Abstract

House prices and exchange rates can potentially amplify the expansionary effects of capital inflows by inflating the value of collateral. We first document that during a boom in capital inflows real exchange rates, house prices and equity prices appreciate; the current account deteriorates; and consumption and GDP expand; while in a bust these dynamics reverse sharply. Next we set up a model of collateralized borrowing in foreign currency with international financial intermediation in which a shock to the international supply of credit is expansionary. In this environment, we illustrate how exchange rate and house price appreciations may contribute to fueling the boom by inflating the value of collateral. We finally show that an identified change to the international supply of credit in a Panel VAR for 50 advanced and emerging countries displays a similar transmission. Moreover, we show that the intensity of the consumption response to such a shock differs significantly across countries and it is associated with country characteristics of both the housing finance system and the monetary policy framework like in our model.

Keywords: Capital Flows, Credit Supply Shock, Leverage, Global Liquidity, Exchange Rates, and Balance Sheet Effects, House Prices.

JEL codes: C32, E44, F44.
1 Introduction

Contrary to the predictions of standard economic theory (Chari et al., 2005, Blanchard et al., 2015), sudden increases in capital inflows are expansionary and pose difficult challenges for policy makers—see for instance, Rey (2013, 2016). Historically, however, some economies appeared to be more sensitive than others, with emerging market economies standing out as particularly vulnerable. So what are the specific mechanisms through which capital inflows lead to macroeconomic booms in the receiving economies? And what are the country characteristics that are associated with these country differences in vulnerability?

In this paper we explore the role of asset price inflation, mortgage market characteristics, and the currency denomination of foreign financing. Appreciating asset prices may amplify the expansionary effects of capital inflows by inflating the value of collateral and expanding the borrowing capacity of the economy. And these channels of amplification may be more relevant, the more developed the domestic credit market and the higher the share of foreign currency denominated liabilities in the domestic economy.

Traditionally, the analysis of capital flows and their impact on the macroeconomy distinguished between “push” and “pull” factors. The former are best thought as shocks that originate abroad and lead capital to flow in or out of individual countries. The latter are instead domestic shocks that attract foreign capital from the rest of the world. In this paper, we focus on one particular type of ”push” shock—an international credit supply shock. We identify such shock empirically by looking at changes in leverage of international financial intermediaries. We also build a model in which a change in the leverage of an international financial intermediary leads to an increase in the international supply of credit as we assumed in our empirical analysis. The model allows us to explore also cross country properties of the transmission of such shock, as we do in the data.

We proceed in three main steps. First, we document that episodes of large swings in cross-border bank claims are expansionary. Consumption and GDP increase, the current
account deteriorates, while all asset prices (the real exchange rate, house prices, and equity prices) appreciate. These dynamics reverse sharply when international bank claims flow out of the country. To describe booms and busts in capital flows, we follow the methodology adopted by Mendoza and Terrones (2008), focusing on the behavior of the economy around the peak of those boom-bust cycles.

Next, we set up a theoretical model of international financial intermediation and collateralized borrowing in foreign currency. Housing is one of the largest asset classes in most countries and the US dollar remains the dominant currency in the international financial system. We assume the main source of collateral is residential housing and borrowing is denominated in foreign currency. Domestic households use housing as collateral for borrowing in domestic or foreign currency. So both house prices and the exchange rate can have an amplification role, which differs depending on whether domestic borrowing is constrained or not and can interact with the structural characteristics of the economy.

The model we use embeds two blocks of different characteristics. One block is small but financially integrated with the rest of the world. In this economy, households are relatively impatient and subject to a standard borrowing constraint (Kiyotaki and Moore, 1997). The other block is large and is the source of the global supply of credit. Households of the foreign economy own financial intermediaries that operate globally and channel funds to the borrowing country. Financial intermediaries are subject to an exogenous capital requirement as in Brunnermeier and Sannikov (2014) and He and Krishnamurthy (2013).

When the capital requirement constraint on intermediaries is relaxed, the international supply of credit expands as we document in the event study and we assume in the VAR analysis. The shock leads to a consumption boom, an appreciation of the real exchange rate and house prices inflation (while the expected return on these assets falls), like in the event study.

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1In practice, several factors, such as regulation, financial innovation, risk appetite, and monetary policy, can determine a change in the leverage constraint. We do not take a stand on the ultimate cause of this shift. Instead, we focus on its consequences for the international supply of credit and the transmission to foreign economies.
If the collateral constraint is binding, house prices expand households’ borrowing capacity. Similarly, when credit is denominated in foreign currency and the constraint is binding, the real exchange rate can boost the domestic borrowing capacity in the model. Movements in the real exchange rate, however, imply valuation effects also when the borrowing constraint is not binding and hence might have additional roles in the transmission of the credit shock. In particular, the value of the domestic endowment increases while the value of borrowing decreases if credit is denominated in foreign currency.

Finally, we investigate empirically the transmission and the relative importance of our international credit supply shock, as well as the cross country differences in its impact. We do so by specifying a Panel Vector Autoregression model (PVAR) for about 50 countries between 1985 and 2012. Following the insight of the theoretical model that we develop, we augment the PVAR model with the leverage of US Broker-Dealers, and then focus on a shock to this variable.

The VAR analysis show that this shock increases international claims of global banks and generates responses of macroeconomic variables (GDP, consumption, and the current account) and asset prices (house prices, the real exchange rates, and the real short-term interest rate) in line with the unconditional evidence of the event study and the transmission in the model. The evidence that we report shows that the shock explains about twice as much macroeconomic and asset price variance as a US monetary policy shock.

The VAR analysis, also, reveals a significant degree of heterogeneity in the transmission mechanism across countries. The the impact of the shock is much stronger in economies with larger share of liabilities denominated in foreign currency and high loan-to-value ratios, also consistent with the model we set up. We show in the model that both the tightness of this constraint (the LTV ratio) and the share of foreign currency liability can potentially affect the transmission of the international credit supply shock consistent with the cross country differences in the vulnerability to shock.
Our paper relates to three strands of literature. A first set of contributions explore how US monetary or regulatory policy stance, innovations in the financial system, and risk-taking behavior can affect leverage of international financial intermediaries and the global financial cycle, both from an empirical (Rey, 2013, 2016, Forbes et al., 2016) and theoretical (Bruno and Shin, 2015, Boz and Mendoza, 2014) perspective. We take this idea one step further and investigate, both empirically and theoretically, possible mechanism of transmission to macroeconomic variables in individual countries. We investigate the next chain in the transmission of such shocks—from the leverage of US Broker-Dealers to macroeconomic dynamics in economies at the receiving end of capital inflows and also study the cross country distribution of these effects.

The second strand consists of papers that studied the role of international capital flows in fueling the US housing boom and subsequent crash—see, among others, Justiniano et al. (2015), and Favilukis et al. (2017). In this paper, we explore the role of house prices and exchange rates for the transmission of capital flow shocks emanating at the center of the international financial system and potentially affecting the to the periphery.

Finally, this paper is also related to the literature on the sensitivity of consumption to house price and credit shocks. Berger et al. (2015) use US micro data to quantify the elasticity of consumption to changes in housing wealth. Kaplan et al. (2016) show that this elasticity depends on the source of the shock moving house prices. Calza et al. (2013) study how this elasticity depends on the mortgage market structure in advanced economies. Almeida et al. (2006) illustrate how housing prices and mortgage demand respond more to income shocks in countries where households can achieve higher LTV ratios, consistent with the earlier evidence of Jappelli and Pagano (1989). Finally, Mian et al. (2016) document a cross-country association between household debt and consumption growth. We condition our analysis on a particular source of exogenous variation in consumption—an international

\footnote{Aizenman and Jinjarak (2009) investigate empirically the impact of shocks to house prices for the current account. See Gete (2009) and Ferrero (2015) for models that rationalize this direction of causality.}
credit supply shock—and document an association between the share of foreign currency borrowing and the maximum level of the LTV and the consumption sensitivity to such a shock for the largest panel of countries studied to date for which quarterly data on house prices are available.

The rest of the paper is organized as follows. Section 2 describes the event study. Section 3 sets up our model that we use to illustrate the nature of the shock, clarify the transmission mechanism, and support the VAR identification assumptions. Section 4 discuss the model properties with a numerical example under a set of specific parameter values. Section 5 reports our Panel VAR analysis. Section 6 concludes. A number of appendices report derivations, additional details, data sources and robustness analysis.

2 Capital Flows, Asset Prices, and Economic Activity: An Event Study

In this section we document the behavior of asset prices and the real economy associated with episodes of boom-bust in international capital flows in a large sample of advanced and emerging markets. We focus on a specific component of capital flows, namely BIS reporting banks’ cross-border claims to all sectors of the receiving economy (i.e. financial and non-financial). For example, if $KF_{ij,t}$ is cross-border bank claims from country $j$ to country $i$ in period $t$, our capital flows variable for country $i$ is defined as:

$$KF_{it} = \sum_{j=1}^{N} KF_{ij,t} \quad \forall j \neq i,$$  \hspace{1cm} (1)

where $j = 1, ..., N$ indexes all BIS reporting countries. We consider the following variables: GDP, private consumption, short-term interest rates, house prices and equity prices, the effective exchange rate, the exchange rate vis-a-vis the US Dollar, and the current account as a share of GDP. All variables are expressed in real terms. The sample period runs from
1970 to 2012 and the frequency is annual. A description of the variables and their sources is reported in the Appendix.

We focus on the behavior of asset prices and the real economy around boom-bust episodes in cross-border claims. To identify boom-bust episodes we define a boom (bust) as a period longer than or equal to three years in which annual cross-border claim growth is positive (negative). The peak (trough) is defined as the last period within the episode in which the annual rate of growth of cross-border credit is positive (negative). We use annual data to avoid seasonal and other noisy components in quarterly data. We then define “boom-bust” episodes as episodes of booms followed by a bust.

This procedure identifies 134 booms, 81 busts, and 50 boom-bust episodes. We then plot the behavior of other macro and financial variables around the identified boom-bust episodes. Figure 1 reports the results. It plots the mean and the median (solid line and dotted line, respectively) across all episodes, using a 6-year window that goes from three years before the peak to three years after the peak. In each panel, time 0 marks the peak of the boom-bust cycle in cross-border bank claims (i.e., the last period of a boom in which cross-border bank claims display a positive growth rate), which is also depicted with a vertical line. All variables are expressed in percentage changes, with the exception of the short-term interest rate and the current account over GDP which are expressed in percentage point changes.

Figure 1 shows that a boom in cross-border banking claims is associated with an economic expansion, as both GDP and consumption display positive and elevated rate of growth (of about 3-5 percent per year). The boom is also accompanied by very fast growing house and equity prices. Real interest rates increase only the year before the peak and are associated with a fall in asset prices and a slowdown in economic activity. On average, the real effective

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3This procedure is similar to the one commonly used in the literature (Gourinchas et al., 2001, Mendoza and Terrones, 2008, Cardarelli et al., 2010, Caballero, 2014, Benigno et al., 2015). The literature typically defines these episodes as periods in which credit (or capital inflows) rise more than one standard deviation above trend level. Our results are robust to using the traditional approach. The advantage of our approach is that we do not need to detrend the data, which introduces spurious variation over time in the analysis.

4The summary statistics for these episodes (such as duration and amplitude) are reported in the Appendix.
**Figure 1. Event Study: Boom-Bust Episodes In Cross-border Lending**

Note. Each panel plots the mean and the median (solid line and dotted line, respectively) across all boom-bust episodes, using a 6-year window that goes from three year before the peak to three years after the peak. In each panel, time 0 marks the peak of the boom-bust cycle in cross-border bank claim growth (i.e., the last period of a boom in which cross-border bank claims displays a positive growth rate), which is also depicted with a vertical line. All variables are expressed in percentage changes, with the exception of the short-term interest rate and the current account over GDP which are expressed in percentage points.

The real effective exchange rate seems unaffected by the capital inflow, but we can see an appreciation vis-a-vis the US dollar during the last year of the boom episode. Moreover, about half of the episodes are associated with large real appreciations. The current account deteriorates sharply for most episodes, and it starts to adjust gradually in about half of them during the last year of the expansion.

During the bust phase, these dynamics partially revert. The economy experiences a contraction, with both GDP and to a lesser extent consumption falling. House prices and equity prices collapse. The real exchange rate depreciates sharply, and the current account...
reverts abruptly into a temporary large surplus. While both GDP and consumption stabilize quickly, both house prices and cross-border flows remain depressed for several years.

This evidence provides support for the view that capital inflows are expansionary and associated with large swings in asset prices. So we now set up a simple model in which house prices and exchange rate can amplify the transmission of a capital flow shock.

3 Model

This section presents a stylized model of international financial intermediation and collateralized borrowing. The model helps us explain how cross-border financial flows can induce boom and bust cycles consistent with the evidence reported in the previous section. We then use the model to identify an international credit supply shock in the data and to interpret its transmission.

The world economy lasts for two periods, and consists of two blocks (countries), Home (H) and Foreign (F), of size $n \in (0, 1)$ and $1 - n$, respectively. In both periods, the representative Home and Foreign household receives a country-specific endowment of goods, and consumes a bundle of the two goods as well as housing services, which are proportional to the stock of housing.

The two blocks only differ in the degree of patience of their representative household. The Home household is relatively impatient and borrows to purchase housing services subject to a collateral constraint. The Foreign household saves via deposits and equity in a global financial intermediary that channels funds to the borrowers and is subject to a leverage constraint (or, equivalently, a capital requirement).
3.1 Goods Markets

The structure of the goods market is standard. The representative Home household consumes a Cobb-Douglas basket of Home and Foreign goods:

\[ c = \frac{c_H c_F^{1-\alpha}}{\alpha^\alpha (1-\alpha)^{1-\alpha}}, \]  

(2)

where \( \alpha \in (0, 1) \) is the steady state share of consumption on Home goods. Following Sutherland (2005), we assume that the weight on imported goods in the Home consumption basket is a function of the relative size of the foreign economy \((1-n)\):

\[ \alpha \equiv 1 - (1-n)\lambda, \]

where \( \lambda \in (0, 1) \) represents the degree of openness, equal for both countries. This assumption implies \( \alpha \in (n, 1]\) and generates home bias in consumption.\(^5\)

Expenditure minimization implies that the demand for Home and Foreign goods by Home households is:

\[ c_H = \alpha \left( \frac{P_H}{P} \right)^{-1} c \quad \text{and} \quad c_F = (1-\alpha) \left( \frac{P_F}{P} \right)^{-1} c, \]

(3)

where \( P_H \) and \( P_F \) are the Home currency prices of the Home and Foreign goods, respectively, and \( P \) is the overall price level, which are related to each other according to:

\[ P = P_H^\alpha P_F^{1-\alpha}. \]

(4)

The representative household in the Foreign block has a symmetric consumption bundle, with \( \alpha^* = n\lambda \) representing the Foreign consumption share of imported goods. The demand

\(^5\)The size of home bias decreases with the degree of openness and disappears when \( \lambda = 1 \). In the limit for \( n \to 0 \), the Home block becomes a small open economy. We will study this special case in details below.
for Home and Foreign goods by the Foreign representative household are symmetric to (3), with the only difference that an asterisk denotes Foreign variables.

3.2 Exchange Rates and Relative Prices

The nominal exchange rate $E$ is defined as the number of units of Home currency required to buy one unit of Foreign currency, so that an increase of the nominal exchange rate corresponds to a depreciation of the Home currency. We assume that the law of one price (LOOP) holds for each good:

$$ P_H = E P_H^* \quad \text{and} \quad P_F = E P_F^*, $$

where $P_H^*$ and $P_F^*$ are the Foreign currency prices of the Home and Foreign goods, respectively.

The terms of trade $\tau$ for the Home country represents the price of imports relative to the price of exports, where both prices are expressed in terms of the Home currency:

$$ \tau = \frac{E P_F^*}{P_H}. $$

An increase in the terms of trade corresponds to a rise in the price of imports relative to exports for the Home consumer in Home currency, so that Foreign imports become relatively more expensive. In this sense, an increase in $\tau$ represents a deterioration of the terms of trade for the Home country (i.e. a depreciation). All relative prices are a function of the terms of trade:

$$ p_H = \tau^{\alpha - 1} \quad \text{and} \quad p_F = \tau^\alpha, $$

where $p_k \equiv P_k / P$, for $k = \{H, F\}$. Similarly, for the Foreign country, we have:

$$ p_H^* = \tau^{\alpha^* - 1} \quad \text{and} \quad p_F^* = \tau^{\alpha^*}. $$
The real exchange rate $s$ is the price of Foreign consumption in terms of Home consumption:

$$s \equiv \frac{\mathcal{E} P^*}{P}. \quad (9)$$

A higher $s$ corresponds to an increase in the price of the Foreign consumption basket relative to the Home consumption basket in terms of the Home currency, and thus to a depreciation of the real exchange rate. In spite of the LOOP, purchasing power parity does not hold because of home bias, that is, the real exchange rate is generally different from one. However, the (log) real exchange rate is proportional to the (log) terms of trade:

$$s \equiv \frac{\mathcal{E} P^*}{P} = \frac{\mathcal{E} P^*_F}{P_H} \times \frac{p_H}{p^*_F} = \tau^{\alpha - \alpha^*}. \quad (10)$$

Therefore, we can characterize the equilibrium indifferently with respect to a single relative price.

### 3.3 Home Households

A continuum of measure $n \in [0, 1]$ of households populate the Home economy. All households are identical and relatively impatient. We denote by $c_1$ and $c_2$ their consumption in the two periods. In addition, in period 1, the household decides once and for all the amount of housing services to purchase, which we assume to be proportional to the housing stock $h_1$. Lifetime utility therefore is:

$$U = u(c_1) + \beta u(c_2) + v(h_1), \quad (11)$$

where $\beta \in (0, 1)$ is the individual discount factor. Preferences are risk-neutral with respect to consumption (i.e. $u'(\cdot) = \bar{c} > 0$), and are increasing and weakly concave with respect to housing (i.e. $v'(\cdot) > 0$ and $v''(\cdot) \leq 0$).

Households are endowed with $y$ units of Home goods in each period and $h_0$ initial units
of housing, and can obtain credit denominated in either Home (b) or Foreign (f) currency. Thus, the budget constraint in period 1 is:

\[ c_1 + qh_1 - b - s_1 f = p_{H1}y + qh_0, \]  

(12)

where \( q \) is the relative price of houses in terms of the consumption good, and we have assumed that the household starts with no credit to repay. In the second period, the household repays the debt contracted in the first period plus a gross interest rate, so that the budget constraint is:

\[ c_2 = p_{H2}y - R^h b - s_2 f, \]  

(13)

where \( R^h \) and \( R \) are the gross interest rates on credit denominated in Home and Foreign currency, respectively.

Following Kiyotaki and Moore (1997), a collateral constraint limits total debt to a fraction \( \theta \in [0, 1] \) of the value of housing purchased in period 1:

\[ b + s_1 f \leq \theta qh_1. \]  

(14)

The parameter \( \theta \) represents a limit that lenders impose on borrowers to mitigate issues related to asymmetric information. In practice, \( \theta \) is also affected by policy as in many national housing finance systems regulation mandates the maximum loan-to-value (LTV) ratio that lenders can offer.

The unconditional evidence reported in the previous section suggests that both the real exchange rate and house prices increase during a boom, and hence may play a role in amplifying the effects of capital inflows. In our model, when the collateral constraint is binding, an increase in house prices boosts the value of the collateral and expands the households’ borrowing capacity, thus increasing consumption. Conversely, when the collateral constraint is not binding, the feedback from house prices to the rest of the economy disappears. This
mechanism corresponds to the standard amplification channel associated with house prices in the closed economy literature (e.g. Kiyotaki and Moore, 1997).

Equation (14) shows that, when the collateral constraint binds, a real exchange rate appreciation amplifies exogenous shocks in the same vein as an increase in house prices, thereby expanding households’ borrowing capacity and their consumption (“collateral valuation effect”). This effect is stronger the higher the share of foreign currency liability (the ratio between $f$ and $b$).

The effects of changes in the real exchange rate, however, are not limited to the case in which the collateral constraint binds. On the one hand, an appreciation of the domestic currency boosts the value of the endowment. This “endowment valuation effect” positively contributes to the purchasing power of Home households. On the other hand, since borrowing is denominated in Foreign currency, an appreciation reduces the purchasing power of a given amount of debt in terms of Home goods. This “debt valuation effect” is increasing in the share of foreign currency liabilities and constitutes a drag on demand by Home households.\footnote{In a dynamic context, the debt valuation effect would trade off the lower purchasing power of a given amount of debt contracted in the current period with the lower repayment on credit obtained in the past.} On balance, an appreciation of the real exchange rate is likely to be expansionary, especially at high levels of debt. In this case, the borrowing constraint is more likely to bind. Therefore, the collateral valuation effect is likely to reinforce the endowment valuation effect, thus resulting in an expansion of domestic demand in the aftermath of an appreciation.

The problem for the domestic representative household is to maximize (11) subject to (12), (13), and (14). Let $\mu \bar{c}$ be the Lagrange multiplier on the borrowing constraint, normalized by the marginal utility of consumption. The first order conditions for the optimal demand of credit are:

$$1 - \mu = \beta R^b$$
$$1 - \mu = \beta R^{s_2/s_1},$$

with $\mu > 0$ when $b + s_1 f = \theta q h_1$. The two expressions in (15) are the consumption Euler
equations under risk neutrality. These two equations show that, when binding, a tighter borrowing constraint (i.e., a higher $\mu$) reduces the cost of forgone consumption today. No arbitrage requires Home households to be indifferent between credit denominated in different currencies:

$$R^b = R\frac{s_2}{s_1},$$

(16)

which corresponds to the uncovered interest rate parity condition in real terms.

The Euler equation for the choice of housing services is:

$$(1 - \theta \mu)q = \frac{v'(h_1)}{c}.$$  

(17)

This equation shows that house prices are higher (i) the higher the maximum LTV ratio $\theta$ (ii) and the tighter the borrowing constraint $\mu$. All else equal, both the level of the LTV and the tightness of the borrowing constraint increase the demand for housing because of the higher value of the collateral. When the collateral constraint is not binding ($\mu = 0$), house prices simply equal their fundamental value, that is, the marginal utility of housing in units of marginal utility of consumption.

The transmission of credit supply shocks occurs through international financial markets. For this purpose, we characterize the equilibrium in terms of the ratio between credit in Home and Foreign currency:

$$\eta \equiv \frac{b}{s_1 f},$$

(18)

so that $1 + \eta$ represents the inverse of the share of Foreign currency liabilities from the perspective of the Home country. If $\eta = 0$, the model corresponds to an extreme case in which all credit is denominated in Foreign currency. As $\eta$ increases, more and more debt is denominated in Home currency, both the debt and collateral valuation effects become less severe.

We can see the mitigation of the debt valuation effect due to a higher fraction of credit
denominated in domestic currency by rewriting the budget constraint in terms of $\eta$:

$$c_1 + qh_1 - (1 + \eta)s_1f = p_{H1}y + qh_0.$$  

A low share of foreign currency liabilities (a high value of $\eta$) dampens the effect of an appreciation of the real exchange rate (a fall in $s_1$) on the purchasing power of a given amount of credit.

The limited collateral valuation effect of the real exchange rate with a low share of credit denominated in Foreign currency is evident from the borrowing constraint at equality, which with the new notation can be written as:

$$(1 + \eta)s_1f = \theta qh_1.$$  

An appreciation of the real exchange rate has a smaller amplification effect when $\eta$ is very large because little debt is denominated in Foreign currency.

In principle, households can choose the optimal allocation of their credit portfolio between loans denominated in Home and Foreign currency. In this paper, we abstract from this choice and treat $\eta$ as a parameter that we calibrate from the data.

### 3.4 Foreign Households

The Foreign economy is populated by a continuum of identical households of measure $1 - n$. Foreign households are relatively patient and derive utility solely from consumption ($c^*$). Their utility function is:

$$U^* = u(c^*_1) + \beta^* u(c^*_2),$$  

with $\beta^* \in (\beta, 1)$. Because of their relative patience, the borrowing constraint of the Foreign representative household never binds in equilibrium. Therefore, we abstract from Foreign
purchases of housing services, as house prices in country F would be irrelevant for the equilibrium. The only difference from explicitly incorporating foreign housing decisions would be to price housing in the lending country—something our empirical evidence has little to say about.\footnote{The Foreign counterpart of equation (17) with $\mu^* = 0$ shows that we would obtain a solution for Foreign house prices of the form $q^* = \frac{v'(h^*_{1\text{}})}{\bar{e}^*}$.}

Foreign households are endowed with $y^*$ units of Foreign goods in each period, and can save via deposits ($d$) or equity holdings of financial intermediaries ($e$), which are subject to adjustments costs. The budget constraint in period 1 is:

$$c_1^* + d + e + \psi(e) = p_{F1}^* y^*, \quad (20)$$

where $\psi(\cdot)$ (with $\psi' > 0$) represents a convex cost of changing the equity position.\footnote{For simplicity, we assume global financial intermediaries are set up in the first period, and normalize to zero initial deposits and equity.} As in Jermann and Quadrini (2012), the equity adjustment cost creates a “pecking” order of liabilities whereby intermediaries always prefer to issue debt relative to equity. The budget constraint in the second period is:

$$c_2^* = p_{F2}^* y^* + R_d^* d + R_e^* e + \Pi, \quad (21)$$

where $R_d^*$ and $R_e^*$ are the real gross returns on deposits and equity, respectively, and $\Pi$ stands for the profits of the global financial intermediary that the Foreign representative household owns.

The problem for the foreign representative household is to maximize (19) subject to (20) and (21). The first order conditions for the optimal choice of deposits and equity are:

$$1 = \beta^* R_d^*, \quad (22)$$
Table 1. Balance sheet of a typical global financial intermediary.

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans (Home currency): $b/s_1$</td>
<td>Deposits: $d$</td>
</tr>
<tr>
<td>Loans (Foreign currency): $f$</td>
<td>Equity: $e$</td>
</tr>
</tbody>
</table>

and

$$1 + \psi'(e) = \beta^* R^e.$$ \hspace{1cm} (23)

Combining these two first order conditions, we obtain:

$$R^e = R^d + \frac{\psi'(e)}{\beta^*}.$$  

Because of the presence of adjustment costs, the return on equity pays a premium over the return on deposits.

3.5 Global Financial Intermediary

A representative financial intermediary (a global bank) operates in international credit markets and channels loans from patient foreign lenders to impatient domestic borrowers, funding its activity with a mix of equity and deposits raised in the Foreign country.

Table 1 summarizes the balance sheet of financial intermediaries in period 1. As discussed earlier, a given fraction $\eta$ of their loan book is denominated in Home currency. Following Bräuning and Ivashina (2016), we assume that global financial intermediaries are able to hedge their exposure to exchange rate volatility by entering a swap contract with perfectly competitive specialized FX operators. These operators are endowed with a large amount of capital $K$ and make zero profits. Using swaps, banks can ensure that only the total asset size of their balance sheet matters for their activity.

The profits of a generic financial intermediary at market value correspond to the the
total return on loans, net of the payouts to depositors and equity holders, and of the costs of hedging:

$$\Pi = Rf + \frac{R^b b}{s_2} - R^d d - R^e e - \phi \left( \frac{b}{s_1} \right),$$  \hspace{1cm} (24)

where $\phi(\cdot)$ (with $\phi'(\cdot), \phi''(\cdot) > 0$) represents the cost of swapping the total amount of credit denominated in Home currency issued by an intermediary.

Because equity is more expensive than deposits, financial intermediaries would like to leverage their balance sheet without bounds. We assume that a capital requirement limits leverage and the size of their balance sheet:

$$e \geq \chi \left( \frac{b}{s_1} + f \right),$$  \hspace{1cm} (25)

with $\chi \in (0, \bar{\chi})$.

The problem for the representative global financial intermediary is to maximize (24) subject to the leverage constraint (25) and the balance sheet constraint. Using the no arbitrage condition (16) and the definition of the share of credit denominated in Home currency (18) introduced earlier, we can rewrite the problem of the representative global bank as:

$$\max_f \Pi = (1 + \eta) Rf - R^d d - R^e e - \phi(\eta f),$$

subject to the balance sheet constraint:

$$(1 + \eta) f = d + e,$$  \hspace{1cm} (26)

and the capital constraint:

$$e \geq \chi(1 + \eta) f.$$

The main theoretical experiment that we focus on in the model is a one-time change in the

\cite{Gabaix2014} obtain a similar constraint assuming financiers can divert part of the funds intermediated through their activity.
capital constraint $\chi$. We will then map the results of this experiment into the identification of an international credit supply shock in the VAR analysis of the next section. For this purpose, we will focus on an equilibrium in which the capital constraint is binding. If the capital constraint were slack, financial intermediaries would become irrelevant, and a shock to $\chi$ would have no effect on macroeconomic variables and asset prices.

After substituting for deposits from the balance sheet constraint and for equity from the binding capital constraint, intermediaries profits become:

$$
\Pi = [R - \chi R^e - (1 - \chi) R^d] (1 + \eta) f - \phi(\eta f).
$$

The first order condition for the optimal choice of lending is:

$$
R = \chi R^e + (1 - \chi) R^d + \frac{\eta}{1 + \eta} \phi'(\eta f).
$$

The lending rate is a weighted average of the funding costs, plus the cost of swapping the position denominated in Home currency. The capital constraint $\chi$ represents the weight on the return on equity: a tighter leverage constraint (a higher $\chi$) implies a higher cost of equity, which is passed on to borrowers in the form of a higher loan rate. The last term on the right-hand side captures the cost of hedging: for given $f$, the loan rate is increasing in the share of credit issued in Home currency.\(^{10}\)

### 3.6 Equilibrium

As the Home household is relatively impatient, in equilibrium, the Home country borrows from Foreign country at the prevailing interest rate. We characterize the equilibrium in terms of the quantity of credit denominated in Foreign currency $f$, for a given share of

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\(^{10}\)Similarly, for given $\eta$, the loan rate is increasing in the amount of credit issued in Foreign currency because a larger balance sheet with a fixed share of Home currency credit corresponds to a larger amount of loans to hedge.
credit denominated in Home currency $\eta$, which we treat as a parameter. Home agents use credit, together with their endowment, to buy non-durable consumption goods and housing services. For simplicity, we abstract from construction and assume that housing is in fixed supply (land). In equilibrium, the demand for housing within each country must equal the available stock, which, without loss of generality, we normalize to one ($h_0 = h_1 = 1$).

A competitive equilibrium for this economy is a collection of quantities and prices such that:

1. Domestic households maximize their utility subject to their budget and collateral constraints.

2. Foreign households maximize their utility subject to their budget constraint.

3. Financial intermediaries maximize their profits subject to their balance sheet and leverage constraints.

4. Goods market clear in every period.

The full list of equations that characterize the equilibrium of our model is reported in Appendix. Here we discuss the special case of a small open economy that we use to pin the identification and transmission of the international credit supply shock we focus on in the VAR analysis of section 5.

4 The Small Open Economy Case: An Example

In our empirical application, we will focus on the transmission of an international credit supply shock to individual countries. The key identifying assumption will be that each country in our sample is too small to influence the global supply of credit. We can analyze this case in the model by taking the limit for $n$ that goes to zero (a small open economy) and
using our assumption about the degree of home bias that links country size, consumption shares, and degree of openness.

The small open economy assumption implies that Home demand does not affect the equilibrium in the market for Foreign goods, but Foreign demand remains relevant for the Home goods market equilibrium. In this case, we can solve for the real exchange rate as a function of the quantity of credit and the interest rate. As the Appendix shows, the global credit market equilibrium is then sufficient to determine the entire equilibrium of the model:

1. **Credit supply:**
   \[
   R = \frac{1 + \chi' \left[ \chi (1 + \eta) f \right]}{\beta^*} + \frac{\eta \phi' (\eta f)}{1 + \eta},
   \]
   (29)

2. **Credit demand:**
   \[
   R = \begin{cases} 
   \frac{1}{\beta} \frac{s_1}{s_2} & \text{if } (1 + \eta)s_1 f < \theta q \\
   \frac{1}{\beta} \frac{s_1}{s_2} \left[ \frac{\kappa}{(1 + \eta)s_1 f} - \frac{1 - \theta}{\theta} \right] & \text{if } (1 + \eta)s_1 f = \theta q,
   \end{cases}
   \]
   (30)

where the terms of trade (and hence the real exchange rate) guarantee that the goods market clear in both periods. The expressions for the real exchange rate in period 1 and 2 are:

\[
\begin{align*}
   s_1 &= \left[ \frac{\lambda y}{\lambda y^* + (1 - \lambda)(1 + \eta)f} \right]^{1-\lambda}, \\
   s_2 &= \left[ \frac{\lambda y}{\lambda y^* - (1 - \lambda)R(1 + \eta)f} \right]^{1-\lambda}.
\end{align*}
\]

(31) (32)

The shock that we study affects the balance sheet of global banks and propagates across countries through the international credit market. In the space \{f, R\}, the credit supply schedule is upward sloping for two reasons. First, a larger balance sheet requires more equity to satisfy the capital constraint. Since equity is costly to raise, global financial intermediaries charge a higher lending rate to borrowers. Second, as mentioned, for given amount of Home currency credit, a larger balance sheet implies a higher hedging cost, which financial
intermediaries pass on to borrowers. As equation (29) shows, an increase in the leverage of financial intermediaries (a reduction of the capital requirement parameter $\chi$) shifts down the credit supply schedule. At any level of credit, the interest rate offered on loans issued to the Home country falls. This mechanism is what underpins our identification assumptions in the VAR of section 5.

The form of the credit demand schedule differs depending on whether the collateral constraint for domestic households binds or not. As equation (30) shows, the credit demand schedule is a piecewise function with a kink at the level of credit where the borrowing constraint becomes binding.

Credit demand interacts with the goods market through the real exchange rate. If the collateral constraint is not binding, for given future value of the exchange rate, an appreciation in the current period reduces the demand for credit. In this region, the debt valuation effect dominates over the endowment valuation effect. Conversely, if the collateral constraint is binding, an appreciation of the real exchange rate increases the demand for credit. The combination of the collateral and endowment valuation effect overcomes the debt valuation effect.

In the Appendix, we show analytically that, if the collateral constraint does not bind, credit demand is always downward-sloping. Moreover, we can prove that credit demand is downward-sloping also in the region where the collateral constraint binds, provided the LTV ratio is high enough.

Figure 2 plots the credit market equilibrium in the space $\{f, R\}$ for a reasonable choice of the parameters values.

Let us focus first on credit demand, which results from combining (30), (31), and (32). We normalize the endowment in both countries to $y = y^* = 1$ and fix the marginal utility of housing in units of marginal utility of consumption to $\kappa = 0.85$. We set $\theta = 0.92$, consistent with the observed (average) maximum LTV limit in our sample of countries, and $\eta = 0.43$. 
Figure 2. **International Credit Market equilibrium.**

![Diagram showing credit market equilibrium with points A and B labeled.]

**Note.** Point A: Unconstrained equilibrium. Point B: Constrained Equilibrium.

...to match the median share of foreign currency liabilities from BIS data.\(^{11}\) We pick a value for the openness parameter \(\lambda = 0.79\) slightly larger than in Gali and Monacelli (2005) but within the range discussed in the literature. Finally, we set the domestic discount factor to \(\beta = 0.9\) to yield a reasonable value for the real interest rate in the credit market, whether the borrowing constraint is binding or not.

The parameters that pin down the supply of credit (equation 29) are the capital requirement, the discount factor of country F, and the the adjustment cost parameters. We choose a capital requirement of 10% \(\chi = 0.1\) to target a leverage ratio of 10, a value that is close to the average leverage of US commercial banks in the data. As common in the literature, we set \(\beta^* = 0.99\) to obtain \(R^d = 4.1\%\) in annualized terms. We assume that the adjustment cost functions for equity and hedging are both quadratic and treat the choice of their parameters residually. Given the rest of the calibration, their values determine whether the equilibrium is in the region where the borrowing constraint is binding or not and the premium bank

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\(^{11}\)For consistency with the VAR, we compute the share of foreign currency liabilities using a confidential version of the BIS dataset used for the empirical analysis that allows us to sort out different currencies. The share is computed as cross-border bank claims in foreign currency over total cross-border bank claims.
Figure 3. **International Credit Supply Shock with Binding Borrowing Constraint.**

![Graphs](image)

**Note.** Shock to the capital requirement parameter $\chi$ from 0.1 to 0.025. Initial equilibrium: constraint is binding like in Point $B$ in Figure 2; new equilibrium: Point $B'$. Credit volume on the horizontal axis.

equity pays over deposits.

Figure 2 displays the two types of credit market equilibrium that can arise in this model. For given cost of hedging, if the equity adjustment cost parameter is relatively high ($\zeta = 0.03$), financial intermediaries pays a large premium over the return on deposits (about ten and a half percentage points), and the interest rate on credit is roughly 5.2%. In this case, the equilibrium is in the unconstrained region (point A). Conversely, when the equity adjustment cost is relatively low ($\zeta = 0.02$), the equity premium is not as large (approximately seven percentage points), and the interest rate on credit is around 4.9%. In this case, the equilibrium is in the constrained region (point B).

Figure 3 illustrates graphically the change in the credit market equilibrium (top-left panel), and the response of the real exchange rate (top-right panel), house prices (bottom-left panel), and consumption (bottom-right panel), to a reduction of $\chi$ from 0.1 to 0.02 in
the region where the collateral constraint is binding. We start from the same constrained equilibrium of Figure 2 (point $B$) with low equity premium. The reduction in capital requirements of global banks increases the international supply of credit. The credit supply schedule shifts downward, and the new credit market equilibrium occurs in point $B'$ (top-left panel of Figure 3), with higher credit and a lower interest rate. The higher availability of credit pushes up house prices (bottom-left panel). As demand rises in the Home country, the real exchange rate also appreciates (top-right panel) and consumption increases (bottom-right panel).

A similar adjustment would occur if the economy experienced the same shock starting from point A in Figure 2. The main difference is that, with a non-binding collateral constraint, house prices in the Home country would not be responsive to the increase supply of credit.\textsuperscript{12}

The next section studies the response of macroeconomic variables and asset prices to an identified international credit supply shock in the data using a large panel of vector autoregressions. This exercise will allow us to compare the prediction of the model with the empirical evidence.

5 The Impact of an International Credit Supply Shock

In this section, we identify an international credit supply shock empirically and discuss its impact and relative importance for a subset of the variables considered in the event study and the model we developed. We use a panel-vector autoregressive model (PVAR) that allows us to investigate both the behavior of the typical economy in response to the shock and the cross countries differences in its transmission.

\textsuperscript{12}Starting from point A, in response to a large enough shock, the economy could also move from the unconstrained to the constrained equilibrium. The adjustment in this case would be qualitatively similar to what happens in Figure 3.
5.1 A PVAR Model

The PVAR model includes a small set of variables which have a direct counterpart in the theoretical model. We include the leverage ratio of US Broker-Dealers (described below), cross-border bank claims to all sectors, real private consumption, real house prices, the real exchange rate vis-a-vis the US Dollar, and the current account balance over GDP.\footnote{We do not include the real interest rate in the vector of endogenous variables because data for interest rate on loans are not easily available over our sample. Below we use the model to link the response of house prices and the real exchange rate to the interest rate on loans.}

The specification for each country $i$ is:

$$x_{it} = a_i + b_i t + c_i t^2 + F_{1i} x_{i,t-1} + u_{it},$$

where $x_{it}$ is the vector of endogenous variables, $a_i$ is a vector of constants, $t$ and $t^2$ are vectors of deterministic trends, $F_{1i}$ is a matrix of coefficients, and $u_{it}$ is a vector of reduced form residuals with variance-covariance matrix $\Sigma_{iu}$. All variables considered enter in log-levels, except for the current account, which is expressed in percentage of GDP.\footnote{We estimate the VAR systems in levels allowing for implicit cointegration among variables. Sims et al. (1990) show that, if cointegration among the variables exists, the system’s dynamics can be consistently estimated in a VAR in levels.} The empirical model is the same for all countries to avoid introducing differences in country responses due to different specifications, and because it would be difficult to find a perfectly data-congruent specification for all countries in the sample. In particular, somewhat arbitrarily, but mindful of the relatively short sample period for some of the emerging economies, we include one lag of each variable in every system. The full sample period is 1985:Q1-2012:Q4, but some country models are estimated starting later depending on data availability.

We estimate the model using the mean group estimator of Pesaran and Smith (1995) and Pesaran et al. (1996).\footnote{Pooled estimators are inconsistent in a dynamic panel data model with slope coefficients varying across countries.} In the estimation, we drop all countries which have less than 40 observations or have unstable dynamics (i.e., with eigenvalues larger than 1). This selection...
leaves us with 51 out of the 57 countries originally in our event study.\footnote{Specifically, we drop from our original sample Brazil, Colombia, Greece, Indonesia because of unstable dynamics, and Morocco and Serbia because of the number of observations.}

Finally, in the estimation of the country-specific VARs, we allow lagged domestic variables to affect the dynamics of leverage. Proceeding in this way we only loose efficiency, but not consistency, for the estimation of the leverage equation. Given that we do not use country-specific standard errors to construct the variance of the mean group estimator, the efficiency loss is not a major concern. The upshot is that our approach significantly simplifies the computations, as we can use OLS rather than maximum likelihood to estimate the reduced form of the country systems.

\subsection*{5.2 Identification}

We want to identify a push shock to the international supply of credit as in the model of the previous section. The model shows that changes in leverage of international financial intermediaries lead to an increase in the international supply of credit. Thus, in the PVAR model, we use innovations to US Broker-Dealers leverage as a source of exogenous changes in the international supply of credit to our collection of small open economies.\footnote{Since the leverage of US Broker-Dealers is endogenous to the US, we do not include the US in the sample, leaving us with 50 countries.} Leverage of US Broker-Dealers is readily available from the data (US Flow of Funds), and these institutions are a good proxy for the global financial intermediaries that we considered in the theoretical analysis.

Consistently with the model, our key assumption is that changes in the leverage of US Broker-Dealers lead to a shift in the international supply of credit, but leverage of US Broker-Dealers is not affected by conditions in individual countries outside the United States.\footnote{\textit{Bruno and Shin} (2015) also show that changes in the leverage of US Broker-Dealers have a well defined theoretical and empirical linkage to changes in BIS cross-border claims.}

Various factors can affect US Broker-Dealers’ leverage, including US monetary policy, financial regulation, financial innovation, and shifts in risk appetite (see, for example, \textit{Bruno and Shin} (2015).\footnote{\textit{Bruno and Shim} (2015) also show that changes in the leverage of US Broker-Dealers have a well defined theoretical and empirical linkage to changes in BIS cross-border claims.}}
and Shin, 2015, Rey, 2013, Bekaert et al., 2013). For our purposes, we do not need to take a
stand on the underlying structural sources of shifts in leverage. As long as country-specific,
domestic pull factors do not affect leverage, we can treat changes in this variable as a proxy
for an exogenous push shock to capital flows, or an international credit supply shock like in
our model above.

Figure 4 plots the sum cross-border bank claims over all countries in our sample (solid
blue line) and the leverage of US Broker- Dealers (dashed yellow line). The two series share
a secular upward trend as well as cyclical variations at relatively low frequency. Albeit to a
different degree and with different timing, the two series increase sharply before the global
financial crisis, and then collapse during the crisis. The correlation between the two series
is 0.38 in levels, but only 0.04 in quarterly differences. As we shall see below, the response
of the VAR system to our leverage shock is stationary. Thus, the shock that we identify is
a persistent cyclical deviation of leverage from its long run trend value.

In practice, we obtain the impulse responses of all other variables in the system to a shock
to US Broker- Dealers’ leverage from the Cholesky decomposition of the variance-covariance
matrix of the estimated reduced-form residuals of each country-specific VAR, with leverage
ordered first in the system.  

5.3 The Typical Response of a Small Open Economy

Figure 5 reports the impulse response to the exogenous shift in the international supply of
credit. The size of the shock is set equal to the standard deviation of the residuals of the
leverage equation, which—is on average across all countries—is equal to 8%. We censor the
responses included in the computation of the mean group estimator at the 10% level (5%  

Note here that the order of the other endogenous variables in the VAR system does not matter for the
transmission of the leverage shock.

We use a simple average of the country-specific estimates to construct the mean-group estimates. Results
are robust to using a weighted average, which is not surprising given the large number of countries in the
sample.  

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**Figure 4.** Leverage of US Broker-Dealers and cross-border bank claims.

![Chart showing leverage and cross-border credit over time](chart.png)

**Note.** International cross-border claims of BIS reporting banks to country i vis-a-vis all sectors (i.e., banks and non-banks), summed across all 57 countries in our sample. Trillions of constant (2008:Q2) US Dollars (left axis, solid line). The leverage of the US Brokers & Dealers sector (right axis, dotted line) is from the US Flow of Funds. Leverage is defined as the ratio between assets and equity.

The dark and light shaded areas represent the one- and two-standard deviation confidence intervals, respectively.

The impulse responses from the VAR are consistent with the findings in our event study, and with the mechanisms at work in the model. In the typical small open economy represented here, the leverage shock leads to a statistically significant and persistent increase in cross-border claims, real consumption and real house prices, a prolonged real exchange rate appreciation, and a deterioration of the current account balance. Cross-border bank claims display a hump-shaped response, with an impact response of slightly less than 1% and a peak response just below 2%. Similarly, consumption and real house prices increase by about 0.3% and 0.75% above their long-run levels, respectively, within a year. The real
Figure 5. Impulse Responses to an International Credit Supply Shock

Note. Impulse responses to a one standard deviation (8%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively.

exchange rate vis-a-vis the US Dollar appreciates on impact by about 0.6%, arguably driven by the nominal exchange rate, strengthens some more, and then reverts very slowly to its equilibrium level. Finally, the current account turns into a deficit, with a trough of about 0.15%. Overall, the shock to US Broker-Dealers’ leverage generates expansionary effects consistent with the transmission of our model.

Data on interest rates on loans, either in domestic or foreign currency are not easy to gather on a large panel dimension. The model, however, helps us connect the response of house prices to these interest rates. For simplicity, assume the LTV parameter $\theta$ is equal to one. Then, the first order conditions for credit (15) and house prices (17) can be combined to give

$$\beta R^b = \frac{X}{q} \quad \text{and} \quad \beta R^s = \frac{X}{s_1}.$$
These two expressions equalize the cost of borrowing, in domestic and foreign currency, respectively, to the return on housing. The first equation shows that increases in house prices reduce the interest rate on loans in domestic currency. In the second equation, the dynamics of the real exchange rate affect the response of the interest rate on loans denominated in foreign currency. Since the real exchange rate appreciates in response to the credit supply shock, and depreciates later on (empirically, after about two years), its evolution reinforces the increase in house prices and contributes to lower the real interest rate also on loans denominated in foreign currency. Therefore, the model predicts that the real interest rate on loans, independently of its currency denomination, falls in response to an international credit supply shock. This point is related to the recent discussion in Blanchard et al. (2015).

In our context, credit is the international asset while housing is the domestic non-financial asset. A positive international credit supply shock appreciates the real exchange rate and decreases the real return on the domestic non-financial asset via an increase in house prices. In practice, the net effect of capital inflows is likely to depend on the balance between the stimulus associated with the domestic asset price boom and the contraction due to the real exchange rate appreciation via the trade channel.

Figure 6 reports the mean group estimates of the variance share of the international credit supply shock. The shock explains a significant share of variance of all other variables in the system. At the same time, leverage is explained largely by shocks to itself within the first a year or so. The shock can explain about fifteen to twenty percent of the long-run forecast error variance of cross-border credit, house prices, and consumption, and a slightly smaller share (but still above 10%) for the real exchange rate and the current account. These magnitudes are economically meaningful and exceed the share of forecast error variance that is typically explained by monetary policy shocks. For example, in our PVAR, a US monetary policy shock explains roughly 5% of the forecast error variance of cross-border bank claims, consumption, house prices and exchange rates (i.e., between half and one third less than the
Figure 6. **Share of Variance Explained by International Credit Supply Shock**

![Graphs of Leverage, Cross-border Credit, Consumption, House Price, Real Exch. Rate, Current Account over Quarters with confidence intervals.

Note. Forecast error variance decomposition of the shock to US Broker-Dealers’ leverage. The dark and light shaded areas are the one and two standard deviation confidence intervals.

Global liquidity shock.\(^{21}\)

### 5.4 Understanding Cross-Country Differences

As we can see from Figure 5, the error bands of the responses of consumption, house price, and the real exchange rate are relatively wide, reflecting significant differences across countries. In this section we investigate whether this heterogeneity follows specific patterns.

We conjecture that the observed cross-country differences may depend on the interaction between the amplification that asset prices generate in response to an international credit supply shock and certain features of the economies in our sample. In particular, our model

\(^{21}\)To conduct this exercise, we identified a shock to US monetary policy relying on high-frequency US monetary policy surprises, constructed by Gurkaynak et al. (2005) also used by Gertler and Karadi (2015) in a monetary VAR for the US. Relative to Gertler and Karadi (2015), we construct a series of monetary surprises based on the 3-month Euro-Dollar futures (ED₄) that covers a longer sample period.
suggests that the intensity of the country responses to the credit shocks may be affected by the share of foreign currency liabilities and the maximum LTV limit prevailing in that country.

As the share of foreign currency debt increases, the collateral valuation channel associated with a binding borrowing constraint becomes stronger. Everything else equal, an appreciation of the real exchange rate relaxes the borrowing constraint more because effectively the purchasing power in domestic currency of credit obtained from global financial intermediaries increases.

Variations in the share of foreign currency liabilities produce two additional effects. First, to the extent that financial intermediation is dominated by global banks, a larger share of local currency denominated debt increases the interest rate burden of debt as domestic borrowers have to bear the cost of hedging transferred to them by global financial intermediaries. Second, a higher share of local currency denominated debt decreases the sensitivity of the real exchange rate to variations in the level of credit. The combination of these two effects implies that consumption, house prices, and the real exchange rate are more sensitive to international credit supply shocks the higher the share of debt denominated in Foreign currency.

Figure 7 provides evidence consistent with this hypothesis. The figure plots the cross-country peak responses of consumption (left panel), house prices (middle panel), and the real exchange rate (right panel) against the share of foreign currency liabilities computed using BIS banking data (horizontal axis). The correlations are particularly strong for consumption and house prices (about 0.6). The correlation is slightly lower (−0.3) but nevertheless statistically significant also for the real exchange rate.

A second candidate explanation to account for the heterogeneity of the impulse responses

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22 For consistency with the VAR, we compute the share of foreign currency liabilities using a confidential version of the BIS dataset that allows us to sort out different currencies. The share is computed as cross-border bank claims in foreign currency over total cross-border bank claims.

23 The results are robust to using the average response over the first 4 quarters or the share of variance of this variables explained by the credit supply shock during the first year.
Figure 7. Cross country differences in response to international credit supply shock: Share of foreign currency liabilities.

The three panels plot the peak impulse response to the global liquidity shock (vertical axis, \( IRs (\text{Max}) \)) of consumption (left panel), house prices (middle panel) and the real exchange rate (right panel) against the share of foreign currency liabilities computed using BIS banking data (horizontal axis).

Across countries is variation in the LTV ratio. For given asset prices, if the borrowing constraint is binding, a higher LTV ratio allows for additional borrowing. The model predicts that, as long as the borrowing constraint is binding, higher LTV ratios typically increase consumption and house prices and lead to an appreciation of the real exchange rate. Obviously, if the borrowing constraint is not binding, a higher LTV ratio is irrelevant for the response of the economy to the credit supply shock.

Figure 8 is also consistent with this explanation of the different intensities of the country responses to the international credit supply shock. In this figure, we plot the peak impulse responses of consumption (left panel), house prices (middle panel), and the real exchange rate (right panel) from the VAR (vertical axis) against the maximum LTV ratio interacted with the home-ownership rate (horizontal axis). The LTV ratio is weighted with the home-ownership ratio to capture both leverage in the local financial system and the availability of housing collateral. Indeed, if high leverage is permitted, but home-ownership is low, like in the case of Germany and Switzerland for instance, the economy’s sensitivity to a credit

\[24\] We obtain the data on maximum LTV ratios from Cerutti et al. (2015). Data on homeownership are from the Housing Finance Information Network (HOFINET). Like before, we obtain the same results by using the average response over the first 4 quarters or the share of the variance due to the credit supply shock.
Figure 8. Cross country differences in response to international credit supply shock: LTV ratios.

Note. The three panels plot the peak impulse response to the global liquidity shock (vertical axis, IRs (max)) of consumption (left panel), house prices (middle panel) and the real exchange rate (right panel) against the maximum LTV weighted by the homeownership ratio (horizontal axis, Home Ownership × max LTV).

shock should be lower according to our model. The correlation is quite strong for house prices (about 0.4) but weaker for consumption and the real exchange rate (plus and minus 0.2, respectively). Nevertheless, all correlations are statistically significant at least at the 10% confidence level.

In summary, the international credit supply shock that we identify has an expansionary effect on the receiving economies, consistent with both the patterns we documented in the event study and the transmission implied by our model. The shocks explains a non-negligible share of the variance decomposition of macroeconomic variables of individual countries. In the cross-country dimension, higher sensitivity to the shock is associated with higher share of foreign currency liabilities and higher access to leverage via housing collateral in a manner that is consistent with the model.

6 Conclusions

In this paper we documented that boom-busts in capital flows are expansionary and associated with appreciating asset prices. Next we set up a general equilibrium model of
collateralized borrowing in foreign currency with international financial intermediation. We then identified a shock to the international supply of credit in an empirical panel VAR framework consistent with this model.

We find that the shock identified in the data has a transmission consistent with that implied by the model. Our international credit supply shock triggers a consumption boom and it is associated with asset price inflation, the more so the higher the share of foreign currency liability and the higher the maximum LTV in the domestic credit market. We also find that this shock explains about twice as much consumption variance as a US monetary shock.

Our findings have important policy implications and suggest areas for future research. As Rey (2013, 2016) noted, flexible exchange rates might not be insulating individual economies from capital flow shocks as much as traditional theory would predict, suggesting that a "dilemma" between capital controls and financial instability is more relevant than the traditional policy trilemma. At the same time, capital controls may be too costly to adopt or too difficult to implement (e.g., Fernandez et al., 2015). Our empirical findings suggest that domestic macro prudential policies, such as lower LTV ratios in domestic credit markets and limits on the foreign currency exposure of borrowers, could be promising tools to help insulate economies from the expansionary impact of capital inflows.

Indeed, optimal macroeconomic stabilization policies may differ depending on which asset price is responsible for the amplification of foreign shocks via collateralized borrowing (Cespedes et al., 2017). If domestic asset prices like house prices are relaxing domestic borrowing constraints, macro-prudential tools, such as loan-to-value (LTV) requirements on individual borrowers or leverage caps on domestic financial intermediaries may be appropriate. However, if the source of amplification is the exchange rate, official reserve accumulation, sterilized intervention, or capital controls may be more effective in containing a boom. We leave exploring these policy questions for future research.
References


A Appendix. Data Sources

This appendix provides a description of the data used in the empirical analysis and on their sources. We consider 57 countries in our empirical analysis: 24 advanced economies (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and US) and 33 emerging economies (Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Estonia, Hong Kong, Hungary, India, Indonesia, Israel, Korea, Latvia, Lithuania, Malaysia, Mexico, Morocco, Peru, Philippines, Poland, Russia, Serbia, Singapore, Slovakia, Slovenia, South Africa, Taiwan, Thailand, Ukraine, and Uruguay).

We collect data over the 1970:Q1 – 2012:Q4 (subject to data availability) for the following variables:

**Total cross-border bank lending.** Foreign claims (all instruments, in all currencies) of all BIS reporting banks vis-à-vis all sectors deflated by US consumer price inflation. Source: BIS.

**Cross-border bank credit.** Foreign claims (loans and deposits, in all currencies) of all BIS reporting banks vis-à-vis the banking sector deflated by US consumer price inflation. Source: BIS.

**House prices.** Nominal house prices deflated by consumer price inflation. Source: OECD house price database, BIS Residential property price statistics, Dallas FED International House Price Database, National Central Banks, National Statistical Offices, academic and policy publications. More details on the definitions and the sources are reported in Table A.1.

**Equity prices.** Equity price index deflated by consumer price inflation. Source: OECD, IMF IFS, Bloomberg.

**Exchange rate vis-à-vis US dollar.** US dollars per unit of domestic currency. A real exchange rate is obtained with US and domestic consumer price inflation. Source: Datasstream.

**Real effective exchange rate.** Index (such that a decline of the index is a depreciation). Source: IMF IFS, BIS, Bloomberg.

**GDP.** Real index. Source: OECD, IMF IFS, Bloomberg.

**Consumption.** Real private final consumption index. Source: OECD, IMF, IFS, Bloomberg.

**Consumer prices.** Consumer price index. Source: OECD, IMF IFS, Bloomberg.
Short-term interest rates. Short-term nominal market rates. A real ex-post interest rate is obtained by subtracting consumer price inflation. Source: OECD, IMF, IFS, Bloomberg.

Current account to GDP ratio. Current account balance divided by nominal GDP. Source: OECD, IMF IFS, Bloomberg.

Home-ownership. HOFINET
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Note. See the extended appendix on the sources of house price series extended with historical data.
Appendix: Model Derivations

The first section below characterizes the equilibrium of the model. The second and third sections derive expressions for the terms of trade and the credit market equilibrium in the case of a small open economy.

B.1 Equilibrium

A competitive equilibrium for this economy is a collection of quantities \( \{c_1, c_2, c_1^*, c_2^*, d, e, f\} \) and prices \( \{q, \mu, R^b, R^d, R^e, \tau_1, \tau_2, s_1, s_2\} \) such that:

1. Domestic households maximize their utility subject to their budget and collateral constraint:

\[
\begin{align*}
1 - \mu &= \beta R^b, \\
1 - \mu &= \beta \frac{R^s}{s_1}, \\
(1 - \mu \theta)q &= \kappa, \\
(1 + \eta)s_1 f &\leq \theta q, \\
c_1 &= \tau_1^{\alpha_1-1} y + (1 + \eta)s_1 f, \\
c_2 &= \tau_2^{\alpha_2-1} y - (1 + \eta)s_2 Rf,
\end{align*}
\]

with \( \mu \geq 0 \), and where \( \kappa \equiv v'(1)/\bar{c} > 0 \) is the marginal utility of housing in units of marginal utility of consumption.

2. Foreign households maximize their utility subject to their budget constraint:

\[
\begin{align*}
1 &= \beta^* R^d, \\
1 + \psi'(e) &= \beta^* R^e, \\
c_1^* &= \tau_1^{\alpha_1^*} y^* - [d + e + \psi(e)], \\
c_2^* &= \tau_2^{\alpha_2^*} y^* + R^d d + R^e e
\end{align*}
\]

3. Financial intermediaries maximize their profits subject to their balance sheet and lever-
age constraints:

\[
R = \chi R^e + (1 - \chi) R^d + \phi'(\eta f),
\]

\[
(1 + \eta) f = d + e,
\]

\[
e = \chi(1 + \eta)f.
\]

4. Goods market clear in every period:

\[
y_n = n\alpha \tau_1^{1-\alpha} c_1 + (1-n)\alpha^* \tau_1^{1-\alpha^*} c_1^*,
\]

\[
y_n = n\alpha \tau_2^{1-\alpha} c_2 + (1-n)\alpha^* \tau_2^{1-\alpha^*} c_2^*,
\]

\[
(1-n)y^* = n (1-\alpha) \tau_1^{-\alpha} c_1 + (1-n) (1-\alpha^*) \tau_1^{-\alpha^*} c_1^*,
\]

\[
(1-n)y^* = n (1-\alpha) \tau_2^{-\alpha} c_2 + (1-n) (1-\alpha^*) \tau_2^{-\alpha^*} c_2^*.
\]

5. The real exchange rate is related to the terms of trade in every period according to:

\[
s_1 = \tau_1^{\alpha-\alpha^*} \quad s_2 = \tau_2^{\alpha-\alpha^*}.
\]

There are 18 equations for 16 variables. By Walras’s Law, two goods market equilibrium conditions (one in each period) are redundant.

**B.2 Small Open Economy**

In this section, we take the limit for \(n \to 0\) so that the Home country becomes a small open economy, consistent with our identification assumption in the VAR analysis.

**B.2.1 Goods Market and the Terms of Trade**

We start from the goods market equilibrium:

\[
y_n = n\alpha \tau^{1-\alpha} c + (1-n)\alpha^* \tau^{1-\alpha^*} c^*, \tag{B.1}
\]

\[
(1-n)y^* = n (1-\alpha) \tau^{-\alpha} c + (1-n) (1-\alpha^*) \tau^{-\alpha^*} c^*, \tag{B.2}
\]
where, for simplicity, we dropped the time subscript as these two expressions are static and have the same form in both periods. We can rewrite these conditions as

\[ y = \alpha \tau^{1-\alpha} c + \frac{1-n}{n} \alpha^* \tau^{1-\alpha^*} c^*, \quad (B.3) \]

\[ y^* = \frac{n}{1-n} (1-\alpha) \tau^{-\alpha} c + (1-n) \big(1-\alpha^*\big) \tau^{-\alpha^*} c^*. \quad (B.4) \]

Next, we use the relationship between the consumption shares, country size, and the degree of openness \((\alpha = 1 - (1-n)\lambda \text{ and } \alpha^* = n\lambda)\) to rewrite

\[ y = [1 - (1-n)\lambda])\tau^{(1-n)\lambda} c + \frac{1-n}{n} n\lambda \tau^{1-n\lambda} c^*, \quad (B.5) \]

\[ y^* = \frac{n}{1-n} (1-n)\lambda \tau^{(1-n)\lambda-1} c + (1-n\lambda) \tau^{-n\lambda} c^*. \quad (B.6) \]

The small open economy assumption corresponds to the limiting case for \(n\) that goes to zero. Simplifying and taking the limit of the previous expressions yields

\[ y = (1 - \lambda) \tau^\lambda c + \lambda \tau c^*, \quad (B.7) \]

\[ y^* = c^*, \quad (B.8) \]

which implies that Home demand does not affect the equilibrium in the market for Foreign goods and that Foreign consumption is exogenous.

As housing is in fixed supply, in equilibrium, the Home household budget constraint in the first period becomes

\[ c_1 = \tau_1^{1-\lambda}(1 + \eta)f + \tau_1^{-\lambda} y, \quad (B.9) \]

where we have used the relation between the real exchange rate and the terms of trade. We replace this expression in the Home goods market equilibrium and solve for the terms of trade to obtain a relation between the terms of trade and credit

\[ \tau_1 = \frac{\lambda y}{\lambda y^* + (1-\lambda)(1+\eta)f}, \]

and thus

\[ s_1 = \left[ \frac{\lambda y}{\lambda y^* + (1-\lambda)(1+\eta)f} \right]^{1-\lambda}. \quad (B.10) \]

Intuitively, higher foreign debt implies higher Home demand, and hence an appreciation of the terms of trade (and consequently of the real exchange rate).
In period 2, the budget constraint of the Home representative household gives

\[ c_2 = \tau_2^\lambda y - \tau_2^{1-\lambda}(1 + \eta)RF. \]

We substitute again into the goods market equilibrium to get an expression for the terms of trade

\[ \tau_2 = \frac{\lambda y}{\lambda y^* - (1 - \lambda)(1 + \eta)RF}, \]

and for the real exchange rate

\[ s_2 = \left( \frac{\lambda y}{\lambda y^* - (1 - \lambda)(1 + \eta)RF} \right)^{1-\lambda}. \]

The terms of trade in period 2 depend on both debt and the lending rate. Intuitively, high foreign debt or lending interest rates in period 1 imply lower resources (and therefore demand) in period 2, and therefore a depreciation.

**B.2.2 Credit Market**

Next, we can characterize the equilibrium in the credit market.

**Credit Supply.** We start with credit supply. Substituting the expressions for the return on deposit and the return on equity in the zero profit condition for financial intermediaries, together with the binding capital constraint, yields an expression for credit supply

\[ R = 1 + \chi \psi' \left[ \chi (1 + \eta) f \right] + \frac{\eta \phi'(\eta f)}{1 + \eta}. \]

This expression is independent of country size and thus holds also in the limit for \( n \to 0 \).

**Credit Demand.** Next, we move on to credit demand. We start from the optimal choice of housing services. If the borrowing constraint is not binding (\( \mu = 0 \)), the equilibrium conditions for domestic households boil down to \( q = \kappa \) (house prices), \( (1 + \eta)s_1 f < \theta q \) (non-binding collateral constraint), and the Euler equation

\[ R = \frac{1}{\beta} \frac{s_1}{s_2}. \]

Now, let us consider the equilibrium with binding borrowing constraint (\( \mu > 0 \)). In this
case, we can solve for the Lagrange multiplier from the Euler equation to get

\[ \mu = 1 - \beta R \frac{s_2}{s_1}. \] (B.13)

We plug this expression into the house price equation to obtain

\[ \left( 1 - \theta + \theta \beta R \frac{s_2}{s_1} \right) q = \kappa. \] (B.14)

Solving for \( q \) and plugging into the borrowing constraint at equality yields

\[ (1 + \eta) s_1 f = \frac{\theta \kappa}{1 - \theta + \theta \beta R s_2 / s_1}. \] (B.15)

We solve this equation for the return on loans to get

\[ R = \frac{1}{\beta s_2} \left[ \frac{\kappa}{(1 + \eta) s_1 f} - \frac{1 - \theta}{\theta} \right]. \]

### B.3 Slope of Credit Demand

In this section, we want to study the slope of the credit demand function. The reason is that the debt valuation effect associated with the real exchange rate may generate portions of the credit demand function that are not downward sloping.

We start from the region in which the collateral constraint is not binding. Substituting the expressions of the real exchange rate gives

\[ R = \frac{1}{\beta} \left[ \frac{\lambda y^* - (1 - \lambda)(1 + \eta)RF}{\lambda y^* + (1 - \lambda)(1 + \eta)f} \right]^{1 - \lambda}. \]

We construct the function

\[ G_1(f, R) \equiv \frac{1}{\beta} \left[ \frac{\lambda y^* - (1 - \lambda)(1 + \eta)RF}{\lambda y^* + (1 - \lambda)(1 + \eta)f} \right]^{1 - \lambda} - R, \]

so that we can use the implicit function theorem to calculate the slope of credit demand in this region. In particular, we have

\[ \frac{\partial R}{\partial f} = - \frac{\partial G_1 / \partial f}{\partial G_1 / \partial R}. \] (B.16)
The derivative at the numerator is

$$\frac{\partial G}{\partial f} = -\frac{1}{\beta} \left( \frac{s_1}{s_2} \right)^{\lambda} \frac{\lambda y^* (1 + \eta)(R + 1)}{[\lambda y^* + (1 - \lambda)(1 + \eta)f]^2} < 0.$$  

The derivative at the denominator is

$$\frac{\partial G}{\partial R} = -\left[ 1 + \frac{1}{\beta} \left( \frac{s_1}{s_2} \right)^{\lambda} \frac{(1 + \eta)f}{\lambda y^* + (1 - \lambda)(1 + \eta)f} \right] < 0.$$  

Because both numerator and denominator of (B.16) are negative, the credit demand function is negatively sloped in the region where the collateral constraint does not bind.

Next, we move to the region of binding collateral constraint. To simplify the analysis, we start from the limiting case $\theta = 1$. Under this assumption, after substituting for the real exchange rate at time 2, we can construct the function

$$G_2(f, R) = \frac{\kappa}{\beta(1 + \eta)f} \left[ \frac{\lambda y^* - (1 - \lambda)(1 + \eta)Rf}{\lambda y} \right]^{1-\lambda} - R.$$  

The slope of credit demand if the collateral constraint binds is

$$\frac{\partial R}{\partial f} = -\frac{\partial G_2/\partial f}{\partial G_2/\partial R}.$$  

(B.17)

In this case, the derivative at the numerator is

$$\frac{\partial G_2}{\partial f} = -\frac{\kappa}{\beta(1 + \eta)s_2 f} \left[ \frac{1}{f} + \frac{(1 + \eta)s_2^{1-\lambda}R}{\lambda y} \right] < 0.$$  

The derivative at the denominator is

$$\frac{\partial G_2}{\partial R} = -\left( 1 + \frac{\kappa s_2^{1-\lambda}}{\beta \lambda y} \right) < 0.$$  

Also in this case, credit demand is unequivocally downward sloping. The result relies on our simplifying assumption about the LTV ratio, which we have set equal to 100%. However, a simple continuity argument suggests that the result carries through for high enough values of $\theta$. Indeed, credit demand is downward sloping when the collateral constraint binds in our numerical example where we calibrate $\theta$ to the cross-country average maximum LTV ratio, which is equal to 92%.
C Sensitivity to $\eta$ and $\theta$

In this section we study the sensitivity of the response to the international credit supply shock to variations in the share of foreign currency liabilities $(1 + \eta)^{-1}$ and in the LTV parameter $\theta$.

We focus on the region in which the collateral constraint binds. For small enough shocks to $\chi$, a log-linear approximation provides an accurate description of the impact of credit shocks.\footnote{We denote the steady state value of a generic variable $x$ with $\bar{x}$ and the log-deviation from steady state as $\hat{x} \equiv (x - \bar{x})/\bar{x}.$}

Starting from the expression for the real exchange rate with period 1 (B.10), we can rewrite

$$s_1 = \left[ \frac{y^*}{y} + \frac{1 - \lambda (1 + \eta) \bar{f}}{\lambda} \right]^{\lambda - 1}.$$  

The linear approximation around the steady state is

$$s_1 = \bar{s}_1 - (1 - \lambda) \left[ \frac{y^*}{y} + \frac{1 - \lambda (1 + \eta) \bar{f}}{\lambda} \right]^{\lambda - 2} \frac{1 - \lambda (1 + \eta) \bar{f}}{\lambda} \bar{s}_1 \bar{f} (f - \bar{f}).$$

Using the expression for $s_1$, we can write the last expression as

$$s_1 - \bar{s}_1 = - \frac{(1 - \lambda)^2 (1 + \eta)}{\lambda y} \bar{s}_1^{1 - \frac{1}{\lambda}} \bar{f} \bar{f} (f - \bar{f}).$$

Dividing by $\bar{s}_1$ and $\bar{f}$ we get

$$\hat{s}_1 = - \frac{(1 - \lambda)^2 (1 + \eta)}{\lambda y} \bar{s}_1^{1 - \frac{1}{\lambda}} (1 + \eta) \bar{f} \bar{f}.$$  \hspace{1cm} (C.1)

Now consider period 2 and rewrite $s_2$ as

$$s_2 = \left[ \frac{y^*}{y} + \frac{1 - \lambda (1 + \eta) \bar{R} f}{\lambda} \right]^{\lambda - 1}.$$  

The linear approximation around the steady state is

$$s_2 = \bar{s}_2 + (1 - \lambda) \left[ \frac{y^*}{y} + \frac{1 - \lambda (1 + \eta) \bar{R} \bar{f}}{\lambda} \right]^{\lambda - 2} \frac{1 - \lambda (1 + \eta) \bar{R}}{\lambda} \bar{s}_2 \bar{f} \bar{f} \left( \bar{f} (f - \bar{f}) + \bar{f} (R - \bar{R}) \right).$$
Using the expression for $s_2$, we can write the last expression as

$$s_2 - \bar{s}_2 = \frac{(1 - \lambda)^2 (1 + \eta)}{\lambda y} \bar{s}_2^{1-\frac{1}{\gamma}} \left[ \bar{R} (f - \bar{f}) + \bar{f} (R - \bar{R}) \right].$$

Dividing by $\bar{s}_2$, $\bar{f}$, and $\bar{R}$ we get

$$\hat{s}_2 = \frac{(1 - \lambda)^2}{\lambda y} \bar{s}_2^{\frac{1}{\gamma-1}} (1 + \eta) \bar{R} \bar{f} \left( \hat{R} + \hat{f} \right). \quad (C.2)$$

The credit demand schedule can be rewritten more conveniently as

$$\hat{R} = \frac{1}{\beta} \left[ \frac{\kappa}{(1 + \eta) s_2 \bar{f}} - \frac{s_1}{s_2} \frac{1 - \theta}{\bar{s}_2} \right].$$

The linear approximation of the demand function around the steady state is

$$R = \bar{R} - \frac{1}{\beta} \frac{\kappa}{(1 + \eta) s_2 \bar{f}}^2 (f_1 - \bar{f}) - \frac{1}{\beta} \frac{\kappa}{(1 + \eta) s_2^2 \bar{f}} (s_2 - \bar{s}_2) - \frac{1 - \theta}{\beta} \frac{1}{s_2} (s_1 - \bar{s}_1) + \frac{1 - \theta}{\beta} \frac{s_1}{s_2} (s_2 - \bar{s}_2).$$

Dividing by $\bar{R}$, we get

$$\hat{R} = -\frac{1}{\beta \bar{R}} \left[ \frac{\kappa}{(1 + \eta) s_2 \bar{f}} \left( \hat{s}_2 + \hat{f} \right) + \frac{1 - \theta}{\theta} \frac{s_1}{s_2} (\hat{s}_1 - \hat{s}_2) \right]. \quad (C.3)$$

Finally, the expression for credit supply is

$$R = \frac{1}{\beta^*} + \frac{\chi' \psi'(1 + \eta)f}{\beta^*} + \frac{\eta \phi'(\eta f)}{1 + \eta}. $$

The linear approximation of the supply function is

$$R - \bar{R} = \left[ \frac{\psi'}{\beta^*} + \frac{\bar{\chi}(1 + \eta)\bar{f}\psi''}{\beta^*} \right] (\chi - \bar{\chi}) + \frac{\bar{\chi}^2 \psi''(1 + \eta)}{\beta^*} (f - \bar{f}) + \frac{\eta \phi''}{1 + \eta} (f - \bar{f}),$$

where $\psi'$ and $\psi''$ represent the first and second derivatives of the equity adjustment cost function, respectively, evaluated at steady state. Dividing through by the steady state real interest rate and expressing variables in percentage deviations from steady state, we obtain

$$\hat{R} = \frac{\bar{\chi}}{\beta^* \bar{R}} \left[ \psi' + \bar{\chi}(1 + \eta)\psi'' \right] \hat{\chi} + \frac{\bar{f}}{\beta^* \bar{R}} \left[ \bar{\chi}^2 \psi''(1 + \eta) + \frac{\eta \phi''}{1 + \eta} \right] \hat{f}. \quad (C.4)$$

Expressions (C.1)-(C.4) constitute a linear system of four equations in four unknowns.
\{\hat{s}_1, \hat{s}_2, \hat{R}, \hat{f}\}$ that depend on $\hat{\chi}$. We can write the solution as

\[
\hat{z} = \Gamma \hat{\chi},
\]

where

\[
z' \equiv \begin{bmatrix} \hat{s}_1 & \hat{s}_2 & \hat{R} & \hat{f} \end{bmatrix}
\]

and $\Gamma \equiv A^{-1} B$, with

\[
A \equiv \begin{bmatrix}
1 & 0 & 0 & a_{14} \\
0 & 1 & a_{23} & a_{24} \\
a_{31} & 1 & 1 & a_{34} \\
0 & 0 & 1 & a_{44}
\end{bmatrix},
\]

and

\[
B' \equiv \begin{bmatrix} 0 & 0 & 0 & b_{41} \end{bmatrix}.
\]

The coefficients of the matrix $A$ are

\[
a_{14} \equiv \frac{(1 - \lambda)^2}{\lambda y} \frac{1}{s_1} (1 + \eta) \bar{f} > 0
\]

\[
a_{23} = a_{24} \equiv -\frac{(1 - \lambda)^2}{\lambda y} \frac{1}{s_2} (1 + \eta) \bar{R} \bar{f} < 0
\]

\[
a_{31} \equiv \frac{1}{\beta \bar{R}} \frac{1 - \theta}{\theta} \frac{1}{s_1} > 0
\]

\[
a_{34} \equiv \frac{\kappa}{\beta \bar{R} s_2 (1 + \eta) \bar{f}} > 0
\]

\[
a_{44} \equiv -\frac{\bar{f}}{\beta^* \bar{R}} \left[ \bar{\chi} \psi'' (1 + \eta) + \frac{\eta^2 \phi''}{1 + \eta} \right] < 0
\]

and the non-zero coefficient of the vector $B$ is

\[
b_{41} \equiv \frac{\bar{\chi}}{\beta^* \bar{R}} \left[ \psi' + \bar{\chi} (1 + \eta) \psi'' \bar{f} \right] > 0.
\]

After inverting the matrix $A$, we can write the solution as

\[
\hat{s}_1 \equiv a_{14} b_{41} (a_{23} - 1) / d
\]

\[
\hat{s}_2 \equiv -b_{41} a_{23} (1 - a_{24} + a_{14} a_{31}) / d
\]

\[
\hat{R} \equiv b_{41} (a_{23} - a_{34} + a_{14} a_{31}) / d
\]

\[
\hat{f} \equiv -b_{41} (a_{23} - 1) / d,
\]

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where

\[ d \equiv a_{44} - a_{34} + a_{14}a_{31} + a_{23}(1 - a_{44}). \]

In the limit for \( \theta \to 1 \), \( a_{31} = 0 \Rightarrow d < 0 \). In this case, it is easy to see that

\[ \frac{\partial \hat{s}_1}{\partial \hat{\chi}} > 0 \quad \frac{\partial \hat{R}}{\partial \hat{\chi}} > 0 \quad \frac{\partial \hat{f}}{\partial \hat{\chi}} < 0. \]

In response to an expansionary credit supply shock (a fall in \( \chi \)), the real exchange rate appreciates, the real interest rate decreases, and the amount of credit extended to the Home country increases.

Given that we are in the region in which the collateral constraint binds, the approximated response of house prices is

\[ \hat{q} = \hat{s}_1 + \hat{f} \Rightarrow \frac{\partial \hat{q}}{\partial \hat{\chi}} = \frac{\partial \hat{s}_1}{\partial \hat{\chi}} + \frac{\partial \hat{f}}{\partial \hat{\chi}}. \]

Substituting the values of the partial derivatives above gives

\[ \frac{\partial \hat{q}}{\partial \hat{\chi}} = \frac{b_{41}(a_{23} - 1)(a_{14} - 1)}{d}, \]

which is positive as long as \( a_{14} > 1 \). For large enough levels of credit over GDP, this condition is always satisfied.

Finally, the response of consumption to the credit shock is

\[ \frac{\partial c_1}{\partial \chi} = (1 + \eta)\hat{s}_1 \frac{\partial f}{\partial \chi} + \left[ (1 + \eta)\tilde{f} - \frac{\lambda}{1 - \lambda} \tilde{s}_1^{-(1 + \lambda/\lambda)} \right] \frac{\partial s_1}{\partial \chi}. \]

A positive international credit supply shock increases consumption, both directly (the first term in the expression above) and because the real exchange rate appreciation makes the domestic endowment more valuable (the second term in square brackets). The appreciation of the real exchange rate, however, also reduces the purchasing power of credit denominated in foreign currency (the first term in square brackets). The overall effect is ambiguous, although our numerical simulations suggest consumption increases in response to a positive shocks for reasonable values of the parameters.