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External Finance, Sudden Stops, and
Financial Crisis:
What is Different This Time?

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**External Finance, Sudden Stops, and Financial Crisis:
What is Different This Time?**

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Abstract

This paper develops a two-country DSGE model to investigate the transmission of a global financial crisis to a small open economy. We find that economies hit by a sudden stop arising from financial distress in the global economy are likely to face a more prolonged crisis than sudden stop episodes of domestic origin. 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.

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I. 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.[2] 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 current global financial crisis is different in two major ways.[3] 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 United States and the United Kingdom 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 are unlikely to be able 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 crucial in the transmission of the current 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

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[2] See, for example, International Monetary Fund (2010).

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

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 microfoundations of financial frictions.[4] 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, Lane, and Xu (2006) and Gertler, Gilchrist, and Natalucci (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 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 modeling strategy enables us to consider important transmission channels which are ignored in earlier studies.

The main channels through which a global financial shock impacts upon the emerging market economy are as follows. The repricing 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

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[4] Kiyotoki and Moore (1997) introduce financial frictions through binding collateral constraints. 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 and others (2004) and Braggion and others (2009) are prominent examples that follow this subset of literature.

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.

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.

II. 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. Based on the financial accelerator mechanism developed by Bernanke, Gertler, and Gilchrist (1999), our model shares its basic features with the recent theoretical studies incorporating the financial accelerator in combination with liability dollarization such as Cespedes, Chang, and Velasco (2004), Devereux, Lane, and Xu (2006), Gertler, Gilchrist, and Natalucci (2007) and Elekdag and Tchakarov (2007). Two important modifications are introduced here. First we incorporate an endogenous change in the risk premium due to the change in the perception of the foreign lenders. Second, 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,

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

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 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).

A. 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, β is the representative consumer's subjective discount factor where $0 < \beta < 1$, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution and $\varphi > 0$ is the inverse elasticity of labor supply.

The composite consumption index, C_t, is given by:

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

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

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

where $j \in [0,1]$ indicates the goods varieties and $\lambda > 1$ is the elasticity of substitution among goods produced within a country. Equation (2) suggests that the expenditure share of the

domestically produced goods in the consumption basket of households is given by α and $0 < \alpha < 1$.

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

$$C_{H,t} = \alpha \left(\frac{P_{H,t}}{P_t} \right)^{-\gamma} C_t, \tag{3}$$

$$C_{M,t} = (1-\alpha) \left(\frac{P_{M,t}}{P_t} \right)^{-\gamma} C_t, \tag{4}$$

and the corresponding price index is given by:

$$P_t = \left[\alpha P_{H,t}^{1-\gamma} + (1-\alpha) P_{M,t}^{1-\gamma} \right]^{1/(1-\gamma)}, \tag{5}$$

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).[6] The corresponding price indices for domestically produced and imported goods are $P_{H,t} \equiv \left[\int_0^1 P_{H,t}(j)^{1-\lambda} dj \right]^{1/(1-\lambda)}$ and $P_{M,t} \equiv \left[\int_0^1 P_{M,t}(h)^{1-\lambda} dh \right]^{1/(1-\lambda)}$, where $h \in [0,1]$ is an index for monopolistically competitive importing firms.

The real exchange rate Q_t is defined as $Q_t = \frac{S_t P_t^*}{P_t}$, 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 enables us to determine P_t^* endogenously in the ROW block.

Households have access to two types of noncontingent 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, $\Psi_{D,t}$,

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[6] Note that, when $\gamma = 1$, openness of the economy is given by $(1-\alpha)$, the consumption index takes the form $C_t = \kappa C_{H,t}^\alpha C_{M,t}^{1-\alpha}$ where κ is the normalizing constant given by $\kappa = \left(\alpha^\alpha (1-\alpha)^{1-\alpha} \right)^{-1}$ and CPI index is read as $P_t = P_{H,t}^\alpha \left(P_{M,t} \right)^{1-\alpha}$.

given by $\Psi_{D,t} = \frac{\Psi_D}{2}\left[\exp\left(\frac{S_t D_{t+1}^H}{P_t GDP_t} - \frac{SD^H}{PGDP}\right) - 1\right]^2$ when they borrow from the rest of the world.[7]

Households own all home production and the importing firms and thus are recipients of profits, Π_t. Other sources of income for the representative household are wages W_t, and new borrowing net of interest payments on outstanding debts, both in domestic and foreign currency. Then, the representative household's budget constraint in period t can be written as follows:

$$P_t C_t + (1 + i_{t-1})B_t + (1 + i_{t-1}^*)\Psi_{D,t-1}S_t D_t^H = W_t H_t + B_{t+1} + S_t D_{t+1}^H + \Pi_t \qquad (6)$$

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 (6). The first order conditions for this optimization problem are given by:

$$\frac{H_t^{\varphi}}{C_t^{-\sigma}} = \frac{W_t}{P_t}, \qquad (7)$$

$$C_t^{-\sigma} = \beta(1 + i_t)E_t\left[C_{t+1}^{-\sigma}\frac{P_t}{P_{t+1}}\right], \qquad (8)$$

$$C_t^{-\sigma} = \beta(1 + i_t^*)\Psi_{D,t}E_t\left[C_{t+1}^{-\sigma}\frac{P_t}{P_{t+1}}\frac{S_t}{S_{t+1}}\right]. \qquad (9)$$

Equation (7) dictates the labor supply decision. Equations (8) and (9) are the Euler equations for the purchase of domestic and foreign currency bonds. In the absence of financial frictions, the combination of (8) and (9) would yield the standard uncovered interest rate parity condition.

B. Firms

Production Firms

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

$$Y_t(j) = A_t N_t(j)^{1-\eta} K_t(j)^{\eta}, \qquad (10)$$

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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 $N_t(j) = H_t(j)^{1-\Omega} H_t^R(j)^{\Omega}$. $K_t(j)$ 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 (9). Omitting the firm-specific indices for notational simplicity, cost minimizing behavior implies the following first order conditions:[8]

$$W_t = \frac{(1-\eta)(1-\Omega)Y_t MC_t}{H_t},$$
(11)

$$W_t^E = (1-\eta)\Omega Y_t MC_t,$$
(12)

$$R_t = \frac{\eta Y_t MC_t}{K_t},$$
(13)

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 $MC_t = \frac{R_t^{\eta} W_t^{1-\eta}}{A_t \eta^{\eta}(1-\eta)^{(1-\eta)}}$. Equations (11)-(13) exhibit the fact that the cost-minimizing input combination that each firm chooses depends on the relative factor price; that is, there is some substitution between labor and capital.

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

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

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[8] For simplicity, we normalize H_t^E to unity.

$$E_0 \sum_{t=0}^{\infty} \frac{\beta^t U_{c,t}}{P_t} \left[\begin{array}{c} P_{H,t}(j)Y_{H,t}(j) + S_t P_{X,t}(j)Y_{X,t}(j) - MC_t Y_t(j) \\[2mm] - P_t \sum_{i=H,X} \frac{\Psi_i}{2} \left(\frac{P_{i,t}(j)}{P_{i,t-1}(j)} - 1 \right)^2 \end{array} \right], \tag{14}$$

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

$$Y_{i,t}(j) = \left(\frac{P_{i,t}(j)}{P_{i,t}} \right)^{-\lambda} Y_{i,t} \quad \text{for } i = H, X, \tag{15}$$

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

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

$$Y_{X,t} = \alpha^* \left(\frac{P_{X,t}}{P_t^*} \right)^{-\gamma^*} Y_t^*, \tag{16}$$

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

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

$$P_{H,t} = \frac{\lambda}{\lambda-1} MC_t - \frac{\Psi_H}{\lambda-1} \frac{P_t}{Y_{H,t}} \frac{P_{H,t}}{P_{H,t-1}} \left(\frac{P_{H,t}}{P_{H,t-1}} - 1 \right)$$
$$+ \frac{\Psi_H}{\lambda-1} E_t \left[\Theta_t \frac{P_{t+1}}{Y_{H,t}} \frac{P_{H,t+1}}{P_{H,t}} \left(\frac{P_{H,t+1}}{P_{H,t}} - 1 \right) \right], \tag{17}$$

$$S_t P_{X,t} = \frac{\lambda}{\lambda-1} MC_t - \frac{\Psi_X}{\lambda-1} \frac{P_t}{Y_{X,t}} \frac{P_{X,t}}{P_{X,t-1}} \left(\frac{P_{X,t}}{P_{X,t-1}} - 1 \right)$$
$$+ \frac{\Psi_X}{\lambda-1} E_t \left[\Theta_t \frac{P_{t+1}}{Y_{X,t}} \frac{P_{X,t+1}}{P_{X,t}} \left(\frac{P_{X,t+1}}{P_{X,t}} - 1 \right) \right], \tag{18}$$

where $\Theta_t = \beta \dfrac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \dfrac{P_t}{P_{t+1}}$. Equation 17 (18) represents a New Keynesian Phillips curve for domestic goods sold in the home country (foreign country). This expression can be simplified to yield the conventional mark up rule in which firms set the price as a mark up over marginal cost when there is no adjustment cost, $\Psi_H = 0$ $(\Psi_X = 0)$.

Importing Firms

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

$$
P_{M,t} = \frac{\lambda}{\lambda-1} S_t P_t^* - \frac{\Psi_M}{\lambda-1} \frac{P_t}{Y_{M,t}} \frac{P_{M,t}}{P_{M,t-1}} \left(\frac{P_{M,t}}{P_{M,t-1}} - 1 \right)
$$
$$
+ \frac{\Psi_M}{\lambda-1} E_t \left[\Theta_t \frac{P_{t+1}}{Y_{M,t}} \frac{P_{M,t+1}}{P_{M,t}} \left(\frac{P_{M,t+1}}{P_{M,t}} - 1 \right) \right],
$$
(19)

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

Unfinished Capital Producing Firms

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

$$
I_t = \left[\alpha^{\frac{1}{\gamma}} I_{H,t}^{(\gamma-1)/\gamma} + (1-\alpha)^{\frac{1}{\gamma}} I_{M,t}^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-1)},
$$
(20)

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

$I_{M,t} = (1-\alpha) \left(\dfrac{P_{M,t}}{P_t} \right)^{-\gamma} I_t$. Competitive firms use investment as an input, I_t and combine it with rented capital K_t to produce unfinished capital goods. Following Kiyotaki and Moore (1997), we assume that the marginal return to investment in terms of capital goods is

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

$$K_{t+1}=\left[\frac{I_t}{K_t}-\frac{\Psi_I}{2}\left(\frac{I_t}{K_t}-\delta\right)^2\right]K_t+(1-\delta)K_t. \qquad (21)$$

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:

$$\frac{Q_t}{P_t}=\left[1-\Psi_I\left(\frac{I_t}{K_t}-\delta\right)\right]^{-1}. \qquad (22)$$

C. 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.[9] There is a continuum of entrepreneurs indexed by k in the interval [0,1]. Each entrepreneur has access to a stochastic technology in transforming $K_{t+1}(k)$ 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 $E(.)=1$.[10]

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:

$$P_tNW_t(k)=Q_tK_{t+1}(k)-S_tD_{t+1}^E(k) \qquad (23)$$

---

[9] See Mishkin (1998) and Eichengreen and Hausmann (1999, 2005) for the importance of foreign currency borrowing in emerging market countries.

[10] The idiosyncratic productivity is assumed to be distributed log-normally; $\log(\omega_t(k))\sim N\left(\frac{-1}{2}\sigma_\omega^2,\sigma_\omega^2\right)$. This characterization is similar to that in Carlstrom and Fuerst (1997), Bernanke, Gertler, and Gilchrist (1999), Cespedes, Chang, and Xu (2004) and Gertler, Gilchrist, and Natalucci (2007).

where D_{t+1}^E denotes foreign currency denominated debt. Equation (23) 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 $\omega_{t+1}^*(k) = \omega_{t+1}(k)\varsigma_t$ where ς_t is the misperception factor over a given interval [0,1]. Further, the misperception factor is assumed to follow $\ln(\varsigma_t) = \rho_\varsigma \ln(\varsigma_{t-1}) + \xi \ln(\varsigma_t^*) + \varepsilon_t$, where ρ_ς denotes the persistence parameter, and ξ measures the degree of financial integration or the extent of financial spillovers from ROW to the domestic economy. Similarly, we assume that ς_ς^*, the perception of lenders regarding the foreign entrepreneurs' productivity, follows an AR(1) process with persistence parameter ρ_{ς^*}. We take the origin of the financial shock as a change in lenders' perception regarding idiosyncratic productivity. 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).[11]

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 (μ) of the return.[12] As shown by Bernanke, Gertler, and Gilchrist (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 payment $\overline{\omega}_{t+1}(k)$ times the return on capital. 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:

$$E_t\left[R_{t+1}^K Q_t K_{t+1}(k)\left(\int_{\overline{\omega}_{t+1}(k)}^{\infty} \omega(k)f(\omega)d\omega - \overline{\omega}_{t+1}(k)\int_{\overline{\omega}_{t+1}(k)}^{\infty} f(\omega)d\omega \right) \right]$$
$$= E_t\left[R_{t+1}^K Q_t K_{t+1}(k) z(\overline{\omega}_{t+1}(k)) \right],$$

(24)

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[11] In Curdia (2007, 2008), the perception factor is kept at its low state value during the sudden stop periods, but there is a certain probability of exiting a sudden stop. Instead, we assume that the perception factor gradually goes back to its steady state level $(\varsigma = 1)$.

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

$$E_t\left[R^K_{t+1}Q_tK_{t+1}(k)\left(\begin{array}{c}\overline{\omega}^*_{t+1}(k)\int_{\overline{\omega}_{t+1}(k)}^{\infty}f(\omega^*)d\omega^* \\ +(1-\mu)\int_0^{\overline{\omega}_{t+1}(k)}\omega^*_{t+1}(k)f(\omega^*)d\omega^*\end{array}\right)\right] \tag{25}$$
$$= E_t\left[R^K_{t+1}Q_tK_{t+1}(k)g(\overline{\omega}_{t+1}(k);\varsigma_t)\right],$$

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 (25) where $g(\overline{\omega}(k);\varsigma)$ represents the lenders' share of the total return, itself a function of both the idiosyncratic shock and the perception factor.

Clearly, the opportunity cost of lending to the entrepreneur is the world interest rate, $(1+i^*_t)$. Thus the loan contract must satisfy the following for the lender to be willing to participate in it:

$$E_t\left[\frac{R^K_{t+1}Q_tK_{t+1}(k)}{S_{t+1}}g(\overline{\omega}_{t+1}(k);\varsigma_t)\right] = (1+i^*_t)D^E_{t+1}(k). \tag{26}$$

The optimal contracting problem identifies the capital demand of entrepreneurs, $K_{t+1}(k)$ and a cut off value, $\overline{\omega}_{t+1}(k)$ such that the entrepreneurs will maximize (24) subject to (26). As shown in the Appendix, the first order conditions yield:

$$E_t[R^K_{t+1}] = E_t[(1+i^*_t)(1+\Phi_{t+1})], \tag{27}$$

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

$$(1+\Phi_{t+1}) = \left[\frac{z'(\overline{\omega}_{t+1}(k))}{g(\overline{\omega}_{t+1}(k);\varsigma_t)z'(\overline{\omega}_{t+1}(k)) - z(\overline{\omega}_{t+1}(k))g'(\overline{\omega}_{t+1}(k);\varsigma_t)}\right]E_t\left\{\frac{S_{t+1}}{S_t}\right\}. \tag{28}$$

By using (24)-(28), it can be shown that the external risk premium depends on the leverage, $\frac{S_tD^E_{t+1}}{Q_tK_{t+1}}$, of the entrepreneur.[13] 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.

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[13] See, Appendix A in Bernanke, Gertler, and Gilchrist (1999).

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 ω_t is independent of all other shocks and identical across time and across entrepreneurs, all entrepreneurs are identical ex-ante. Then, each entrepreneur faces the same financial contract specified by the cut off value and the external finance premium. This allows us to specify the rest of the model in aggregate terms.

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

$$P_t NW_t = \vartheta \left[R_t^K Q_{t-1} K_t z(\overline{\omega}_t) \right] + W_t^E \tag{29}$$

Equation (29) 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 $z(\overline{\omega}_t) + g(\overline{\omega}_t, \varsigma_t) = 1 - v_t$ (where v_t is the cost of monitoring, a deadweight loss associated with financial frictions) and by using the participation constraint (26), we can rewrite the net worth of the entrepreneur as:

$$P_t NW_t = \vartheta \left[R_t^K Q_{t-1} K_t (1 - v_t) - \left(1 + i_{t-1}^* \right) S_t D_t^E \right] + W_t^E \tag{30}$$

It is clear from (30) 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:[14]

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[14] 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:

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

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

$$P_t C_t^E = (1-\vartheta)\left[R_t^K Q_{t-1} K_t (1-v_t) - (1+i_{t-1}^*) S_t D_t^E\right] \tag{31}$$

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 $\left(\dfrac{Q_{t+1}}{Q_t}\right)$:

$$E_t R_{t+1}^K = E_t\left[\frac{R_{t+1}^K}{Q_t} + \frac{Q_{t+1}}{Q_t}\left\{(1-\delta) + \Psi_I\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\frac{I_{t+1}}{K_{t+1}} - \frac{\Psi_I}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)^2\right\}\right]. \tag{32}$$

D. Monetary Policy

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

$$1+i_t = (1+i)(\pi_t)^{\varepsilon_\pi}, \tag{33}$$

where i denotes the steady-state level of nominal interest rate and π_t is the CPI inflation.

E. 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:

$$Y_t = Y_{H,t} + Y_{X,t} \tag{34}$$

where

$$Y_{H,t} = C_{H,t} + C_{H,t}^E + I_{H,t} + \alpha\left(\frac{P_{H,t}}{P_t}\right)^{-\gamma}\left[\sum_{i=H,X}\frac{\Psi_i}{2}\left(\frac{P_{i,t}}{P_{i,t-1}} - 1\right)^2 + \frac{\Psi_M}{2}\left(\frac{P_{M,t}}{P_{M,t-1}} - 1\right)^2 + v_t\frac{R_t^K}{P_t}Q_{t-1}K_t\right], \tag{35}$$

with $Y_{X,t}$ is the foreign demand for domestic goods and $C_{H,t}$ is the household consumption demand, $C_{H,t}^{E}$ 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 (35), Ψ_{H}, Ψ_{X} and Ψ_{M} denote price adjustment costs for domestic, exported and the imported good, respectively and v_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:

$$Y_{M,t} = C_{M,t} + C_{M,t}^{E} + I_{M,t} + (1-\alpha)\left(\frac{P_{M,t}}{P_t}\right)^{-\gamma}\left[\begin{matrix}\sum_{i=H,X}\frac{\Psi_i}{2}\left(\frac{P_{i,t}}{P_{i,t-1}}-1\right)^2 + \frac{\Psi_M}{2}\left(\frac{P_{M,t}}{P_{M,t-1}}-1\right)^2 \\ + v_t\frac{R_t^K}{P_t}Q_{t-1}K_t\end{matrix}\right]. \quad (36)$$

where $C_{M,t}$ and $C_{M,t}^{E}$ 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:

$$N_t = H_t^{1-\Omega}, \quad (37)$$

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

Substituting (34) 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:

$$S_t P_{X,t} Y_{X,t} - S_t P_t^* Y_{M,t} = S_t\left(1+i_{t-1}^*\right)\left(D_t^H \Psi_{D,t-1} + D_t^E\right) - S_t\left(D_{t+1}^H + D_{t+1}^E\right), \quad (38)$$

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. The market for domestic bonds must clear at all times, $B_t = 0$. Since all households and firms behave symmetrically,

the rational expectations equilibrium of the model is a set of stationary stochastic processes satisfying stationary representations of the equations (3)-(5), (7)-(17), (21)-(23), (26)-(33); along with equilibrium conditions for the goods market (34) and the labor market (37); the balance of payments equation (38); and the definitions of $z(\overline{\omega}_t)$, $g(\overline{\omega}_t)$, $z'(\overline{\omega}_t)$ and $g'(\overline{\omega}_t)$ and their counterparts in ROW block.

III. 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).[15] Our choice of parameter values used in the calibration is explained in the next section.

A. Consumption, Production, and Monetary Policy

We set the discount factor, β at 0.99, implying a riskless annual return of approximately 4 percent 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 labor supply φ is set to 2 since it is assumed that 1/2 of the time is spent on working. We set the degree of openness, $(1-\alpha)$, to be 0.25 and the share of capital in production, η, is taken to be 0.35, following Elekdag and Tchakarov (2007). 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, as set in Devereux, Lane, and Xu (2006). The quarterly depreciation rate δ is 0.025, a conventional value used in the literature. Similar to Gertler, Gilchrist, and Natalucci (2007), we set the share of entrepreneurs' labor, Ω, at 0.01, implying that 1 percent 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 percent of the total foreign demand and thus set α^* at 0.1 with a price elasticity of unity, $\gamma^* = 1$. In the baseline calibration, we use the original Taylor estimates and set $\varepsilon_\pi = 1.5$.

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[15] The nonstochastic 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 nonstochastic steady state and the stationary model equations are available upon request.

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

$\beta = 0.99$	Discount factor
$\sigma = 1$	Inverse of the intertemporal elasticity of substitution
$\gamma = 1$	Elasticity of substitution between domestic and foreign goods
$\varphi = 2$	Frisch elasticity of labor supply
$(1 - \alpha) = 0.25$	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
$\Psi_i, \Psi_M, \Psi_F = 120$	Price adjustment costs for $i=H, X$
$\epsilon_\pi = 1.5$	Coefficient of CPI inflation in the policy

B. 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 leverage ratio in the domestic economy, κ, at 0.9. The monitoring cost parameter, μ, is taken as 0.2 for the SOE as in Devereux, Lane, and Xu (2006). We follow Elekdag and Tchakarov (2007), in setting the steady state value of the quarterly external risk premium, Φ_t, at 185 basis points. These parameter values imply a survival rate, ϑ, of approximately 98.73 percent in the SOE.

For the ROW, we closely follow Bernanke, Gertler, and Gilchrist (1999). The foreign leverage ratio is set to 0.5. The risk spread of 2 percent in the steady state is reported for the U.S. economy so we set a quarterly external risk premium, Φ_t^*, of 0.005. The cost of monitoring, denoted by μ^*, is taken to be 0.12. Given these parameter values, the implied survival rate is 99.66 percent in the ROW. Note that setting a higher leverage ratio for domestic entrepreneurs implies greater financial frictions in the SOE as compared with the ROW. [16] The persistence of the perception shock is assumed to be 0.5. In the baseline scenario, the degree of financial integration (ξ) is assumed to be 1.

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[16] Hence, the domestic economy is assumed to be more vulnerable to changes in financial conditions. The fact that advanced economies have deeper and more sophisticated financial markets implies, however, that there are likely to be better financing opportunities for firms in these economies, presumably leading to a higher economy-wide leverage. Nevertheless, international evidence suggests that leverage in general and foreign currency borrowing in particular is higher in emerging market countries, which makes the financial systems in these economies much more fragile than the ones in mature economies (see, for example, IMF, 2008).

Table 2. Parameter Values for Entrepreneurial Sector

Small Open Economy

$\Phi_t = 0.0185$ External risk premium
$\mu = 0.2$ Monitoring cost
$\vartheta = 0.9873$ Survival rate

Rest of the World

$\Phi_t^* = 0.005$ External risk premium
$\mu^* = 0.12$ Monitoring cost
$\vartheta = 0.9966$ Survival rate

IV. 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. We assume that both ς_t and ς_t^*, the perception of lenders regarding the domestic and the foreign entrepreneurs' productivity, follow AR(1) processes with persistence ρ_ς and ρ_{ς^*}, respectively

A. 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 to as the sudden stop.

The response of the domestic economy to the sudden stop is presented in Figure 1.[17] When the investors' perception about the distribution of the entrepreneurs' productivity changes, lending to domestic entrepreneurs becomes more risky, and this leads 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. Therefore output falls and real exchange rate depreciates. The decrease in the inflow of capital also lowers the demand for

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[17] The impulse responses show the responses of the economy to a 2 percent (negative) misperception shock. The variables are presented as log deviations from the steady state, multiplied by 100 to have an interpretation of percentage deviations.

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. The increase in the ROW's demand for domestic goods, following the depreciation of the domestic currency, raises net exports, although this effect is not strong enough to offset the decline in domestic demand in our simulations. In practice, the export channel is generally very 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 agreed to be an important factor in their swift recoveries (see, for example, Bleaney, 2005). It is worth noting that this favorable impact of export demand on output recovery not only disappears but starts to work in the opposite direction when we consider a financial crisis originating in the global economy, as is presented in the following section.

B. Financial Crisis in the ROW

We now turn to exploring the channels through which a financial shock originating in the ROW is transmitted to the SOE. 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. We also assume that investors' perception regarding the true distribution of entrepreneurs' productivity in the ROW and the SOE are inherently related. The main rationale for this assumption is twofold. First, investors optimally choose the scale and the terms of credits 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. Second, 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).

Figure 2 presents the domestic economy's response to a global financial shock - defined as an unfavorable change in investors' perception regarding entrepreneurs in the ROW. We set the foreign shock to be the same in magnitude (2 percent) as in the previous case so that the

responses are comparable with Figure 1. 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 twice as large as that of the previous case, leading to a much sharper depreciation of the domestic currency. Likewise, changes in inflation, asset prices and employment under the global financial shock are much more pronounced than with the sudden stop of domestic origin.

There are two mechanisms that amplify the effects of a global shock on the domestic economy. The first works through the unfavorable impact of the contraction in the ROW on net exports of the domestic economy. The reduction in net worth, capital, investment and output in the ROW is shown in Figure 3. The output fall in the rest of the world reduces the domestic economy's net exports and deteriorates the domestic GDP. 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 pre-crisis level, the export demand improves though trade balance continues to deteriorate owing to the rise in imports tracing the recovery in domestic output.

The second mechanism through which the global financial shock impacts upon the domestic economy is through the financial spillovers. 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.

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 vary with, among other factors, the degree of an economy's trade and financial integration with the rest of the world. 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, Izquierdo, and Mejía, 2004, 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 current financial crisis have been Singapore, Taiwan Province of China, and Turkey, all of which are highly open economies.[18] Figures 4 and 5 depict the domestic

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

responses to a foreign financial shock under varying degrees of trade and financial integration between the domestic and foreign economy, 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.

A similar relationship between financial integration, measured by the parameter ξ, and the severity of the crisis is revealed by Figure 5. It can be clearly seen from the figures that the greater the financial integration between the domestic and the foreign economy, the greater the spillovers between the financial sectors of the two countries.

V. 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 current 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. 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.

**Figure 1. Dynamic Responses to a Financial Crisis in Domestic Economy:
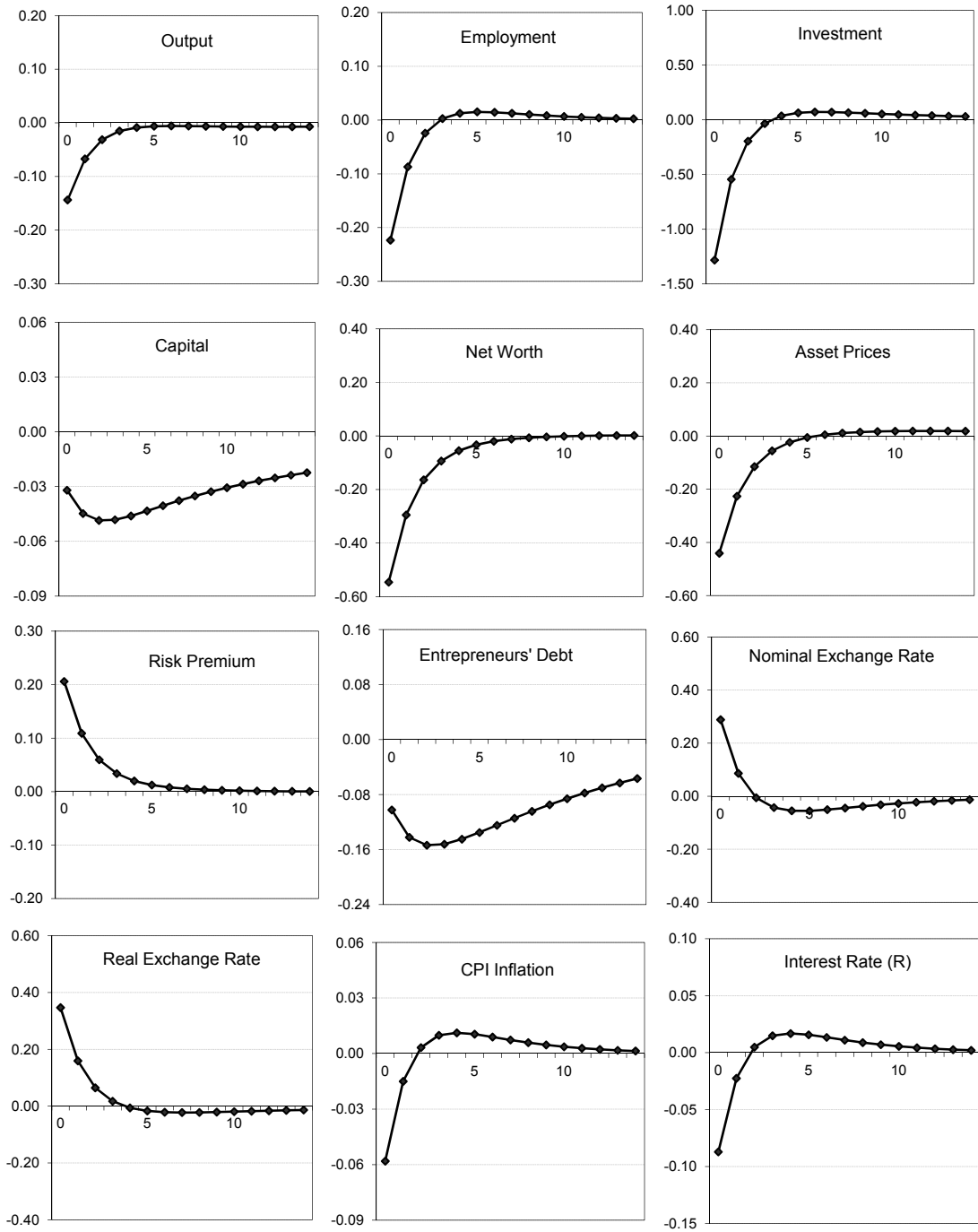Domestic Economy**
(Percent deviations from steady state)

Figure 2. Dynamic Responses to a Financial Crisis in ROW: Domestic Economy
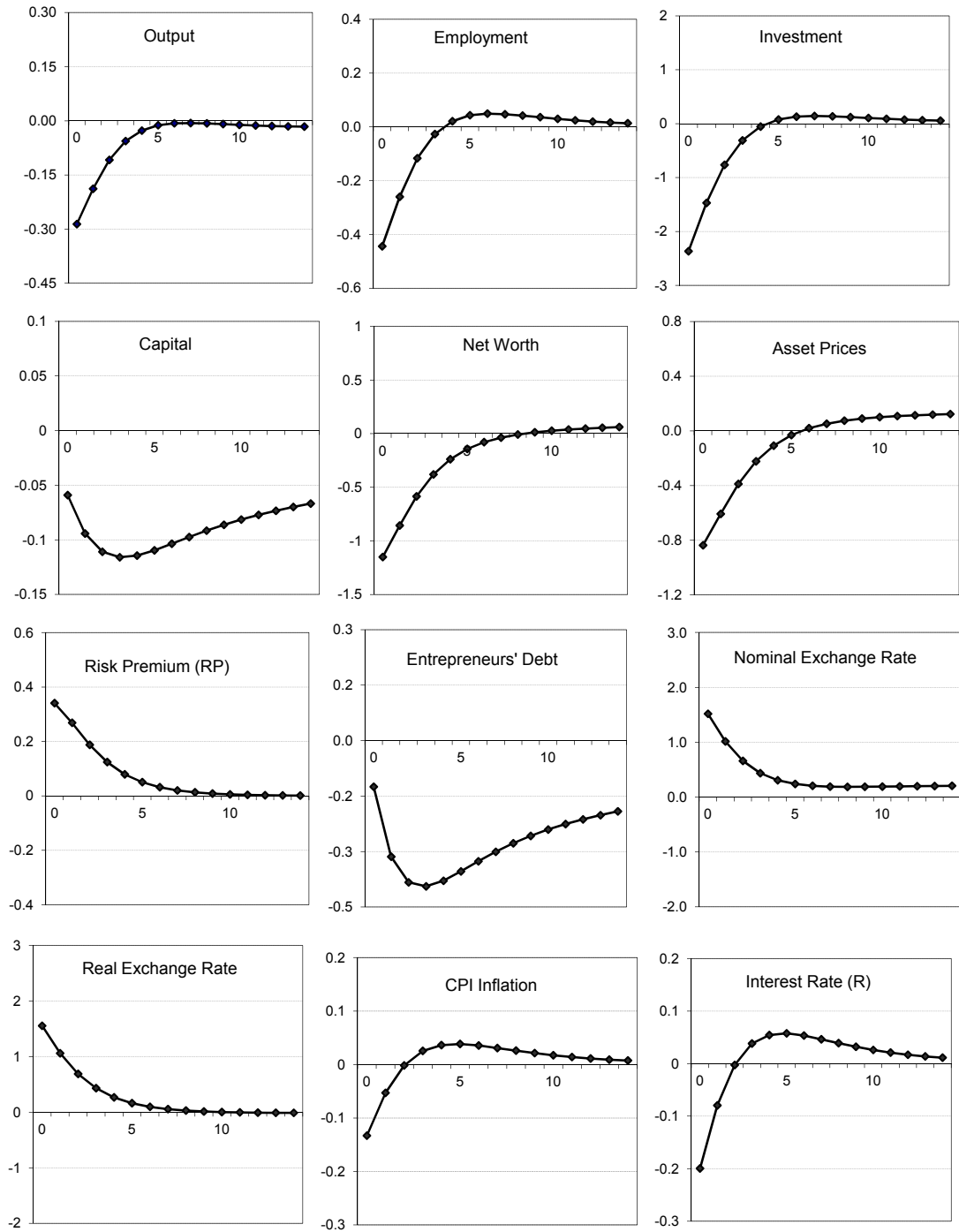(Percent deviations from steady state)

Figure 3. Dynamic Responses to a Financial Crisis in ROW: ROW
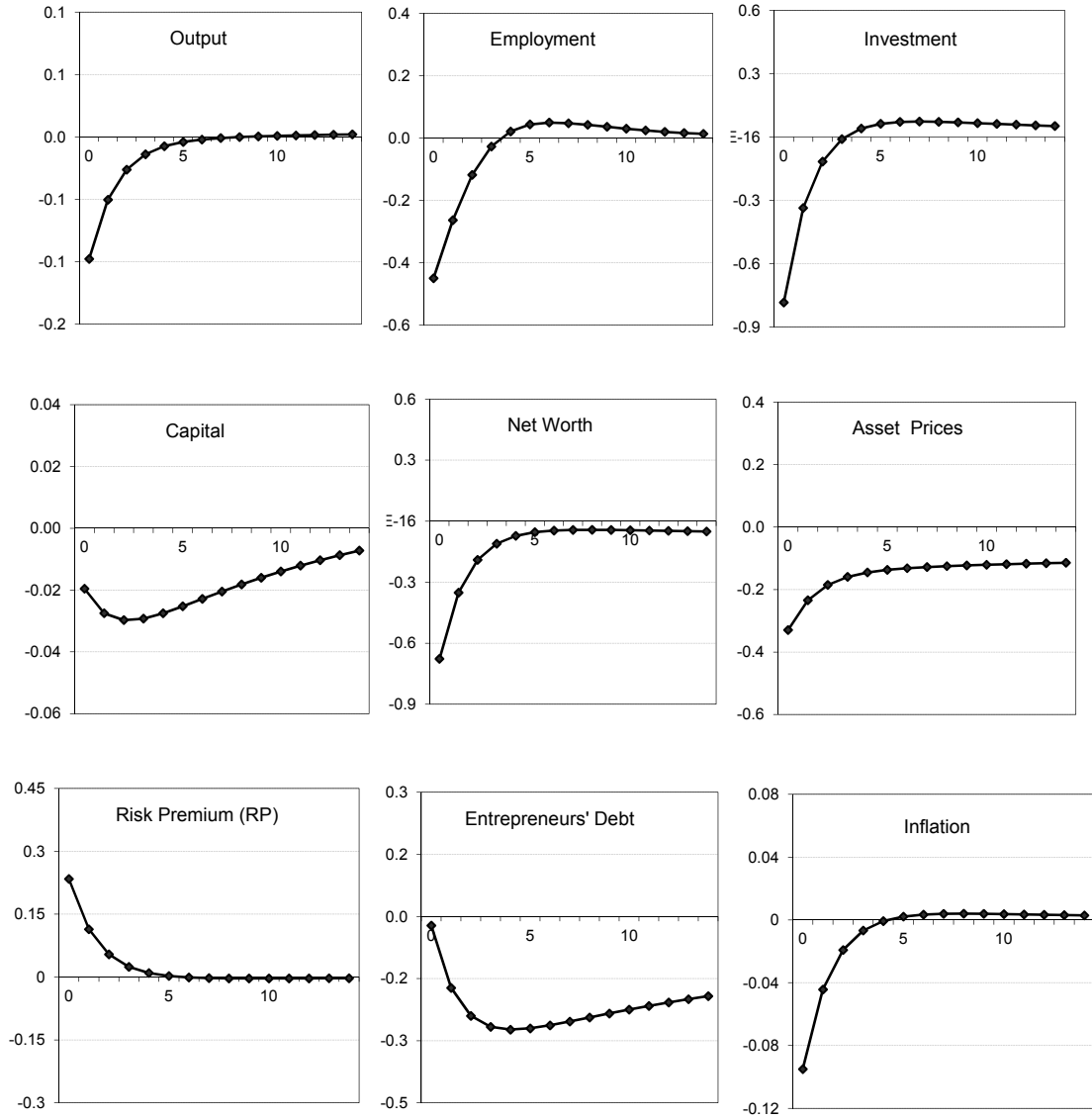(Percent deviations from steady state)

Figure 4. Dynamic Responses to a Financial Crisis in ROW: Domestic Economy
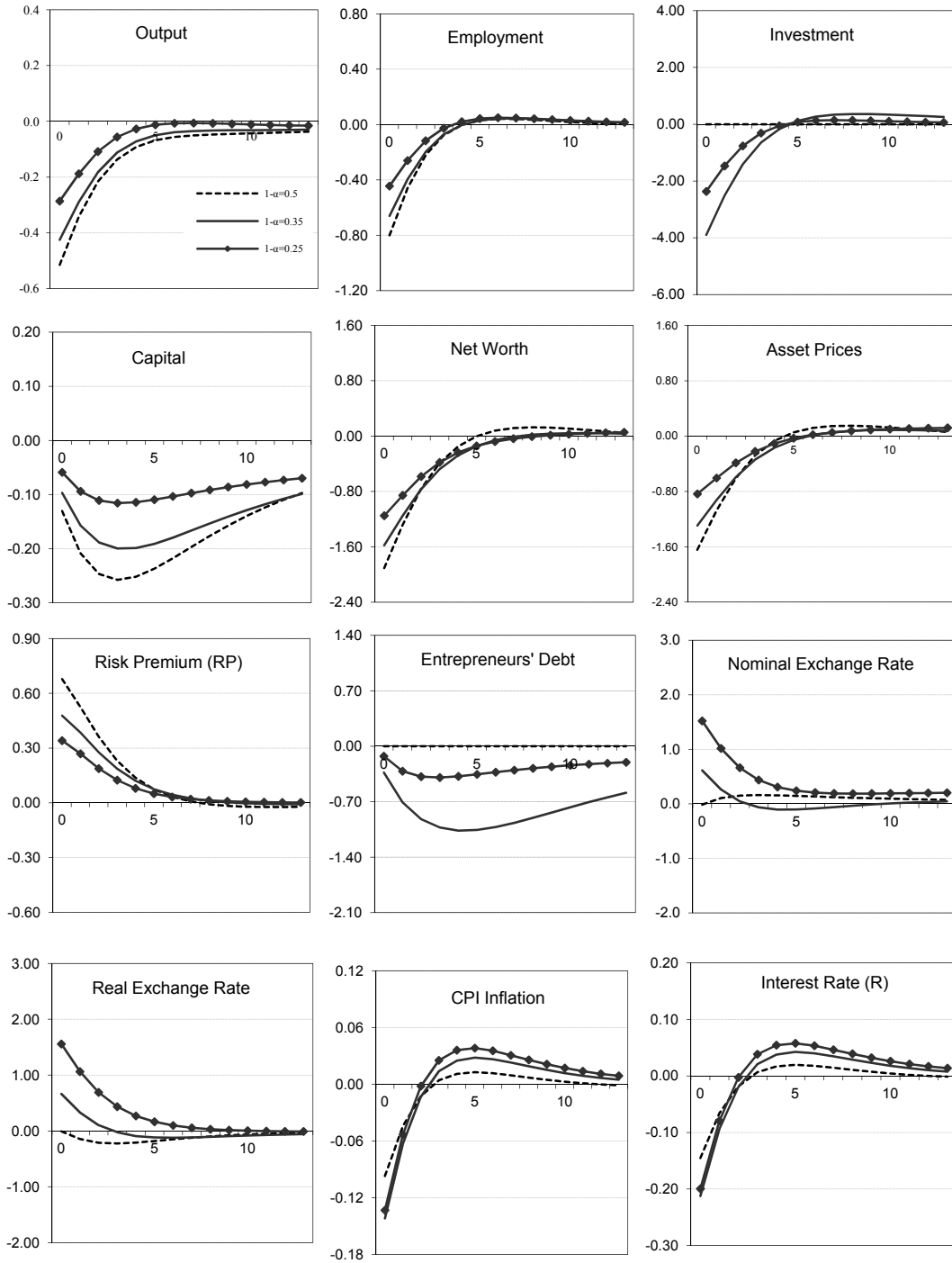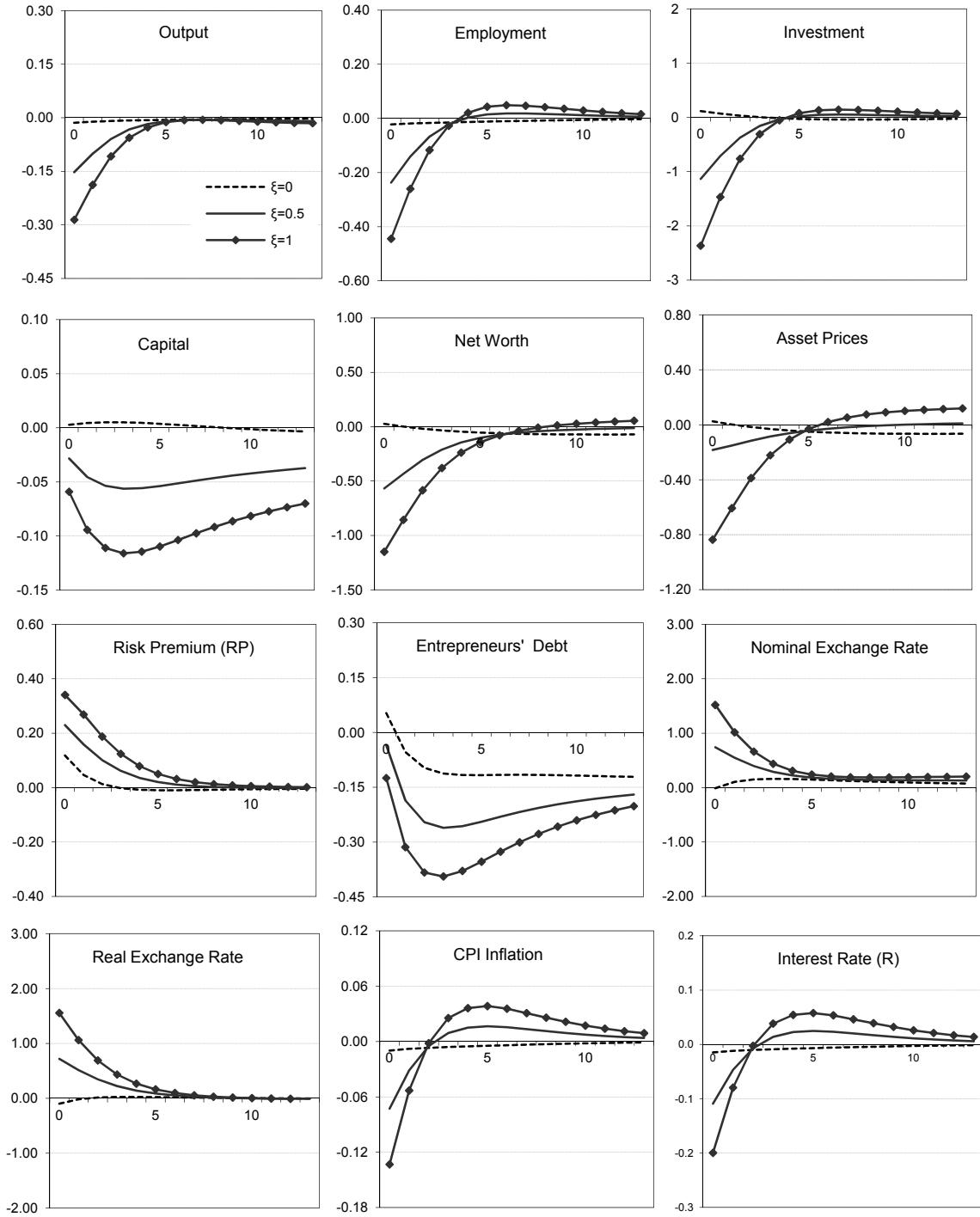(Percent deviations from steady state- degree of openness; 1-α)

Figure 5. Dynamic Responses to a Financial Crisis in ROW: Domestic Economy
(Percent deviations from steady state degree of financial integration; ξ)

APPENDIX

Optimal Contracting Problem

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):

$$
\begin{aligned}
z(\overline{\omega}) &\equiv \int_{\overline{\omega}}^{\infty} \omega f(\omega) d\omega - \overline{\omega} \int_{\overline{\omega}}^{\infty} f(\omega) d\omega \\
&\equiv 1 - \int_{0}^{\overline{\omega}} \omega f(\omega) d\omega - \overline{\omega} \int_{\overline{\omega}}^{\infty} f(\omega) d\omega \qquad \text{(A1)} \\
&\equiv 1 - \Gamma(\overline{\omega}),
\end{aligned}
$$

where $\Gamma(\overline{\omega}) = [1 - F(\overline{\omega})]\overline{\omega} + \int_{0}^{\overline{\omega}} \omega dF(\omega)$, following Bernanke, Gertler, and Gilchrist (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:

$$
\frac{\overline{\omega}_{t+1}(k) R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}} = R_{t+1}^C(k) D_{t+1}^E(k) \qquad \text{(A2)}
$$

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

$$
\begin{aligned}
(1 + i_t^*) D_{t+1}^E(k) = E_t \big[(1 - F^*(\overline{\omega}_{t+1}(k))) R_{t+1}^C(k) D_{t+1}^E(k) \big] \\
+ (1 - \mu) E_t \left[\int_{0}^{\overline{\omega}_{t+1}(k)} \omega^*(k) dF^*(\omega^*(k)) \frac{R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}} \right] \qquad \text{(A3)}
\end{aligned}
$$

Define:

$$
\begin{aligned}
F^*(\overline{\omega}) &\equiv \Pr(\omega^* \le \overline{\omega}) \\
&\equiv \Pr(\omega\varsigma \le \overline{\omega}) \\
&\equiv \Pr\left(\omega \le \frac{\overline{\omega}}{\varsigma}\right) \qquad \text{(A4)} \\
&\equiv F\left(\frac{\overline{\omega}}{\varsigma}\right).
\end{aligned}
$$

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

$$
\begin{aligned}
G^*(\bar{\omega}) &= F^*(\bar{\omega}) E(\omega^* | \omega^* < \bar{\omega}) \\
&= F\left(\frac{\bar{\omega}}{\varsigma}\right) E\left(\omega \middle| \omega < \frac{\bar{\omega}}{\varsigma}\right) \\
&= \varsigma G\left(\frac{\bar{\omega}}{\varsigma}\right).
\end{aligned}
\tag{A5}
$$

Noting that the monitoring cost (v_t) is given by $\mu G^*(\bar{\omega})$ and substituting (A2), (A4), and (A5) into (A3) we get:

$$
(1+i_t^*) D_{t+1}^E(k) = E_t \left[\frac{R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}} \left\{ \left(1 - F\left(\frac{\bar{\omega}_{t+1}(k)}{\varsigma_t}\right)\right) \bar{\omega}_{t+1}(k) + (1-\mu)\varsigma_t G\left(\frac{\bar{\omega}_{t+1}(k)}{\varsigma_t}\right) \right\} \right]
\tag{A6}
$$

which can be rearranged to yield:

$$
(1+i_t^*) D_{t+1}^E(k) = E_t \left[g\big(\bar{\omega}_{t+1}(k); \varsigma_t\big) \frac{R_{t+1}^K Q_t K_{t+1}(k)}{S_{t+1}} \right]
\tag{A7}
$$

which is presented as equation (26) in the text. In (A7) $g(\bar{\omega}; \varsigma)$ is defined as

$$
g(\bar{\omega}; \varsigma) \equiv \varsigma \left[\Gamma\left(\frac{\bar{\omega}}{\varsigma}\right) - \mu G\left(\frac{\bar{\omega}}{\varsigma}\right) \right].
\tag{A8}
$$

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, Chang, and Velasco (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 $(\bar{\omega})$ 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 $\bar{\omega}_t$ and $K_{t+1}(k)$ solving the following maximization problem:

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

subject to the participation constraint (A6). The optimality conditions for this maximization problem are:

$$
E_t \left[R_{t+1}^K Q_t z\big(\bar{\omega}_{t+1}(k)\big) \right] + E_t \left[\Lambda_{t+1} \left(\frac{R_{t+1}^K Q_t g\big(\bar{\omega}_{t+1}(k); \varsigma_t\big)}{S_{t+1}} - \frac{(1+i_t^*) Q_t}{S_t} \right) \right] = 0
\tag{A9}
$$

$$
\Lambda_{t+1}(U) = -\frac{\pi(U) z'\big(\bar{\omega}_{t+1}^U(k)\big) S_{t+1}^U}{g'\big(\bar{\omega}_{t+1}^U(k); \varsigma_t\big)}
\tag{A10}
$$

where U is the state of the world, $\pi(U)$ is the probability of the state U and Λ_{t+1} is the Lagrangian multiplier. Substituting (A10) into (A9) yields:

$$E_t \left[R_{t+1}^K \left(\frac{z'(\bar{\omega}_{t+1}(k)) g(\bar{\omega}_{t+1}(k); \varsigma_t)}{g'(\bar{\omega}_{t+1}(k); \varsigma_t)} - z(\bar{\omega}_{t+1}(k)) \right) \right]$$
$$= (1 + i_t^*) E_t \left[\frac{S_{t+1}}{S_t} \frac{z'(\bar{\omega}_{t+1}(k))}{g'(\bar{\omega}_{t+1}(k); \varsigma_t)} \right] \tag{A11}$$

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:

$$1 + \Phi_{t+1} = \left[\frac{z'(\bar{\omega}_{t+1})}{g(\bar{\omega}_{t+1}, \varsigma_t) z'(\bar{\omega}_{t+1} - z(\bar{\omega}_{t+1})) g'(\bar{\omega}_{t+1}, \varsigma_t)} \right] E_t \left\{ \frac{S_{t+1}}{S_t} \right\} \tag{A12}$$

Using (A12), (A11) can be rewritten as $E_t[R_{t+1}^K] = E_t[(1 + i_t^*)(1 + \Phi_{t+1})]$. These two equations correspond to (28) and (27) in the text.

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