\log(\omega_t(k)) \sim N(\frac{-1}{2}\sigma_\omega^2, \sigma_\omega^2)$. This characterization is similar to that in Carlstrom and Fuerst (1997), Bernanke et al. (1999), Cespedes et al. (2004) and Gertler et al. (2007).

¹²We assume that when there is uncertainty about the underlying distribution, lenders take the worst case scenario as the mean of the distribution of $\omega_{t+1}^v(k)$. See Appendix in Ozkan and Unsal (2010) for more details on the specification of the ambiguity aversion faced by lenders.

Entrepreneurs observe $\omega_{t+1}^v(k)$ *ex-post*, but the lenders can only observe it at a monitoring cost which is assumed to be a certain fraction (μ) of the return.¹³ As shown by Bernanke et al. (1999), the optimal contract between the lender and the entrepreneur is a standard debt contract characterized by a default threshold, $\bar{\omega}_{t+1}^v(k)$, such that if $\omega_{t+1}^v(k) \geq \bar{\omega}_{t+1}^v(k)$, the lender receives a fixed return in the form of a contracted interest on the debt. If $\omega_{t+1}^v(k) < \bar{\omega}_{t+1}^v(k)$, then the borrower defaults, the lender audits by paying the monitoring cost and keeps what it finds. Therefore, we can define the expected return to entrepreneurs lenders, respectively, for $v = F, D$ as follows:

$$\begin{aligned} & E_t[R_{t+1}^{Kv} Q_t K_{t+1}^v(k) (\int_{\bar{\omega}_{t+1}^v(k)}^{\infty} \omega^v(k) f(\omega^v) d\omega^v - \bar{\omega}_{t+1}^v(k) \int_{\bar{\omega}_{t+1}^v(k)}^{\infty} f(\omega^v) d\omega^v)] \\ = & E_t[R_{t+1}^{Kv} Q_t K_{t+1}^v(k) z^v(\bar{\omega}_{t+1}^v(k))], \end{aligned} \quad (14)$$

$$\begin{aligned} & E_t[R_{t+1}^K Q_t K_{t+1}^v(k) (\bar{\omega}_{t+1}^{v*}(k) \int_{\bar{\omega}_{t+1}^{v*}(k)}^{\infty} f(\omega^{v*}) d\omega^{v*} \\ & + (1 - \mu) \int_0^{\bar{\omega}_{t+1}^{v*}(k)} \omega_{t+1}^{v*}(k) f(\omega^{v*}) d\omega^{v*})] \\ = & E_t[R_{t+1}^K Q_t K_{t+1}^v(k) g^v(\bar{\omega}_{t+1}^v(k); \varrho_t^v)], \end{aligned} \quad (15)$$

where R_t^K denotes the *ex-post* realization of return to capital, and is the same regardless of the source of the financing due to arbitrage. $z^v(\bar{\omega})$ is the borrowers' share of the total return. We use the definition of the lender's perception of productivity shock $\omega_{t+1}^{v*}(k)$ in Equation (15) where $g^v(\bar{\omega}^v(k); \varrho^v)$ represents the lenders' share of the total return, itself a function of both the idiosyncratic shock and the perception factor.

Clearly, for domestic and foreign lenders, the opportunity cost of lending to the entrepreneur is the domestic interest rate $(1 + i_t)$ and $(1 + i_t^*)$. Thus the loan contract must satisfy the following for the lenders to be willing to participate in it:

$$E_t\left[\frac{R_{t+1}^K Q_t K_{t+1}^F(k)}{S_{t+1}} g^F(\bar{\omega}_{t+1}^F(k); \varrho_t^F)\right] = (1 + i_t^*) D_{t+1}^F(k). \quad (16)$$

$$E_t[R_{t+1}^K Q_t K_{t+1}^D(k) g^D(\bar{\omega}_{t+1}^D(k); \varrho_t^D)] = (1 + i_t) D_{t+1}^D(k). \quad (17)$$

The optimal contracting problem identifies the capital demand of entrepreneurs, $K_{t+1}^v(k)$ and a cut off value, $\bar{\omega}_{t+1}^v(k)$ such that the entrepreneurs will maximize (14) subject to (16) and (17). The first order conditions yield:

$$E_t[R_{t+1}^K] = E_t[(1 + i_t^*)(1 + \Phi_{t+1}^F)], \quad (18)$$

$$E_t[R_{t+1}^K] = E_t[(1 + i_t)(1 + \Phi_{t+1}^D)], \quad (19)$$

¹³This corresponds to the costly state verification problem indicated by Gale and Hellwig (1985).

where $(1 + \Phi_{t+1}^F)$ and $(1 + \Phi_{t+1}^D)$ are the external risk premium on foreign and domestic borrowing defined by:

$$1 + \Phi_{t+1}^F = \left[\frac{z^{F'}(\bar{\omega}_{t+1}^F(k))}{g^F(\bar{\omega}_{t+1}^F(k); \varrho_t^F) z^{F'}(\bar{\omega}_{t+1}^F(k)) - z^F(\bar{\omega}_{t+1}^F(k)) g^{F'}(\bar{\omega}_{t+1}^F(k); \varrho_t^F)} \right] E_t \left\{ \frac{S_{t+1}}{S_t} \right\}. \quad (20)$$

$$1 + \Phi_{t+1}^D = \left[\frac{z^{D'}(\bar{\omega}_{t+1}^D(k))}{g^D(\bar{\omega}_{t+1}^D(k); \varrho_t^D) z^{D'}(\bar{\omega}_{t+1}^D(k)) - z^D(\bar{\omega}_{t+1}^D(k)) g^{D'}(\bar{\omega}_{t+1}^D(k); \varrho_t^D)} \right]. \quad (21)$$

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 risk premium. Therefore, any shock that has a negative (positive) impact on the entrepreneurs' net worth increases (decreases) their leverage, resulting in an upward (downward) adjustment in the external risk premium.

In order to guarantee that self financing never occurs and borrowing constraints on debt are always binding, we follow Kiyotaki and Moore (1997) and Carlstrom and Fuerst (1997), in assuming that a proportion of entrepreneurs die in each period to be replaced by new-comers. Given that $\omega^v(k)$ is independent of all other shocks and identical across time and across entrepreneurs, all entrepreneurs are identical *ex-ante*. Then, each entrepreneur faces the same financial contract specified by the cut off value and the external finance premium. This allows us to specify the rest of the model in aggregate terms.

At the beginning of period t , the entrepreneurs collect revenues and repay their debt contracted at period $t - 1$. Denoting the fraction of entrepreneurs who survive each period by ϑ , the net worth can be expressed as follows:

$$P_t NW_t^v = \vartheta [R_t^K Q_{t-1} K_t^v z^v(\bar{\omega}_t^v)] + W_t^{vE}. \quad (22)$$

Equation (22) indicates that the entrepreneur's net worth is made up of the return on investment and the entrepreneurial wage income. Given that the borrower's and the lender's share of total return should add up to $z^v(\bar{\omega}_t^v) + g^v(\bar{\omega}_t^v, \varrho_t^v) = 1 - \nu_t^v$ (where ν_t^v is the cost of monitoring, a deadweight loss associated with financial frictions) and by using the participation constraint (16), we can rewrite the net worth of the entrepreneurs borrowing from foreign and domestic sources as:

$$P_t NW_t^F = \vartheta [R_t^K Q_{t-1} K_t^F (1 - \nu_t^F) - (1 + i_{t-1}^*) S_t D_t^F] + W_t^{FE}. \quad (23)$$

$$P_t NW_t^D = \vartheta [R_t^K Q_{t-1} K_t^D (1 - \nu_t^D) - (1 + i_{t-1}) D_t^D] + W_t^{DE}. \quad (24)$$

The entrepreneurs leaving the scene at time t consume their return on capital. The consumption of the exiting entrepreneurs, C_t^{vE} , can then be written as:¹⁴

¹⁴It is assumed that the entrepreneurs consume an identical mix of domestic and foreign goods in their consumption basket as is given by the composite consumption index in equation (2). Therefore the entrepreneurs' demand for domestic and imported consumption goods are given by:

$$C_{H,t}^{vE} = \alpha \left(\frac{P_{H,t}}{P_t} \right)^{-\gamma} C_t^{vE},$$

$$P_t C_t^{FE} = (1 - \vartheta)[R_t^K Q_{t-1} K_t^F (1 - \nu_t^F) - (1 + i_{t-1}^*) S_t D_t^F]. \quad (25)$$

$$P_t C_t^{DE} = (1 - \vartheta)[R_t^K Q_{t-1} K_t^D (1 - \nu_t^D) - (1 + i_{t-1}) D_t^D]. \quad (26)$$

The total capital in the economy is $K_t = K_t^F + K_t^D$. Because of investment adjustment costs and incomplete capital depreciation, entrepreneurs' return on capital on average is not identical to the rental rate of capital, R_t . The entrepreneurs' return on capital is the sum of the rental rate on capital paid by the firms that produce final consumption goods, the rental rate on used capital from the firms that produce unfinished capital goods, and the value of the non-depreciated capital stock, after the adjustment for the fluctuations in the asset prices ($\frac{Q_{t+1}}{Q_t}$):

$$E_t[R_{t+1}^K] = E_t\left[\frac{R_{t+1}}{Q_t} + \frac{Q_{t+1}}{Q_t}\left\{(1 - \delta) + \Psi_I\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\frac{I_{t+1}}{K_{t+1}} - \frac{\Psi_I}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)^2\right\}\right].$$

2.4 Financial Intermediaries and Macroprudential Policy

There exists a continuum of perfectly competitive financial intermediaries which collect deposits from households and loan the money out to entrepreneurs in each period. They also receive capital inflows from the ROW in the form of foreign loans to domestic entrepreneurs. The sum of deposits and capital inflows make up the total supply of loanable funds. The zero profit condition on financial intermediaries implies that the lending rates are just equal to $E_t[(1 + i_t^*)(1 + \Phi_{t+1}^F)]$ and $E_t[(1 + i_t)(1 + \Phi_{t+1}^D)]$ in the absence of macroprudential measures.

Either in the form of capital requirements or loan-to-value ceiling, or some other type, macroprudential policy entails higher costs for financial intermediaries. Rather than driving the impact of a particular type of macroprudential measure on the borrowing cost, we follow Kannan et al. (2009) and focus on a generic case where macroprudential measures lead to additional cost to financial intermediaries. These costs are then reflected to borrowers in the form of higher interest rates.¹⁵ The increase in the lending rates brought by macroprudential measures are named as “regulation premium” and is linked to nominal credit growth, rising as credit growth increases.¹⁶ Macroprudential policy is therefore countercyclical by design: countervailing to the natural decline in perceived risk in good times and the subsequent rise in the perceived risk in bad times.

In the presence of macroprudential regulations, the spread between lending rate and policy rate is affected by both the risk premium and “the regulation premium”. Hence, the lending costs for foreign borrowing and domestic borrowing, equations

$$C_{M,t}^{vE} = (1 - \alpha)\left(\frac{P_{M,t}}{P_t}\right)^{-\gamma} C_t^{vE}.$$

¹⁵By adopting a more elaborate banking sector, Angeloni and Faia (2009), Angelini et al. (2010), and Gertler et al. (2010) show that macroprudential measures in fact lead to increase in cost of borrowing. In an open economy framework, following a similar approach would make the model hardly tracable. Therefore, we use a simpler specification here, and leave analysis of frictions related to financial intermediaries for future work.

¹⁶See Borio and Drehman (2009), Borge and others (2009), Gerdesmeier and others (2009) for a specific emphasize on the potential of nominal credit growth in a regulation tool.

(18) and (19), become:

$$E_t[R_{t+1}^{LF}] = E_t[(1 + i_t^*)(1 + \Phi_{t+1}^F)(1 + RP_t)], \quad (27)$$

$$E_t[R_{t+1}^{LD}] = E_t[(1 + i_t)(1 + \Phi_{t+1}^D)(1 + RP_t)], \quad (28)$$

where RP_t is the regulation premium, which is defined in the baseline case a function of the aggregate nominal credit growth:

$$RP_t = \Psi\left(\frac{D_t}{D_{t-1}} - 1\right) \quad (29)$$

where $D_t = S_t D_t^F + D_t^D$. In this definition of macroprudential policy, it is implicit that the policy objective is defined in terms of aggregate credit activity. However, it should be noted that in the case of macroprudential measures that discriminate against foreign liabilities, the regulation premium only applies to foreign borrowing (27) and macroprudential policy instrument (RP_t) is defined only in terms of growth of nominal credit from foreign credit.

2.5 Monetary Policy

In the baseline calibration, we adopt a standard formulation for the structure of monetary policy-making. We assume that the interest rate rule is of the following form:

$$1 + i_t = (1 + i_{t-1})^\varsigma ((1 + i) (\pi_t)^{\epsilon_\pi} (Y_t/Y)^{\epsilon_Y})^{1-\varsigma}, \quad (30)$$

where i and Y denote the steady-state level of nominal interest rate and output, and π_t is the CPI inflation.

The foreign variables Y_t^* , P_t^* and i_t^* are endogenously determined in the ROW block of the model. Although asymmetric in size, SOE and ROW share the same preferences, technology and market structure for consumption and capital goods. We also assume an identical characterization for monetary policy in the SOE and the ROW.

3 Solution and Model Parametrization

We first transform the model to reach a stationary representation where a steady state exists. The model is then solved numerically up to a second order approximation using Sims (2005).¹⁷ Our choice of parameter values used in the calibration is explained in the next section.

3.1 Consumption, Production and Monetary Policy

We set the discount factor, β at 0.99, implying a riskless annual return of approximately 4 per cent in the steady state (time is measured in quarters). The inverse of the elasticity of intertemporal substitution is taken as $\sigma = 1$, which corresponds to log utility. The inverse of the elasticity of labour supply φ is set to 2, which implies that 1/2 of the time is spent on working. We set the degree of openness, $1 - \alpha$, to

¹⁷The non-stochastic steady state of the model is solved numerically in MATLAB, and then the second order approximation of the model and the stochastic simulations are computed using Michel Juillard's software Dynare. Details of the computation of the non-stochastic steady state and the stationary model equations are available upon request.

Table 1: Parameter Values for Consumption, Production Sectors and Monetary Policy

$\beta = 0.99$	Discount factor
$\sigma = 1$	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
$\alpha^* = 0.1$	Share of exports in foreign demand
$\gamma^* = 1$	Foreign demand price elasticity
$\Psi_I = 12$	Investment adjustment cost
$\Psi_D = 0.0075$	Responsiveness of household risk premium to debt/GDP
$\Psi_i, \Psi_M = 120$	Price adjustment costs for $i = H, X$
$\epsilon_\pi = 1.5$	Coefficient of CPI inflation in the policy rule
$\epsilon_Y = 0.5$	Coefficient of output gap in the policy rule
ρ_ϱ	Persistence of the domestic perception shock

be 0.35 which is within the range of the values used in the literature.¹⁸ The share of capital in production, η , is taken to be 0.35 consistent with other studies.¹⁹ 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 0.025, a conventional value used in the literature. Similar to Gertler et al. (2007), we set the share of entrepreneurs' labour, Ω , at 0.01, implying that 1 per cent of the total wage bill goes to the entrepreneurs. With regard to the parameters of export demand, we follow Curdia (2007, 2008), and assume that exports constitute 10 per cent of the total foreign demand and thus set α^* at 0.1 with a price elasticity of unity, $\gamma^* = 1$. In the baseline calibration, we use the original Taylor estimates and set $\epsilon_\pi = 1.5$ and $\epsilon_Y = 0.5$, and the degree of interest rate smoothing parameter (ς) is chosen as 0.5. ρ_ϱ is assumed to 0.5, so that it takes 9 quarters for the shock to die away. Table 1 summarizes the parametrization of the model for consumption, production, and monetary policy used in the baseline calibration.²⁰

¹⁸The values set in the literature for openness range between 0.25 (Cook, 2004; Elekdag and Tchakarov, 2007) and 0.5 (Gertler et al., 2007). We choose to set a middle value of the range.

¹⁹See, for example, Cespedes et al. (2004) and Elekdag and Tchakarov (2007).

²⁰We carry out several sensitivity analyses in order to assess robustness of our results under the benchmark calibration. To conserve space, we don't report these results here but they are available upon request.

Table 2: Parameter Values for the Entrepreneurial Sector

Domestic Economy	
$\Phi_t = 0.02$	External risk premium
$\mu = 0.2$	Monitoring cost
$\vartheta = 0.9933$	Survival rate
Rest of the World	
$\Phi_t^* = 0.005$	External risk premium
$\mu^* = 0.12$	Monitoring cost
$\vartheta = 0.9966$	Survival rate

3.2 Entrepreneurs

The parameter values for the entrepreneurial sector in the SOE and ROW are set to reflect their defining characteristics and are listed in Table 2. We set the steady state leverage ratio and the value of quarterly external risk premium in the domestic economy at 0.3 and 200 basis points, reflecting the historical average of emerging market economies within the last decade.²¹ The monitoring cost parameter, μ , is taken as 0.2 for the SOE as in Devereux et al. (2006). These parameter values imply a survival rate, ϑ , of approximately 99.33 per cent in the SOE.

For the ROW, we closely follow Bernanke et al. (1999). The foreign leverage ratio is set to 0.5. The risk spread of 2 per cent in the steady state is reported for the U.S. economy so we set a quarterly external risk premium, Φ_t^* , of 0.005. The cost of monitoring, denoted by μ^* , is taken to be 0.12. Given these parameter values, the implied survival rate is 99.66 per cent in the ROW. A higher leverage ratio for entrepreneurs in foreign economy reflects the fact that advanced economies have deeper and more sophisticated financial markets, and therefore there are likely to be better financing opportunities for firms in these economies, leading to a higher economy-wide leverage. Moreover, after having experienced dramatic financial crises in the 90s and at the beginning of the century, many emerging market economies have been more vigilant towards lending activities through tighter financial regulation, which in many cases has helped to avoid high leverage.²²

4 Interactions between Macprudential and Monetary Policies when Capital Inflows Surge

In what follows, we explore how an unanticipated (temporary) favorable shock to the investors' perception of the entrepreneurs' productivity is transmitted to the rest

²¹This is the average number for emerging Americas, emerging Asia, and emerging Europe between 2000-2010. Wordscope data (debt as a percentage of assets- data item WS 08236) is used for the leverage ratio. External risk premium is calculated as the difference between lending and policy rate for emerging market countries, where available, using data from Haver Analytics for the same time period. Variations in these parameters affect our results only quantitatively, but not qualitatively.

²²See Kalemli-Ozcan et al. (2011) for stylized facts on bank and firm leverage for 2000- 2009 for both advanced and emerging economies.

of the economy and the role of monetary and macroprudential policies in mitigating the impact of the shock. We present responses of the economy to an unanticipated 1 percent reduction of perceived risk, which results in an increase in capital flows of about 0.1 percent of output.

When the investors' perception of entrepreneurs' productivity changes, lending to domestic entrepreneurs becomes less risky, and this leads to a decline in the external risk premium on impact. As the cost of borrowing declines, entrepreneurs increase their use of external financing by undertaking more projects. Higher borrowing also increases the future supply of capital and hence brings about a raise in investment in the economy. Therefore output increases and the real exchange rate appreciates. The surge in capital inflows also increases the demand for domestic currency, leading to its appreciation. For the entrepreneurs' whose borrowing is denominated in foreign currency, this unanticipated change in the exchange rate also creates balance sheet effects through a decline in the real debt burden. The outcome is higher demand and inflation pressures, together with a boom in credit growth in the economy following the capital inflow surge, in line with the experience of several emerging market countries in the current episode of capital inflows.

4.1 Can Macroprudential Measures Complement Monetary Policy?

We first analyze the impact of the shock under three different alternative policy options: (i) standard Taylor rule, (ii) Taylor rule with macroprudential measures, and (iii) optimized Taylor rule and macroprudential measures. Figure 1 shows the responses.

In the first —baseline — scenario, the Taylor rule, policy rates are raised in response to a positive output gap and a higher inflation. The higher policy rates partially offset the impact of the lower risk premium on lending rates, and stabilize output as consumption becomes more costly. The stabilization of demand helps to reduce inflation, whereas the welfare loss (calculated as the sum of variances of output gap and inflation) is about $2\frac{1}{2}$ percent of steady state consumption (Table 4).

In the second scenario, Taylor rule with macroprudential measures, policymakers also adopt macroprudential measures that directly counteract the easing of the lending standards and thus the financial accelerator affect. Indeed, both domestic debt and foreign debt increase less than the first scenario, and the increase in asset prices is also lower. The responses of output and inflation are therefore more muted, and the welfare loss after the shock decreases by more than half compared with the simple Taylor rule.

In the third scenario, optimized Taylor rule and macroprudential measures, the parameters of the Taylor rule and macroprudential regulation are optimized so as to minimize the variation in inflation and output gap after the shock. Hence, the policy response in this case is the most successful in stabilizing the economy and reducing the welfare loss. More importantly, although this optimal reactions calls for a more hawkish monetary response (as the inflation term has a higher weight in the macroprudential rule than the previous two cases), there is still room for macroprudential measures. Indeed, the optimal weight of credit growth in the macroprudential rule is higher than under the second scenario (Table 3).

Table 3: Parameter of the Policy Rules

	Monetary policy			Macropr. policy
	Lag int. rate	Inf. rate	Output gap	Credit growth
Taylor rule	0.5	1.5	0.5	0
Taylor rule with macroprudential	0.5	1.5	0.5	0.5
Opt. Taylor rule with macropr.	0	2.4	0.8	1.3
Taylor rule with capital controls	0.5	1.5	0.5	0.5
Macropr. without monetary pol.				2.5

Table 4: Performance of Policies in Reaction to a Financial Shock

	Std. dev. inflation	Std. dev. output gap	Welfare loss [∨]
Taylor rule	0.03	0.15	2.46
Taylor rule with macroprudential	0.05	0.12	1.25
Opt. Taylor rule with macropr.	0.0	0.02	0.02
Taylor rule with capital controls	0.06	0.14	2.32
Macropr. without monetary pol.	0.19	0.53	31.5

[∨]Welfare loss is calculated as the sum of volatility of inflation and output gap, multiplied by 100.

4.2 How Effective are Macroprudential Measures on Foreign Liabilities (Prudential Capital Controls)?

We look at the policy mix which combines Taylor rule with macroprudential measures that discriminate against foreign borrowing (Figure 2). In this case, the regulation premium only applies to the loans from international resources, Equation (27), and the risk premium is defined as a function of the nominal foreign credit growth. Naturally, the effect of the financial shock on foreign borrowing is less pronounced; the surge in the capital flows is almost one-third of the baseline case, and the exchange rate depreciates. Nevertheless, macroprudential regulation in this case fails to achieve its very first objective of limiting financial vulnerabilities. The policy almost only brings a shift from foreign loans to domestic loans, leaving the aggregate credit growth nearly unchanged compared to the baseline scenario. In fact, the welfare losses are sizably higher than the case where there is no distinction between domestic and foreign borrowing.²³

If there is a shock to the perception of the foreign investors only, then the amount of foreign borrowing increases and that of domestic borrowing declines, until the costs of borrowing from these two sources equalized. In that case, broad-based measures could be unnecessary as macroprudential regulations on foreign liabilities could help to alleviate financial instability risk at its source. In this case, the performance of prudential capital controls improves upon a more general macroprudential approach. However, we do not report this case here as the perceptions of domestic and foreign investors are unlikely to deviate from each other for a prolonged period.

4.3 Can Macroprudential Measures be a Substitute for an Appropriate Monetary Policy Reaction?

To illustrate that macroprudential responses alone are not sufficient, and should not be seen as a substitute for an appropriate monetary reaction, we model a policy regime with macroprudential regulation while maintaining the policy rate unchanged. Under this scenario, the regulation premium is calibrated to replicate the initial change of lending rate under the baseline (Taylor rule) scenario, to reflect policymakers' objective of achieving the same increase in the lending rate through macroprudential measures only. This policy would constrain firms' borrowing and investment, but not consumption, as it would leave the interest rate constant. Demand and inflation would thus be higher than under the other policy regimes and the welfare loss would be excessively large (Table 1). The size of the required macroprudential measure is likely to be far reaching, significantly constraining the financial sector and damaging the potential growth.

4.4 How do Macroprudential Measures Perform Following Different Shocks?

We have analyzed so far the role of macroprudential measures in macroeconomic policy making under a financial shock, an exogenous change in investors' perception

²³Macroprudential measures could also be applied to domestic borrowing only. For example, a number of emerging market countries such as China, Korea, and Turkey have recently increased reserve requirement rates in an effort to tighten monetary conditions. Nevertheless, similarly to the case of capital controls, such a measure is likely to bring a shift in the source of borrowing from domestic to foreign markets, causing only a limited change in the aggregate credit growth.

Table 5: Performance of Policies in Reaction to a Technology Shock

	Std. dev. inflation	Std. dev. output gap	Welfare loss [∨]
Taylor rule	0.06	0.02	0.46
Taylor rule with macroprudential	0.06	0.02	0.44
Opt. Taylor rule with macropr.	0.0	0.01	0.51
Taylor rule with capital controls	0.07	0.03	2.32

[∨]Welfare loss is calculated as the sum of volatility of inflation and output gap, multiplied by 100.

of risk. There could be other shocks that can trigger capital inflows, such as a positive technology shock. In this case, entrepreneurs increase their borrowings, asset prices and capital inflows rise as in the previous scenario. However, inflation declines under a technology shock (Figure 3). On the one hand, the monetary authority would respond the shock by decreasing the interest rate under Taylor rule, which would ease financial conditions even further. On the other hand, however, macroprudential measures would call for a higher lending rate in order to dampen the expanding leverage in the economy. Therefore, a technology shock generates a tradeoff between macroeconomic and financial stability objectives.

Indeed, simulations show that benefits of introducing macroprudential measures substantially decline under a technology shock. The differences in the impulse responses under Taylor rule and Taylor rule with macroprudential measures are generally negligible (Figure 3) and welfare gains are smaller (Table 5). The optimized coefficient for the nominal credit growth in the macroprudential rule is also lower (0.4) compared to the case of a risk perception shock (1.3).

5 Conclusions

This paper has developed an open economy DSGE model to investigate whether there is a potential role for macroprudential policies in helping monetary policy stabilize the economy under a financial shock that triggers capital flows. The simulations suggest that macroprudential tools could be useful at times in helping to achieve twin objectives of macroeconomic and financial stability. In particular, macroprudential measures are shown to improve welfare in the case of a surge in capital inflows. Even under optimal monetary policy, which calls for rather aggressive response of the policy interest rate to inflation changes, macroprudential measures could still be beneficial. Macroprudential measures that discriminate against foreign liabilities (capital controls), however, are less effective than broader measures in mitigating the impact of the shock. In that approach, although capital inflows are smaller in size, domestic financial imbalances could still build up. Moreover, macroprudential measures are not a substitute for a tighter monetary policy and can not stabilize the economy alone.

Our results support the use of macroprudential policies in macroeconomic policy making under large capital inflows generated by a positive shock to investors' perception. Whether macroprudential measures could also help monetary policy in

stabilizing the economy under other types of shocks is not obvious. As an example, we consider a technology shock that creates a tradeoff between macroeconomic stability and financial stability objectives. Under this shock also, macroprudential measures have a role to play, but their positive contribution to economic stability is not sizeable.

Although the way macroprudential measures are modeled in this paper is intuitive, it does not allow us to focus on a particular type of these measures, such as reserve requirements or capital requirements. To address this issue, we are extending the model with a fully optimized banking sector, which will also make it possible to derive the regulation premium from micro-foundations.

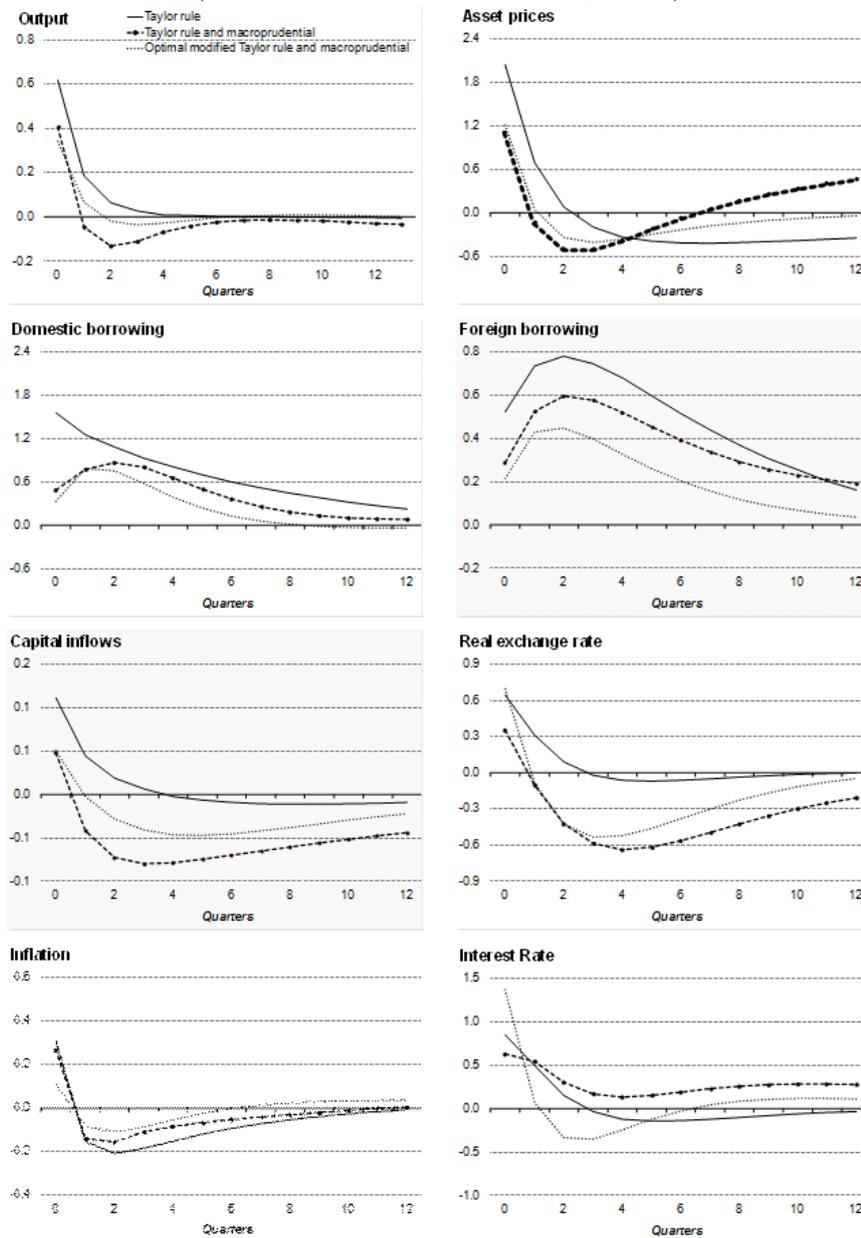
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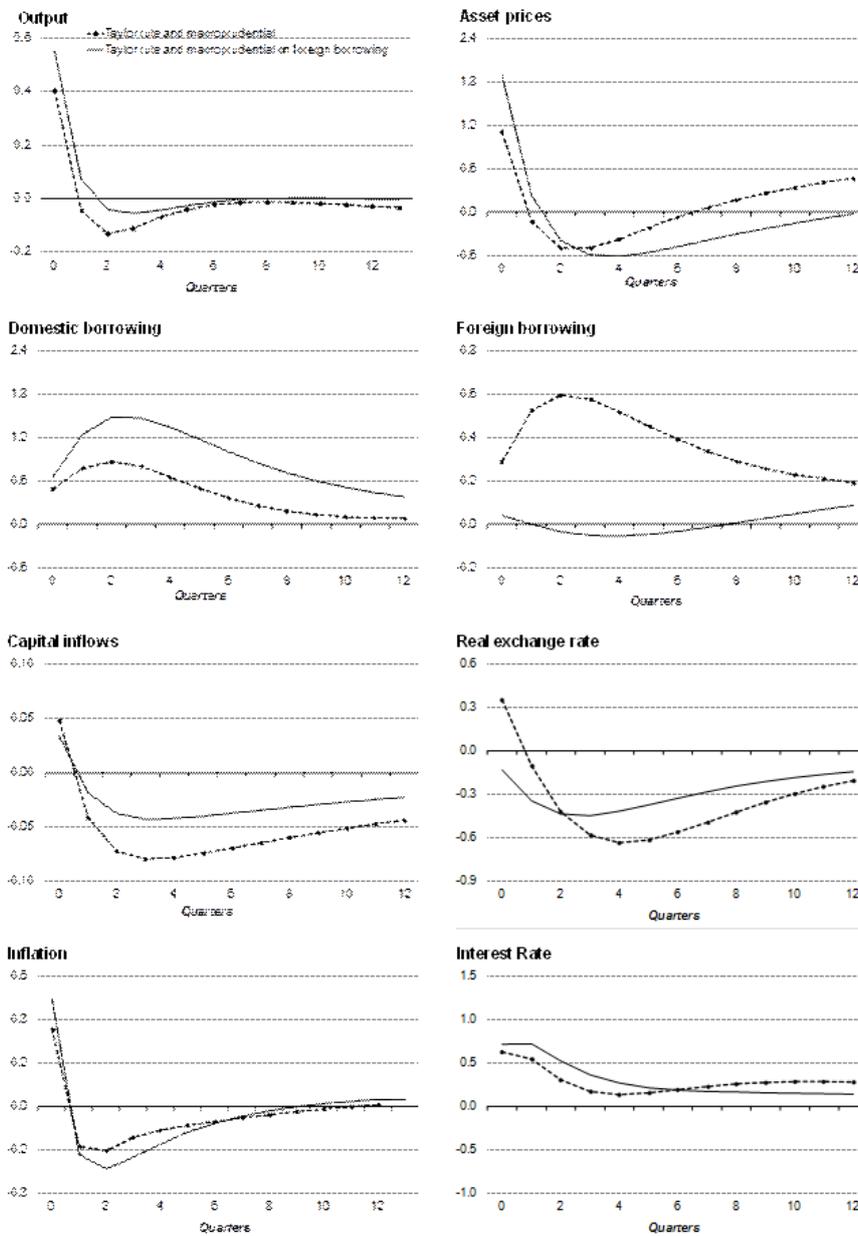
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Figure 1. Dynamic Responses to a Positive Financial Shock¹
 (Percent deviations from steady state)



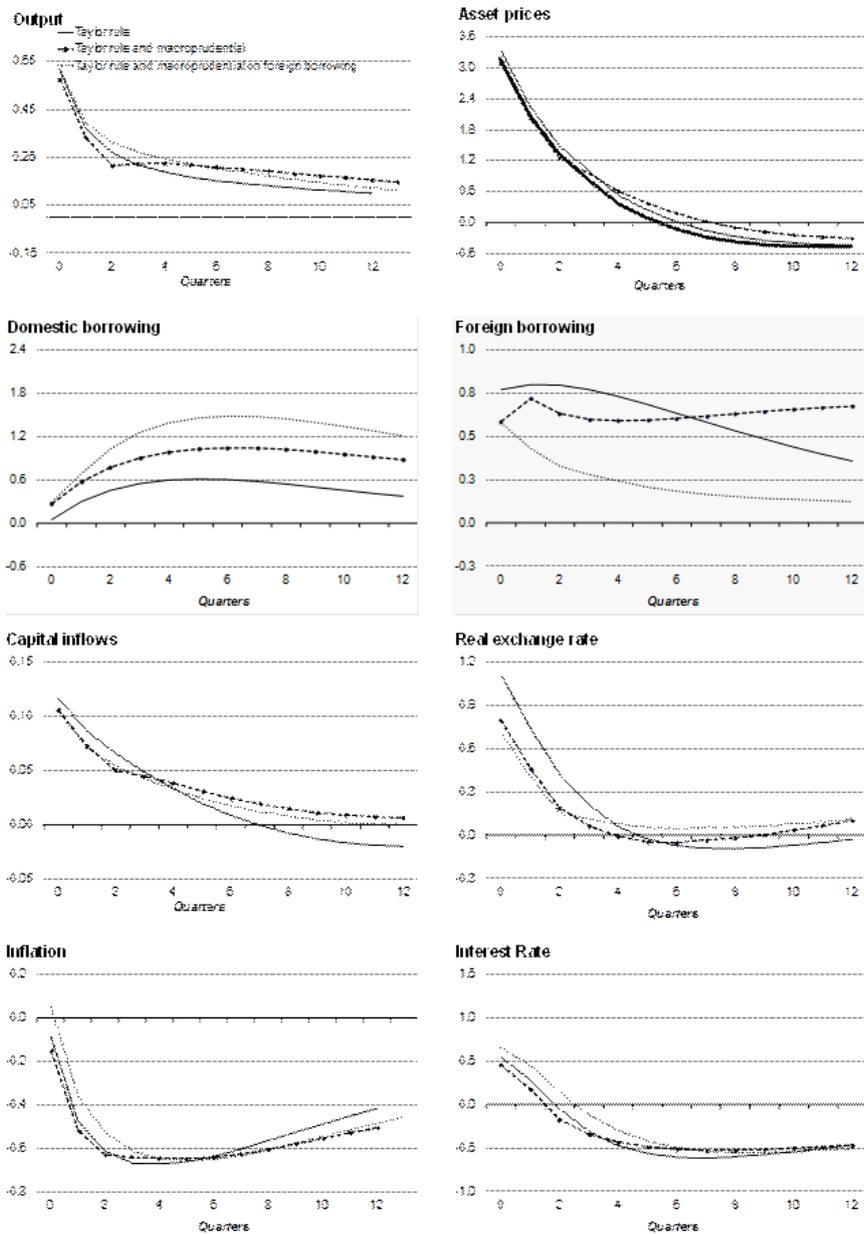
¹The figures show the impact of a 1% negative shock to the perception of investors regarding the productivity of domestic entrepreneurs. The variables are presented as log-deviations from the steady state (except for interest rate), multiplied by 100 to have an interpretation of percentage deviations.

Figure 2. Dynamic Responses to a Positive Financial Shock¹
 (Percent deviations from steady state)



¹The figures show the impact of a 1% negative shock to the perception of investors regarding the productivity of domestic entrepreneurs. 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 3. Dynamic Responses to a Positive Technology Shock¹
 (Percent deviations from steady state)



¹The figures show the impact of a 1% negative shock to the productivity of domestic entrepreneurs. 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.