Capital Flows and Financial Stability: Monetary Policy and Macroprudential Responses *

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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. Against this background, this paper analyses the interplay between monetary and macroprudential policies in an open economy DSGE model with nominal and real frictions. There are four key results of the paper. First, macroprudential measures can usefully complement monetary policy. Even under the "optimal policy," introducing macroprudential measures is welfare improving. Second, broad-based macroprudential measures are more effective than those that discriminate against foreign liabilities (prudential capital controls). Third, the exchange rate regime matters for the desirability of using macroprudential policies as a seperate policy tool. Forth, macroprudential measures are not as useful in helping economic stability under a productivity shock.

Keywords: capital inflows, monetary policy, macroprudential policies, exchange rate regimes, emerging markets.

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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. 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-

[1] The 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.

[2] See 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. Open economy feature of the model also allows us to consider the role of exchange rate regime in defining the role for macroprudential policies in monetary policy framework. Further, we assess the stabilization performance of macroprudential measures that discriminate against foreign liabilities - prudential 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 polices 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, macroprudential measures and prudential capital controls in a two-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

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

[4]The 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).

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, 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, broad-based macroprudential ensures are defined as an additional *"regulation premium"* to the cost of borrowing that rises with nominal credit growth.[5] 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 under a flexible exchange rate regime. 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.

We first study dynamic responses to the financial shock under alternative monetary and macroprudential policy options. We show that macroprudential policies help monetary policy stabilizing the economy in the face of the shock. In our analysis, broad-based macroprudential measures are more effective than prudential capital controls as the latter bring only a change in the composition of debt from foreign debt to domestic debt, leaving aggregate credit growth elevated. These results hold also under a fixed exchange rate regime. Based on the second order approximation of the utility function, we then perform welfare evaluations and compute welfare-maximizing monetary and macroprudential policies. We find that even under the optimal monetary policy, macroprudential policies are still useful in helping monetary policy achieve macroeconomic and financial stability. The exchange rate regime matters for the optimal stabilization role of macroprudential measures: the optimal reaction of macroprudential instrument to nominal credit growth is higher under a fixed exchange rate regime. Finally, we show that macroprudential measures are less useful in helping economic stability under a productivity shock.

The remainder of the paper is organized as follows. Section 2 sets-out the structure of the 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 under alternative monetary and macroprudential policies. Section 5 provides a welfare analysis of alternative policy responses. Section 6 discusses impulse responses and welfare evaluations under a productivity shock. Finally, Section 7 provides the concluding remarks.

[5] When we consider prudential capital controls, the regulation premium is set to be a function of nominal foreign credit growth and imposed only on foreign borrowing.

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.

The world economy consists of two economies; a domestic economy, and a foreign economy, each of which is inhabited by infinitely lived households. The total measure of the world economy is normalized to unity, with domestic and foreign having measure n and $(1-n)$ respectively. Following, Gali and Monacelli (2002), Faia and Monacelli (2007), De Paoli (2009), among many others, we adopt "a limiting case" where domestic economy is small in size relative to the foreign economy.

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. 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.

In our framework, macroprudential measures are modeled as an increase in financial intermediaries' lending costs, which are then passed onto borrowers in the form of higher interest rates. We refer to the increase lending rates brought by macroprudential measures as the *"regulation premium"* and maintain that it is positively linked to nominal credit growth. 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.

The model for the domestic small economy is presented in this section and we use a similar version of the model for the foreign economy[6]. Although asymmetric

[6]Appendix A and Appendix B present the model equations for domestic small economy and foreign economy, respectively.

in size, domestic and foreign countries share the same preferences, technology and market structure for consumption and capital goods. 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:

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

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, χ is the utility weight of labor, and $\varphi > 0$ is the inverse elasticity of labour supply. Our specification for household's utility allows for Greenwood, Hercowitz and Huffman (GHH, 1988) preferences over hours, which eliminates wealth effects from labor supply.[7]

The composite consumption index, C_t, is given by:

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

where $\gamma > 0$ is the elasticity of substitution between domestic and imported (foreign goods), and $0 < \alpha < 1$ denotes the weight of imported goods in domestic consumption basket. This weight, $\alpha \equiv (1-n)\upsilon$, depends on $(1-n)$, the relative size of foreign economy, and on υ, the degree of trade openness of the domestic economy. $C_{H,t}$ 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.

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

Households in domestic economy participate in domestic and foreign financial markets: they lend entrepreneurs in domestic currency, D_t^D, or they borrow from international financial markets in foreign currency, D_t^H, with a nominal interest rate of i_t and $i_t^* \Psi_{D,t}$ respectively. We follow the existing literature in assuming that households need to pay a premium, $\Psi_{D,t}$, given by $\Psi_{D,t} = \frac{\Psi_D}{2}[\exp(\frac{S_t D_{t+1}^H}{P_t GDP_t} -$

[7] We adopt GHH preferences as it improves the ability of the model to capture business cycle dynamics as shown by Mendoza (1991), Correia et al. (1995), and Neumeyer and Perri (2005). In Section 3, we analyze the performance of the model to reproduce some stylized facts for a sample of both emerging economies and advanced economies.

$\frac{SD^H}{PGDP}) - 1]^2$ when they borrow from the rest of the world.[8] 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:

$$P_tC_t + D^D_{t+1} + (1 + i^*_{t-1})\Psi_{D,t-1}S_tD^H_t = W_tH_t + (1 + i_{t-1})D^D_t + S_tD^H_{t+1} + \Pi_t. \quad (3)$$

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

2.2 Firms

2.2.1 Production Firms

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

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

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, $H^E_t(j)$; defined as $N_t(j) = H_t(j)^{1-\Omega} H^E_t(j)^\Omega$. $K_t(j)$ 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).

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 $\frac{\Psi_i}{2}(\frac{P_{i,t}(j)}{P_{i,t-1}(j)} - 1)^2$ for different market destinations $i = H, X$. The presence of menu costs 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 $\beta^tU_{c,t}$. The objective function of firm j can thus be written as:

$$E_o \sum_{t=0}^{\infty} \frac{\beta^tU_{c,t}}{P_t}[P_{H,t}(j)Y_{H,t}(j) + S_tP_{X,t}(j)Y_{X,t}(j) - MC_tY_t(j)$$
$$-P_t \sum_{i=H,X} \frac{\Psi_i}{2}(\frac{P_{i,t}(j)}{P_{i,t-1}(j)} - 1)^2], \quad (5)$$

[8] As Schmitt-Grohe and Uribe (2003) show, introducing a premium for households' foreign borrowing is required to maintain the stationarity in the economy's net foreign assets. In our calibration, 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.

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,

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

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 $P_{X,t} \equiv [\int_0^1 P_{X,t}(j)^{1-\lambda} dj]^{1/(1-\lambda)}$.

2.2.2 Importing Firms

There is a set of monopolistically competitive importing firms, owned by domestic households, who buy foreign goods at prices $P^*_{X,t}$ (in local currency) 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.

2.2.3 Unfinished Capital Producing Firms

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

$$I_t = \left[\alpha^{\frac{1}{\gamma}} I_{H,t}^{(\gamma-1)/\gamma} + (1-\alpha)^{\frac{1}{\gamma}} I_{M,t}^{(\gamma-1)/\gamma}\right]^{\gamma/(\gamma-1)}, \tag{7}$$

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.

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 $\frac{\Psi_I}{2}(\frac{I_t}{K_t} - \delta)^2$ where δ is the depreciation rate. Then, the production technology of the firms producing unfinished capital can be represented by $\Xi_t(I_t, Kt) = [\frac{I_t}{K_t} - \frac{\Psi_I}{2}(\frac{I_t}{K_t} - \delta)^2]K_t$ which exhibits constant returns to scale so that the unfinished capital producing firms earn zero profit in equilibrium. The stock of capital used by the firms in the economy evolves according to:

$$K_{t+1} = [\frac{I_t}{K_t} - \frac{\Psi_I}{2}(\frac{I_t}{K_t} - \delta)^2]K_t + (1-\delta)K_t. \tag{8}$$

The optimally 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:

$$\frac{Q_t}{P_t} = [1 - \Psi_I(\frac{I_t}{K_t} - \delta)]^{-1}. \tag{9}$$

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 $F(.)$, with p.d.f of $f(.)$ and $E(.) = 1$.[9]

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:

$$P_t NW_t^F(k) = Q_t K_{t+1}^F(k) - S_t D_{t+1}^F(k), \tag{10}$$

$$P_t NW_t^D(k) = Q_t K_{t+1}^D(k) - D_{t+1}^D(k), \tag{11}$$

where $D_{t+1}^F$and D_{t+1}^D denote foreign currency denominated debt and domestic currency denominated debt respectively. Equations (10 and 11) 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 $\omega_{t+1}^{v*}(k) = \omega_{t+1}^{v}(k)\varrho_t$ where ϱ_t is the misperception factor over a given interval [0,1].[10] Further, the misperception factor, ϱ_t, is assumed to follow $\ln(\varrho_t) = \rho_\varrho \ln(\varrho_{t-1}) + \varepsilon_\varrho$ 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).[11]

The optimal contracting problem identifies the capital demand of entrepreneurs, $K_{t+1}^{v}(k)$ and a cut off value, $\overline{\omega}_{t+1}^{v}(k)$ such that the entrepreneur will maximize their expected return subject to the participation constraints of the lender. The resulting first order conditions are:

$$E_t[R_{t+1}^K] = E_t[(1+i_t^*)(1+\Phi_{t+1}^F)], \tag{12}$$

[9] The 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).

[10] We assume that perception factor for foreign and domestic lenders share the same dynamics. Given that there is no information friction between foreign and domestic lenders in our model, it is a plausible assumption.

[11] We 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.

$$E_t[R^K_{t+1}] = E_t[(1+i_t)(1+\Phi^D_{t+1})], \tag{13}$$

where R^K_{t+1} is return on capital, which is the same across entrepreneurs borrowing from domestic and foreign resources to avoid arbitrage (see below). $(1+\Phi^F_{t+1})$ and $(1+\Phi^D_{t+1})$ are the external risk premium on foreign and domestic borrowing, and they are given by:

$$1+\Phi^F_{t+1} = [\frac{z^{F\prime}(\overline{\omega}^F_{t+1}(k))}{g^F(\overline{\omega}^F_{t+1}(k);\varrho_t)z^{F\prime}(\overline{\omega}^F_{t+1}(k)) - z^F(\overline{\omega}^F_{t+1}(k))g^{F\prime}(\overline{\omega}^F_{t+1}(k);\varrho_t)}]E_t\{\frac{S_{t+1}}{S_t}\}. \tag{14}$$

$$1+\Phi^D_{t+1} = [\frac{z^{D\prime}(\overline{\omega}^D_{t+1}(k))}{g^D(\overline{\omega}^D_{t+1}(k);\varrho_t)z^{D\prime}(\overline{\omega}^D_{t+1}(k)) - z^D(\overline{\omega}^D_{t+1}(k))g^{D\prime}(\overline{\omega}^D_{t+1}(k);\varrho_t)}]. \tag{15}$$

where $z(\overline{\omega})$ and $g(\overline{\omega}(k);\varrho)$ are the borrowers' and lenders' share of the total return, respectively. 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.

We follow the existing literature in assuming that a proportion of entrepreneurs die in each period to be replaced by new-comers.[12] This assumption guarantees that self financing never occurs and borrowing constraints on debt are always binding. 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.

One of the key mechanism of the model is the evolution of net worth, NW^v_t,which is a function of entrepreneurs' capital net of borrowing costs carried over the previous period, and entrepreneurial wage. Denoting the fraction of entrepreneurs who survive each period by ϑ, we express the net worth as follows

$$P_t NW^v_t = \vartheta[R^K_t Q_{t-1} K^v_t z^v(\overline{\omega}^v_t)] + W^{vE}_t. \tag{16}$$

The total capital in the economy is $K_t = K^F_t + K^D_t$. Because of investment adjustment costs and incomplete capital depreciation, entrepreneurs' return on capital , R^K_{t+1}, is not identical to the rental rate of capital, R_t. R^K_{t+1} 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 $(\frac{Q_{t+1}}{Q_t})$:

$$E_t[R^K_{t+1}] = E_t[\frac{R_{t+1}}{Q_t} + \frac{Q_{t+1}}{Q_t}\{(1-\delta) + \Psi_I(\frac{I_{t+1}}{K_{t+1}} - \delta)\frac{I_{t+1}}{K_{t+1}} - \frac{\Psi_I}{2}(\frac{I_{t+1}}{K_{t+1}} - \delta)^2\}]. \tag{17}$$

[12]See, for example, Carlstrom and Fuerst (1997), Gertler et al. (2007).

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 foreign economy in the form of 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.[13] 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.[14]

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 (12) and (13), become:

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

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

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

$$RP_t = \Psi(\frac{S_t D_t}{S_{t-1} D_{t-1}} - 1) \tag{20}$$

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 (prudential capital controls), the regulation premium only applies to foreign borrowing (18) and macroprudential policy instrument (RP_t) is defined only in terms of growth of nominal 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:

$$1+i_t = [(1+i)\ (\pi_t)^{\epsilon_\pi}(Y_t/Y)^{\epsilon_Y}]^{\varpi}[1+i_{t-1}]^{1-\varpi}, \tag{21}$$

[13] By 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 traceable. Therefore, we use a simpler specification here, and leave analysis of frictions related to financial intermediaries for future work.

[14] See Borio and Drehman (2009), Borgy et al. (2009), Gerdesmeier et al. (2009) for a specific emphasize on the potential of nominal credit growth in a regulation tool.

with $\{\epsilon_\pi\} \in (1, \infty]$, $\{\epsilon_Y\} \in (0, \infty]$, and $\varpi \in [0, 1]$. In (21) ϖ is interest rate smoothing parameter, i and Y denote the steady-state level of nominal interest rate and output, π_t is the CPI inflation. We start with an initial set of values for ϵ_π, ϵ_Y,and ϖ in the calibration. We then numerically compute the optimal values of ϵ_π and ϵ_Y that maximize the total welfare of economic agents (further discussion is presented below).

3 Calibration, Solution Strategy, and Model Evaluation

The parameters for consumption, production and monetary policy are set equally for domestic and foreign economies. One exception is the relative size parameter, n , which is set to 0.1 so that the domestic economy is relatively small. 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). Following Gertler and Karadi (2009), we set the inverse of the elasticity of intertemporal substitution (σ) equal to 2, the inverse of the elasticity of labour supply (φ) to 1/3, and the weight of labor utility (χ) to 1/4. We set openness, υ, to be 0.35 which is within the range of the values used in the literature.[15] The share of capital in production, η, is taken to be 0.35 consistent with other studies.[16] 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. 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. 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 (ϖ) 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.[17]

The parameter values for the entrepreneurial sector in domestic and foreign economy are assumed to be identical. We set the steady state leverage ratio and the value of quarterly external risk premium at 0.3 and 200 basis points, reflecting the historical average of emerging market economies within the last decade.[18] The monitoring cost parameter, μ, is taken as 0.2 for the domestic economy as in Devereux et al. (2006). These parameter values imply a survival rate, ϑ, of approximately 99.33 per cent.

Our model has a potential to have reasonable implications in terms of predictions of macroeconomic variables. In our analysis, we eliminate several other shocks used in the literature, and instead focus on only one shock (a shock to investors' percep-

[15] The 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.

[16] See, for example, Cespedes et al. (2004) and Elekdag and Tchakarov (2007).

[17] We carry out several sensitivity analyses in order to asses robustness of our results under the benchmark calibration. To conserve space, we do not report these results, but they are available upon request.

[18] This is the average number for emerging Americas, emerging Asia, and emerging Europe between 2000-2010. Wordlscope 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 do not affect our results qualitatively.

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

$n = 0.1$	Relative size of the domestic economy
$\beta = 0.99$	Discount factor
$\sigma = 2$	Inverse of the intertemporal elasticity of substitution
$\gamma = 1$	Elasticity of substitution between domestic and foreign goods
$\varphi = 1/3$	Frisch elasticity of labour supply
$\upsilon = 0.35$	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 $i = H, X$
$\epsilon_\pi = 1.5$	Coefficient of CPI inflation in the policy rule
$\epsilon_Y = 0.5$	Coefficient of output gap in the policy rule
$\varpi = 0.5$	Degree of interest rate smoothing
$\rho_\varrho = 0.5$	Persistence of the domestic perception shock
$\Phi_t = 0.02$	External risk premium
$\mu = 0.2$	Monitoring cost
$\kappa = 0.3$	Leverage

tion; or an "optimism" shock- see below) that derives our policy results. Therefore we can not expect that the model match in all dimensions the data. However, to generate confidence on the model's ability to correctly capture dynamics, and on the proposed calibration of the parameters values, we compare movements and comovements of some key variables.

Following Neumeyer and Perri (2005), we report business cycle statistics for Argentina, Brazil, Korea, Mexico, and Philippines. We use data over 1995Q1-2010Q4 period, obtained from International Financial Statistics (IFS) of the International Monetary Fund. All data variables are reported in percent deviations from HP filtered trend, and all model variables are reported in percent deviation from the steady state. One exception is the current account which is reported as a share of GDP both in data and in the model variables.

We report data and simulated moments in Table 2. The model does quite well in getting the dynamics of the variables. Despite the fact that the model has only one shock, standard deviations of data and model variables are reasonably close. The relative standard deviations of variables with respect to standard deviation of output matches well with the model-based results. However, the correlations of output with consumption, investment, and current account in the model are higher than the data.

4 Interactions between Macroprudential 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 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 1 percent of output.

When the investors' become more optimistic about the ability of entrepreneurs to pay their debt, 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, consumption, and output in the economy. Overall, following the capital inflow surge, the economy experiences higher demand and inflation pressures, together with a boom in credit growth.[19] In that case, macroprudential policies which directly counteracting easing in the lending standards might mitigate the impact of the shock on financial and therefore macroeconomic instability.

The exchange rate regime is an important determinant of how the shocks transmits to the rest of the economy and the role of macroprudential policies. The surge in capital inflows increases the demand for domestic currency, and exchange rate appreciates under Taylor rule type monetary policy framework. This has three implications. First, for the entrepreneurs whose borrowing is denominated in foreign currency, this unanticipated change in the exchange rate creates a (positive) balance sheet effect through a decline in the real debt burden, and net worth of the entre-

[19] These are in line with the experience of several emerging market countries in capital inflows episodes (Cardarelli et al., 2010).

Table 2: Business Cycles in Emerging Economies: Data vs. Model

i) Standard deviations (in %)

	Output	Consumption	Investment	Current Account
Argentina	4.58	5.95	12.94	1.01
Brazil	1.94	1.95	4.89	2.19
Korea	2.57	3.52	5.49	3.40
Mexico	2.55	3.57	6.98	5.80
Philippines	2.58	1.93	7.03	4.24
Average	2.84	3.38	7.47	3.33
Model	3.12	3.56	12.34	3.24

ii) Standard deviations relative to output

	Output	Consumption	Investment	Current Account
Argentina	1.0	1.30	2.83	0.22
Brazil	1.0	1.01	2.52	1.13
Korea	1.0	1.37	2.14	1.32
Mexico	1.0	1.40	2.74	2.27
Philippines	1.0	0.75	2.72	1.64
Average	1.0	1.16	2.59	1.32
Model	1.0	1.14	3.96	1.04

iii) Correlations with Output and Autocorrelation of Output

	$\rho(C,Y)$	$\rho(I,Y)$	$\rho(CA,Y)$	$\rho(Y_t,Y_{t-1})$
Argentina	0.92	0.83	-0.54	0.83
Brazil	0.77	0.38	-0.03	0.35
Korea	0.87	0.86	-0.72	0.80
Mexico	0.78	0.85	-0.45	0.82
Philippines	0.82	0.10	0.01	0.78
Average	0.83	0.61	-0.35	0.72
Model	0.91	0.92	-0.9	0.65

preneurs increases, declining the risk premium even further. Second, the decline in the nominal exchange rate puts an downward pressure on the CPI-based inflation. Third, following the appreciation of the domestic currency, the foreign economy's demand for domestic goods decreases. As imports increase on account of both income and exchange rate effects, trade balance deteriorates. Therefore, the impact of large capital inflows can be mitigated by letting the exchange rate appreciate under a floating exchange rate regime. Under a fixed exchange rate regime, however, the adjustment on the external balance has to rely on an increase in the domestic price level. Interest rates remain low, and the responses of consumption and output are more pronounced. Given the absence of independent policy tool, the use of macroprudential policies and prudential capital controls can provide a mechanism for promoting macroeconomic stability.

4.1 Can Macroprudential Measures Complement Monetary Policy?

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

In the first —baseline — scenario, the Taylor rule, output and inflation increase about 0.6 and 0.8 percent on impact following the surge in capital inflows. Both domestic and foreign credit growth rise up to 1.5 percent, and exchange rate appreciates which limits the inflation pressures. Asset prices also increases by more than 2.5 percent after the shock. Under the inflation targeting regime, the policy rate is raised in response to the overheating in the economy. The higher policy rates partially offset the impact of the lower risk premium on lending rates, and stabilize output as consumption becomes more costly. Eventually, the stabilization of demand helps to reduce inflation, and the economy goes back to normalcy.

In the second scenario, Taylor rule with a macroprudential policy, policymakers also adopt a macroprudential tool that directly counteracts the easing of the lending standards and thus the financial accelerator affect. The responsiveness of the macroprudential instrument to nominal credit growth is set at 0.5 (Table 3). In that case, both domestic debt and foreign debt increase less than the first scenario (by about 50 percent at the peak), and the increase in capital inflows and asset prices are also lower. The responses of output and inflation are therefore more muted by about 1/4 of the response under the first scenario.

The experiment shows that macroprudential policies monetary policy in providing macroeconomic and financial stability. However, it is not clear from the analysis whether there would still be a role for macroprudential measures if monetary policy is set in an "optimal" way, instead of ad-hoc parameters. This requires a more rigorous welfare analysis which is taken up in the Section 4.

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

We next look at the policy mix which combines Taylor rule with prudential capital controls (Figure 2). In this case, the regulation premium only applies to the loans from international resources, Equation (18), and the risk premium is defined as a function of the nominal foreign credit growth. Under that scenario, the effect of the financial shock on foreign borrowing is less pronounced; the surge in the capital

Table 3: Parameter of the Policy Rules

	Taylor Rule		Macroprudential Policy
	Inflation rate	Output gap	Credit growth
Taylor rule (TR)	1.5	0.5	0
TR with macroprudential policy (MP)	1.5	0.5	0.5
TR with capital controls (CC)	1.5	0.5	0.5 (on foreign credit)
Fixed exchange rate (FER)	-	-	-
FER with MP	-	-	0.5
FER with CC	-	-	0.5 (on foreign credit)
Optimal Taylor rule (OTR)	1.1	0	-
OTR with MP	2.7	0.25	1.4
FER with optimal MP	-	-	2.7

flows is almost two-third of the baseline case, and the exchange rate appreciates less. Nevertheless, the macroprudential regulation fails to achieve its very first objective of promoting financial stability. 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.[20]

If there is a shock to the perception of the foreign investors only, 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. As the perceptions of domestic and foreign investors are unlikely to deviate from each other for a prolonged period, we assume here that the perceptions of domestic and foreign investors are alike.

4.3 Does The Exchange Rate Regime Matter for the Role of Macroprudential Policies?

We next analyze the dynamic responses of the macroeconomic variables to the financial shock under a fixed exchange rate regime with and without a macroprudential policy (Figure 3). Under the fixed exchange rate regime, output and inflation increase more than under the Taylor rule (Figure 1) where the nominal currency appreciation helps to limit the overheating and inflation pressures. The increase in asset prices is also higher by about 1/5 of the response under the Taylor rule. The responses of foreign and domestic credit, however, are more muted due to the absence of the positive impact of exchange rate appreciation on the net worth of entrepreneurs, which would make borrowing cheaper by lowering risk premium under the flexible exchange rate regime.

[20] Macroprudential 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.

The qualitative impact of the macroprudential policy under the fixed exchange rate regime is virtually identical to that in the case of a flexible exchange rate economy. Introducing regulation premium increases effective lending rate for foreign and domestic entrepreneurs, reduces the impact of the shock on credit growth and investment. Overall, macroprudential policy improves macroeconomic and financial stability also under the fixed exchange rate regime.

We further investigate the impact of prudential capital controls under the fixed exchange rate regime (Figure 4). As in the case of Taylor rule, the prudential capital control is less effective then the broad-based macroprudential instrument in our simulations. The responses of capital inflows and real exchange rate appreciation are smaller, but the responses of asset prices, output and inflation are almost the same with the fixed exchange rate regime without a macroprudential tool. In the next section, we present welfare gains associated with macroprudential policies and prudential capital controls.

5 Welfare Evaluation of Alternative Policy Options and The Optimal Policy

To provide a full assessment of optimal policy design, we consider the welfare gains from responding to financial market developments - proxied by nominal credit growth in our experiments - through monetary and macroprudential policy instruments and compute the optimal degree of intervention. We take the utility function of consumers as the objective.

Following Faia and Monacelli (2007), and Gertler and Karadi (2010), we start with expressing the household utility function recursively:

$$V_t = U(C_t, H_t) + \beta E_t V_{t+1} \tag{22}$$

where $V_t \equiv E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, H_t)$ denotes the utility function. We take a second order approximation of V_t around deterministic steady state. Using the second order solution of the model, we then calculate V_t in each of the separate cases of monetary and macroprudential policies.[21] We compare alternative monetary and macroprudential policis in terms of a consumption equivalent, Ω, given by the fraction of consumption required to equate welfare under any given monetary and macroprudential policies, V_t^*, to the under the optimal Taylor rule type monetary policy, V_t^{opt}(Table 4). In our specification of the utility function, and under $\sigma = 2$,

$$\Omega = (\frac{(V_t^{opt} - V_t)(1-\beta)(C - \frac{\chi}{1+\varphi} H^{1+\varphi})^2}{C(1 - (V_t^{opt} - V_t)(1-\beta)(C - \frac{\chi}{1+\varphi} H^{1+\varphi}))} \tag{23}$$

where the variables without subscripts are the steady state values of the corresponding variables. We then search numerically in the grid of parameters $\{\epsilon_\pi, \epsilon_y, \Psi\}$ that optimize V_t in response to the financial shock (Table 3).

The main result emerge from this analysis is that, there exists a positive effect on welfare of using macroprudential policies. With the calibrated parameters, introducing macroprudential measures decreases welfare losses by about 0.8 percent

[21] It is rather standard in the literature to calculate the welfare using a second order approximation to utility function. See Scmitt-Grohe and Uribe (2004) for a lengthly discussion on the topic.

Table 4: Welfare Results under a Financial Shock, in percent of steady state consumption

	Ω
Taylor rule (TR)	1.19
TR with macroprudential policy (MP)	0.43
TR with capital controls (CC)	1.06
Fixed exchange rate (FER)	2.47
FER with MP	1.03
FER with CC	1.70
Optimal Taylor rule (OTR)	-
OTR with MP	-0.05
FER with optimal MP	0.28

of steady state consumption under Taylor-rule type monetary policy reaction function, and more than 1 percent of steady state consumption under a fixed exchange rate regime. More interestingly, even under optimal monetary policy, the optimized coefficient for the macroprudential instrument is not zero; i.e. there is a room for macroprudential policies to play. The welfare gains obtained from prudential capital controls, however, are negligible, confirming results obtained in the previous section.

Our analysis yields another important result–the exchange rate regime matters for the desirability of using macroprudential policies. The optimized coefficient of the monetary policy instrument is higher under the fixed exchange rate regime (2.7) than under the Taylor rule type of monetary policy regime (1.4). The intuition for why is as follows. Under Taylor rule, interest rate raises in the response to rising inflation and output. This rise in the interest rate decreases consumption and investment, but also limits the increase credit growth. Under a fixed exchange regime, the impact of the shock on the economy is more dramatic given the absence of independent interest rate tool, which puts more of the burden to macroprudential policies to provide macroeconomic and financial stability.[22]

6 How do Macroprudential Measures Perform Following a Productivity Shock?

We have analyzed so far the role of macroprudential measures in macroeconomic policy making under a financial shock, an exogenous change in investors' perception about the entrepreneurs' productivity. Under that scenario, the responses of monetary policy and macroprudential measures are aligned (both are contractionary). However, there could be other shocks that generate a trade-off between macroeconomic and financial stability objectives. For example, under productivity shock,

[22] This is in line with the survey results reported in IMF (2010) on the use of macroprudential measures, which found that economies with fixed or managed exchange rate regimes tend to use macroprudential tools more frequently.

Table 5: Welfare Results under a Productivity Shock, in percent of steady state consumption

	Ω
Taylor rule (TR)	2.17
TR with macroprudential policy (MP)	2.36
Optimal Taylor rule (OTR)	-

entrepreneurs increase their borrowings, investment and asset prices rise as in the previous scenario. On the one hand, inflation declines, the monetary authority responds by decreasing the interest rate under Taylor rule (Figure 5). On the other hand, macroprudential measures call for a higher lending rate in order to dampen the expanding leverage in the economy.

Overall, simulations show that stabilization benefits of introducing macroprudential measures decline under a productivity shock. When the macroprudential policy implemented, the output response change only marginally, while the response of inflation is even higher and the policy rate is lowered by almost two times more than the case without macroprudential policies.

In fact, under a productivity shock, macroprudential measures are not welfare improving (Table 5). Not surprisingly, the coefficient of the macroprudential instrument that maximizes welfare turns out to be zero.

7 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, macroprudential measures could still be beneficial. Macroprudential measures that discriminate against foreign liabilities (prudential 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.

The exchange rate regime matters for the desirability of using macroprudential policies as a separate policy tool. Macroprudential policies are useful both under fixed and flexible exchange rate regimes. However, under fixed exchange rate regime, the optimal response through the macroprudential tool is bigger as the absence of independent interest rate tools puts more of the burden on macroprudential policies to address macroeconomic and financial instabilities.

Our results support the use of macroprudential policies in macroeconomic policy making under large capital inflows. 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 productivity shock that creates a trade-off between macroeconomic stability and financial stability objectives. In our simulations, macroprudential policies are not welfare improving under a productivity shock. This has implications for the implementation of the macroprudential policies. Policymakers should be cautious in reacting rigidly to financial market developments with fixed rules. Rather, some form of discretion to deal appropriately with various types of shocks could be more desirable.

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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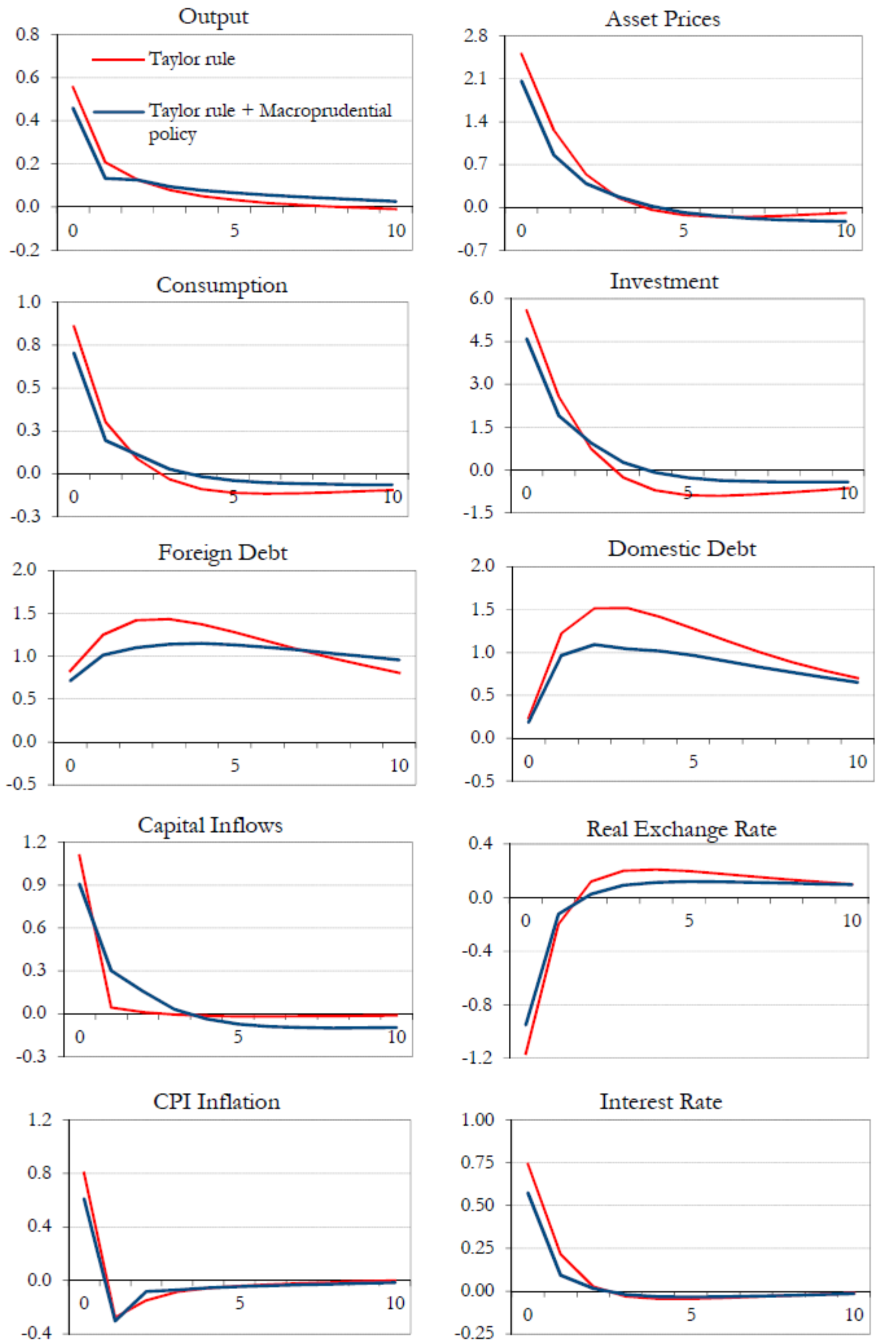
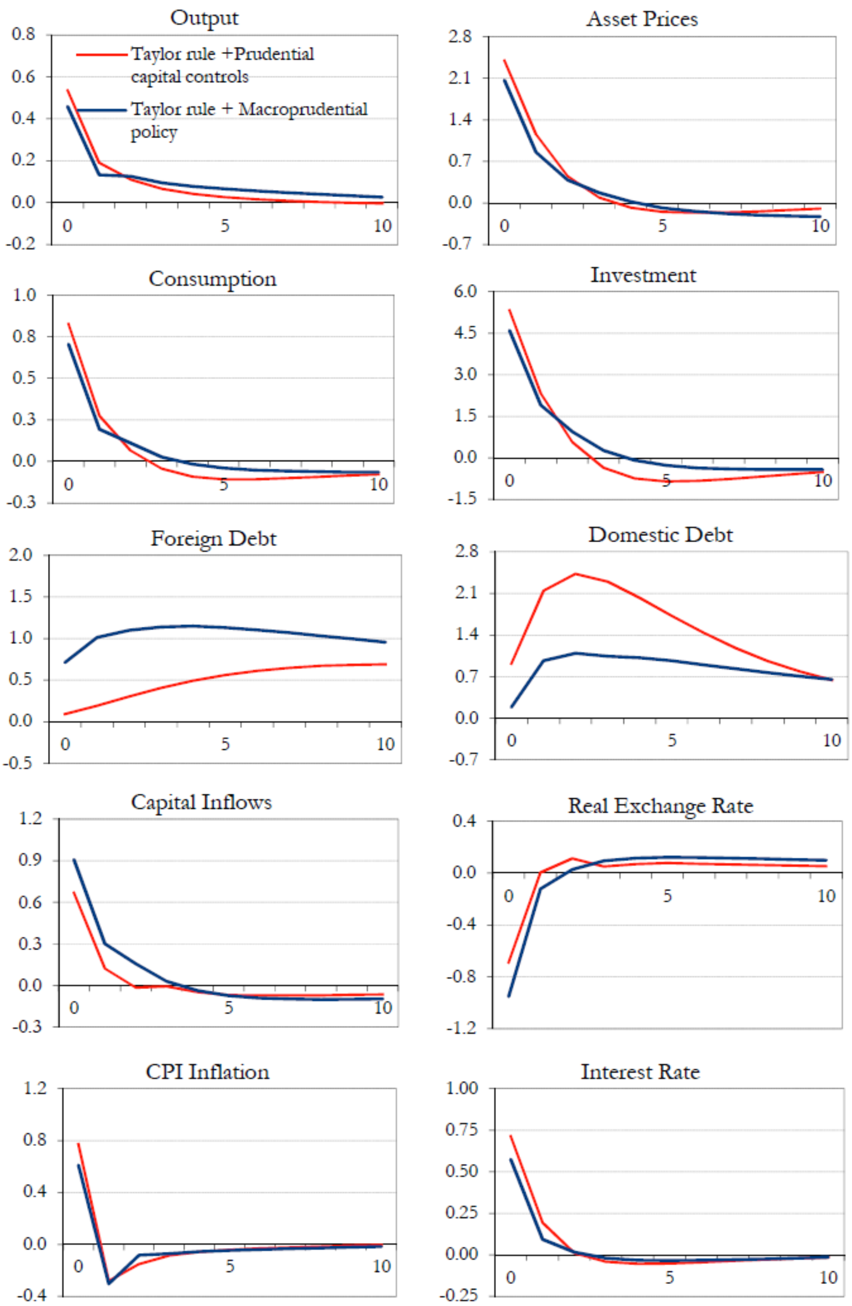
Figure 1. A Positive Financial Shock: Taylor Rule and Macroprudential Policy[⊥]
(percent deviations from steady state)



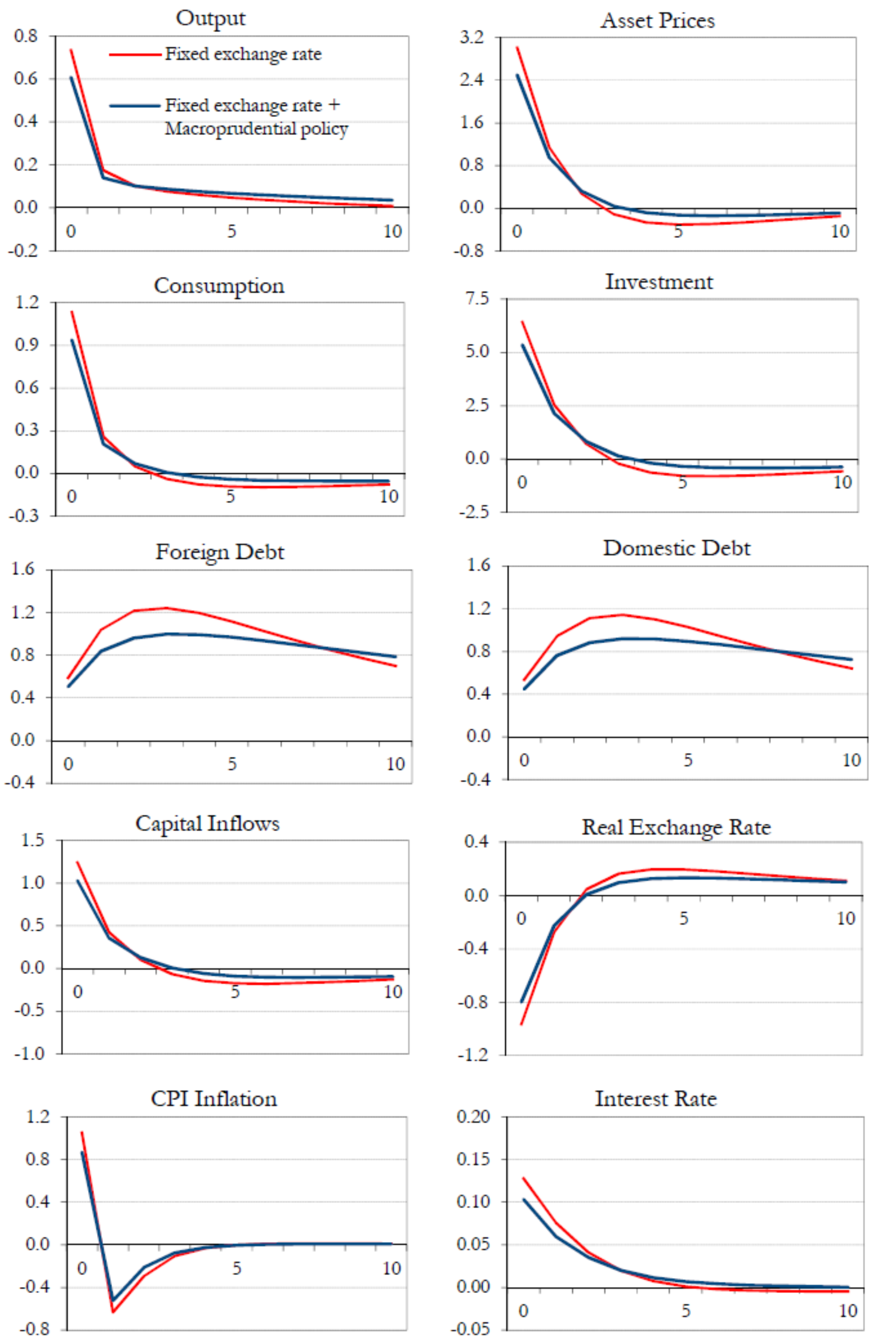
[⊥] The figures show the impact of a 1% positive shock to the perception of investors regarding the productivity of domestic entrepreneurs. The variables are presented as log-deviations from the steady state (except for interest rate), multiplied by 100 to have an interpretation of percentage deviations.

Figure 2. A Positive Financial Shock: Macroprudential Policy and Prudential Capital Controls under Taylor Rule[⊥]
(Percent deviations from steady state)



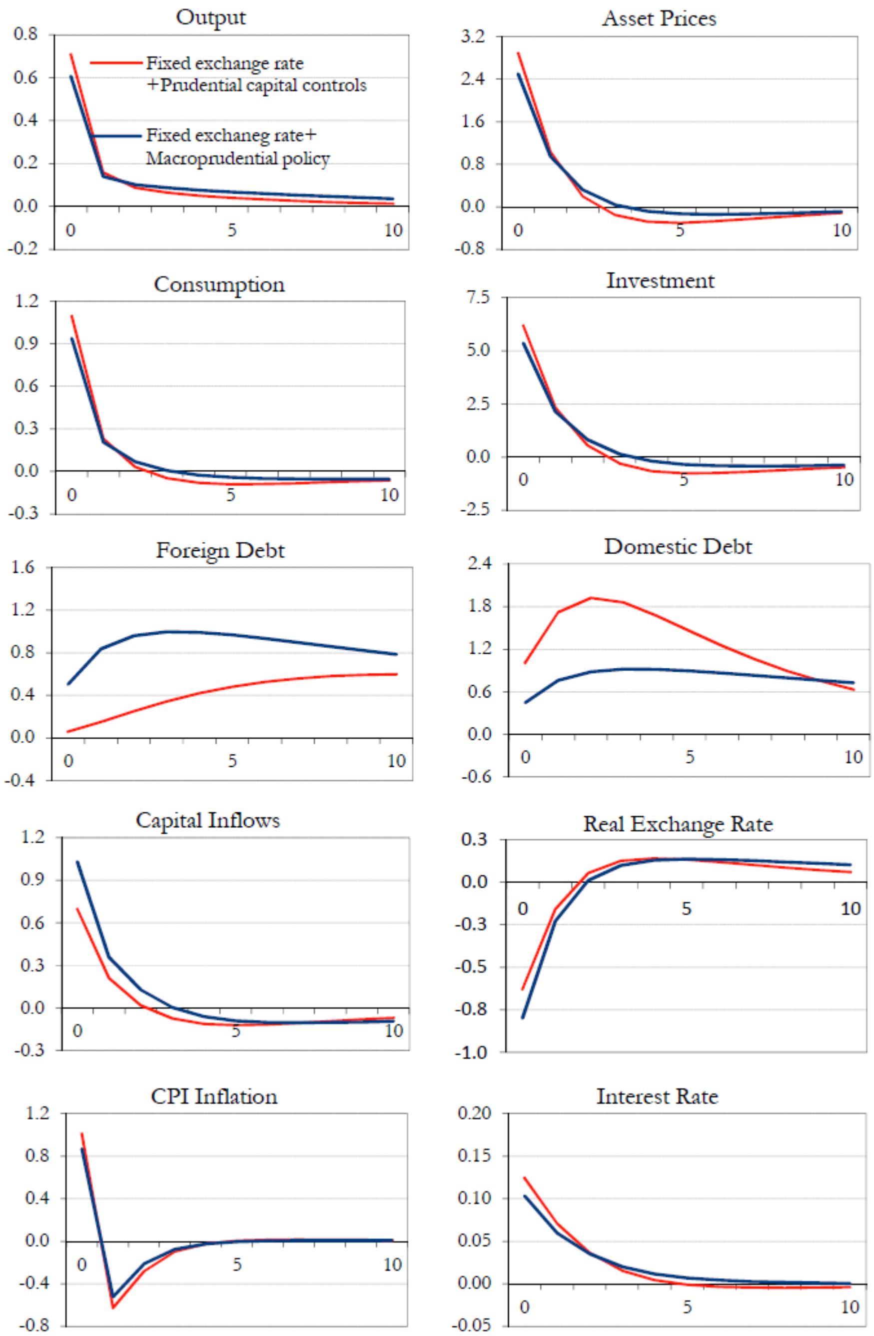
[⊥] The figures show the impact of a 1% positive shock to the perception of investors regarding the productivity of domestic entrepreneurs. The variables are presented as log-deviations from the steady state (except for interest rate), multiplied by 100 to have an interpretation of percentage deviations.

Figure 3. A Positive Financial Shock: Fixed Exchange Rate and Macroprudential Policy ⊥
(Percent deviations from steady state)



⊥ The figures show the impact of a 1% positive 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.

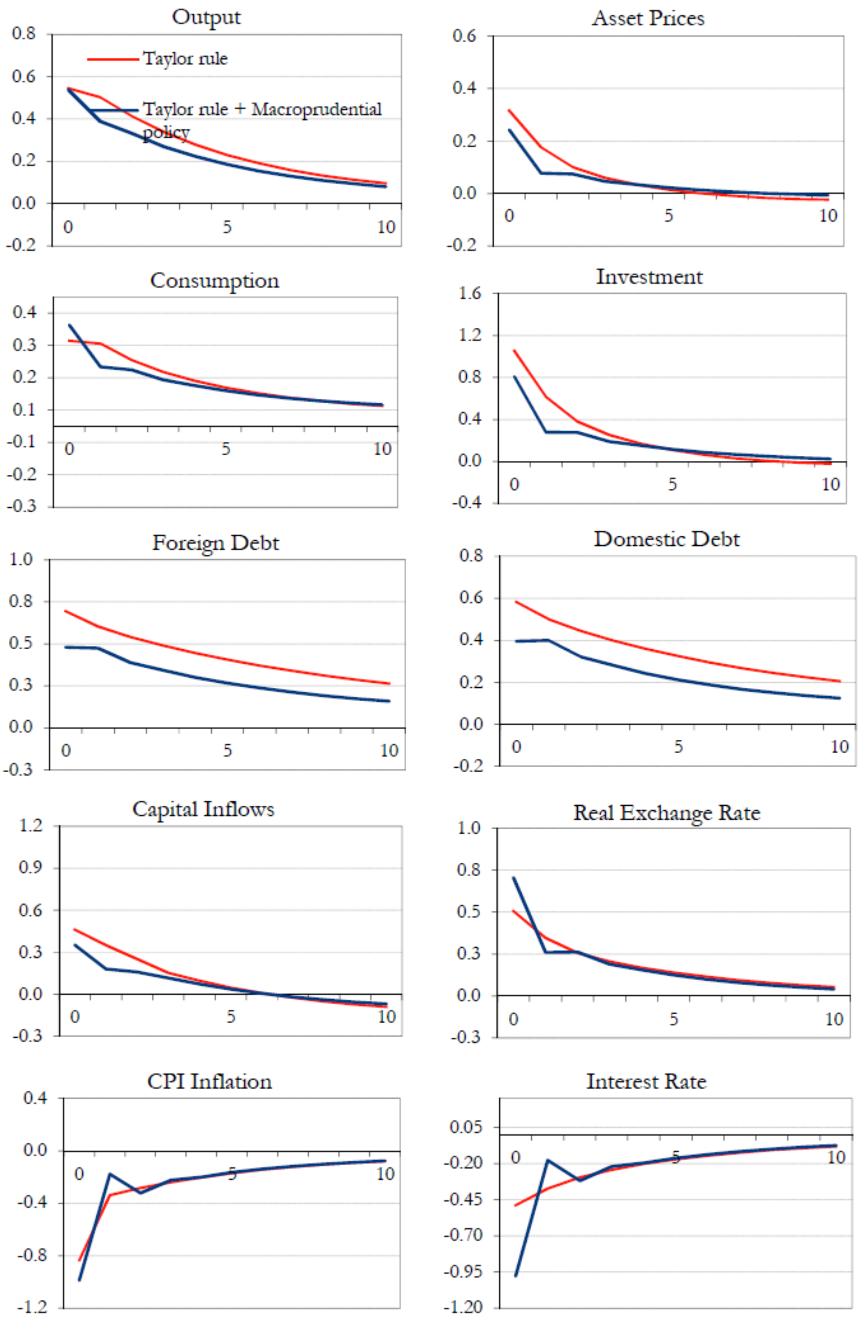
Figure 4. A Positive Financial Shock: Macroprudential Policy and Prudential Capital Controls under Fixed Exchange Rate [⊥]
(Percent deviations from steady state)



[⊥] The figures show the impact of a 1% positive 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 5. A Positive Productivity Shock: Taylor Rule and Macroprudential Policy[⊥]

(Percent deviations from steady state)



[⊥]The figures show the impact of a 1% positive productivity shock. 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.

Appendix

A. Model Equations: Domestic Economy

A.1. Households

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

$$C_{H,t} = \alpha(\frac{P_{H,t}}{P_t})^{-\gamma}C_t, \tag{A.1}$$

$$C_{M,t} = (1-\alpha)(\frac{P_{M,t}}{P_t})^{-\gamma}C_t, \tag{A.2}$$

and the corresponding price index is given by:

$$P_t = [\alpha P_{H,t}^{1-\gamma} + (1-\alpha)P_{M,t}^{1-\gamma}]^{1/(1-\gamma)}, \tag{A.3}$$

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).

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 Equation (1) subject to the budget constraint in Equation (3). The first order conditions for this optimization problem are given by:

$$\chi H_t^{\varphi} = W_t, \tag{A.4}$$

$$(C_t - \frac{\chi}{1+\varphi}H_t^{1+\varphi})^{-\sigma} = \beta(1+i_t)E_t[(C_{t+1} - \frac{\chi}{1+\varphi}H_{t+1}^{1+\varphi})^{-\sigma}\frac{P_t}{P_{t+1}}], \tag{A.5}$$

$$(C_t - \frac{\chi}{1+\varphi}H_t^{1+\varphi})^{-\sigma} = \beta(1+i_t^*)\Psi_{D,t}E_t[(C_{t+1} - \frac{\chi}{1+\varphi}H_{t+1}^{1+\varphi})^{-\sigma}\frac{P_t}{P_{t+1}}\frac{S_{t+1}}{S_t}]. \tag{A.6}$$

In the absence of the premium paid on foreign borrowing ($\Psi_{D,t}$), last two equations would yield the standard uncovered interest rate parity condition.

A.2. Production Firms

Assuming that the price of each input is taken as given, the production firms minimize their costs subject to (4). Omitting the firm-specific indices for notational simplicity, cost minimizing behavior implies the following first order conditions:

$$W_t = \frac{(1-\eta)(1-\Omega)Y_t MC_t}{N_t}, \tag{A.7}$$

$$W_t^E = (1-\eta)\Omega Y_t MC_t, \tag{A.8}$$

$$R_t = \frac{\eta Y_t MC_t}{K_t}, \tag{A.9}$$

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 $MC_t = \frac{R_t^{\eta}W_t^{1-\eta}}{A_t\eta^{\eta}(1-\eta)^{1-\eta}}$.

Let $Y_{X,t}$ denote the foreign aggregate export demand for domestic goods which is determined in the foreign economy (see Appendix B). Since the profit maximization condition is symmetric among firms, the optimal price setting equations can be written in aggregate terms. Using 5 and 6, we derive:

$$\begin{aligned} P_{H,t} &= \frac{\lambda}{\lambda-1}MC_t - \frac{\Psi_H}{\lambda-1}\frac{P_t}{Y_{H,t}}\frac{P_{H,t}}{P_{H,t-1}}(\frac{P_{H,t}}{P_{H,t-1}}-1) \\ &+ \frac{\Psi_H}{\lambda-1}E_t[\Theta_t\frac{P_{t+1}}{Y_{H,t}}\frac{P_{H,t+1}}{P_{H,t}}(\frac{P_{H,t+1}}{P_{H,t}}-1)], \end{aligned} \tag{A.10}$$

$$\begin{aligned} S_tP_{X,t} &= \frac{\lambda}{\lambda-1}MC_t - \frac{\Psi_X}{\lambda-1}\frac{P_t}{Y_{X,t}}\frac{P_{X,t}}{P_{X,t-1}}(\frac{P_{X,t}}{P_{X,t-1}}-1) \\ &+ \frac{\Psi_X}{\lambda-1}E_t[\Theta_t\frac{P_{t+1}}{Y_{X,t}}\frac{P_{X,t+1}}{P_{X,t}}(\frac{P_{X,t+1}}{P_{X,t}}-1)], \end{aligned} \tag{A.11}$$

where $\Theta_t = \beta\frac{(C_{t+1} - \frac{\chi}{1+\varphi}H_{t+1}^{1+\varphi})^{-\sigma}}{(C_t - \frac{\chi}{1+\varphi}H_t^{1+\varphi})^{-\sigma}}\frac{P_t}{P_{t+1}}$.

A.3. Importing Firms

Let $Y_{M,t}$ denote the aggregate import demand of the domestic economy. Similar to production firms, profit maximization condition for importing firms gives the price index for the imported goods:

$$\begin{aligned} P_{M,t} &= \frac{\lambda}{\lambda-1}S_tP_t^* - \frac{\Psi_M}{\lambda-1}\frac{P_t}{Y_{M,t}}\frac{P_{M,t}}{P_{M,t-1}}(\frac{P_{M,t}}{P_{M,t-1}}-1) \\ &+ \frac{\Psi_M}{\lambda-1}E_t[\Theta_t\frac{P_{t+1}}{Y_{M,t}}\frac{P_{M,t+1}}{P_{M,t}}(\frac{P_{M,t+1}}{P_{M,t}}-1)], \end{aligned} \tag{A.12}$$

A.4. Unfinished Capital Producing Firms

Given 7, the cost minimization problem of the unfinished capital producer firms yields:

$$I_{H,t} = \alpha(\frac{P_{H,t}}{P_t})^{-\gamma}I_t \tag{A.13}$$

and

$$I_{M,t} = (1-\alpha)(\frac{P_{M,t}}{P_t})^{-\gamma}I_t. \tag{A.14}$$

Equations (A.13) and (A.14), together with the equation defining the dynamics of stock of capital, Equation (8), and price of capital, Equation (9), describe unfinished capital producing firms in the model.

A.5. Entrepreneurs

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.[23] 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, $\overline{\omega}_{t+1}^v(k)$, such that if $\omega_{t+1}^v(k) \geq \overline{\omega}_{t+1}^v(k)$, the lender receives a fixed return in the form of a contracted interest on the debt. If $\omega_{t+1}^v(k) < \overline{\omega}_{t+1}^v(k)$, then the borrower

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

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:

$$
\begin{aligned}
& E_t[R^{Kv}_{t+1} Q_t K^v_{t+1}(k)(\int_{\overline{\omega}^v_{t+1}(k)}^{\infty} \omega^v(k) f(\omega^v) d\omega^v - \overline{\omega}^v_{t+1}(k) \int_{\overline{\omega}_{t+1}(k)}^{\infty} f(\omega^v) d\omega^v)] \\
= \;& E_t[R^{Kv}_{t+1} Q_t K^v_{t+1}(k) z^v(\overline{\omega}^v_{t+1}(k))], \qquad \text{(A.15)}
\end{aligned}
$$

$$
\begin{aligned}
& E_t[R^K_{t+1} Q_t K^v_{t+1}(k)(\overline{\omega}^{v*}_{t+1}(k) \int_{\overline{\omega}^v_{t+1}(k)}^{\infty} f(\omega^{v*}) d\omega^{v*} \\
& +(1-\mu) \int_0^{\overline{\omega^v}_{t+1}(k)} \omega^{v*}_{t+1}(k) f(\omega^{v*}) d\omega^{v*})] \\
= \;& E_t[R^K_{t+1} Q_t K^v_{t+1}(k) g^v(\overline{\omega}^v_{t+1}(k); \varrho^v_t)], \qquad \text{(A.16)}
\end{aligned}
$$

where R^K_t denotes the *ex-post* realization of return to capital, and is the same regardless of the source of the financing due to arbitrage. $z^v(\overline{\omega})$ is the borrowers' share of the total return. We use the definition of the lender's perception of productivity shock $\omega^{v*}_{t+1}(k)$ in Equation (A.16) where $g^v(\overline{\omega}^v(k); \varrho^v)$ represents the lenders' share of the total return, itself a function of both the idiosyncratic shock and the perception factor.

For domestic and foreign lenders, the opportunity cost of lending to the entrepreneur is the domestic interest rate 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:

$$
E_t[\frac{R^K_{t+1} Q_t K^F_{t+1}(k)}{S_{t+1}} g^F(\overline{\omega}^F_{t+1}(k); \varrho^F_t)] = (1+i^*_t) D^F_{t+1}(k). \qquad \text{(A.17)}
$$

$$
E_t[R^K_{t+1} Q_t K^D_{t+1}(k) g^D(\overline{\omega}^D_{t+1}(k); \varrho^D_t)] = (1+i_t) D^D_{t+1}(k). \qquad \text{(A.18)}
$$

The optimal contracting problem identifies the capital demand of entrepreneurs, $K^v_{t+1}(k)$ and a cut off value, $\overline{\omega^v}_{t+1}(k)$ such that the entrepreneurs will maximize (A.15) subject to (A.17) and (A.18).The first order conditions yield (12)-(15) in the text.

Given that the borrower's and the lender's share of total return should add up to $z^v(\overline{\omega}^v_t) + g^v(\overline{\omega}^v_t, \varrho^v_t) = 1 - \nu^v_t$ (where ν^v_t is the cost of monitoring, a deadweight loss associated with financial frictions) and by using the participation constraint (A.17), we can rewrite the net worth of the entrepreneurs (16) as:

$$
P_t NW^F_t = \vartheta[R^K_t Q_{t-1} K^F_t (1-\nu^F_t) - (1+i^*_{t-1}) S_t D^F_t] + W^{FE}_t. \qquad \text{(A.19)}
$$

$$
P_t NW^D_t = \vartheta[R^K_t Q_{t-1} K^D_t (1-\nu^D_t) - (1+i_{t-1}) D^D_t] + W^{DE}_t. \qquad \text{(A.20)}
$$

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

$$
P_t C^{FE}_t = (1-\vartheta)[R^K_t Q_{t-1} K^F_t (1-\nu^F_t) - (1+i^*_{t-1}) S_t D^F_t]. \qquad \text{(A.21)}
$$

$$P_tC_t^{DE} = (1-\vartheta)[R_t^K Q_{t-1} K_t^D (1-\nu_t^D) - (1+i_{t-1})D_t^D]. \tag{A.22}$$

It 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:

$$C_{H,t}^{vE} = \alpha(\frac{P_{H,t}}{P_t})^{-\gamma} C_t^{vE}, \tag{A.23}$$

$$C_{M,t}^{vE} = (1-\alpha)(\frac{P_{M,t}}{P_t})^{-\gamma} C_t^{vE}. \tag{A.24}$$

To define $z^v(\overline{\omega})$ and $g^v(\overline{\omega}^v(k);\varrho^v)$, we use the relationship between the functions $\mathrm{erf}(.)$ and $\mathrm{erf}\,c(.)$ and the c.d.f. of a standard normal distribution $\Theta(.)$:

$$\begin{aligned} \mathrm{erf}(x) &= 2\Theta(x\sqrt{2}) - 1, \\ \mathrm{erf}\,c(x) &= 2(1-\Theta(x\sqrt{2})). \end{aligned} \tag{A.25}$$

Using (A.25) and two artificial variables $z_{1t}^v = \frac{\ln\omega_t^v + 0.5\sigma_\omega^{v2}}{\sigma_\omega^v}$ and $z_{2t}^v = \frac{\ln(\frac{\omega_t^v}{\varrho_t}) + 0.5\sigma_\omega^{v2}}{\sigma_\omega^v}$, we re-define $z^v(.)$, $g^v(.)$, $z^{v\prime}(.)$ and $g^{v\prime}(.)$:

$$z^v(\overline{\omega}_t^v) = 1 - \Theta(z_{1t}^v - \sigma_\omega^v) - \overline{\omega}_t^v(1-\Theta(z_{1t}^v)) \tag{A.26}$$

$$g^v(\overline{\omega}_t^v;\varrho_t) = \varrho_t[\frac{\overline{\omega}_t^v}{\varrho_t}(1-\Theta(z_{2t}^v)) + (1-\mu)\Theta(z_{2t}^v - \sigma_\omega^v)] \tag{A.27}$$

$$z^{v\prime}(\overline{\omega}_t^v) = -(1-\Theta(z_{1t}^v)) \tag{A.28}$$

$$g^{v\prime}(\overline{\omega}_t^v;\varrho_t) = \varrho_t[1-\Theta(z_{2t}^v) - \frac{\mu}{\sqrt{2\pi}\sigma_\omega^v}\exp(-\frac{z_{2t}^{v2}}{2}) \tag{A.29}$$

Equations (A.17)-(A.29), together with (12)-(17) form the entrepreneurs block of the model.

A.6. Financial Intermediaries and Macroprudential Policy

Model equations for financial intermediaries and macroprudential policies are given in (18)-(20).

A.7. Monetary Policy

In the baseline case, we assume that monetary policy reaction function follows a Taylor-type rule with interest rate smoothing as given in (21).

A.8. General Equilibrium and Balance of Payments Dynamics

Market clearing in the final good sector requires that total domestic output be equal to domestic consumption, domestic investment and exports to the rest of the world. Frictions such as adjustment and monitoring costs are included in the output given that they are expressed in terms of the final composite good. Thus the overall resource constraint faced by the domestic economy can be written as:

$$Y_t = Y_{H,t} + Y_{X,t}, \tag{A.25}$$

where

$$\begin{aligned} Y_{H,t} &= C_{H,t} + C^E_{H,t} + I_{H,t} + \alpha(\frac{P_{H,t}}{P_t})^{-\gamma}[\sum_{i=H,X} \frac{\Psi_i}{2}(\frac{P_{i,t}}{P_{i,t-1}} - 1)^2 \\ &+ \frac{\Psi_M}{2}(\frac{P_{M,t}}{P_{M,t-1}} - 1)^2 + \sum_{j=F,D} \nu^j_t \frac{R^K_t}{P_t} Q_{t-1} K^j_t], \end{aligned} \tag{A.26}$$

The import demand of the domestic economy (which is the export of the foreign economy) $Y^*_{X,t}$, can be expressed as follows:

$$\begin{aligned} Y^*_{X,t} &= C_{M,t} + C^E_{M,t} + I_{M,t} + (1-\alpha)(\frac{P_{M,t}}{P_t})^{-\gamma}[\sum_{i=H,X} \frac{\Psi_i}{2}(\frac{P_{i,t}}{P_{i,t-1}} - 1)^2 \\ &+ \frac{\Psi_M}{2}(\frac{P_{M,t}}{P_{M,t-1}} - 1)^2 + \sum_{j=F,D} \nu^j_t \frac{R^K_t}{P_t} Q_{t-1} K^j_t]. \end{aligned} \tag{A.27}$$

where $C_{M,t}$ and $C^E_{M,t}$ are demand for imports by households and entrepreneurs, respectively and $I_{M,t}$ is the domestic economy's import demand for investment goods.

Substituting (A.25) and the profits of both the final good producing and the importing firms into the budget constraints of the households and the entrepreneurs yields the following balance of payments condition after aggregation:

$$S_t P_{X,t} Y_{X,t} - S_t P^*_t Y^*_{X,t} = S_t(1+i^*_{t-1})(D^H_t \Psi_{D,t-1} + D^F_t) - S_t(D^H_{t+1} + D^F_{t+1}), \tag{A.28}$$

where the first and the second terms on the left are exports and imports, respectively. On the right is simply the change in the net foreign asset position, aggregated over households and entrepreneurs.

B. Model Equations: Foreign Economy

Apart from being asymmetric in size, domestic and foreign countries share the same preferences, technology and market structure for consumption and capital goods. Therefore, we only present equations, and give only brief explanation when necessary.

B.1. Households

$$C^*_{H,t} = \alpha^*(\frac{P^*_{H,t}}{P^*_t})^{-\gamma^*} C^*_t, \tag{B.1}$$

$$C^*_{M,t} = (1-\alpha^*)(\frac{P^*_{M,t}}{P^*_t})^{-\gamma^*} C^*_t, \tag{B.2}$$

$$P^*_t = [\alpha^* P^{*1-\gamma^*}_{H,t} + (1-\alpha^*) P^{*1-\gamma^*}_{M,t}]^{1/(1-\gamma^*)}, \tag{B.3}$$

$$\chi H_t^{*\varphi} = W_t^*, \tag{B.4}$$

$$(C_t^* - \frac{\chi}{1+\varphi} H_t^{*1+\varphi})^{-\sigma} = \beta(1+i_t^*)E_t[(C_{t+1}^* - \frac{\chi}{1+\varphi} H_{t+1}^{*1+\varphi})^{-\sigma} \frac{P_t^*}{P_{t+1}^*}], \tag{B.5}$$

B.2. Production Firms

$$W_t^* = \frac{(1-\eta)(1-\Omega)Y_t^* MC_t^*}{N_t^*}, \tag{B.6}$$

$$W_t^{*E} = (1-\eta)\Omega Y_t^* MC_t^*, \tag{B.7}$$

$$R_t^* = \frac{\eta Y_t^* MC_t^*}{K_t^*}, \tag{B.8}$$

$$\begin{aligned} P_{H,t}^* &= \frac{\lambda}{\lambda-1} MC_t^* - \frac{\Psi_H}{\lambda-1} \frac{P_t^*}{Y_{H,t}^*} \frac{P_{H,t}^*}{P_{H,t-1}^*} (\frac{P_{H,t}^*}{P_{H,t-1}^*} - 1) \\ &+ \frac{\Psi_H}{\lambda-1} E_t[\Theta_t^* \frac{P_{t+1}^*}{Y_{H,t}^*} \frac{P_{H,t+1}^*}{P_{H,t}^*} (\frac{P_{H,t+1}^*}{P_{H,t}^*} - 1)], \end{aligned} \tag{B.9}$$

$$\begin{aligned} S_t^* P_{X,t}^* &= \frac{\lambda}{\lambda-1} MC_t^* - \frac{\Psi_X}{\lambda-1} \frac{P_t^*}{Y_{X,t}^*} \frac{P_{X,t}^*}{P_{X,t-1}^*} (\frac{P_{X,t}^*}{P_{X,t-1}^*} - 1) \\ &+ \frac{\Psi_X}{\lambda-1} E_t[\Theta_t^* \frac{P_{t+1}^*}{Y_{X,t}^*} \frac{P_{X,t+1}^*}{P_{X,t}^*} (\frac{P_{X,t+1}^*}{P_{X,t}^*} - 1)], \end{aligned} \tag{B.10}$$

where $\Theta_t^* = \beta \frac{(C_{t+1}^* - \frac{\chi}{1+\varphi} H_{t+1}^{*1+\varphi})^{-\sigma}}{(C_t^* - \frac{\chi}{1+\varphi} H_t^{*1+\varphi})^{-\sigma}} \frac{P_t^*}{P_{t+1}^*}$.

B.3. Importing Firms

$$\begin{aligned} P_{M,t} &= \frac{\lambda}{\lambda-1} S_t^* P_t^* - \frac{\Psi_M}{\lambda-1} \frac{P_t}{Y_{M,t}} \frac{P_{M,t}}{P_{M,t-1}} (\frac{P_{M,t}}{P_{M,t-1}} - 1) \\ &+ \frac{\Psi_M}{\lambda-1} E_t[\Theta_t \frac{P_{t+1}}{Y_{M,t}} \frac{P_{M,t+1}}{P_{M,t}} (\frac{P_{M,t+1}}{P_{M,t}} - 1)], \end{aligned} \tag{B.11}$$

B.4. Unfinished Capital Producing Firms

$$I_{H,t}^* = \alpha^* (\frac{P_{H,t}^*}{P_t^*})^{-\gamma} I_t^* \tag{B.12}$$

$$I_{M,t}^* = (1-\alpha^*)(\frac{P_{M,t}^*}{P_t^*})^{-\gamma} I_t^*. \tag{B.13}$$

$$K_{t+1}^* = [\frac{I_t^*}{K_t^*} - \frac{\Psi_I}{2}(\frac{I_t^*}{K_t^*} - \delta)^2] K_t^* + (1-\delta) K_t^*. \tag{B.14}$$

$$\frac{Q_t^*}{P_t^*} = [1 - \Psi_I(\frac{I_t^*}{K_t^*} - \delta)]^{-1}. \tag{B.15}$$

B.5. Entrepreneurs

Entrepreneurs in foreign economy only borrow domestically in their own currency.

$$\begin{aligned} & E_t[R^{K*}_{t+1}Q^*_tK^*_{t+1}(k)(\int_{\overline{\omega}^*_{t+1}(k)}^{\infty}\omega^*(k)f(\omega^*)d\omega^* - \overline{\omega}^*_{t+1}(k)\int_{\overline{\omega^*}_{t+1}(k)}^{\infty}f(\omega^*)d\omega^*)] \\ = \quad & E_t[R^{K*}_{t+1}Q^*_tK^*_{t+1}(k)z^*(\overline{\omega}^*_{t+1}(k))], \end{aligned} \tag{B.16}$$

$$\begin{aligned} & E_t[R^{K*}_{t+1}Q^*_tK^*_{t+1}(k)(\overline{\omega}^*_{t+1}(k)\int_{\overline{\omega}^*_{t+1}(k)}^{\infty}f(\omega^*)d\omega^* \\ & +(1-\mu)\int_0^{\overline{\omega^*}_{t+1}(k)}\omega^*_{t+1}(k)f(\omega^*)d\omega^*)] \\ = \quad & E_t[R^{K*}_{t+1}Q_tK^*_{t+1}(k)g^*(\overline{\omega}^*_{t+1}(k);\varrho^*_t)], \end{aligned} \tag{B.17}$$

$$E_t[R^{K*}_{t+1}Q^*_tK^*_{t+1}(k)g^*(\overline{\omega}^*_{t+1}(k);\varrho^*_t)] = (1+i^*_t)D^*_{t+1}(k). \tag{B.18}$$

$$P^*_tNW^*_t = \vartheta[R^{K*}_tQ^*_{t-1}K^*_t(1-\nu^*_t) - (1+i^*_{t-1})D^*_t] + W^{E*}_t. \tag{B.19}$$

$$P^*_tC^{E*}_t = (1-\vartheta)[R^{K*}_tQ^*_{t-1}K^*_t(1-\nu^*_t) - (1+i^*_{t-1})D^*_t]. \tag{B.20}$$

$$C^{E*}_{H,t} = \alpha^*(\frac{P^*_{H,t}}{P^*_t})^{-\gamma}C^{E*}_t, \tag{B.21}$$

$$C^{E*}_{M,t} = (1-\alpha^*)(\frac{P^*_{M,t}}{P^*_t})^{-\gamma}C^{E*}_t. \tag{B.22}$$

$$E_t[R^{K*}_{t+1}] = E_t[(1+i^*_t)(1+\Phi^*_{t+1})], \tag{B.23}$$

$$1+\Phi^*_{t+1} = [\frac{z^{*\prime}(\overline{\omega}^*_{t+1}(k))}{g^*(\overline{\omega}^*_{t+1}(k);\varrho^*_t)z^{*\prime}(\overline{\omega}^*_{t+1}(k)) - z^*(\overline{\omega}^*_{t+1}(k))g^{*\prime}(\overline{\omega}^*_{t+1}(k);\varrho^*_t)}]. \tag{B.24}$$

$$z^*(\overline{\omega}^*_t) = 1 - \Theta(z^*_{1t} - \sigma^*_\omega) - \overline{\omega}^*_t(1-\Theta(z^*_{1t})) \tag{B.25}$$

$$g^*(\overline{\omega}^*_t;\varrho^*_t) = \varrho^*_t[\frac{\overline{\omega}^*_t}{\varrho^*_t}(1-\Theta(z^*_{2t})) + (1-\mu)\Theta(z^*_{2t}-\sigma^*_\omega)] \tag{B.26}$$

$$z^{*\prime}(\overline{\omega}^*_t) = -(1-\Theta(z^*_{1t})) \tag{B.27}$$

$$g^{*\prime}(\overline{\omega}^*_t;\varrho^*_t) = \varrho^*_t[1-\Theta(z^*_{2t}) - \frac{\mu}{\sqrt{2\pi}\sigma^*_\omega}\exp(-\frac{z^{*2}_{2t}}{2}) \tag{B.28}$$

$$E_t[R^{K*}_{t+1}] = E_t[\frac{R^*_{t+1}}{Q^*_t} + \frac{Q^*_{t+1}}{Q^*_t}\{(1-\delta)+\Psi_I(\frac{I^*_{t+1}}{K^*_{t+1}}-\delta)\frac{I^*_{t+1}}{K^*_{t+1}} - \frac{\Psi_I}{2}(\frac{I^*_{t+1}}{K^*_{t+1}}-\delta)^2\}]. \quad \text{(B.29)}$$

B.6. Financial Intermediaries and Macroprudential Policy

We assume that there is no macroprudential policy in the foreign economy block.

B.7. Monetary Policy

$$1 + i^*_t = [(1+i^*)\ (\pi^*_t)^{\epsilon_\pi}(Y^*_t/Y^*)^{\epsilon_Y}]^{\varpi}[1+i^*_{t-1}]^{1-\varpi}, \quad \text{(B.26)}$$

B.8. General Equilibrium and Balance of Payments Dynamics

$$S^*_t = 1/S_t \quad \text{(B.27)}$$

$$Y^*_t = Y^*_{H,t} + Y^*_{X,t}, \quad \text{(B.28)}$$

$$\begin{aligned} Y^*_{H,t} &= C^*_{H,t} + C^{E*}_{H,t} + I^*_{H,t} + \alpha^*(\frac{P^*_{H,t}}{P^*_t})^{-\gamma}[\sum_{i=H,X}\frac{\Psi_i}{2}(\frac{P^*_{i,t}}{P^*_{i,t-1}}-1)^2 \\ &+ \frac{\Psi_M}{2}(\frac{P^*_{M,t}}{P^*_{M,t-1}}-1)^2 + \nu^*_t\frac{R^{K*}_t}{P^*_t}Q^*_{t-1}K^*_t], \end{aligned} \quad \text{(B.29)}$$

$$\begin{aligned} Y_{X,t} &= C^*_{M,t} + C^{E*}_{M,t} + I^*_{M,t} + (1-\alpha^*)(\frac{P^*_{M,t}}{P^*_t})^{-\gamma}[\sum_{i=H,X}\frac{\Psi_i}{2}(\frac{P^*_{i,t}}{P^*_{i,t-1}}-1)^2 \\ &+ \frac{\Psi_M}{2}(\frac{P^*_{M,t}}{P^*_{M,t-1}}-1)^2 + \nu^*_t\frac{R^{K*}_t}{P^*_t}Q^*_{t-1}K^*_t]. \end{aligned} \quad \text{(B.30)}$$