# Global financial crisis, financial contagion and emerging markets*

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**Abstract**

The recent global financial crisis was the first in recent history that was triggered by problems in the financial system of the mature economies. Existing work on financial crisis in emerging market countries, however, almost exclusively focus on the role of financial frictions in the domestic economy (see, for example, Dooley, 2000 and Caballero and Krishnamurty, 2001). In contrast, in this paper we propose a two-country dynamic, stochastic general equilibrium (DSGE) model to investigate the transmission of a global financial crisis that originates from financial frictions in the rest of the world. We find that the scale of financial spillovers from the global to the domestic economy is a key determinant of the severity of the financial crisis for the domestic economy. Moreover, in contrast to the existing literature, our results suggest that the greater a country's trade integration with the rest of the world, the greater the response of its macroeconomic aggregates to a sudden stop of capital flows.

Keywords: sudden stops, financial crises, emerging markets.

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# 1 Introduction

The global financial turmoil that has gripped the world economy since August 2007 has been widely viewed as unprecedented, at least since the Great Depression of the 1930s. The turbulence in financial systems was followed by a significant reduction in real economic activity in a large number of countries.[1] For emerging market and developing economies, financial crisis is not a new phenomenon. Indeed, since the early 1990s countries as diverse as Mexico, Russia, a group of East Asian countries, Brazil, Turkey and Argentina have all been hit by either currency or financial crises, or both. Although country experiences have varied with regard to the source of difficulty in each episode, the profile of crises has been fairly similar. A "sudden stop" of capital inflows is almost always followed by a sharp contraction in economic activity. Furthermore, many countries witnessed substantial losses in the value of their currencies, which greatly helped in recovering from the crises. In essence, these countries were able to expand net exports to alleviate or compensate for the contractionary effects of foreign currency liabilities following devaluations – the so-called balance sheet effects. For instance, sharp current account reversals were a common feature of recovery processes in most Asian countries following the 1997 crisis.

When set against this background, the recent global financial crisis has been different in two major ways.[2] Firstly, from the viewpoint of an emerging market economy, the source of the sharp reduction in capital inflows on this occasion has been the severe liquidity squeeze in the financial markets of developed economies, unlike in any of the previous experiences. Indeed, the slowdown in financial flows to the emerging market economies followed from the virtual standstill in the credit markets in the US and the UK spreading to other major financial markets. Secondly, emerging market countries have also witnessed a substantial fall in their exports as the financial crisis hit consumer spending in the developed world. Hence, given the strong downturn in the global economy, countries have been unable to export their way out of the crisis even though a large number of countries experienced substantial devaluations of their currencies.

The above evaluation suggests that both financial and trade channels have been

[1] See, for example, IMF (2010).

[2] See, Reinhart and Rogoff (2009) for a comprehensive evaluation of the differences between the current and previous experiences of financial crises.

crucial in the transmission of the global financial crisis to emerging market countries. Motivated by this observation, in this paper, we develop a two-country dynamic stochastic general equilibrium (DSGE) model with an explicit treatment of both trade and financial linkages between the countries. This enables us to investigate possible spillover effects of a financial crisis originating in the global economy on to a domestic, small open economy (hereafter SOE). There are three features of our model economy that are representative of emerging market economies. First, the domestic economy exhibits financial frictions in the form of high leverage; that is, a large share of investment is financed with external resources. Second, the borrowing is taken to be in foreign currency terms as is common in emerging market countries. In the presence of foreign currency debt, a change in the perception of foreign lenders of the current state of the economy leads to an endogenous adjustment in the cost of borrowing, generating a negative feedback loop between real and financial sectors. Finally, our model gives explicit consideration to exchange rate pass-through, the scale of which distinguishes the experiences of emerging and mature economies.

Our model differs from those in the existing literature in a number of ways. First, we incorporate explicitly a financial accelerator mechanism, with proper consideration of micro-foundations of financial frictions.[3] Second, the external finance premium is fully derived from first principles of the optimal contract problem between the borrower and the lender. This is of particular importance as it allows us to obtain analytical insights into the causes and consequences of endogenous changes in credit conditions. Third, in our model sudden stops take the form of a change in lenders' perception regarding the state of the economy (as in Curdia, 2007, 2008). This contrasts with existing work on sudden stops such as Devereux et al. (2006) and Gertler et al. (2007) which defines the initial shock as either an aggregate structural shock, such as a rise in foreign interest rates, or an adverse shock to fundamentals.

A crucial departure from the conventional financial accelerator is that, *ex ante*, lenders have imperfect knowledge about borrowers' productivity. An unfavorable change in lenders' perception creates a self-fulfilling pessimism about the economy through the enforcement of tighter credit conditions and the associated decline in the

[3] On a different subset of the literature, credit frictions are introduced through (binding) collateral constraints following Kiyotaki and Moore (1997). In this framework, financial constraints arise because lenders cannot force borrowers to repay their debt and thus physical assets are used as collateral for the borrowing. Christiano et al. (2004) and Braggion et al. (2009) are prominent examples that incorporate collateral constraints to provide an explanation of sudden stops.

productivity of capital-producing entrepreneurs in equilibrium. Given our explicit treatment of the rest of the world (hereafter ROW), we are able to fully consider exchange rate, trade and financial channels that transmit direct and indirect effects of global financial shocks to the SOE. Such a modelling strategy enables us to consider important transmission channels which are ignored in earlier studies.[4]

The main channels through which a global financial shock impacts upon the emerging market economy are as follows. The re-pricing of credit risk increases the cost of external financing, inducing a sharp decline in output and domestic inflation, and a depreciation of the domestic currency. Since the external risk premium is tied to the leverage ratio, firms reduce new borrowing in order to decrease the endogenous component of the risk premium. Moreover, the fall in domestic inflation and the depreciation of the domestic currency increase the real debt burden for leveraged households, leading to a decrease in consumption. The depreciation of the domestic currency enables the home country to compensate, at least partly, for the decline in consumption and investment demand. However, this only applies if the financial crisis originated in the domestic economy. In contrast, when the source of the financial shock is global, the export channel works in the opposite direction with global contraction leading to a fall in export demand for the domestic output resulting in a further decline in domestic economic activity.

We also explore the role of financial contagion and trade openness on the propagation of international financial shocks. Our results reveal that the greater the financial contagion from the ROW, the greater the severity of the financial crisis for the domestic economy. This is due to the fact that, a higher level of financial contagion induces a greater increase in external risk premium and thus a greater fall in capital inflows reducing investment, output and consumption. Furthermore, we find that the degree of financial contagion plays a key role in how monetary policy regimes influence the effects of the global financial shock on the domestic economy. In the absence of financial spillovers between countries, the domestic economy achieves low-

[4] One exception is a recent study by Devereux and Sutherland (2011) who also utilize a two-country general equilibrium model that features financial frictions in both countries. However, this paper differs from Devereux and Sutherland (2011) in a number of ways. First, the source of financial frictions in their model is binding enforcement constraints on credit supply in both countries - as in Kiyotaki and Moore (1997) - as opposed to high leverage that is financed by external resources in ours. Second, their paper focuses on the impacts of various degrees of financial integration whereas we examine the implications of both financial and trade integration. Finally, they analyze the role of productivity and financial shocks in the two countries, while our interest is in understanding how a small open economy responds to a financial shock originating in the global economy.

est risk premiums and thus highest net worth, investment, output and consumption under the fixed exchange rate regime following the global financial crisis, a result that is overturned in the presence of financial contagion. We also explore the role of trade integration with the ROW on the domestic economy's response to the global financial shock. We find that, in contrast to the existing literature, the greater a country's trade integration with the rest of the world, the greater the response of its macroeconomic aggregates to a sudden stop of capital flows.

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 special emphasis on the description of financial frictions. Section 3 presents the solution and the calibration of the model. Section 4 presents impulse responses to the financial shock and discusses the results. Finally, Section 5 provides the concluding remarks.

## 2 The Model

Based on the financial accelerator mechanism developed by Bernanke et al. (1999), our model shares its basic features with the recent theoretical studies incorporating the financial accelerator in combination with liability dollarization such as Cespedes et al. (2004), Devereux et al. (2006), Gertler et al. (2007) and Elekdag and Tchakarov (2007). However, our framework differs from the existing studies in three important ways. First, we develop a two-country sticky price DSGE model where both the trade and financial linkages between the two countries are fully specified. Modelling the foreign economy explicitly enables us to investigate the propagation of global financial crisis on the domestic economy by considering both the trade and financial channels. Second, we incorporate an endogenous change in the risk premium due to the change in the perception of the foreign lenders. Third, we enrich the model to reflect incomplete pass through in the short run by considering pricing to market behavior of the firms.

In our framework, both the SOE and the ROW are populated by households, firms, entrepreneurs and a monetary authority. Households receive utility from consumption and provide labor to the production firms. They obtain loans from both domestic and (incomplete) international financial markets. The households also own the firms in the economy, and therefore receive profits from these firms.

There are three types of firms in the model. Production firms produce a differentiated final consumption good using both capital and labor as inputs. These firms engage in local currency pricing and face price adjustment costs. As a result, final goods' prices are sticky in terms of the local currency of the markets in which they are sold. Importing firms 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 SOE is presented in this section and we use a simplified (closed-economy) version of the model for the 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:

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

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 $t$, $\beta$ 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.

[5] There is considerable empirical evidence of pricing-to-market and incomplete exchange rate pass-through in small open economies. See, for example, Naug and Nymoen (1996) and Campa and Goldberg (2005).

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 $\alpha$ and $0 < \alpha < 1$.

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, our two-country framework allows us to determine $P_t^*$ endogenously in the ROW block.

Households have access to two types of non-contingent one-period debt; one denominated in domestic currency, $B_t$, and the other 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 $\Psi_{D,t} = \frac{\Psi_D}{2}[\exp(\frac{S_t D_{t+1}^H}{P_t GDP_t} - \frac{SD^H}{PGDP}) - 1]^2$ when borrowing from the rest of the world.[6] Households own all home production and the importing firms and thus are recipients of profits, $\Pi_t$. 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).

[6] Following 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.

## 2.2 Firms

### 2.2.1 Production Firms

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

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

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, $H_t^E(j)$; 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).

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 $i = H, X$.[7] 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:

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

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,

[7] This generates a gradual adjustment in the prices of goods in both markets, as suggested by Rotemberg (1982).

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

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

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

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

where $\alpha^*$ denotes the fraction of world demand for domestic country's exports, $\gamma^*$ 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.[8]

### 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.[9]

[8] Since the profit maximization condition is symmetric among firms, the optimal price setting equations can be written in aggregate terms as follows

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

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

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

[9] The price index for the imported goods is then given by:

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

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:

$$I_t = \left[\alpha^{\frac{1}{\gamma}} I_{H,t}^{(\gamma-1)/\gamma} + (1-\alpha)^{\frac{1}{\gamma}} I_{M,t}^{(\gamma-1)/\gamma}\right]^{\gamma/(\gamma-1)}, \tag{8}$$

where the domestic and imported investment goods' prices are assumed to be the same as the domestic and imported 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 $I_{H,t} = \alpha(\frac{P_{H,t}}{P_t})^{-\gamma} I_t$ and $I_{M,t} = (1-\alpha)(\frac{P_{M,t}}{P_t})^{-\gamma} I_t$.

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 $\frac{\Psi_I}{2}(\frac{I_t}{K_t} - \delta)^2$ where $\delta$ 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:

$$K_{t+1} = [\frac{I_t}{K_t} - \frac{\Psi_I}{2}(\frac{I_t}{K_t} - \delta)^2]K_t + (1-\delta)K_t. \tag{9}$$

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 $Q_t$:

$$\frac{Q_t}{P_t} = [1 - \Psi_I(\frac{I_t}{K_t} - \delta)]^{-1}. \tag{10}$$

## 2.3 Entrepreneurs

As stated earlier, entrepreneurs are key players in our model. They transform unfinished capital goods and sell them to the production firms. They finance their investment by borrowing from foreign lenders.[10] There is a continuum of entrepre-

[10] See, Mishkin (1998) and Eichengreen and Hausmann (2005) for the importance of foreign currency borrowing in emerging market countries.

neurs indexed by $k$ in the interval [0,1]. Each entrepreneur has access to a stochastic technology in transforming $K_{t+1}(k)$ units of unfinished capital into $\omega_{t+1}(k)K_{t+1}(k)$ units of finished capital goods. 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 $E(.) = 1$.[11]

At the end of period $t$, each entrepreneur $k$ has net worth denominated in domestic currency, $NW_t(k)$. The budget constraint of the entrepreneur is defined as follows:

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

where $D^E_{t+1}$ denotes foreign currency denominated debt. Equation (11) simply states that capital financing is divided between net worth and foreign debt. It is clear that the entrepreneurs are exposed to exchange rate risk -fluctuations in the nominal exchange rate create balance sheet effects in the model.

Productivity is observed by the entrepreneur, but not by the lenders who have imperfect knowledge of the distribution of $\omega_{t+1}(k)$. Following Curdia (2007, 2008) we specify the lenders perception of $\omega_{t+1}(k)$ as given by $\omega^*_{t+1}(k) = \omega_{t+1}(k)\varrho_t$ where $\varrho_t$ is the misperception factor over a given interval [0,1]. Further, the misperception factor, $\varrho_t$, is assumed to follow $\ln(\varrho_t) = \rho_\varrho \ln(\varrho_{t-1}) + \xi \ln(\varrho^*_t) + \varepsilon_\varrho$ where $\rho_\varrho$ denotes the persistence parameter, and $\xi$ measures the degree of financial contagion from ROW to the domestic economy. Similarly, we assume that $\varrho^*_t$, the perception of lenders regarding the the foreign entrepreneurs' productivity, follows an AR(1) process with persistence parameter $\rho_{\varrho^*}$. We take the origin of the financial shock as a change in lenders' perception regarding idiosyncratic productivity ($\varepsilon_\varrho$). We assume that when there is uncertainty about the underlying distribution, lenders take the worst case scenario as the mean of the distribution of $\omega_{t+1}(k)$. The Appendix provides more details on the specification of the ambiguity aversion faced by lenders and the optimal contracting problem.

The optimal contract identifies the capital demand of entrepreneurs, $K_{t+1}(k)$ and a cut off value, $\overline{\omega}_{t+1}(k)$ such that the entrepreneur will maximize their expected

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

return subject to the participation constraints of the lender. As shown in the Appendix, the first order conditions yield:

$$E_t[R^K_{t+1}] = E_t[(1+i^*_t)(1+\Phi_{t+1})], \tag{12}$$

where $(1+\Phi_{t+1})$ is the external risk premium defined by:

$$1+\Phi_{t+1} = [\frac{z'(\overline{\omega}_{t+1}(k))}{g(\overline{\omega}_{t+1}(k);\varrho_t)z'(\overline{\omega}_{t+1}(k)) - z(\overline{\omega}_{t+1}(k))g'(\overline{\omega}_{t+1}(k);\varrho_t)}]E_t\{\frac{S_{t+1}}{S_t}\}. \tag{13}$$

where $z(\overline{\omega})$ and $g(\overline{\omega}(k);\varrho)$ are the borrowers' and lenders' share of the total return, respectively. As shown in Bernanke et al. (1999), this external risk premium depends on the leverage, $\frac{S_t D^E_{t+1}}{Q_t K_{t+1}}$, of the entrepreneur. 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 impact on the entrepreneurs' net worth increases their leverage, resulting in an upward adjustment in the external risk premium.

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. This assumption guarantees that self financing never occurs and borrowing constraints on debt are always binding. Given that $\omega(k)$ 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 $\vartheta$, the net worth can be expressed as follows:

$$P_t NW_t = \vartheta[R^K_t Q_{t-1} K_t z(\overline{\omega}_t)] + W^E_t. \tag{14}$$

Equation (14) 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 $z(\overline{\omega}_t)+g(\overline{\omega}_t,\varrho_t) = 1-\nu_t$ (where $\nu_t$ is the cost of monitoring, a deadweight loss associated with financial frictions) and

by using the participation constraint of the lenders, we can rewrite the net worth of the entrepreneur as:

$$P_t NW_t = \vartheta[R_t^K Q_{t-1} K_t (1-\nu_t) - (1+i_{t-1}^*) S_t D_t^E] + W_t^E. \tag{15}$$

It is clear from (15) that unanticipated changes in the nominal exchange rate increase the debt burden of the entrepreneur, and therefore decrease its net worth. This, in turn, increases the leverage of the entrepreneur and raises the external risk premium, implying a higher cost of financing. This is an additional mechanism that magnifies the role of the financial accelerator in the economy through transmitting fluctuations in the nominal exchange rate to the balance sheets of entrepreneurs.

The entrepreneurs leaving the scene at time $t$ consume their return on capital. The consumption of the exiting entrepreneurs, $C_t^E$, can then be written as:[12]

$$P_t C_t^E = (1-\vartheta)[R_t^K Q_{t-1} K_t (1-\nu_t) - (1+i_{t-1}^*) S_t D_t^E]. \tag{16}$$

Because of investment adjustment costs and incomplete capital depreciation, entrepreneurs' return on capital, $R_t^K$, 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 ($\frac{Q_{t+1)}}{Q_t}$):

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

## 2.4 Monetary Policy

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

$$1 + i_t = (1+i)\ (\pi_t)^{\epsilon_\pi} (Y_t/Y)^{\epsilon_Y}, \tag{18}$$

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

[12] 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).

## 2.5 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. Also, given that frictions such as adjustment and monitoring costs are expressed in terms of the final composite good, part of the output is taken up with the price adjustment costs for final consumption goods as well as those for imported and exported goods and the monitoring costs. Thus the overall resource constraint faced by the domestic economy can be written as:

$$Y_t = Y_{H,t} + Y_{X,t}, \tag{19}$$

where

$$\begin{aligned} Y_{H,t} &= C_{H,t} + C^E_{H,t} + I_{H,t} + \alpha(\frac{P_{H,t}}{P_t})^{-\gamma}[\sum_{i=H,X}\frac{\Psi_i}{2}(\frac{P_{i,t}}{P_{i,t-1}}-1)^2 \\ &\quad + \frac{\Psi_M}{2}(\frac{P_{M,t}}{P_{M,t-1}}-1)^2 + \nu_t\frac{R^K_t}{P_t}Q_{t-1}K_t], \end{aligned} \tag{20}$$

where $Y_{X,t}$ is the foreign demand for domestic goods and $C_{H,t}$ is the household consumption demand, $C^E_{H,t}$ is the entrepreneur's consumption demand, both for domestic goods and $I_{H,t}$ is the domestic investment goods used by the unfinished capital producing firms. In (20), $\Psi_H, \Psi_X$ and $\Psi_M$ denote price adjustment costs for domestic, exported and the imported good, respectively and $\nu_t$ is the cost of monitoring for the lenders that is passed on to the domestic economy through the external finance premium.

The import demand of the domestic economy, $Y_{M,t}$, can be expressed as follows:

$$\begin{aligned} Y_{M,t} &= C_{M,t} + C^E_{M,t} + I_{M,t} + (1-\alpha)(\frac{P_{M,t}}{P_t})^{-\gamma}[\sum_{i=H,X}\frac{\Psi_i}{2}(\frac{P_{i,t}}{P_{i,t-1}}-1)^2 \\ &\quad + \frac{\Psi_M}{2}(\frac{P_{M,t}}{P_{M,t-1}}-1)^2 + \nu_t\frac{R^K_t}{P_t}Q_{t-1}K_t]. \end{aligned} \tag{21}$$

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.

Equilibrium in the labor market requires that:

$$N_t = {H_t}^{1-\Omega}, \tag{22}$$

where ${H_t}^{1-\Omega}$ is the labor demand for non-entrepreneurial labour.

Substituting (19) 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:

$$S_t P_{X,t} Y_{X,t} - S_t P_t^* Y_{M,t} = S_t(1 + i_{t-1}^*)(D_t^H \Psi_{D,t-1} + D_t^E) - S_t(D_{t+1}^H + D_{t+1}^E), \quad (23)$$

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.

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).[13] 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, $\beta$ 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 $\varphi$ 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 be 0.35 which is within the range of the values used in the literature.[14] The share

[13] The 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.

[14] The values for openness in the existing literature range between 0.25 (Cook, 2004; Elekdag and Tchakarov, 2007) and 0.5 (Gertler et al., 2007). We chose to set a middle value of this range, but we conduct a sensitivity analysis regarding the value of openness in Section 4.2.2.

of capital in production, $\eta$, is taken to be 0.35, consistent with other studies.[15] Following Devereux et al. (2006), the elasticity of substitution between differentiated goods of the same origin, $\lambda$, 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 $\delta$ is taken to be 0.025, a conventional value used in the literature. Similar to Gertler et al. (2007), we set the share of entrepreneurs' labour, $\Omega$, 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 $\alpha^*$ at 0.1 with a price elasticity of unity, $\gamma^* = 1$. Regarding monetary policy, we use the original Taylor estimates and set $\epsilon_\pi = 1.5$ and $\epsilon_Y = 0.5$ in the baseline calibration, and the degree of financial contagion from ROW to the domestic economy, $\xi$, is assumed to 1. Both $\rho_\varrho$ and $\rho_{\varrho^*}$ are taken to be 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.[16]

### 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.[17] The monitoring cost parameter, $\mu$, is taken as 0.2 for the SOE as in Devereux et al. (2006). These parameter values imply a survival rate, $\vartheta$, 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

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

[16] We carry out a series of sensitivity analyses in order to asses the robustness of our results under the benchmark calibration. In Section 4, we report the results regarding the degree of financial contagion, trade openness, and monetary policy parameters. We also conduct sensitivity checks with regard to the degree of exchange rate pass-through and export demand parameters, and find that our main results are not sensitive to changes in these parameters. These are not reported due to space limitations.

[17] These figures are decade averages for emerging Americas, emerging Asia, and emerging Europe between 2000-2010. Worldscope data (debt as a percentage of assets- data item WS 08236) are used for the leverage ratio. External risk premium is calculated as the difference between the lending and the 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.

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 |
| $\xi = 1$ | Degree of financial contagion |
| $\rho_\varrho$ | Persistence of the domestic perception shock |
| $\rho_{\varrho^*}$ | Persistence of the foreign perception shock |

Table 2: Parameter Values for the Entrepreneurial Sector

| | |
|---|---|
| Small Open 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 |

US economy so we set a quarterly external risk premium, $\Phi_t^*$, of 0.005. The cost of monitoring in the ROW, denoted by $\mu^*$, 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 better financing opportunities, leading to a higher economy-wide leverage. Moreover, having experienced dramatic financial crisis at the turn of the century, emerging market economies have been more vigilant towards lending activities through tighter financial regulation, which in many cases has helped to contain leverage ratios in these economies.[18]

# 4 Impulse Responses to Financial Shocks

In this section, we analyze the response of macroeconomic aggregates to two types of financial shock: one is originated in the domestic economy and the other is global. In both cases, the source of the financial shock is the change in lenders' perception of the entrepreneurs' productivity.

## 4.1 Financial Crisis in the Domestic Economy

We first investigate the case of a domestic financial crisis. In what follows, we explore how an unanticipated (temporary) shock to the investors' perception of the entrepreneurs' productivity is transmitted to the rest of the economy. Such a perception shock leads to a reversal of capital flows out of the domestic country, which we refer

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

to as the sudden stop. The response of the domestic economy to the sudden stop is presented in Figure 1. When the investors' perception about the distribution of the entrepreneurs' productivity changes, lending to domestic entrepreneurs becomes more risky, leading to a rise in the external risk premium on impact. As the cost of borrowing rises, entrepreneurs reduce their use of external financing by undertaking fewer projects. This decline in leverage causes a downward adjustment in the risk premium, mitigating the initial impact of a sudden stop to some extent. Lower borrowing, however, decreases the future supply of capital and hence brings about a decrease in investment in the economy. The fall in the inflow of capital also lowers the demand for domestic currency, leading to its depreciation. Since the entrepreneurs' borrowing is denominated in foreign currency, this unanticipated change in the exchange rate also creates balance sheet effects through a rise in the real debt burden. The outcome is lower investment and output in the economy following the sudden stop, in line with the experience of several emerging market countries during the 1990s.

Although the rise in the nominal exchange rate puts an upward pressure on the CPI based inflation, the decrease in the domestic price level more than offsets this effect, bringing about a fall in the CPI. In spite of this lower price level, however, aggregate demand falls due to lower investment and output, resulting in lower labor demand and thereby lower real wages.

There is an additional channel through which the effect of the shock is transmitted to the rest of the economy, working through the export demand. Following the depreciation of the domestic currency, the ROW's demand for domestic goods increases. On the other hand, imports decline on account of both income and exchange rate effects. Trade balance improves, but this effect is not strong enough to offset the decline in domestic demand in our simulations, and hence output contracts. In practice, the export channel is generally highly effective for countries that are hit by financial crises and experience a sizable loss of value of their currencies. For instance, most East Asian countries benefitted from significant improvements in their exports following the 1997 Asian crisis, which has been widely viewed to be an important factor in their swift recoveries (see, for example, Bleaney, 2005). It is important to note, however, that this favorable impact of export demand on output recovery not only disappears but starts to work in the opposite direction when the financial crisis

originates in the global economy, as is explored in the following section.

## 4.2 Financial crisis in the ROW

In this section, we explore the channels through which a financial shock originating in the ROW is transmitted to the SOE and the role of monetary policy in shaping the domestic economy's responses to the financial shock. The perception shock is now taken to be faced by the ROW entrepreneurs and we take this to represent the case of a global financial crisis.

### 4.2.1 Channels of transmission - the global financial crisis

The global financial shock is transmitted to the domestic economy through three separate channels involving both financial and trade linkages. The first of these is through financial spillovers. We postulate that investors' perception regarding the true distribution of entrepreneurs' productivity in the ROW and the SOE are inherently related. This is based on the notion that investors optimally choose the scale and the terms of credit they extend to borrowers in a forward looking manner. For instance, when faced with credit tightening in the global economy, investors can anticipate *ex-ante* that this will be transmitted to the SOE through real and financial cross-country linkages, implying an unfavorable change in their perceptions of the domestic entrepreneurs today. Also, some asset market linkages such as herding behavior only or mainly exist during times of crisis, a phenomenon commonly referred to as "pure contagion" (see, for example, Kaminsky and Reinhart, 2000 and Moser, 2003). Motivated by these observations, we maintain that one channel through which the financial shock spills over onto the domestic economy is through an unfavourable shift in investors' perception of the domestic entrepreneurs. In what follows, we refer to this mechanism as the financial contagion channel.

The second channel through which the global financial shock is propagated to the domestic economy is the export channel. The financial crisis in the ROW reduces output and thereby export demand in the ROW and thus net exports of the domestic economy. There is also a third channel of propagation of the global financial shock, which works through a substitution effect. The unfavourable change in investors' perception of the foreign entrepreneurs' productivity induces investors to look for alternative investment opportunities, leading to an increase in capital inflows into the SOE, which would, partly offset the impact of the first two channels. Clearly, the

lower the financial contagion from the ROW to the domestic economy, the greater the impact of the favourable substitution effect. We now turn to exploring these channels separately.

Figure 2 and 3 present the domestic economy's response to a global financial shock, with and without financial contagion, respectively. Figure 2 features two alternative scenarios; full contagion, $\xi = 1$ and partial contagion, $\xi = 0.5$. We set the foreign shock to be the same magnitude (2 per cent) as in the previous case so that the responses are comparable with Figure 1. The deterioration in investors' perception in the domestic economy following that in the ROW raises the external risk premium, setting in motion the process described above. Responses presented in Figure 2 reveal that the impact of the global financial shock on the domestic economy is larger than that of a domestic one. Although the change in the perception of foreign investors about the state of the domestic economy is identical under the two scenarios, falls in both capital and investment are greater with the global financial shock and the fall in output is twice the size. Similarly, the decrease in foreign borrowing is larger than that of the previous case, leading to a much sharper depreciation of the domestic currency. Likewise, changes in inflation and asset prices are much more pronounced under the global financial shock than with the sudden stop of domestic origin.

One main difference between this case of a foreign financial shock and the domestically originated one, as explored in the previous section, is in the way the export channel works. As is seen above, when the economy is hit by a financial crisis of domestic origin, the depreciation of the currency brings about an improvement in net exports, which partly offsets the initial decline in output. In contrast, when the financial shock is originated in the ROW the export channel works in the opposite direction, adding to the unfavourable impact that works through financial contagion, hence worsening the overall fall in output. This is because the global financial crisis in the ROW reduces net worth, capital, investment and output in the ROW, and therefore decreases the domestic economy's exports and therefore output. This effect is present even though the exchange rate depreciates much more in this case than under the previous scenario where the crisis is of domestic origin. As output in the ROW returns to its previous level, the export demand improves although the trade balance continues to deteriorate owing to the rise in imports following the

recovery in domestic output.

In order to explore the non-contagion channels more explicitly we now have a further experiment where we shut off the contagion channel and thus focus on the export and substitution channels. Figure 3 denotes the changes in the domestic economy following the financial crisis in the ROW, without contagion in the form of a further financial shock in the SOE. There are now two opposing effects of the ROW's financial crisis on the outcomes in the SOE. The first is through the reduced net exports due to the contraction in the ROW following the financial crisis. The second, in contrast, is a favourable impact leading to an increase in capital inflows. This is because lending to domestic entrepreneurs is now perceived to be more profitable as the domestic economy is in a better financial position. The overall response is determined by the balance of the two effects. As is seen from Figure 3, in the absence of financial contagion, the increase in risk premium is considerably lower than that in the above two cases and that of the foreign economy. As a result, capital inflows, net worth and investment all increase following the financial shock, and thus contraction in output in the domestic economy is smaller.

### 4.2.2 The role of trade openness

Having established that a global financial shock is transmitted to the domestic economy through both the trade and financial channels, it follows that the extent of the domestic response to a global financial tightening will be determined by, among other factors, the openness of the domestic economy. We now turn to exploring the role of trade openness in the propagation of the foreign financial shock more explicitly.

Figure 4 and Figure 5 illustrate the domestic responses to a foreign financial shock under varying degrees of trade integration between the domestic economy and the ROW with and without financial contagion, respectively. In our simulations the degree of trade integration is measured by $(1-\alpha)$, the share of imports in domestic consumption. The profile of the SOE in Figure 4 clearly exhibits the important role played by the degree of trade openness in the amplification of the global financial shock. As is seen from the responses in Figure 4, the greater the trade integration between the two countries, the more significant is the impact of the global financial crisis on the SOE. It is also clear that, a rise in openness leads to a greater decline in output since in the presence of financial contagion, there are second round effects

setting in motion further deterioration in the domestic economy in this case, as explained earlier. The relationship between a country's openness to trade and its vulnerability to sudden stops has already been the focus of an extensive literature (see, for example Calvo et al. 2006 and Martin and Rey, 2006). A common finding in this literature has been that openness makes countries less vulnerable to crises. In contrast, we find that when the financial shock originates in the rest of the world - when the crisis is a global one- the more open an economy, the greater the unfavorable consequences of the financial crisis for the domestic economy. Indeed, among the countries that have experienced largest falls in economic activity during the recent financial crisis have been Singapore, Taiwan and Turkey, all of which are highly open economies.[19]

### 4.2.3 The role of monetary policy

What is the role of monetary policy in determining the domestic economy's response to the global financial shock? We attempt to answer this question by exploring the effects of the financial shock on the domestic economy under three separate monetary policy regimes. These are a fixed exchange rate regime; a strict inflation targeting (IT) regime where the central bank only cares about inflation and a flexible IT regime where monetary authority responds to both inflation and the output gap. Figure 6 and 7 illustrate the responses under the three regimes with and without financial contagion, respectively and offer a number of interesting insights. As is seen from Figure 6, in the presence of financial contagion, the global financial shock brings about a sharp rise in the external risk premium, a steep fall in capital inflows and thus in investment under all three regimes. However, as is also clear from Figure 6, the impact of the crisis on output is more pronounced under the fixed exchange rate regime than under the either of the IT regimes. This is because the competitiveness gain from the depreciation of the currency following the financial shock under both types of IT regime is absent under the fixed exchange rate regime, resulting in greatest decline in net exports and hence output of all three cases.

In contrast, when there is no financial contagion output in the domestic economy rises under the fixed exchange rate regime, as is depicted by Figure 7. Since

[19] The fall in output in the first quarter of 2009 as compared with a year earlier was 10.1, 10.2 and 13.8 per cent for Singapore, Taiwan and Turkey, respectively. Similarly, Germany and Japan, that are among the most open of mature economies, contracted by 6.9 and 8.8 per cent, respectively over the same period (The Economist, July 4th, 2009).

the nominal exchange rate is constant under this scenario, the increase in the risk premium is lower than that under the two alternative monetary policy rules due to the presence of foreign currency denominated debt. Lower external risk premiums under the fixed exchange rate regime, in turn, lead to a rise in the net worth of firms, and thus in investment and output without increasing debt. Similar to the case with financial contagion, the flexible IT regime is associated with a higher nominal and real depreciation, higher investment and output than the strict IT regime.

# 5 Conclusions

This paper has developed an open economy DSGE model to investigate the transmission of a global financial crisis to a small open economy. Our framework has two important novel features. First, in contrast to most existing small open economy models, we present a two-country framework where both trade and financial linkages between the countries are fully specified. Secondly, we incorporate financial frictions in an explicit manner where the external finance premium is fully derived from first principles of the optimal contract problem between the borrowers and the lenders.

This framework allows us to account for some important aspects of the recent global financial crisis experience. We find that small open economies facing a sudden stop of capital inflows arising from financial distress in the global economy are likely to face a more prolonged crisis than sudden stop episodes of domestic origin. This is largely attributable to an important source of difficulty in responding to a global financial shock - the inability of countries to export their way out of a crisis due to the slump in world consumer demand initiated by the global financial distress. In contrast, when the financial shock is of domestic origin, the domestic economy benefits from the depreciation of its currency and the resulting current account reversal, which at least partly compensates for the fall in economic activity. This beneficial export channel disappears and indeed works in the opposite direction when the rest of the world also faces an unfavorable financial disturbance. The resulting contraction in output in the foreign economy is transmitted to the domestic economy through a fall in export demand, further reducing aggregate demand for home produced goods. This, in turn, is likely to increase the duration and the severity of crises for both countries in question, as mutual reductions in export demand set in motion a vicious circle, even in the absence of any protectionist

policies.

Our results are also suggestive of the role of contagion. We find that the lower the financial contagion from the global economy, the less significant the impact of a global financial shock on the domestic economy. We argue that this finding may shed some light on why the recent financial crisis has been relatively short-lived for a number of emerging market countries, especially those with limited financial exposure to the financial distress in the global economy. Our results also suggest that the degree of financial contagion is a key determinant of how monetary policy regimes influence the propagation of the global financial shock. We find that in the absence of financial spillovers between countries, risk premiums are lowest, net worth is highest so are investment, consumption and output under the fixed exchange rate regime, a result which is overturned in the presence of financial contagion. Moreover, in contrast to the existing literature, we find that the greater a country's trade integration with the rest of the world, the greater the response of its macroeconomic aggregates to a sudden stop of capital flows.

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# Appendix

## Optimal Contracting Problem

Entrepreneurs observe $\omega_{t+1}(k)$ *ex-post*, but the lenders can only observe it at a monitoring cost which is assumed to be a certain fraction ($\mu$) of the return. 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, $\overline{\omega}_{t+1}(k)$, such that if $\omega_{t+1}(k) \geq \overline{\omega}_{t+1}(k)$, the lender receives a fixed return in the form of a contracted interest on the debt. If $\omega_{t+1}(k) < \overline{\omega}_{t+1}(k)$, 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 entrepreneur and lender, respectively, as follows:

$$\begin{aligned} & E_t[R^K_{t+1} Q_t K_{t+1}(k)(\int_{\overline{\omega}_{t+1}(k)}^{\infty} \omega(k) f(\omega) d\omega - \overline{\omega}_{t+1}(k) \int_{\overline{\omega}_{t+1}(k)}^{\infty} f(\omega) d\omega)] \\ = \; & E_t[R^K_{t+1} Q_t K_{t+1}(k) z(\overline{\omega}_{t+1}(k))], \end{aligned} \tag{A1}$$

$$\begin{aligned} & E_t[R^K_{t+1} Q_t K_{t+1}(k)(\overline{\omega}^*_{t+1}(k) \int_{\overline{\omega}_{t+1}(k)}^{\infty} f(\omega^*) d\omega^* \\ & + (1-\mu) \int_0^{\overline{\omega}_{t+1}(k)} \omega^*_{t+1}(k) f(\omega^*) d\omega^*)] \\ = \; & E_t[R^K_{t+1} Q_t K_{t+1}(k) g(\overline{\omega}_{t+1}(k); \varrho_t)], \end{aligned} \tag{A2}$$

where $R^K_t$ denotes the *ex-post* realization of return to capital and $z(\overline{\omega})$ is the borrowers' share of the total return. We use the definition of the lender's perception of productivity shock $\omega^*_{t+1}(k)$ in Equation (A2) where $g(\overline{\omega}(k); \varrho)$ represents the lenders' share of the total return, itself a function of both the idiosyncratic shock and the perception factor.

We assume that each entrepreneur is subject to an idiosyncratic shock $\omega_t \in [0, \infty)$ with $E(\omega_t) = 1$ and c.d.f and p.d.f are given by $F(\omega_t)$ and $f(\omega_t)$. We define $z(\overline{\omega})$ as the expected gross share of the proceeds going to the borrower (ignoring the time subscript $t$ and entrepreneur index $k$ for notational simplicity):

$$
\begin{aligned}
z(\overline{\omega}) &\equiv \int_{\overline{\omega}}^{\infty} \omega f(\omega) d\omega - \overline{\omega} \int_{\overline{\omega}}^{\infty} f(\omega) d\omega \\
&\equiv 1 - \int_{0}^{\overline{\omega}} \omega f(\omega) d\omega - \overline{\omega} \int_{\overline{\omega}}^{\infty} f(\omega) d\omega \\
&\equiv 1 - \Gamma(\overline{\omega}),
\end{aligned} \tag{A3}
$$

where $\Gamma(\overline{\omega}) = [1 - F(\overline{\omega})]\overline{\omega} + \int_0^{\overline{\omega}} \omega dF(\omega)$, following Bernanke et al. (1999).

Let $R_t^C$ be the contractual rate specified by the lender. By definition, the default threshold ($\overline{\omega}_{t+1}(k)$) is set at the level of returns that is just enough to honor the debt contract obligations, satisfying the following equation:

$$
\frac{\overline{\omega}_{t+1}(k) R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}} = R_{t+1}^C(k) D_{t+1}^E(k) \tag{A4}
$$

Recall that the misperception of investors regarding the distribution of $\omega_{t+1}$ is represented by $\varrho_t$ such that $\omega_{t+1}^*(k) = \omega_{t+1}(k)\varrho_t$. As in Curdia (2007, 2008), we write the participation constraint of the investors (in foreign currency):

$$
\begin{aligned}
(1 + i_t^*) D_{t+1}^E(k) &= E_t[(1 - F^*(\overline{\omega}_{t+1}(k))) R_{t+1}^C(k) D_{t+1}^E(k)] \\
&\quad + (1 - \mu) E_t[\int_0^{\overline{\omega}_{t+1}(k)} \omega^*(k) dF^*(\omega^*(k)) \frac{R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}}]
\end{aligned} \tag{A5}
$$

Define:

$$
\begin{aligned}
F^*(\overline{\omega}) &\equiv \Pr(\omega^* \leq \overline{\omega}) \\
&= \Pr(\omega \varrho \leq \overline{\omega}) \\
&= \Pr(\omega \leq \frac{\overline{\omega}}{\varrho}) \\
&= F(\frac{\overline{\omega}}{\varrho}).
\end{aligned} \tag{A6}
$$

We also define $G(\overline{\omega}) \equiv \int_0^{\overline{\omega}} \omega f(\omega) d\omega \equiv \int_0^{\overline{\omega}} \omega dF(\omega)$ and note that $G(\overline{\omega}) = F(\overline{\omega}) E(\omega | \omega < \overline{\omega})$. Then we similarly express:

$$
\begin{aligned}
G^*(\overline{\omega}) &= F^*(\overline{\omega}) E(\omega^* | \omega^* < \overline{\omega}) \\
&= F(\frac{\overline{\omega}}{\varrho}) E(\omega | \omega < \frac{\overline{\omega}}{\varrho}) \\
&= \varrho G(\frac{\overline{\omega}}{\varrho}).
\end{aligned} \tag{A7}
$$

Noting that the monitoring cost ($v_t$) is given by $\mu G^*(\overline{\omega})$ and substituting (A4), (A6) and (A7) into (A5) we get:

$$\begin{aligned}(1+i_t^*)D_{t+1}^E(k) &= E_t[\frac{R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}}\{(1-F(\frac{\overline{\omega}_{t+1}(k)}{\varrho_t}))\overline{\omega}_{t+1}(k) \\ &\quad +(1-\mu)\varrho_t G(\frac{\overline{\omega}_{t+1}(k)}{\varrho_t})\}] \end{aligned} \tag{A8}$$

which can be re-arranged to yield:

$$(1+i_t^*)D_{t+1}^E(k) = E_t[g(\overline{\omega}_{t+1}(k);\varrho_t)\frac{R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}}] \tag{A9}$$

In (A9) $g(\overline{\omega};\varrho)$ is defined as

$$g(\overline{\omega};\varrho) \equiv \varrho[\Gamma(\frac{\overline{\omega}}{\varrho}) - \mu G(\frac{\overline{\omega}}{\varrho})]. \tag{A10}$$

We assume that the aggregate risk in terms of exchange rate and return to capital is borne by lenders such that the participation constraint holds with expectations as in Cespedes et al. (2004), Elekdag and Tchakarov (2007) and Curdia (2007, 2008). Therefore, it should be clear that return to capital ($R^K$) and the cut off value ($\overline{\omega}$) are state contingent and the participation constraint holds *ex post* with equality at each possible state.

We can now analyze the optimal contract which determines a state contingent cut off value $\overline{\omega}_t$ and $K_{t+1}(k)$ solving the following maximization problem:

$$\max\ E_t[R_{t+1}^K Q_{t+1} K_{t+1}(k) z(\overline{\omega}_{t+1}(k))]$$

subject to the participation constraint (A8). The optimality conditions for this maximization problem are:

$$E_t[R_{t+1}^K Q_t z(\overline{\omega}_{t+1}(k))] + E_t[\Lambda_{t+1}(\frac{R_{t+1}^K Q_t g(\overline{\omega}_{t+1}(k);\varrho_t)}{S_{t+1}} - \frac{(1+i_t^*)Q_t}{S_t})] = 0 \tag{A11}$$

$$\Lambda_{t+1}(U) = -\frac{\pi(U) z'(\overline{\omega}_{t+1}^U(k)) S_{t+1}^U}{g'(\overline{\omega}_{t+1}^U(k);\varrho_t)} \tag{A12}$$

where $U$ is the state of the world, $\pi(U)$ is the probability of the state $U$ and $\Lambda_{t+1}$ is the Lagrangian multiplier. Substituting (A12) into (A11) yields:

$$E_t[R^K_{t+1}(\frac{z'(\overline{\omega}_{t+1}(k))g(\overline{\omega}_{t+1}(k);\varrho_t)}{g'(\overline{\omega}_{t+1}(k);\varrho_t)} - z(\overline{\omega}_{t+1}(k)))] \tag{A13}$$

$$= \quad (1+i^*_t)E_t[\frac{S_{t+1}}{S_t}(\frac{z'(\overline{\omega}_{t+1}(k))}{g'(\overline{\omega}_{t+1}(k);\varrho_t)})]$$

Given that entrepreneurs are identical *ex ante,* each entrepreneur faces the same financial contract. We can then write the external risk premium $(1+\Phi_{t+1})$ as follows:

$$1+\Phi_{t+1} = [\frac{z'(\overline{\omega}_{t+1})}{g(\overline{\omega}_{t+1},\varrho_t)z'(\overline{\omega}_{t+1} - z(\overline{\omega}_{t+1})g'(\overline{\omega}_{t+1},\varrho_t)}]E_t\{\frac{S_{t+1}}{S_t}\}. \tag{A14}$$

Using (A14), (A13) can be re-written as $E_t[R^K_{t+1}] = E_t[(1+i^*_t)(1+\Phi_{t+1})]$. These two equations correspond to (13) and (12) in the text.

Figure 1. Dynamic Responses to a Financial Crisis in Domestic Economy: Domestic Economy[⊥]

(Percent deviations from steady state)

[⊥] The figures show impact of a 2% negative shock to the perception of investors regarding 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 Financial Crisis in Foreign Economy with Financial Contagion:Domestic Economy[⊥]

(Percent deviations from steady state)

[⊥]The figures show impact of a $2\%$ negative shock to the perception of investors regarding productivity of foreign entrepreneurs under two different levels of financial contagion ($\xi$). 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 Financial Crisis in Foreign Economy without Financial Contagion: Domestic Economy[⊥]

(Percent deviations from steady state)

[⊥]The figures show impact of a 2% negative shock to the perception of investors regarding productivity of foreign entrepreneurs without financial contagion. 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. Dynamic Responses to a Financial Crisis in Foreign Economy with Financial Contagion: Domestic Economy—The Impact of Openness[⊥]

(Percent deviations from steady state)

[⊥]The figures show impact of a 2% negative shock to the perception of investors regarding productivity of foreign entrepreneurs with financial contagion under three different level of trade integration $(1-\alpha)$. 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. Dynamic Responses to a Financial Crisis in Foreign Economy without Financial Contagion: Domestic Economy—The Impact of Openness[⊥]

(Percent deviations from steady state)

[⊥]The figures show impact of a 2% negative shock to the perception of investors regarding productivity of foreign entrepreneurs without financial contagion under three different level of trade integration $(1-\alpha)$. 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 6. Dynamic Responses to a Financial Crisis in Foreign Economy with Financial Contagion: Domestic Economy—The Impact of Monetary Policy Strategy[⊥]

(Percent deviations from steady state)

[⊥]The figures show impact of a 2% negative shock to the perception of investors regarding productivity of foreign entrepreneurs with financial contagion under three different monetary policy regimes; fixed exchange rate, inflation targeting,and strict inflation targeting. 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 7. Dynamic Responses to a Financial Crisis in Foreign Economy without Financial Contagion: Domestic Economy—The Impact of Monetary Policy Strategy[⊥]

(Percent deviations from steady state)

[⊥]The figures show impact of a 2% negative shock to the perception of investors regarding productivity of foreign entrepreneurs without financial contagion under three different monetary policy regimes; fixed exchange rate, inflation targeting,and strict inflation targeting. 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.