Financial frictions, financial integration and the international propagation of shocks*

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First version: July 2009
This version: June 2010

Abstract

This paper develops a two-country model with a financial accelerator to study how the international transmission of asymmetric shocks is affected when leveraged investors can hold cross-border risky assets.

Foreign exposure in interconnected balance sheets of leveraged investors can act as a powerful propagation mechanism across countries. However, in the model financial and real interdependence can be very strong even with minimal balance sheet exposure to foreign risky assets, if asset markets are integrated across the board, resulting in a strong pressure towards the cross-border equalization of external finance premia faced by leveraged investors. As a consequence, “flight to quality” episodes precipitated by shocks of financial origin are globally propagated, and bring about tight international linkages in financial and macroeconomic dynamics.

*We thank Larry Christiano, Mick Devereux, Marty Eichenbaum, Ester Faia, Simon Gilchrist, Mathias Hoffmann, Nobuhiro Kiyotaki, Robert Kollmann, Cedric Tille, Oreste Tristani and Paolo Vitale, and participants at seminars at ECARES, the San Francisco Fed, the 2009 NBER Summer Institute, the 1st Bundesbank-CFS-ECB Workshop on Macro and Finance, the 2010 CEPR MGI Conference in Eltville, and the Workshop on "Financial market imperfections, corporate governance and economic outcomes", for many helpful comments. The views expressed here are those of the authors and do not necessarily reflect those of the European Central Bank.
1 Introduction

A striking feature of the current “Great Recession” is often argued to be the unprecedented global repercussions of an ostensibly US-originated shock (e.g. Imbs (2010)). According to virtually any definition, most advanced countries have entered a recession since late 2008. The universal dimension of this episode represents an unequivocal challenge to the understanding of the international transmission mechanism, unless (almost tautologically) it is attributed to a common shock. A specific issue is that even models accounting for business cycle correlations as the result of asymmetric shocks such as country specific technology shocks, are able to do so under limited degrees of financial integration; conversely tight financial linkages have allegedly featured prominently as a key propagation channel (e.g. Krugman (2008)).

This paper develops a two-country model to analyze the concept of an international financial multiplier working through the balance sheets of cross-border leveraged investors, as postulated in the literature on international transmission through financial channels (e.g. Calvo (1998) and Krugman (2008)), and study its effects for the cross-border propagation of shocks. These contributions argue that the need to rebalance the overall risk of an investor’s cross-border asset portfolio and to deleverage following the losses after an initial shock can lead to a marked reversal in investment and asset prices across markets where the investor has substantial exposure. For instance, Kaminsky and Reinhart (2000) find that in the context of fundamentals-based “contagion” of financial shocks and crises this helps explain cross-border spillovers, since if the lender is confronted with a marked rise in nonperforming loans in one country it is likely to be called upon to reduce the overall risk of its assets by pulling out of other high risk projects elsewhere. Furthermore, the lender will cut loans across the board, to recapitalize and adjust to its lower level of net worth.

While the above mentioned literature has emphasized the degree of the exposure to foreign assets and borrowers, several episodes of rapid international propagation of asymmetric shocks, particularly of financial origin, are difficult to reconcile with this view of an exclusive role of adverse valuation effects on net worth as a transmission channel. For instance, Rose and Spiegel (2009) argue that exposure to the US can hardly account for the cross-country heterogeneity in key aspects of the “Great Recession”. Figures 1 and 2 report scatter plots showing, for the large set of countries studied by Rose and Spiegel (2009), various measures of exposure to the US vs. GDP growth and change of stock-market prices in 2008, respectively.\(^1\) For each country, we

\(^1\)Using the series of (projected) GDP growth in 2009 provided by Rose and Spiegel (2009) would not change the results.
report four measures of exposure as of 2006 considered by Rose and Spiegel (2009): i) US-issued assets held as a share of total foreign assets; ii) claims of US-based banks as a share of total claims by foreign banks; iii) liabilities towards the US as a share of total foreign liabilities; and, finally, iv) the share of overall trade (including imports and exports) with the US over total exports and imports. These scatter plots show that the four measures of exposure to the US are broadly uncorrelated with GDP growth or stock-market crashes across a large set of countries in the 2008 financial crisis. This lends (informal but intriguing) support to the idea that not only traditional trade linkages, but also US financial exposure are unlikely to have been among the main determinants of the comovements between the US and other countries, and thus that there may be other relevant channels of international propagation at work, at least in this apparent episode of strong cross-country interdependence.\(^2\)

In this paper, in addition to modeling cross-border asset exposure in the net worth of financially constrained agents, we analyze a further source of international propagation arising from international financial integration. This paper is the first, to our knowledge, to show that the combination of financial integration and financial frictions can be a powerful source of international transmission of asymmetric disturbances, particularly of those originating in the financial sector. In our model economy “investors” in each country can buy and sell claims to capital stocks installed both domestically and abroad. Returns on capital accrue from capital gains and rental rates paid by producers of local, country-specific goods, which in turn are traded internationally for consumption and investment demand. In the spirit of Bernanke et al. (1999), when borrowing to finance their domestic and foreign capital holdings investors face an external finance premium, which is an inverse function of their net worth. Financial frictions thus impinge on the amount of funds that can be invested in a given economy into productive but risky activities, domestically and abroad, making these assets effectively illiquid.

This environment broadly captures the above mentioned idea of an international financial multiplier working through the cross-border exposure of assets in the balance sheet of leveraged agents. When asset prices (Tobin’s Q price of capital) fall heavily in one country, investors find themselves undercapitalized, and have to restore their net worth by decreasing borrowing and thus investment across-the-board, effectively selling off both domestic and foreign assets. This in turn puts pressure on the balance sheet of investors abroad, and so on, potentially enhancing cross-border spillovers.

\(^2\)Formal econometric evidence is provided by Rose and Spiegel (2009), who argue that the only variable robustly associated with the cross-country intensity of the 2008 crisis is GDP per capita, whereas country size, a proxy for openness, is never significant.
For a variety of technology and financial shocks, we then study how the international transmission mechanism is shaped by the degree of financial integration across countries, captured by the set of assets that can be traded internationally, in the presence of financial frictions. Specifically, starting from the case of complete financial autarky, we study the implications of gradually expanding international trade in assets to short-term bonds and capital claims, drawing from the recent literature solving for optimal portfolio allocations in DSGE models with perturbation methods, pioneered by Van Wincoop and Tille (2007) and Devereux and Sutherland (2008).

Our main results are as follows. We find that a large degree of exposure to foreign assets in the balance sheets of financially constrained investors may lead to a heightened international propagation of asymmetric shocks, consistent with the hypothesis e.g. by Krugman (2008), formulated in a partial equilibrium setting. However, we also find that international financial integration constitutes a further powerful channel of propagation of asymmetric shocks, especially concerning financial shocks. By leading to tight linkages in the premia paid by financially constrained investors, through the imposition of no arbitrage conditions across different asset classes, financial integration could result in cross-border “flight to quality” away from illiquid assets, irrespective of the actual incidence of foreign assets in their portfolios. Intuitively, consider a situation in which, abstracting from exchange rate fluctuations, financial integration results in a common risk-free rate — in our model this will be the case when households can trade in short-term bonds. If the financially constrained agents have access to the same portfolio investment opportunities at the margin, the spreads they face on their borrowing in domestic credit markets over the common risk free rate will have to be equalized because of arbitrage in the risky investment. Thus, integration in financial markets, irrespective of portfolio composition, will be a powerful source of propagation of shocks in equilibrium in the presence of financial frictions, above and beyond the cross-border balance-sheet exposure.\(^3\)

These additional market-based transmission channels in our model are notable in light of the debate on the international propagation of financial shocks. Against the backdrop of the evidence presented in Figures 1 and 2 above concerning the association between exposure and effects of the recent US financial shocks, a quite different picture emerges when looking at measures of premia across countries before and after to onset of the financial crisis.\(^4\) Figure 3 reports proxies for these premia in

\(^3\)In our framework we will assume that while investors borrow in purely local credit markets, households can trade international bonds. However, it is straightforward to show that our results about the equalization of credit spreads would also obtain if we instead assumed cross-border credit markets, allowing investors to borrow in both countries, even facing loan rates potentially differentiated across borrowers and location.

\(^4\)Ehrmann et al. (2009) find that the transmission of the 2008 US financial crisis to stock prices
the US and the euro area (blue and red line, respectively) starting from January 2000, computed using spreads between corporate bonds of different ratings (A and BBB, first and second row respectively) and risk-free rate with similar, long-term maturity (between 7 and 10 years), where the risk-free rate is approximated alternatively using government bonds or swaps (left and right column, respectively). Remarkably, in line with the predictions of our simple model, a very tight correlation between cross-country spreads is immediately apparent even before the onset of the financial crisis – the lowest correlation between January 2000 and July 2007 is 0.89. Furthermore, as argued by many observers, starting in August 2007 credit spreads dramatically climbed in the US and the euro area simultaneously, peaking at the end of 2008 at values between 600 and 800 basis points, to subsequently revert, always in tandem, to levels more similar to those prevailing before the second half of 2007.

Similarly to our paper, a recent and growing literature has analyzed financial frictions à la Bernanke et al. (1999) in an open economy context, including Gilchrist (2003), Gilchrist et al. (2002), Gertler et al. (2007) and Faia (2007a,b). The paper by Gilchrist et al. (2002) is close to our work in that it considers financially constrained entrepreneurs undertaking cross-border capital investment. These entrepreneurs, however, are modeled as multi-nationals with production operations in different countries and a consolidated balance sheet, while our investors are assumed to face pure portfolio investment decisions.⁵ Faia (2009) uses a two-country model with a financial accelerator to assess quantitatively the implications of financial frictions in the presence of different exchange rate regimes, finding that the introduction of foreign exposure of entrepreneurs’ liabilities in the form of foreign currency denomination of debt does not alter significantly the propagation of shocks. Significant effects stemming from foreign denomination of debt are found by Gertler et al. (2007), however.

in other countries has been stronger the more correlated the stock returns of those countries with US stock returns.

⁵Faia (2007b) studies the business-cycle properties of a two-country model with financial accelerator with particular focus on a currency area, while Faia (2007a) extends the focus by comparing the model with data from a larger set of OECD countries. Neither contribution, however, considers the effects of foreign exposure of financially constrained agents.
It is important to notice that the type of exposure discussed in this earlier literature (namely currency mismatch between the assets and liabilities of financially constrained agents) is radically different from the one that we study in this paper. First, the balance-sheet effect of foreign asset-price movements (as opposed to exchange rate movements) is absent in models that focus only on the currency composition of debt. Second, and most importantly, the key driver of our results is the endogeneity of the cross-border investment decisions: as we illustrate below, ad-hoc assumptions regarding the degree of exposure of balance sheets (either to the exchange rate through debt in foreign currency or to the domestic-currency value of foreign assets through investment composition) would neglect the effects of fundamental no-arbitrage conditions on returns and prices.

Finally, most similarly to this paper, although assuming collateral constraints in the fashion of Kiyotaki and Moore (1997) and Iacoviello (2005), Devereux and Yetman (2009) have introduced capital portfolio choice in a two-country model, finding that high foreign exposure results in a powerful propagation mechanism of asymmetric technology shocks. In contrast to our paper, this contribution does not study the implications of full asset market integration for technology shock propagation, nor a variety of shocks including financial shocks.

The structure of the paper is as follows. The next section presents in detail the structure of our two-country model, while Section 3 discusses the concept of the financial multiplier in the literature in light of our setting. After reporting our benchmark model parameterization in Section 4, Section 5 illustrates our main results in terms of impulse responses to asymmetric shocks. Finally, Section 6 concludes.

2 A two-country model with financial frictions and endogenous portfolio choice

This section develops a general equilibrium framework that incorporates capital market imperfections into an international environment, following Gilchrist et al. (2002), and in particular Gilchrist (2003), who shows how to incorporate financial frictions in a simple yet tractable way in such an environment. The building block of the model corresponds to a two-country monetary economy under a flexible exchange rate regime. Both countries are similar in size and structure and are characterized by a continuum of agents of equal measure. While labor is internationally immobile, we allow capital in each country to be owned by domestic and foreign investors, which may or may not be subject to financial frictions. Each country is specialized in the

\footnote{Faia (2007a,b) also uses a two-country model with “financial accelerator”.}
production of a set of differentiated goods, but consumers in any country consume both sets of goods. We assume incomplete international financial markets: households in each country have access to nominal bonds denominated in domestic and foreign currency (and potentially to domestic and foreign equities, defined as claims to aggregate profits), but do not have access to a complete set of contingent assets. There is imperfect competition in the goods markets, allowing the introduction of nominal rigidities due to price contracts à la Calvo (1983).

2.1 Households

The representative infinitely lived household in each country chooses consumption, C, and hours, H. Consumption, C, is a composite of the two goods indexed by H for the good produced in the domestic country and F for the good produced in the foreign country, according to the following CES aggregator:

\[ C_t \equiv \left[ n^{\frac{1}{\theta}} C_{H,t}^{1 - \theta} + (1 - n)^{\frac{1}{\theta}} C_{F,t}^{1 - \theta} \right]^{\frac{\theta}{1 - \theta}}, \tag{1} \]

where \( n \) is the weight on the consumption of Home traded goods, \( \theta \) is the constant (trade) elasticity of substitution between \( C_{H,t} \) and \( C_{F,t} \). The associated utility based price index is

\[ \Pi_t = \left[ n P_{H,t}^{1 - \theta} + (1 - n) P_{F,t}^{1 - \theta} \right]^{\frac{1}{1 - \theta}}. \]

We define \( C_t(h) \) as the Home agent’s consumption as of time \( t \) of the Home good \( h \); similarly, \( C_t(f) \) is the Home agent’s consumption of the imported good \( f \). We assume that each good \( h \) (or \( f \)) is an an imperfect substitute for all other goods’ varieties, with constant elasticity of substitution \( \eta > 1 \):

\[ C_{H,t} \equiv \left[ \int_0^1 C_t(h)^{\frac{2}{1 - \eta}} \, dh \right]^{\frac{1}{1 - \eta}}, \quad C_{F,t} \equiv \left[ \int_0^1 C_t(f)^{\frac{2}{1 - \eta}} \, df \right]^{\frac{1}{1 - \eta}}; \]

the price index of the Home goods is given by:

\[ P_{H,t} = \left[ \int_0^1 P_t(h)^{1 - \eta} \, dh \right]^{\frac{1}{1 - \eta}}. \]

Throughout the paper we assume that the law of one price holds, so that prices of goods, will obey \( \mathcal{E}_t P_{H,t}^* = P_{H,t} \) and \( \mathcal{E}_t P_{F,t}^* = P_{F,t} \), where an asterisk denotes foreign variables. Notice however that \( \mathcal{E}_t P_{H,t}^* \) will generally be different from \( \Pi_t \) because of the different weights attached to goods in the foreign consumption basket, giving rise
to deviations from PPP and fluctuations in the real exchange rate $RER = \frac{E_t P_t^*}{P_t}$. Thus, an increase in $RER$ will indicate a real depreciation from the Home country perspective.

**Budget constraint and asset markets** Households solve the following standard intertemporal problem

$$\max_{C_t, H_t, B_t, s,t} E_t \sum \beta(\tau) \left[ U(C_t, C_{\tau-1}) - \phi(H_t) \right]$$

(where, following Schmitt-Grohé and Uribe (2003), we have allowed for external habit in consumption as a function of aggregate domestic consumption $C_{\tau-1}$ in preferences) subject to the following budget constraint in real terms:

$$C_t + B_t + \sum \alpha_{s,t} = w_t H_t + r_t B_{t-1} + \sum \alpha_{s,t-1} r_{s,t} + \Pi_t + T_{t}^e,$$  \hspace{1cm} (2)

where $r_t = \frac{R_{t-1}}{\pi_t}, R_t$ is the nominal policy rate and $\pi_t$ is the CPI inflation rate $\frac{P_t}{P_{t-1}}$.

Households receive income in the form of wage $w_t$, profits in the form of lump-sum transfers from all domestic firms ($\Pi_t$, to be fully specified below), and (ex-post) real returns ($r_t, r_{s,t}$) from asset holdings ($B_t, \alpha_{s,t}$). We first assume that households, through financial intermediaries, provide loans to the domestic capital investors ($B_t$, in consumption units), earning the ex-post real rate $r_t$. Depending on the degree of integration of international financial markets, households can also hold different types of financial assets; in the benchmark case we assume they can trade in short-term foreign and domestic nominal bonds, whose holdings in consumption units we denote with $\alpha_{d,t}$ and $\alpha_{d,t}$, respectively, yielding ex-post returns $r_{d,t} = r_t$ and $r_{d,t} = \frac{RER_t}{RER_{t-1}} r_{d,t}^*$. We can also extend the model allowing households to trade in claims to aggregate profits $\Pi_t$. The variable $T_{t}^e$ denotes a net lump-sum transfer to households arising from the presence of financial frictions. This net-transfer consists of resources transferred from households to new investors minus resources generated by lending to the investment sector (see Gilchrist et al. (2003)). Further below we discuss this term in more detail.

A similar program applies to households abroad; notice that because of market clearing in financial markets,

$$\begin{align*}
\alpha_{d,t} + \alpha_{d,t}^* &= 0 \\
\alpha_{d,t} + \alpha_{d,t}^* &= 0,
\end{align*}$$
where $\alpha^*_{s,t}$ denotes bond holdings abroad.

It is useful to rearrange the budget constraint defining households net wealth $W_t$ as follows:

$$W_t = B_t + \sum \alpha_{s,t},$$

$$C_t + W_t = w_t H_t + r_t W_{t-1} + \alpha_{d^*,t-1} \left( \frac{RER_t}{RER_{t-1}} r^*_t - r_t \right) + \Pi_t + T^e_t;$$

this rearrangement underlines that households are not at all constrained by the amount of loans $B_t$ and can choose any position in domestic bonds they want in equilibrium.

The representative household optimization yields the following standard first order conditions:

$$C_t : \lambda_t = U_C (C_t)$$
$$H_t : w_t = \frac{\phi_H (H_t)}{\lambda_t}$$
$$W_t : \lambda_t = \beta (t) E_t r^*_{t+1} \lambda_{t+1}$$
$$\alpha_{d^*,t} : E_t \lambda_{t+1} \left( \frac{RER_{t+1}}{RER_t} r^*_t - r_{t+1} \right) = 0.$$

Finally, we assume standard functional forms for preferences $U (\cdot) = \frac{(C - \overline{C})^{1-\sigma}}{1 - \sigma}$, $\phi (H) = \frac{H^{1+\eta}}{1+\eta}$; however, we also assume that the discount factor $\beta (\tau)$ is endogenous to ensure stationarity of the steady state.

Similar equations hold for the foreign representative households; notice however that the last equation implies that up to first order

$$E_t \left( E_t \hat{r}^*_{t+1} + E_t \hat{RER}_{t+1} - \hat{RER}_t - E_t \hat{r}_{t+1} \right) = 0,$$

so that we would have two linearly dependent equations. Therefore, up to first order, i.e. under certainty equivalence, the portfolio choice is indeterminate. However, following the perturbation approach of Devereux and Sutherland (2008) and Judd and Guu (2001), we can take a second order approximation of the difference of the two nonlinear first order conditions,

$$E_t \left[ \left( \lambda_{t+1} - \lambda^*_{t+1} \frac{RER_t}{RER_{t+1}} \right) \left( \frac{RER_{t+1}}{RER_t} r^*_t - r_{t+1} \right) \right] = 0$$

and use it to solve for the steady state portfolio allocation. This is enough to characterize the first order equilibrium system dynamics.
2.2 Production

The production sector in each country is divided into a monopolistically competitive retail sector, a competitive wholesale sector which produces capital goods and a competitive sector of “investors”. Final goods producers in both countries specialize in an array of imperfectly substitutable goods sold to households and capital goods producers. Final goods are produced with labor, hired from households, and capital, hired from investors. The latter in turn purchase capital from capital goods producers in both countries at the beginning of each period, and rent it to final goods producers; they resell capital to capital goods producers at the end of next period. Given that the retailers are price setters, this structure allows the introduction of nominal rigidities while maintaining a constant-returns-to-scale assumption in the wholesale sector, which is necessary for aggregation when financial market imperfections are introduced.

2.2.1 Final goods producers

In each country a large number of monopolistically competitive producers use capital together with labor to produce a final good sold domestically and abroad.

The cost-minimization problem of the representative firm is

$$\min_{L_t,K_t} w_t L_t + r_{K,t} K_{H,t}$$

s.t. $$Y_t = \varepsilon_{Y,t} L_t^{1-\alpha} K_{H,t}^{\alpha}$$

so that, under flexible prices,

$$P_{H,t} = \frac{\eta}{\eta - 1} \frac{1}{\varepsilon_{Y,t}} \frac{w_t^{1-\alpha} r_{K,t}^{\alpha}}{\alpha (1 - \alpha)^{1-\alpha}}$$

and

$$L_t = (1 - \alpha) \frac{P_{H,t} Y_t}{\mu_C} \frac{w_t}{r_{K,t}}$$

$$K_{H,t} = \alpha \frac{P_{H,t} Y_t}{\mu_C} \frac{r_{K,t}}{r_{K,t}}$$

**Price setting** When retail firms are subject to nominal rigidities à la Calvo, at any time $t$, they keep their price fixed with probability $\zeta$. We assume that when
firms update their prices, they do so simultaneously in the Home and in the Foreign market, in the respective currencies. The maximization problem is then as follows:

\[
\max_{p(h), p^*(h)} E_t \left\{ \sum_{k=0}^{\infty} \Lambda_{t+k} \zeta^k \left( \frac{p_t(h) D_{t+k}(h) + \varepsilon_t p_t^*(h) D_{t+k}^*(h)}{MC_{t+k}(h) \left[ D_{t+k}(h) + D_{t+k}^*(h) \right]} \right) \right\}
\]

where \( \Lambda_{t+k} \) is the firm’s stochastic discount factor between \( t \) and \( t + k \), which we assume is the same as that of the household, and the firm’s demand at Home and abroad is given by:

\[
D_t(h) = \left( \frac{p_t(h)}{p_{H,t}} \right)^{-\eta} (C_{H,t} + I_{H,t})
\]

\[
D_t^*(h) = \left( \frac{p_t^*(h)}{p_{H,t}^*} \right)^{-\eta} (C_{H,t}^* + I_{H,t}^*)
\]

In these expressions, \( p_{H,t} \) and \( p_{H,t}^* \) denote the price index of industry \( h \) and of Home goods, respectively, in the Foreign country, expressed in Foreign currency.

By the first order condition of the producer’s problem, the optimal price \( p_t(h) \) in domestic currency charged to domestic customers is:

\[
p_t(h) = \frac{\frac{\eta}{\eta - 1} \frac{E_t \sum_{k=0}^{\infty} \zeta^k \Lambda_{t+k} D_{t+k}(h) MC_{t+k}(h)}{E_t \sum_{k=0}^{\infty} \zeta^k \Lambda_{t+k} D_{t+k}(h)}}{;}
\]

as we posit that firms set prices in producer currency, the price charged to foreign consumers is a function of the optimal Home price and the exchange rate via the law of one price: \( p_t^*(h) = \frac{p_t(h)}{\xi_t} \).

Since all the producers that can choose their price set it to the same value, we obtain the following equations for \( p_{H,t} \):

\[
p_{H,t}^{1-\eta} = \zeta p_{H,t-1}^{1-\eta} + (1 - \zeta) p_t(h)^{1-\eta}.
\]

The representative retailer pricing decision implies (to first order of approximation) the standard new Keynesian Phillips curve, where current inflation is a function of expected inflation and marginal costs \( \mu_t \):

\[
\pi_{H,t} = \beta E_t \pi_{H,t+1} + \xi \mu_t,
\]

where \( \xi \) is a function of the probability of adjustment \( \zeta \). Similar relations hold for the Foreign firms.
2.2.2 Capital goods producers

In each country there is a representative competitive capital goods producer that uses final goods to produce physical capital. The latter is sold at the beginning of the period to entrepreneurs and re-purchased (net of depreciation) at the end of next period. Investments generates adjustment costs as in Christiano et al. (2005). The problem of this firm is thus:

$$\max_{L_t, K_{t+1}} E_t \sum_{i=0}^{\infty} \beta^i \lambda_{t+i} [Q_{K,t+i} K_{H,t+1+i} - I_{t+i} - Q_{K,t+i} K_{H,t+i}]$$

s.t. \(K_{H,t+1} = (1 - \delta) K_{H,t} + \varepsilon_{I,t} F(I_t, I_{t-1})\)

where \(K_{H,t}\) is the capital stock installed in the Home country at the beginning of period \(t\), and

\[
F(I_t, I_{t-1}) = \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t,
\]

\[
S\left(\frac{I_t}{I_{t-1}}\right) = \exp\left(\gamma_t \left(\frac{I_t}{I_{t-1}} - 1\right)\right) + \exp\left(-\gamma_t \left(\frac{I_t}{I_{t-1}} - 1\right)\right) - 2,
\]

where \(\gamma_t \geq 0\), and where \(\lambda_t\) is the household marginal utility, and \(I_t\) is a composite of domestic and foreign goods obtained with the same CES aggregator as domestic consumption. Notice that the assumed form of capital accumulation introduces embodied technological change in the form of the shock \(\varepsilon_{I,t}\).

After substituting the constraints into the objective function we can derive the FOC, that is

\[
I_t: -1 + Q_{K,t} \varepsilon_{I,t} F_{1,t} + \beta \lambda_{t+1} Q_{K,t+1} F_{2,t+1} = 0
\]

where

\[
F_{1,t} = -S'\left(\frac{I_t}{I_{t-1}}\right) \left(\frac{I_t}{I_{t-1}}\right) + 1 - S\left(\frac{I_t}{I_{t-1}}\right),
\]

\[
F_{2,t} = S'\left(\frac{I_t}{I_{t-1}}\right) \left(\frac{I_t}{I_{t-1}}\right)^2
\]

and where \(Q_{K,t}\) is the Lagrange multiplier on the capital accumulation constraint, relative to household's marginal utility, (Tobin's Q).
2.3 Investors sector

We introduce financial frictions in capital accumulation following Gilchrist (2003). In order to combine them with the choice of capital holdings in each country as a standard portfolio problem, we assume a large number of identical capitalist firms (entrepreneurs or investors) which in each period rent out domestic and foreign capital purchased in period \( t - 1 \) from capital producers. In order to finance capital purchases, we assume that these firms have to borrow short term at the rate of interest \( R_t^D \), potentially at a premium over the local domestic nominal risk free rate.

The problem of the representative investor is thus to maximize discounted profits by choosing domestic and foreign capital holdings \( K_{t+1}, K^*_t \):

\[
\max_{K_{t+1},K^*_t} \sum_{i=0}^{\infty} E_t R^e_{t|i} \left[ r_{K,t+i} K_{t+i} + RER_t r^*_{K,t+i} K^*_t - Q_{K,t+i} (K_{t+1+i} - (1 - \delta) K_t) \right]
\]
\[
- RER_t Q^*_{K,t+i} (K^*_{t+1+i} - 1 - \delta K^*_{t+i}) - D_t^{D} \ \frac{D_{t-1+i}}{\pi_{t+i}} + D_{t+i}
\]

s.t. \( Q_{K,t+1} + RER_t Q^*_{K,t} K^*_t = D_t + N_t \),

where \( D_t \) is the real value of the debt, \( N_t \) is the real value of the net-worth of the firm (equity) and \( R^e_{t|i+1} \) is the investor’s discount rate (discussed below).

The first order condition for the investor’s problem are

\[
K^*_{t+1} : \quad E_t R^e_{t|i} \left( RER_t r^*_{K,i+1} + RER_t (1 - \delta) Q_{K,t+1}^* - RER_t \frac{R^D_t}{\pi_{t+1}} Q^*_{K,t} \right) = 0
\]

(9)

we can rewrite

\[
E_t \left[ R^e_{t|i+1} R^K_{t|i} \right] \equiv E_t \left[ R^e_{t|i+1} \frac{r_{K,i+1} + Q_{K,t+1} (1 - \delta)}{Q_{K,t}} \right] = E_t \left[ R^e_{t|i+1} \frac{R^D_t}{\pi_{t+1}} \right]
\]

and

\[
E_t \left[ R^e_{t|i+1} \frac{RER_t r^*_{K,i+1} + Q^*_{K,t+1} (1 - \delta)}{Q^*_{K,t}} \right] = E_t \left[ R^e_{t|i+1} \frac{R^D_t}{\pi_{t+1}} \right]
\]

and for the foreign entrepreneur

\[
E_t \left[ R^e_{t|i+1} \frac{RER_t}{RER_{t+1}} R^K_{t|i} \right] \equiv E_t \left[ R^e_{t|i+1} \frac{RER_t}{RER_{t+1}} \frac{r_{K,t+i} + Q_{K,t+i} (1 - \delta)}{Q_{K,t+i}} \right] = E_t \left[ R^e_{t|i+1} \frac{R^D_t}{\pi_{t+1}} \right]
\]

\[13\]}
and

\[
E_t \left[ R_{t+1}^{e} R_{t+1}^{K*} \right] \equiv E_t \left[ R_{t+1}^{e} \frac{r_{K,t+1}^{e} + Q_{K,t+1}^{e} (1 - \delta)}{Q_{K,t}^{e}} \right] = E_t \left[ R_{t+1}^{e} \frac{R_{t+1}^{D}}{\pi_{t+1}} \right].
\]

Writing these FOCs in differences, i.e.

\[
E_t \left[ R_{t+1}^{K} \left( R_{t+1}^{e} - \frac{RER_{t+1}^{e} R_{t+1}^{K*}}{RER_{t}^{e}} \right) \right] = 0
\]

(10)

and

\[
E_t \left[ R_{t+1}^{e} \left( \frac{RER_{t}^{e} R_{t+1}^{K} - R_{t+1}^{K*}}{RER_{t+1}^{e} R_{t+1}^{K} - R_{t+1}^{K*}} \right) \right] = 0,
\]

(11)

\[
E_t \left[ \frac{RER_{t+1}^{e} R_{t+1}^{K}}{RER_{t}^{e}} \left( \frac{RER_{t}^{e} R_{t+1}^{K} - R_{t+1}^{K*}}{RER_{t+1}^{e} R_{t+1}^{K} - R_{t+1}^{K*}} \right) \right] = 0,
\]

(12)

it is easy to see that these conditions, to first order, give exactly the same information, so that in order to solve the model up to the first order of approximation, only one of these equations could be kept. Notice also that, to first order, these conditions simply equate the ex-ante gross return on the two types of capital in each investor’s real currency.

However, as in the case of households, we know that the optimal portfolio must satisfy the following equation to order of approximation higher than one\(^7\)

\[
E_t \left[ \left( \frac{R_{t+1}^{e} RER_{t}^{e}}{RER_{t+1}^{e} RER_{t+1}^{e}} - R_{t+1}^{e} \right) \left( R_{t+1}^{K} - \frac{RER_{t+1}^{e} R_{t+1}^{K}}{RER_{t}^{e}} \right) \right] = 0,
\]

(13)

so that we can use the same approach as before to solve for the optimal long run portfolio composition for Home and Foreign investors. Specifically, observe that if, following Gilchrist (2003), we assume that \( R_{t+1}^{e} = \frac{\lambda_{t+1}}{\lambda_{t}} \), the household discount factor, in the absence of financial frictions, the expected return on capital would be equated to the risk-free return and hence satisfy the household Euler equation:

\[
E_t \left[ \frac{\lambda_{t+1}}{\lambda_{t}} R_{t+1}^{K} \right] = E_t \left[ \frac{\lambda_{t+1}}{\lambda_{t}} R_{t+1}^{K} \right] = 1.
\]

\(^7\)Satisfying these conditions yields the optimal portfolio. Either of the previous three equations will be used in solving the model, hence ensuring that all of them are simultaneously satisfied.
Therefore, such a specification encompasses standard models of the optimal choice of foreign and domestic capital holdings without financial frictions, such as Coeurdacier et al. (2008).\(^8\)

Finally, capital holdings by Home and Foreign investors must add up to installed capital stocks in each country. For the Home country it must be that \(K_{H,t} = K_t + K_{st},\) where \(K_{st}\) denotes Foreign holdings of Home capital.

### 2.3.1 Financial frictions and the evolution of net worth

A convenient way to model financial frictions is by introducing a financial accelerator, in the spirit of Bernanke et al. (1999). The key mechanism involves an inverse relation between the external finance premium, broadly defined as the difference between the cost of funds raised externally and the opportunity cost of funds internal to the firm, and the net worth of borrowers, \(N.\) The inverse relationship between external finance premiums and the strength of the balance sheet arises because when borrowers have little wealth to contribute to project financing, the potential divergence of interests between the borrowers and the lenders is greater, implying increased agency costs. In equilibrium, lenders must be compensated for higher agency costs by a large premium. Because borrower net worth is procyclical through the behavior of profits and asset prices, the financial accelerator enhances swings in borrowing and thus in investment, spending, and production.

Following the formulation in Gilchrist (2003) and Gertler et al. (2007), in the presence of the financial accelerator, the rate \(R^D_t\) in the above equations would reflect a premium on external finance, arising from monitoring costs:

\[
R^D_t = \chi \left( \frac{D_t}{N_t}, \varepsilon_{e,t} \right) R_t,
\]

where the function \(\chi (\cdot)\) is the external finance premium. We also include a shock \(\varepsilon_{e,t}\) to the external finance premium, which following Christiano et al. (2007) or Jermann and Quadrini (2009) can be interpreted as a shock affecting the financial sector.

Notice that the latter equation and the following one, reproducing the above condition for the optimal choice of domestic capital investment,

\[
E_t \left[ R^e_{t|t+1} \left( \frac{r_{K,t+1} + Q_{K,t+1} (1 - \delta)}{Q_{K,t}} - \frac{R^D_t}{\pi_{t+1}} \right) \right] = 0,
\]

\(^8\)In this latter case investors borrowing rates \(R^D_t\) and \(R^D_t\) would coincide with the nominal risk-free rate paid on bonds traded by households, these conditions together reproduce the UIP condition above up to first order, and are therefore jointly collinear with it. In this case we should only retain one of these conditions, as it would impose a restriction on the gross return on capital being equal to the gross return on bonds.
up to first order are the same as in a setting in which the financial accelerator could be motivated from microfoundations (see e.g. Bernanke, Gertler, and Gilchrist, (1999)).\textsuperscript{9} It can be shown that in such a setting the function $\chi (\cdot )$ is strictly increasing and convex over the relevant range, so that the external finance premium is negatively related to the share of the capital investment that is financed by borrowers’ own net worth.

By analogy with the BGG model we assume that the evolution of investors’ net worth, $N_t$, reflects their equity stake, specifically:\textsuperscript{10}

$$N_t = \varepsilon_{\gamma,t} \gamma \left[ R^K_t Q_{t-1} K_t + \frac{RER_t}{RER_{t-1}} R^K_{t-1} Q^*_t RER_{t-1} K^*_t - R^D_t \frac{D_{t-1}}{\pi_t} \right] + (1 - \gamma) T_t$$

or

$$N_t = \varepsilon_{\gamma,t} \gamma \left[ R^K_t W e_{t-1} + \left( RER_t R^K_t - RER_{t-1} R^K_{t-1} \right) \alpha_{K^*} - R^D_t \frac{D_{t-1}}{\pi_t} \right] + (1 - \gamma) T_t,$$

where $\alpha_{K^*} \equiv Q^*_t K^*_t$ denotes holdings capital abroad by Home investors, and

$$W e_t = Q_{K,t} K_{t+1} + RER_t Q^*_{K,t} K^*_{t+1}$$

is the total value of asset holdings by the investor, which has to be equal to $D_t + N_t$. $\varepsilon_{\gamma,t}$ is a stochastic shock that we will discuss in the simulation of further below. The coefficient $0 < \gamma < 1$ ensures the existence of a well-defined steady state, and is usually interpreted as the share of borrowers exiting the market every period. Finally, in order to close the model we need to define the lump sum transfer to investors, $T_t$, which include the real value of a transfer to investors start-ups, plus resources reflecting the presence of financial frictions. Assuming that, as, for example, in Carlstrom and Fuerst (1997) and Bernanke et al. (1999), competitive financial intermediaries collect nominal deposits ($B_t$) from domestic households against payment of a nominal

\textsuperscript{9}The original setting in BGG requires that entrepreneurs be risk neutral, whereas in order to pin down their portfolio choice we will assume that they have the same discount factor as households and are thus risk averse. However, since we solve the model up to first order, in equilibrium the dynamics of all aggregate variables will be the same as in the standard BGG setting, for a given portfolio composition. In turn, the latter, as we will show below, will be basically immaterial for the properties of the model under cross-border integration of bond and capital markets.

\textsuperscript{10}The financial accelerator mechanism that we assume in this paper captures the salient features of the financial accelerator described in Bernanke et al. (1999). However, while the external finance premium can be made identical to that in Bernanke et al. (1999), the net-worth dynamics in Bernanke et al. (1999) would be slightly different from ours. Nevertheless, the two definitions of net-worth are generally very highly correlated.
risk-free rate \( (R_t) \), in equilibrium \( D_t = B_t \). In the financial accelerator literature, the net resources from financial intermediation (the difference between interest paid on deposits and interest earned from loans, \( \chi D \)) are used to cover intermediation costs (e.g. verification of the state of the borrower, bankruptcy costs etc.).\(^{11}\) We assume that this revenue is transferred lump-sum to the domestic households and investors, implying that \( T_t = T_t^r + \Omega_t \), where the latter term is a fraction of intermediation resources.\(^{12}\)

### 2.4 Monetary policy

In order to close the model, we need to assume a behavioral rule for monetary policy. We assume that each central bank follows the following standard Taylor-type rule

\[
R_t = R_{t-1}^{\lambda_R} \left( (\pi_t)^{\lambda_x} \left( \frac{Y_t}{Y_{t-1}} \right)^{\lambda_Y} \right)^{(1-\lambda_R)} \varepsilon_{Rt},
\]

where interest rates respond only to inflation with a smoothing coefficient, and \( \varepsilon_{Rt} \) represents a monetary policy shock.

### 3 On modeling the international financial multiplier: Balance-sheet and no-arbitrage effects

In this section we discuss how the propagation mechanism in our model economy compares with the idea of an international financial multiplier, e.g. as recently formulated by Krugman (2008) in a partial equilibrium framework, and formalized

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\(^{11}\) Starting with Bernanke et al. (1999) and in many applications of the financial accelerator (e.g. Cúrdia and Woodford (2009)) this revenue is used to purchase final goods.

\(^{12}\) In Bernanke et al. (1999) the default cost is smaller relative to GDP than intermediation resources in our model. It is possible to show, though, that both are functions only of the leverage of the entrepreneurs, so that they are proportional to first order. In the reduced-form à la Gilchrist (2003) there is no explicit modeling of the relation between the external finance premium and the default cost. Under standard parametrization of the financial accelerator model, the default cost is about one order of magnitude smaller than the total external finance cost in the steady state. Moreover, its response to shocks is about one fifth of the response of the cost in our model. By transferring about 87% of the external finance cost to borrowers, we obtain similar magnitudes of the fully fledged model, to first order. The remaining fraction is transferred to the households as opposed to imputing it to aggregate demand as in BGG. This latter assumption has virtually no implications.
by Devereux and Yetman (2009) in a dynamic general equilibrium context, though in an alternative way relative to ours.

Krugman (2008) dubs international financial multiplier the channel of cross-border transmission of changes in asset prices through balance-sheet effects of leveraged agents.\(^{13}\) In our setting, the main gist of Krugman’s argument can be rendered by postulating that entrepreneurs have a preferred, exogenously given composition of their holdings of domestic and foreign risky assets \(\omega_k\) and \(\omega_{k^*}\), implying that:

\[
K_{t+1} = \omega_k \left( 1 + \frac{D_t}{N_t} \right) \frac{N_t}{Q_{K,t}} = \omega_k \left( 1 + \chi^{-1} (\cdot) \right) \frac{N_t}{Q_{K,t}}
\]

\[
K^*_{t+1} = \omega_{k^*} \left( 1 + \chi^{-1} (\cdot) \right) \frac{N_t}{RER_t Q^*_{K,t}}
\]

where we have seen above that \(N_t\) depends on the gross returns of assets and thus on their price.

The implications for the comovements of the price of domestic and foreign risky assets through their effects on investors’ net worth are apparent. In the words of Krugman (2008, page 5) “Home and Foreign risky assets become complements: a rise in \([Q_{K,t}]\), by increasing [the leveraged investor’s] capital, increases the demand for Foreign assets, a rise in \([RER_t Q^*_{K,t}]\) similarly increases the demand for Home assets.”\(^{14}\) It is clear that, as argued by Krugman (2008), this propagation channel via balance sheet effects will be stronger the larger the international cross-holdings of assets, other things equal.

In a full-fledged model like ours, however, other linkages are at work. As noted above, a first important mechanism is that desired leverage is endogenously determined by investors taking into account the cost of external debt and the return on capital investment. In our setting, balance-sheet exposure of leveraged investors to foreign asset prices not only will affect the cross-border demand of assets, as e.g. highlighted by Krugman (2008), but it may also make broad financial conditions and thus leverage dynamics more similar across countries. Nevertheless, this tendency to equalization of premia will be ensured in our setting quite independently

\(^{13}\)Krugman (2008) credits Calvo (2000) for the original insight in analyzing the contagion of financial turmoil to other emerging markets after the 1998 Russian default.

\(^{14}\)Krugman (2008) also argues that the demand for risky assets by leveraged investors may be upward sloping in its own prices. It can be shown that in our framework this could occur as well, if, taking the leverage ratio as exogenous,

\[
\frac{\partial K_{t+1}}{\partial Q_{K,t}} = \omega_k \left( 1 + \chi^{-1} (\cdot) \right) \frac{(1 - \delta) Q_{K,t} - N_t}{Q^2_{K,t}} > 0;
\]

precisely this would be the case when net worth is relatively low and leverage high.
of the amount of balance sheet exposure to foreign assets when we consider a second important mechanism, namely cross-border trade in assets. Specifically, after some manipulations of the first order conditions of the home and foreign entrepreneurs we get

$$\frac{\chi_t}{\chi_t^*} = \frac{E_t \left( R_{t,t+1}^{e*} r_{t+1}^* \right)}{E_t \left( R_{t,t+1}^{e*} R_{t,t+1}^{K*} \right)} \frac{E_t \left( R_{t,t+1}^{e} R_{t,t+1}^{K} \right)}{E_t \left( R_{t,t+1}^{e} R_{t,t+1}^{K} \right)}.$$  \hspace{1cm} (16)

When log-linearized this relationship implies that

$$\hat{\chi}_t - \hat{\chi}_t^* = E_t \tilde{r}_{t+1}^* + E_t \tilde{R} \tilde{R}_{t+1} - \tilde{R} \tilde{R}_t - E_t \tilde{r}_{t+1},$$

where now a “$\sim$” denotes log deviations. The right-hand-side of this expression coincides, to first order, to the UIP emerging from the first order conditions of the households’ portfolio problem. Our model, therefore, predicts that, up to first order, if there is international trade in nominal assets in the two currencies, the home and foreign external finance premia are equalized.\(^{15}\) Importantly, this result is independent of the assumed discount factor of the leveraged investors.\(^{16}\)

Intuitively, consider a situation in which financial integration results in a common risk-free rate, abstracting from exchange rate fluctuations. If the financially constrained agents have access to the same investment opportunities at the margin, the spreads they face on their borrowing in domestic credit markets over the common risk free rate will have to be equalized because of arbitrage. Thus, integration in financial markets, irrespective of portfolio composition, could be a powerful source of propagation of shocks in equilibrium in the presence of financial frictions, above and beyond the cross-border balance-sheet exposure.\(^{17}\) The portfolio composition, how-

\(^{15}\)Effectively, in order for the arbitrage conditions to hold up to first order, it would be enough that claims on just one capital stock and just one bond be traded internationally.

\(^{16}\)An interesting case is when we consider equation (16) under the assumption that the entrepreneur is risk neutral so that $R_{t,t+1}^{e*} = 1$. In this case the gap between the two external finance premia is determined by the ratio of the risky assets return over the risk-free rate (a proxy of the equity premium) in the two economies. To higher orders of approximation the gap between the two external finance premia would fluctuate only to the extent that the gap between the two equity premia fluctuates.

\(^{17}\)In our framework we have assumed that investors borrow in segmented credit markets, but households can trade international bonds. However, it is straightforward to show that our results about the equalization of credit spreads under financial integration would also obtain if we instead assumed segmented deposit markets for households, but cross-border credit markets by allowing investors to borrow in both countries, even potentially facing loan rates differentiated across borrower nationality and location of the loan.
ever, will still determine the general equilibrium wealth effects on aggregate demand, especially consumption.

These additional market-based linkages in our model are notable in light of the evidence on the international propagation of financial shocks. A case in point is again the turmoil in the aftermath of the 1998 Russian default. According to Calvo (1998, p. 3) “an exogenous and unexpected negative shock, like Russia’s debt repudiation, will lower […] investors’ portfolio values and, in turn, trigger margin calls, i.e., instant debt repayment obligations on leveraged positions. In an ideal perfect-information world, deleveraging associated with the collapse of a very small share of world’s financial portfolio (as Russian debt is), should not result in an across-the-board implosion of […] markets” — our emphasis added.

The following two things are important to stress. First, a propagation based only on balance-sheet exposure, as the one stressed by Krugman (2008), would not be able to account for the above and other similar episodes — the recent evidence by Rose and Spiegel (2009) discussed in the introduction seems to suggest that also the international propagation of the current financial crisis can be hardly understood by simply looking at balance-sheet exposure measures. Second, our model can rationalize a strong propagation to (illiquid) asset prices even when the balance sheets of leveraged investors are only marginally exposed to foreign assets, reflecting simple pricing in integrated financial markets — let us dub this instance of “flight to quality” no arbitrage effects — without resorting to any additional informational friction, as e.g. postulated by Calvo (1998).

Before turning to a quantitative analysis of the different propagation channels that we have so far discussed only qualitatively, namely the balance-sheet and the no-arbitrage effects, it is useful to consider alternative ways of introducing financial frictions to model an international financial multiplier, particularly as implied by the recent paper by Devereux and Yetman (2009) — henceforth DY.

Following the collateral borrowing constraints introduced by Kiyotaki and Moore (1997), DY assume that capital investors can borrow only in proportion to the value of their holdings of domestic and foreign equities. Namely, these investors face the following borrowing constraint:

\[ D_t \leq \kappa \left( Q_{K,t} K_t + RER_t Q_{K,t} \right), \]

which is assumed to be always binding with equality as in Iacoviello (2005). This implies that the first order conditions of the investors’ utility maximization problem yield that, up to first order, there is a wedge between the risk free rate they pay on their debt \( D_t \) and the expected return on their capital investment:

\[ E_t \left[ \hat{R}_{t+1}^K \right] = E_t \left[ \hat{R}_{t+1}^{K^*} \right] = E_t \left[ \hat{r}_{t+1} \right] + \hat{\zeta}_t. \]
The term $\tilde{\pi}_t$ is the (first order approximation of the) Lagrange multiplier on the above investors’ borrowing constraint and can effectively be interpreted as a first order premium that borrowers have to pay on the risk free rate to invest in risky assets.

As DY assume that only claims to capital are traded across borders by investors, the following relation, similar to the one derived above for our model, holds up to first order:

$$E_t [\tilde{\pi}_{t+1}] + \tilde{\pi}_t = E_t [\tilde{\pi}_{t+1}] + \tilde{\pi}_t,$$

implying that the "premium" differential across countries, up to first order, should be equal to the expected real interest differential.\(^\text{18}\) Thus, if trade in short term bonds were also allowed, a case not entertained in the original version of DY, the premia $\tilde{\pi}_t$ and $\tilde{\pi}_t^*$ would be equalized across countries, as in our model, strengthening the cross-border propagation.\(^\text{19}\)

4 Calibration and steady state portfolio composition

We parameterize our model picking standard values for preference and technology parameters – see Table 1 for a synopsis. As the purpose of this calibration is only illustrative, namely to investigate the interactions between the no-arbitrage conditions in the bond and capital market and balance-sheet exposure in shaping the international transmission of different asymmetric shocks, we focus on a symmetric parameterization. While we don’t aim at reproducing particular stylized facts, we try to obtain responses of the premium and of output to productivity and shocks to the external finance premium that are, in relative terms, in the ballpark of those shown by Gilchrist et al. (2009) and Christiano et al. (2008).

Focusing first on the benchmark parameterization of financial frictions, we set the steady state ratio $\frac{D + N}{N}$ to 3. This value is 50% larger than in BGG as we think of our investors as including cross-border financial intermediaries and not merely non-financial corporations. The steady state premium is set to 1.0164, implying an

\(^{18}\)As DY study a one-good economy their analysis abstracts from real exchange rate fluctuations, implying that real rates are expressed in the same consumption units across countries.

\(^{19}\)Alternative theoretical frameworks for financial frictions that would give rise to borrowing constraints in the spirit of Kiyotaki and Moore with implications similar to those discussed here for financial integration have been recently developed in closed economy by Jermann and Quadrini (2009) and Gertler and Karadi (2009).
average credit spread of 164 basis points.20 Finally the elasticity of premium to leverage \( \frac{D}{N} \) is set to 0.04, implying that a 1 percent climb in leverage would lead to a 4 basis points increase in the premium (see for example Gilchrist et al. (2009)).

Concerning trade parameters, we set the trade elasticity to 1.2 and the import shares in consumption and investment to 15%, in line with relatively large and closed economies like the US, Japan and the euro area. Finally, the fraction of retail firms keeping their price constant is set to 0.75 per period in both countries, implying an average price duration of 4 quarters.

Concerning the stochastic structure of the model, we consider the following three shocks in each country: an autoregressive technology shock, \( \varepsilon_{Y,t} \), to the production function of final goods producers, with standard deviation 0.0026 and persistence 0.92; a monetary policy shock \( \varepsilon_{Rt} \) with standard deviation 0.0024 and persistence 0.22; and an autoregressive shock \( \varepsilon_{e,t} \) to the external financial premium with standard deviation 0.0028 and persistence 0.9.21 For simplicity we assume that these shocks are orthogonal across countries.

As the discussion of the results is based on normalized impulse-response functions (i.e. normalized to the trough of Foreign GDP) the actual size of the standard deviation of the shocks is of little practical consequence. However, both the relative volatility and persistence of the shocks have a bearing on the equilibrium portfolio composition, so while being in the ballpark of the evidence, they have been picked out as to generate a portfolio composition that displays a reasonable degree of home bias in capital claims, in line with the well-known evidence on cross-border holdings of equities (e.g. Lewis, 1999).

On the basis of this parameterization we obtain that the (near-stochastic) steady state portfolio composition under full integration implies that each country holds about 16% of the capital abroad, thus generating substantial home equity bias as observed in the data; the value of the position in foreign currency bonds is (short) 91% of home GDP, implying an offsetting long position in domestic currency bonds.

\footnote{Approximately corresponding to the mean value of the spread on loans to non-financial corporations by monetary and financial institutions with maturity of up to one year over the treasury-bill rate in the euro area . This parameter does not play a crucial role in our analysis.}

\footnote{For the persistence of these shocks see Gilchrist et al. (2009). We will the same calibration for both premium and net-worth shocks in our experiments in the next section.}
5 Balance sheet and no-arbitrage effects in the international propagation of shocks

In this section we analyze numerically the implications of financial frictions and international financial integration for the cross-country transmission of shocks. As discussed above, at least since the Asian financial crisis in the 1990s, the literature on fundamental-based “contagion” in financial markets has highlighted international cross-holdings of assets as a crucial determinant of exposure to foreign financial turbulence. According to this view, as recently put forward by Krugman (2008) to account for the cross-country diffusion of the 2008 financial crisis, a large share of foreign assets held by leveraged domestic agents should result in a strong international transmission of shocks. In the discussion above, we have referred to this channel as the balance-sheet (valuation) effect.

In Section 3, however, we have argued that the strength of the international transmission of shocks may or may not be directly related to the foreign exposure of the balance sheet of leveraged agents, depending on the degree of international financial markets integration. One key factor governing the international transmission is arbitrage in international financial markets: namely, the fact that leveraged cross-border investors equate the returns that they can obtain from different assets in different countries, quite distinctly from the exact amount of foreign assets that they will end up holding — we have referred to this channel as the no-arbitrage effect.

Here, we provide an illustration of both these channels in the calibrated version of our two-country economy, by looking at the international ramifications of a variety of asymmetric shocks. A key aspect we want to investigate is how and to what extent propagation across asset prices and financial market conditions will entail real synchronization in aggregate variables like output and investment. Specifically, in what follows we will focus on two types of asymmetric shocks: a (negative) Foreign neutral technology shock, and a (positive) shock to the Foreign external finance premium. We can expect that the reaction of credit spreads in the Home country to Foreign shocks will be a crucial factor in shaping the responses of investment and output, namely that an increase in the Home premium will be key in the propagation of recessions from the Foreign to the Home country.

In order to better compare the valuation effects on balance sheets and the no-arbitrage effect on credit spread equalization, we will consider the following different scenarios concerning international financial integration: i) the case of no trade in capital but integration in bond markets \((\text{capital autarky})\); ii) the case of no trade in bonds but integration in the market for capital claims \((\text{bond autarky})\); iii) the case of trade in both bonds and capital claims \((\text{full integration})\). For each of these scenarios
we will display the response of the model economy for the following two cases: a) full home bias, when the actual amount of foreign capital holdings are set to zero; and b) full diversification, when the capital investors’ portfolio is evenly split between holdings of domestic and foreign capital.

Specifically, while under capital autarky investors optimally decide their level of borrowing according to the following (log-linearized), purely domestic, first order condition (and its Foreign counterpart)

\[ E_t \left[ \hat{R}^K_{t+1} \right] = \hat{\chi}_t (\cdot) + E_t [\hat{r}_{t+1}] , \]

we nevertheless will assume that net worth evolves according to the following law of motion (and its Foreign counterpart):

\[ N_t = \gamma \left[ R^K_t Q_{t-1} K_t + \frac{RER_t}{RER_{t-1}} R^K_t Q^*_t - R^K_{t-1} K^*_t - R^D_{t-1} \frac{D_{t-1}}{\pi_t} \right] + (1 - \gamma) T_t , \]

or

\[ N_t = \gamma \left[ \alpha_k R^K_t + \alpha_{k^*} \frac{RER_t}{RER_{t-1}} R^K_t - \frac{D_{t-1}}{\pi_t} R^D_{t-1} \right] , \]

where under full home bias we set (steady state) holdings of Foreign capital \( \alpha_{K^*} \equiv Q^*_{t-1} K^*_t = 0 \) — which is the actual equilibrium outcome under no trade in capital claims — and, admittedly in ad-hoc way, under full diversification that holdings of domestic and Foreign capital claims are the same, \( \alpha_{K^*} = \alpha_K \).\(^{22}\)

Conversely, under cases ii) and iii) when we allow for trade in capital claims and the no-arbitrage conditions also hold — namely, implying the following from the perspective of the Home investors

\[ E_t \left[ \hat{R}^K_{t+1} \right] = E_t \left[ \hat{R}^K_{t+1} + \hat{RER}_{t+1} - \hat{RER}_t \right] = \hat{\chi}_t (\cdot) + E_t [\hat{r}_{t+1}] , \]

the full home bias and full diversification portfolios could be interpreted as two possible equilibrium portfolio allocations under the assumption of risk-neutral capital investors (\( R^e_{t|t+1} \) constant), as their portfolio choice would be indeterminate at any

\(^{22}\)However, assuming an exogenous portfolio composition may find a counterpart in the literature studying the interactions of financial frictions and foreign currency debt, where the latter is often assumed to constitute an exogenously given fraction of total borrowing by financially constrained agents.
order of approximation. Furthermore, as the optimal portfolio choice with risk-averse investors obtained under our calibration above also falls between these two extremes, results under it should also be bracketed by those presented below under the full home bias and full diversification portfolios.

For all experiments, the figures below display the following variables for each country in percentage deviations from their steady-state values: the external finance premium ($\chi_t$), the ex-ante real rate $\left( E_t \left[ r_{t+1} \right] \right)$, Tobin’s Q ($Q_t$), GDP ($Y_t$), investment ($I_t$), consumption ($C_t$), leverage ($\frac{D_t}{N_t}$), and the real exchange rate ($RER_t$) — the latter defined in such a way that an increase would denote a real depreciation for the Home country. Notice that the changes in premia and interest rates can be interpreted as basis points, once multiplied by 100. A black (circled) line denotes variables’ responses in the case of full home bias in capital holdings ($\alpha_k = 0$), while the red line denotes variables’ responses in the case of full diversification ($\alpha_{k*} = \alpha_k$). Throughout all exercises, the size of the driving shock is normalized so that the trough in Foreign GDP after each shock is always of 1 percentage point across all experiments.

5.1 The cross-border propagation of asymmetric technology shocks

Figures 4 to 6 report impulse responses to a neutral technology shock to the Foreign country for the scenarios i) to iii) with varying degrees of international financial integration. We start with capital autarky — scenario i) — in which nominal short term bonds denominated in both currencies are freely traded by households (though their portfolio allocation is kept the same as that optimally prevailing under full integration), but capital trade is not allowed — again recall that in this case the first order conditions for endogenous cross-border capital choices are not included in the model solution, so that the effect of no-arbitrage on returns on capital is ruled out. Interestingly, the setting under full home bias (depicted by the black circled line) is very similar to the environments studied by most contributions analyzing the consequences of financial frictions from an open economy perspective, usually assuming complete markets among households (see e.g. Gilchrist et al. (2002) ) or at least trade in short-term bonds (e.g. Gilchrist, 2003 and Faia, 2007b,a).

Figure 4 shows that a Foreign negative technology shock brings about a persistent and hump-shaped fall in Foreign GDP, investment, consumption and asset prices. The contractionary effect of the financial accelerator is illustrated by the countercyclicality of the Foreign credit spread, which climbs on impact by 10 basis
points and then reverts back to zero, mirroring the increase in leverage by Foreign investors; in turn this dynamics is due to the larger drop in their net worth relative to investment triggered by asset price deflation. The persistent increase in marginal costs due to lower productivity entails a rise in Foreign inflationary pressures, and, given the assumed monetary reaction function, a gradual tightening of the Foreign monetary policy stance. Finally, the real exchange rate persistently appreciates from the Foreign country perspective, as indicated by its rise in the bottom right corner chart.

Comparing the black and the red lines for the responses of Foreign variables in Figure 4, it is clear that under capital autarky there are no qualitative differences between the case of full home bias and full diversification in capital holdings. There are instead quantitative differences, with the main ones arising in the case of full diversification concerning a more pronounced fall in Foreign investment and, to a lesser extent, in Foreign asset prices, and a larger increase in the finance premium, in line with the fall in investment.

Conversely, as expected, the propagation abroad of the Foreign shock to the Home country is significantly affected by the degree of exposure to cross-border assets of balance sheets of financially constrained agents — recall that in this case the first order conditions for the endogenous choice of cross-border capital holdings do not belong in the model, ruling out the no-arbitrage equalization effect on credit spreads. Under full home bias (the black circled line), in addition to the traditional goods trade channel, international transmission works through intertemporal trade and some ex-ante risk sharing by households via the assumed non-zero gross holdings of domestic and foreign currency bonds. Therefore, the adverse technology shock abroad brings about a decline in domestic consumption and asset prices, and, because of the ensuing rise in the external finance premium, investment; Home GDP however increases for a few quarters, reflecting the larger import demand by the Foreign country.

The introduction under full diversification in capital holdings (depicted by the plain red lines) of a large exposure of investors’ net-worth to cross-border valuation effects, though in an admittedly crude and partial equilibrium way, affects the responses of the Home spread, asset prices, and especially GDP and investment. While the climb in Home GDP is more persistent, asset prices and investment decline by less, in line with the smaller increase in the Home premium. The reason for the favorable spillovers onto the Home economy is clear when the response of the real exchange rate is taken into account: the Home real depreciation (the real exchange rate increase depicted in the bottom line) partially offsets the fall in Foreign asset prices in local Home (real) currency, under full diversification working to attenuate the negative valuation effects of the asset price deflation on the net worth of Home.
investors. In this case, the (mechanically assumed) higher exposure to foreign assets actually helps in shielding the domestic economy from the external negative shock.

These results seem at odds with the conjecture discussed above and entertained by some of the (partial equilibrium) literature on the international financial multiplier, namely, that more exposure to foreign risky assets in the portfolio of leveraged investors should per se entail stronger positive cross-border spillovers, particularly concerning asset prices. Yet, mere balance-sheet effects in an otherwise fully specified and worked out model seem to make asset prices across countries more substitutes rather than more complements, in contrast with the hypothesis by Krugman (2008), at least in response to standard technology shocks.

The next two Figures turn to the examination of the consequences of introducing trade in capital claims and the ensuing no arbitrage effects, reporting impulse responses without and with international trade in bonds between households — here we continue to stick to the assumption of ad-hoc portfolio compositions of capital holdings and do not report results under the investors’ optimal portfolio, as it is obvious they would represent just an intermediate case, adding little to the analysis presented here.

Starting first with the case of no cross-border bond trade (bond autarky) depicted in Figure 5, it is clear that the differences in the sign and intensity of the international propagation between the cases of full home bias and full diversification are greatly reduced with respect to those depicted in Figure 4. Irrespective of the degree of diversification, the responses of most variables are quite synchronized, with the notable exception of GDP, and obviously the monetary policy stance. Credit spreads, though not perfectly equalized are quite similar across countries; in addition to no-arbitrage in capital claims, this reflects the equilibrium behavior of short-term interest rates and the real exchange rate, which closely mimics the UIP relation — however recall that UIP is not assumed in this version of the model under bond autarky. Therefore, relative to the case of bond trade in Figure 4, in equilibrium the no-arbitrage effect on capital returns arising from the endogenous choice of cross-border capital claims is enough to increase synchronization in most variables, whereas more exposure to assets abroad in investors’ portfolio overall makes little difference in affecting cross-border synchronization.

Finally, Figure 6 displays the results when full international trade in bonds and capital claims is allowed, which are very similar to those in the previous figure given that now UIP holds exactly by assumption. As a result of financial integration and the ensuing global increase in credit spreads, most variables are tightly and positively correlated — with premia and leverage obviously perfectly correlated — while the degree of exposure makes no difference, except for consumption. However, the climb
in credit premia is not enough to overturn the intrinsic mechanism prevailing in most open-economy models pushing towards a decoupling of activity across countries, with Home GDP going up for a few quarters rather than falling as its counterpart abroad.

Our results so far are also notable in light of the recent paper by Devereux and Yetman (2009), which in experiments under integration of capital trade only, similar to those in our Figure 5 under bond autarky, finds that increased diversification in capital holdings results in a heightened international transmission of technology shocks, reflecting the greater sensitivity of domestic leverage constraints to developments in asset prices abroad. In DY setting à la Iacoviello (2005), the greater is the exposure of Home balance sheets to foreign asset prices, the larger the negative impact on leverage constraints and thus on Home investment and output following a drop in Foreign productivity.  

To summarize our results so far, we have shown that once financial markets are integrated across-the-board, including trade in risky (illiquid) assets, the size of home bias in portfolios of leveraged investors may be largely inconsequential for the sign and strength of the international propagation of technology shocks in economies with financial frictions. Conversely, under full financial integration a crucial channel of transmission is the spillover in external finance premia, implying that countercyclical premia that are positively correlated across countries should be associated with more positively correlated responses in investment and possibly activity across countries. These results are not limited to the propagation of neutral technology shocks, as we obtain similar outcomes when we look at other business cycle drivers, like investment-specific technology shocks — we do not present these results here to save on space.

In turn, this suggests that the combination of financial frictions and financial integration can be an important factor in bringing open economy models more in line with key stylized facts of the international business cycle, such as the strong cross-country correlation of output, investment and labor inputs. A convenient way to investigate this aspect is to consider the transmission of technology shocks in a flexible price version of our model under full integration, with and without financial frictions. As argued above, once we abstract from financial frictions our model is very close to multiple goods prototypical international business cycle models, with flexible prices, such as Backus et al. (1994) or sticky prices, such as Chari et al.

23As we have argued above, a first difference between DY and our setting is due to the different mechanisms of financial frictions adopted. A further difference reflects the lack of endogenous labor supply in the DY model, so crucial in generating the negative conomovements in production inputs highlighted by the international business cycle literature, which (together with their assumption of purchasing power parity) can account for the unambiguously negative spillovers to investment and GDP in response to a Foreign negative technology shock.
(2002).

Figure 7 reports impulse responses to a negative Foreign technology shock under full integration and flexible prices, where a black circled line now depicts an economy without financial frictions, while the plain red line depicts an economy with financial frictions parameterized according to our benchmark calibration. It is clear that introducing financial frictions induces a tighter synchronization of asset prices, investment and thus GDP across countries, due to the stronger countercyclicality of credit spreads, which now increase globally by 30 basis points in response to the adverse Foreign technology shock. This experiment lends support to the claim that pervasive financial frictions can go same way to account for tighter international synchronization in the presence of higher financial integration even in the face of asymmetric technology shocks, in stark contrast to standard predictions by open-economy models abstracting from this kind of frictions.

5.2 The cross-border propagation of asymmetric financial shocks

In this subsection we turn to the investigation of the international transmission of financial shocks. The recent DSGE literature studying the financial accelerator distinguishes two types of financial shocks: a shock to the external finance premium and a shock to the net-worth of borrowers. Gilchrist et al. (2009) shows that the estimated effects of these two shocks on macro variables can radically differ quantitatively. Specifically, Gilchrist et al. (2009) estimate confidence bands for the response of the economy to a premium shock and to a net-worth shock that imply a ratio of peak-premium to trough-output in the approximate ranges of 1.25-6 and 0.1-0.23 respectively.

In the following two subsections we analyze the response of our economy to these shocks under the alternative scenarios for the degree of financial integration and portfolio composition discussed in the previous subsection. Our results are in line with an elasticity of output to the premium much larger in the aftermath of a net-worth shock than that implied by a premium shock, although the qualitative response of the economy is very similar in the two cases.\(^\text{25}\)

\(^\text{24}\)Such an economy with flexible prices could be interpreted as our benchmark sticky-price economy under a monetary policy following a strict inflation targeting in terms of domestic GDP deflator. In turn, this stresses the key role of sticky prices and monetary policy in models with financial frictions. For comparability reason we assume in both cases that there is full diversification in capital and keep the households bond portfolio at its benchmark (but clearly now suboptimal) value.

\(^\text{25}\)One should notice that while for simplicity we assume the same stochastic structure for the two shocks, Gilchrist et al. (2009) estimate separate processes, finding a much more persistent process for the net-worth shock.
5.2.1 The cross-border propagation of asymmetric premium shocks

We first turn to the analysis of the consequences of a shock to the external finance premium, which can be interpreted, in line with Christiano et al. (2007) or Jermann and Quadrini (2009), as an adverse shock to the credit worthiness of leveraged agents not directly related to the health of their balance sheets. For instance, in the original BGG framework this shock could represent an increase in the (cross-sectional) riskiness of individual borrowers’ undertakings and thus in their default probability, or in the costs associated with recouping debt payments after default, perhaps reflecting changes in the ability by lenders to resell the borrower’s (illiquid) assets. Considering the patterns of international propagation of such a shock could be particularly interesting in the context of the 2008 financial crisis, characterized by large and synchronized declines in asset prices and macroeconomic variables in many countries, driven by negative developments in financial institutions and markets.

Figures 8 and 9 report impulse responses to an unexpected increase in the Foreign external finance premium for cases i) and iii) above, i.e. with financial integration going from trade in short-term bonds only (capital autarky) to trade in both bonds and capital claims (full integration). The format is the same as before — in all figures the black (circled) line depicts responses under full home bias in capital holdings ($\alpha_{K*} = 0$), while the red (dashed) line depicts the response of the variables under full diversification ($\alpha_{K*} = \alpha_K$). Furthermore, we normalize the impulse responses as before by the value of foreign output at the trough.

Starting with the case of capital autarky displayed in Figure 8, it is clear that the climb in the Foreign premium brings about a large and persistent decline in Foreign asset prices and investment, while GDP contracts by less and consumption temporarily increases; leverage expands reflecting the fall in net worth, further adding to the exogenous jump in the premium, reaching 600 basis points. Finally, the real exchange rate now depreciates from the Foreign country perspective.

The comparison of the circled (black) and the plain (red) line shows that introducing exposure of the investors’ balance sheets to asset prices abroad under full diversification has strong effects on the response of the Foreign and especially Home variables, although its implications for the workings of international transmission are somehow surprising. Under full diversification, Foreign GDP and investment display a more pronounced and persistent decline, while the real exchange rate is also more volatile, despite the smaller climb in the premium; asset prices and consumption are barely affected though.

As expected, both the sign and the strength of the propagation of the Foreign premium shock to the Home country are affected by cross-border capital holdings. Under full home bias (the black circled line), the Home country is only slightly af-
fected by the shock abroad, with the credit spread even slightly falling. Asset prices, investment and consumption all temporarily increase. The expansion of Home consumption and investment is mainly due to the very large decline in Foreign investment that frees resources for Home absorption, and appears to be robust to different specifications of the model concerning the allocation of the credit spreads from borrowers to the rest of the economy. Labor inputs in the Home country contract so that domestic output slightly falls for 2 years before persistently improving. We conjecture that this response of labor and output might not be robust to wage rigidities or weaker responses of labor supply to consumption. The introduction of large cross-border asset holdings under full diversification (the plain red line) implies that the combination of falling asset prices abroad and real currency appreciation transpire into adverse valuation effects on Home investors’ net worth, temporarily depressing domestic Tobin’s Q and driving up their credit spreads. However the latter is not enough to offset the push to increase investment and consumption discussed above, leading to persistent GDP expansion. Overall, the balance-sheet effect generated by the (ad-hoc) composition of the portfolio does not seem to produce by itself the expected sign of international propagation of the shock.

Turning to the effects of across-the-board financial integration, Figure 9 displays impulse responses when cross-border no-arbitrage conditions for both bonds and capital claims hold as a consequence of endogenous portfolio decisions. It is immediately apparent that the differences between the cases of full home bias and full diversification are again negligible — as before, reporting results under the optimal capital portfolio composition would add little. Remarkably, full integration, leading to equalization of the premia across countries, now brings about perfect synchronization of the responses of all variables in the Figure to the asymmetric financial shock, with the (obvious) exception of leverage. Since credit spreads are equalized, but reflect the combined effect of the shock and the endogenous leverage ratio, the latter must increase by more in the Home country, not directly affected by the exogenous disturbance. However, as shown in the Figure, the asymmetric response of leverage has no sizable consequences for the dynamics of the main macroeconomic variables. The global decline in investment leads to a larger consumption expansion in both countries, particularly at Home; however, the real exchange rate appreciates by more, implying a sharp and remarkable departure from well-known risk-sharing conditions.

To summarize, our results point to the fact that when asset-markets are integrated, including those of risky illiquid assets in which financially constrained agents

\[26\text{Under the assumed preferences only very low elasticity of labor supply and very high intertemporal elasticity of substitution revert the sign of the response.}\]
are the main investors, no-arbitrage effects resulting in tight linkages in cross-country credit spreads can act as powerful complements to valuation effects on balance sheets in economies with financial frictions. This would occur to the extent that the size of home bias in portfolios could be largely inconsequential for the sign and strength of the international propagation of shocks. As discussed above, this is particularly important in light of the (otherwise puzzling) rapid propagation of shocks across asset markets even when exposure to those very assets in cross-border portfolios appears to be rather limited.

5.2.2 The cross-border propagation of asymmetric net-worth shocks

In the previous subsection we have modeled the financial shock as a disturbance directly affecting the external finance premium. In the financial accelerator framework there is another typical way of modeling financial shocks, i.e. as shocks to the fraction of net-worth that is carried over to the next period and that affects the amount of leverage of the surviving financially constrained agents. Gilchrist et al. (2009) for example, show that this kind of shock can be quantitatively very important in explaining the business cycles in the data.

Figures 10 and 11 reproduce the cases studied in Figures 8 and 9 respectively, under an exogenous contraction of the Foreign entrepreneurs’ net worth. While this shock implies responses that are qualitatively very similar to those induced by an external finance premium shock (except for leverage for obvious reasons), quantitatively the elasticity of output relative to the premium is much larger with the present shock. A net-worth shock that generates on impact an increase in the premium of about 100 basis points per quarter generates a drop in output that is about 1% at the trough.

6 Concluding remarks

In this paper we have developed a two-country model with financial frictions à la Bernanke et al. (1999) and cross-border capital investment to study how the international transmission of asymmetric shocks is affected by the presence of leveraged investors holding foreign and domestic risky assets. In line with the hypothesis formulated in the literature, e.g. by Calvo (2000) and more recently Krugman (2008), we have found that foreign exposure in interconnected balance sheets can indeed act as a powerful propagation mechanism of asymmetric shocks across countries.

However, in our setting financial and real interdependence can be very strong even with minimal balance sheet exposure to foreign illiquid assets by financially
constrained agents, if asset markets are integrated. Because of the no-arbitrage conditions it imposes, a high degree of integration in the relevant asset classes exerts a strong pressure towards the cross-border equalization of external finance premia faced by financially constrained investors, thus imparting tight linkages in leverage and macroeconomic dynamics across countries.

This mechanism based on a global “flight to quality” due to pricing effects in integrated asset markets has the potential to account for fundamentals-based financial and real propagation even in episodes where the foreign exposure of leveraged investors is not substantial, similarly to the recent evidence documented by Rose and Spiegel (2009). While noting that this mechanism is potentially consistent with evidence in cases of “fundamentals-based contagion” among integrated financial markets (e.g. Kaminsky & Reinhart (2000), who proxy integration with return correlations), we believe this could be an important feature given the rather pervasive degree of home bias in cross-border holdings of (illiquid) assets still prevalent even among advanced countries. Under a high degree of financial integration, external premia have to be literally equalized across countries up to a first order approximation, a very strong empirical implication, which is shared by different models of financial frictions, but which does not seem to be inconsistent with preliminary evidence on credit spreads in the US and the euro area even before the onset of the recent financial crisis.
FIGURES AND TABLES
Figure 1: Rose and Spiegel (2009)
Figure 4: Capital account: Foreign productivity shock (circled = full home bias; plain = perfect diversification)
Figure 5: Bond autarky: Foreign productivity shock.
Figure 6: Full integration: Foreign productivity shock.
Figure 7: The effect of financial frictions under flexible prices; (circled $\rho = \chi = \chi^* = 0$, plain $\rho = \chi = \chi^* = 0.04$).
Figure 8: Capital autarky: Foreign financial shock.
Figure 9: Full financial integration: Foreign financial shock.
Figure 10: Capital stock. Foreign networth shock.
Figure 11: Full financial integration: Foreign networth shock.
Table 1: Calibrated parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
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<tr>
<td>Home bias in consumption and investment</td>
<td>( n (n^*) )</td>
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<td>Calvo probability of not-adjusting prices</td>
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<tr>
<td>Steady-state depreciation of capital</td>
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<td>Investment adjustment cost parameter</td>
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<td>Elasticity of Labor supply</td>
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</tr>
<tr>
<td>Intratemporal elasticity of substitution</td>
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<tr>
<td>Intertemporal elasticity of substitution</td>
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<tr>
<td>Final-goods producers’ mark-up</td>
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<td>Habit formation in consumption</td>
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<tr>
<td>Interest rule response to inflation</td>
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<td>Interest rule response to output growth</td>
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<td>Interest rule inertia</td>
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<td>Households discount factor</td>
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<td>Leverage ratio</td>
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<td>Steady-state premium (p.a.)</td>
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<td>Share of surviving investors</td>
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References


