International Credit Supply Shocks☆

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Abstract

House prices and exchange rates can potentially amplify the expansionary effect of capital inflows by inflating the value of collateral. We first set up a model of collateralized borrowing in domestic and foreign currency with international financial intermediation in which a change in leverage of global intermediaries leads to an international credit supply increase. In this environment, we illustrate how house price increases and exchange rates appreciations contribute to fueling the boom by inflating the value of collateral. We then document empirically, in a Panel VAR model for 50 advanced and emerging countries estimated with quarterly data from 1985 to 2012, that an increase in the leverage of US Broker-Dealers also leads to an increase in cross-border credit flows, a house price and consumption boom, a real exchange rate appreciation and a current account deterioration consistent with the transmission in the model. Finally, we study the sensitivity of the consumption and asset price response to such a shock and show that country differences are associated with the level of the maximum loan-to-value ratio and the share of foreign currency denominated credit.

Keywords: Cross-border claims, Capital Flows, Credit Supply Shock, Leverage, Exchange Rates, House Prices, International Financial Intermediation.
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1 Introduction

Capital inflows are expansionary and pose difficult challenges for policy makers—see, for instance, Rey (2013, 2016).[1] Historically, however, some economies have been more sensitive than others to the volatility of capital inflows, with emerging market economies standing out as particularly vulnerable (e.g. Chari et al., 2017).

What are the mechanisms through which capital inflows lead to macroeconomic booms? And what are the characteristics that account for the differences in sensitivity across countries? In this paper, we explore the role of asset price inflation and credit market characteristics. Our main finding is that the currency denomination of credit flows and loan-to-value ratios are associated with the strength of the consumption response to international credit supply shocks.

Figure 1 shows that capital inflows are expansionary and associated with large swings in asset prices.[2] The figure shows that, during a boom, cross-border banking claims and equity prices grow more than 10 percent per year in real terms. GDP, consumption, and house prices grow about 4-5 percent per year. The current account balance deteriorates significantly before reverting during the last year of the expansion. The real exchange rate appreciates during the last two years of the boom phase (both in real effective terms and vis-a-vis the US dollar), while the economy starts to slow. Short term real interest rates are hight throughout the boom phase and increase further during the last year.

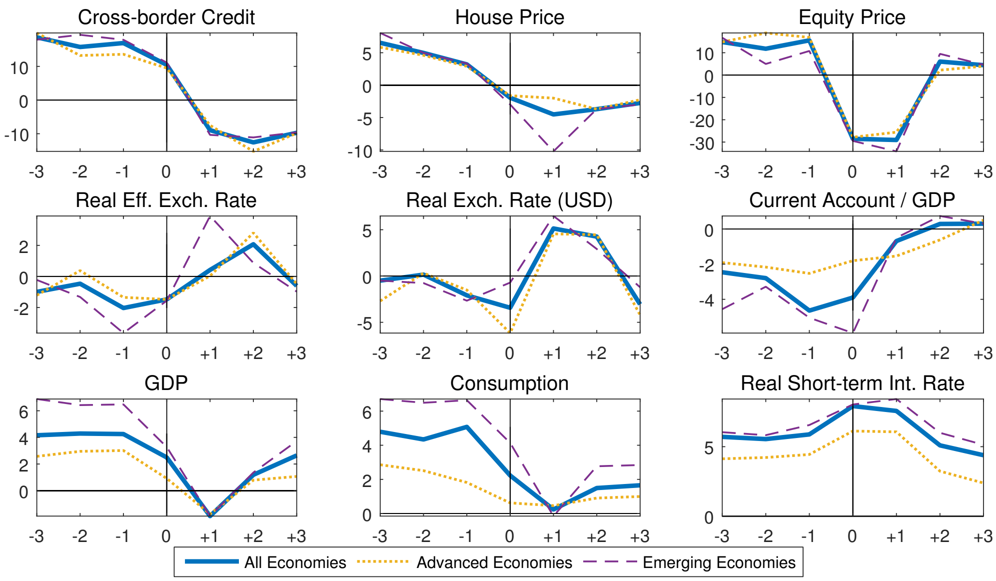
During the bust phase, these dynamics partially revert. Cross-border claims and house prices fall as fast as they grew during the boom phase for three years in a row. Equity prices drop very sharply for two consecutive years and, once they rebound, grow about half as fast as during the boom. GDP growth declines sharply and then resumes, but only at about a third the pace during the boom years. Consumption slows and then remains depressed. The current account deficit closes quickly and remains in a small surplus position. The real exchange rate depreciates sharply, and short term real interest rates decline, remaining elevated.

Not all countries behave alike though. For instance, Figure 1 shows that emerging

[1]This observation provides a challenge for some theories. See, for example, Blanchard et al. (2015) on the Mundell-Fleming model and Chari et al. (2005) on sudden stops in the neoclassical growth model.

[2]See Appendix A and B for details on this event study and the underlying data.

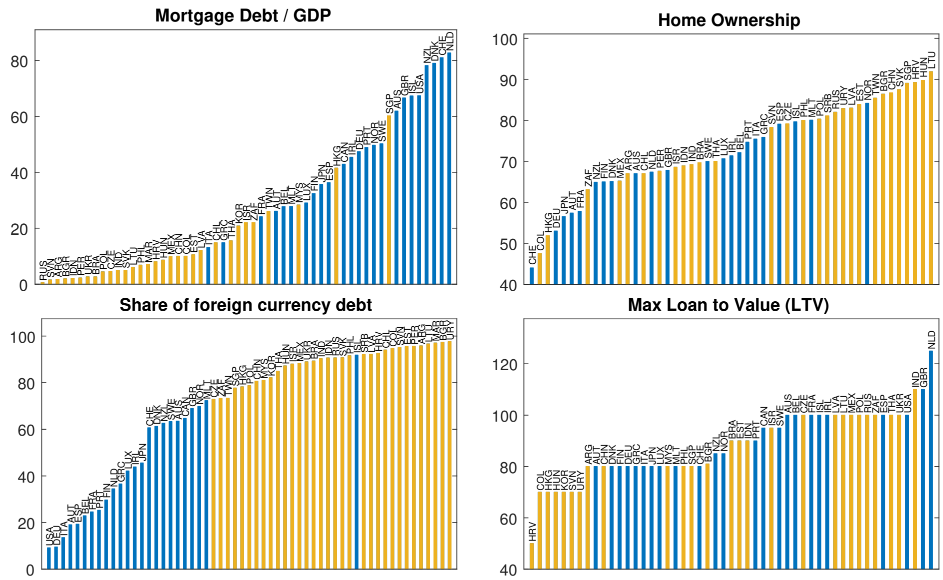
Figure 1. Boom-Bust Episodes in Capital Flows.



Note. The solid line plots the median pattern in whole cross section of countries in our sample, together with the median for advanced and emerging markets (dotted and dashed lines, respectively) across a set of boom-bust episodes in BIS cross-border claims, using a 6-year window, from three year before the peak to three years after the peak. In each panel, time 0 is 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 percent. See Appendix A and B for more details of the identification of the episodes, including summary statistics, and the definition and data sources of the variables considered.

economies experience much larger and more persistent boom-bust cycles than advanced ones (dashed and dotted lines, respectively). But this characterization of heterogeneity is an over-simplification as countries differ in ways that cannot always be reduced to the emerging market and advanced economies divide. For example, Figure 2 focuses on a few selected characteristics of credit markets. While emerging markets (lighter, yellow bars) tend to have shallower mortgage markets and higher shares of foreign currency debt than advanced economies (darker, blue bars), maximum LTV limits and home ownerships are distributed much more evenly. More generally, countries that are now member of the OECD, like South Korea and Mexico, in the past experienced some of the wildest capital flow gyrations. At the same time, more advanced economies like Ireland and other South European countries experienced deeper and longer-lasting financial crises than most emerging market economies during the global financial crisis.

Figure 2. Selected Country Characteristics.



Note. Each bar corresponds to a country. The lighter (yellow) bars are classified as emerging markets and the darker (blue) bars as advanced economies in Figure (1). See the data appendix for variable definitions and data sources.

In this paper, therefore, we will study differences in experiences with capital inflows at the country level based on specific characteristics, as opposed to comparing country-groupings formed from the outset, focusing on variables that have a counterpart in a fully specified model of international borrowing and lending to help the interpretation of the empirical findings.

Traditionally, the analysis of capital flows and their impact on the macroeconomy distinguished between "push" and "pull" factors (Calvo et al., 1996). The former are best thought as shocks that originate abroad and lead capital to flow in or out of individual countries. The latter are domestic shocks that attract foreign capital from the rest of the world. In this paper, we focus on one particular push shock—a shock to the international supply of credit. Focusing on a specific shock facilitates isolating causal effects in the empirical analysis. It also allows us to explore both the transmission mechanism and the cross-country heterogeneity in more detail from a theoretical point of view.

We proceed in three main steps. First, we set up a theoretical model of international financial intermediation and collateralized borrowing in domestic and foreign currency.

Second, we identify an international credit supply shock in the data and document its transmission and relative importance. Third, we study the differential incidence of this shock across countries considering country characteristics that affect its transmission in the model.

Both house prices and the exchange rate can have an amplification effect, by inflating the value of collateral and expanding the borrowing capacity of the economy. These channels of amplification may be more relevant depending on the characteristics of the credit market. We focus on the maximum loan-to-value ratio and the share of foreign currency liabilities over total liabilities. We assume that the source of collateral is residential housing, and borrowing can be denominated in either foreign or domestic currency. We take both the LTV and the share of foreign currency denominated liabilities as given and study the implications of varying them exogenously across countries. Housing is usually the largest asset class in households portfolios and it is used as collateral for both mortgage and commercial borrowing. The US dollar remains the dominant currency in the international financial system with relatively constant portfolio shares over time.

The model we use has two main blocks. 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 like in (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 international financial intermediaries that operate globally and channel funds from savers to borrowers. These intermediaries are subject to an exogenous capital requirement as in Brunnermeier and Sannikov (2014) and He and Krishnamurthy (2013). A change in the leverage of international financial intermediaries leads to an increase in the international supply of credit, as we will assume in our empirical analysis.

In the model, the shift in the international credit supply leads to a consumption boom, an appreciation of the real exchange rate, and house prices inflation (while the expected return on these assets falls), in line with the unconditional evidence we document in Figure 1. If the collateral constraint is binding, house prices always expand households' borrowing capacity in the model. Similarly, when credit is denominated in foreign currency and the constraint is binding, a real exchange rate appreciation boosts the borrowing capacity of the economy in foreign currency. Movements in the real exchange rate, however, affect the economy also through two other channels. In particular, the value of the domestic endowment increases, while the purchasing power of any new debt declines, if this is denominated in foreign currency. While the collateral effect of a house price increase is always expansionary, the net effect of the appreciation is an empirical/quantitative matter.

Overall, the predictions of the model provide a solid theoretical foundation for our empirical analysis, even though we make a number of simplifying assumptions to keep the framework tractable and highlight the key mechanisms at work. The model not only underpins the identification of our international credit supply shock in the data, but also highlights specific mechanisms of transmission that are useful to interpret the evidence we report. The model also helps us select country characteristics that may be associated with a different sensitivity to such a shock, illustrating that the house price and exchange rate collateral effects can be stronger the higher the LTV ratio and the share of foreign currency debt.

Next, 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 an unbalanced Panel Vector Autoregression model (PVAR) for 50 countries estimated with quarterly data from 1985:Q1 to 2012:Q4.

Based on the insights from 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. While regulation and financial innovation determine it in the longer-term (Boz and Mendoza, 2014), over the business cycle several factors, such as monetary policy, the state of the cycle, and risk appetite can affect the leverage constraint (Rey, 2013, 2016, Forbes et al., 2016). We focus on the cyclical changes and do not take a stand on the ultimate cause of these shifts. Instead, we investigate their consequences for the international supply of credit and the transmission to small open economies.

The PVAR analysis shows that our international credit supply shock triggers a sharp and persistent increase in cross-border claims, house prices and consumption. The real exchange rate appreciates and the current account deteriorates. After about five years, these dynamics revert with some overshooting in line with the event study in Figure 1 and the transmission in the model. Our international credit supply shock is also an important source of business cycle variation, accounting for variance share of most variables between 10 and 20 percent depending on the particular model specification.

In the last step of the analysis, we study the sensitivity of the transmission to country characteristics. The individual country estimates reveal a significant degree of heterogeneity. Consistent with the predictions of the model, the impact of the shock is stronger in economies with a larger share of liabilities denominated in foreign currency and a higher loan-to-value ratio. In the model, both the tightness of the LTV limit and the share of domestic currency debt can potentially affect the impact of the international credit supply shock that we identify in the data.

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 these ideas one step further and investigate, both empirically and theoretically, possible mechanisms of transmission to macroeconomic variables and asset prices in individual countries. We study the next chain in the transmission of such shocks, that is from the leverage of US Broker-Dealers to macroeconomic dynamics and asset prices in economies at the receiving end of capital inflows, also exploring the cross-country distribution of these effects.

The second strand of the literature we relate to consists of papers that study 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).[3] 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 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 a few advanced economies. We investigate this elasticity in an open-economy setting, in a large cross section of advanced and emerging economies, focusing on how it is affected by

[3] 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.

the share of foreign currency debt and the maximum LTV ratio. Almeida et al. (2006) document empirically 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). Our theoretical and empirical analysis takes a general equilibrium approach. 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 credit supply shock—and uncover a relation 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 estimated implied elasticity is quantitatively sizable and estimated precisely.

The rest of the paper is organized as follows. Section 2 sets up the model that we use to illustrate the nature of the shock and support the VAR identification assumptions. Section 3 discusses the transmission mechanism. Section 4 presents the Panel VAR model and reports the response of the typical economy in our cross section to the identified international credit supply shock. Section 5 investigates the cross-country sensitivity to LTV levels and the share of foreign currency debt. Finally, Section 7 concludes. The paper's appendix contains details of the event study described above, the definition and the sources of all data used in the paper. A supplement (not for publication) contains all model derivations, additional empirical results and robustness checks on the PVAR analysis.

2 A Model of International Borrowing and Lending

This section presents a stylized model of international financial intermediation and collateralized borrowing. The model helps us to identify an international credit supply shock in the data, to interpret its transmission, and the sensitivity of its effect to country characteristics.

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 non-durable goods, and consumes a bundle of the two tradable goods as well as non-tradable housing services, which are proportional to the stock of housing. For simplicity, we abstract from construction and assume that housing is in fixed supply, like land. The two blocks 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 holdings in a global financial intermediary that channels funds to the borrowers and is subject to a leverage constraint (or, equivalently, a capital requirement).

2.1 Goods Markets

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

$$c = \frac{c_H^{\alpha} c_F^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}, \tag{1}$$

where $\alpha \in (0,1)$ is the steady state share of consumption on Home goods. Following Sutherland (2005), we assume that the weight of 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.[4]

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

$$c_H = \alpha \left(\frac{P_H}{P}\right)^{-1} c \qquad \text{and} \qquad c_F = (1-\alpha)\left(\frac{P_F}{P}\right)^{-1} c, \tag{2}$$

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. These price indexes are related to each other according to:

$$P = P_H^{\alpha} P_F^{1-\alpha}. \tag{3}$$

[4]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.

The consumption bundle of the representative household in the Foreign block corresponds to (1), with $\alpha^* \equiv n\lambda$ representing the Foreign consumption share of imported goods. The demand for Home and Foreign goods by the Foreign household are identical to (2), with the only difference that an asterisk denotes Foreign variables.

2.2 Exchange Rates and Relative Prices

The nominal exchange rate $\mathcal{E}$ 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:

$$P_H = \mathcal{E}P_H^* \qquad \text{and} \qquad P_F = \mathcal{E}P_F^*, \tag{4}$$

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

The terms of trade τ 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:

$$\tau = \frac{\mathcal{E}P_F^*}{P_H}. \tag{5}$$

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 τ 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:

$$p_H = \tau^{\alpha-1} \qquad \text{and} \qquad p_F = \tau^{\alpha}, \tag{6}$$

where $p_k \equiv P_k/P$, for $k = \{H, F\}$. The same conditions hold for the Foreign country.

The real exchange rate s is the price of Foreign consumption in terms of Home consumption:

$$s \equiv \frac{\mathcal{E}P^*}{P}. \tag{7}$$

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:

$$s \equiv \frac{\mathcal{E}P^*}{P} = \frac{\mathcal{E}P_F^*}{P_H} \times \frac{p_H}{p_F^*} = \tau^{\alpha-\alpha^*}. \tag{8}$$

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

2.3 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, households decide 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:

$$\mathbb{U} = u(c_1) + \beta u(c_2) + v(h_1), \tag{9}$$

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:

$$c_1 + qh_1 - b - s_1 f = p_{H1}y + qh_0, \tag{10}$$

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:

$$c_2 = p_{H2}y - R^b b - s_2 Rf, \tag{11}$$

where R^b and R are the gross interest rates on credit denominated in Home and Foreign currency, respectively.

While households (and banks) choose the currency denomination of their credit portfolio, in this paper, we abstract from this decision and treat the share of foreign currency denominated credit as given.[5] In particular, we will characterize the equilibrium in terms of the ratio between credit in Home and Foreign currency:

$$\eta \equiv \frac{b}{s_1 f}, \tag{12}$$

so that $1/(1+\eta)$ represents the share of Foreign currency liabilities in total credit from the perspective of the Home country, which can be measured in the data. If $\eta = 0$, the model corresponds to the limiting case in which all credit is denominated in Foreign currency. As f decreases, η increases, and in the limit the share of Foreign currency debt goes to zero.

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:

$$b + s_1 f \leq \theta q h_1. \tag{13}$$

The parameter θ represents a limit that lenders impose on borrowers to mitigate issues related to asymmetric information. In practice, however, θ 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. Because borrowing is denominated in foreign-currency, both house prices and the exchange rate enter this constraint. Thus, equation (13) combines the typical specifications adopted in the housing and the open economy macroeconomics literatures.

The Home household maximizes (9) subject to (10), (11), and (13). Let $\mu\bar{c}$ be the Lagrange multiplier on the borrowing constraint, normalized by the marginal utility of consumption ($\bar{c}$). The first order conditions for the optimal demand of credit in period 1 in Home and Foreign currency are, respectively:

$$1 - \mu = \beta R^b \qquad \text{and} \qquad 1 - \mu = \beta R \frac{s_2}{s_1}, \tag{14}$$

[5] In Figure D.1 of the supplement we show that, at the country level, the share of foreign currency liabilities in total liabilities is rather constant over time.

with $\mu > 0$ when $b + s_1 f = \theta q h_1$. The two expressions in (14) are the consumption Euler equations under risk neutrality. Under these assumptions, when binding, a tighter borrowing constraint (i.e., a higher μ) reduces the cost of forgoing consumption today (or increases the benefits of saving today). No arbitrage requires Home households to be indifferent between credit denominated in Home and Foreign currencies and yields:

$$R^b = R\frac{s_2}{s_1}, \tag{15}$$

which corresponds to the uncovered interest rate parity condition in real terms.[6]

The Euler equation for the choice of housing services is:

$$(1 - \theta\mu)q = \frac{v'(h_1)}{\bar{c}}, \tag{16}$$

and shows that house prices are higher (i) the higher the maximum LTV ratio θ (ii) and the tighter the borrowing constraint μ.

Note here that, all else equal, both the level of the LTV and the tightness of the borrowing constraint increase housing demand. A higher LTV directly allows for more borrowing in equation (14) and hence more consumption, including more housing services. Similarly, a tighter borrowing constraint (a higher value of the multiplier μ) increases house prices via higher demand for scarce collateral.[7] However, when the collateral constraint is not binding ($\mu = 0$), housing demand is constant and house prices are equal to their fundamental value, that is the marginal utility of housing in units of marginal utility of consumption. In this case, the housing market is insulated from exogenous shocks that affect other parts of the economy.

The unconditional evidence reported in the previous section suggests that both the real exchange rate and house prices increase during periods of capital inflows. In our model, both asset prices can amplify the effects of an international credit supply shock, but with different mechanisms. An increase in house prices boosts the (Home currency) value of the collateral and expands the households' borrowing capacity, thus supporting

[6] It is well known that the uncovered interest rate parity condition fails in the data, at least in the short-run. For instance, by using loan-level data for Turkey, Baskaya et al. (2017) document that persistent differentials in domestic and foreign borrowing costs vary with the global financial cycle. Salomao and Varela (2017) analyze the implications of UIP failure for the currency composition of credit. In the model, we abstract from frictions that may lead the UIP to fail.

[7] This effect is particularly stark in our model because of the assumptions of risk neutrality and fixed housing supply.

consumption of housing and non housing only when the collateral constraint binds. This "collateral house price effect" is evident from equation (13), and the mechanism corresponds to the standard amplification channel associated with house prices in the closed economy literature (e.g. Kiyotaki and Moore, 1997). Note here that this effect is stronger the higher is the LTV. When the collateral constraint is not binding, however, the feedback from house prices to the rest of the economy disappears because of our simplifying assumptions on housing preferences and technology.

In contrast, the exchange rate can amplify the effects of an international credit supply shock independently of whether the collateral constraint is binding or not. When total borrowing is constrained, equation (13) shows that an exchange rate appreciation expands the borrowing capacity of the economy like house prices do, but in Foreign as opposed to Home currency; an effect that we label "collateral exchange rate effect." Note here that this effect is stronger the higher the share of foreign currency liability. As we can see from the budget constraint (10), an appreciation also boosts the purchasing power of the Home endowment, but it reduces that of any given amount of foreign currency debt regardless of whether the constraint binds or not.[8] We call these two latter effects "endowment valuation effect", and "debt valuation effect", respectively. Note here again that the debt valuation effect is also increasing in the share of foreign currency liabilities like the collateral exchange rate effect.

Both the debt and collateral exchange rate effects become less severe as the share of foreign currency declines (i.e., η gets bigger). We can see the dependency of the debt valuation effect on the share of foreign currency credit by rewriting the budget constraint in terms of η as:

$$c_1 + qh_1 - (1+\eta)s_1 f = p_{H1}y + qh_0.$$

Similarly, rewriting the borrowing constraint at equality as a function of η, we can see that collateral exchange rate effect is also declining in η:

$$(1+\eta)s_1 f = \theta qh_1.$$

In both cases, a higher value of η dampens the effect of an appreciation of the real

[8]In a fully dynamic setting, the latter 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.

exchange rate (a fall in s_1) on the purchasing power of a given amount of credit in Foreign currency f.

The collateral exchange rate effect reinforces the endowment valuation effect, but could be offset by the debt valuation effect. The overall impact on the economy is a quantitative matter that depends on the total level of borrowing as well as its currency composition. But an appreciation is more likely to be expansionary in our model at higher levels of debt and higher shares of foreign currency debt, so that the borrowing constraint is more likely to bind and hence to activate the exchange rate collateral effect.

2.4 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:

$$\mathbb{U}^* = u(c_1^*) + \beta^* u(c_2^*), \tag{17}$$

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.[9]

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

$$c_1^* + d + e + \psi(e) = p_{F1}^* y^*, \tag{18}$$

where $\psi(\cdot)$ (with $\psi',\ \psi'' > 0$) is a convex cost of changing the equity position.[10] As in Jermann and Quadrini (2012), the equity adjustment cost creates a "pecking order"

[9]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. The Foreign counterpart of equation (16) with $\mu^* = 0$ shows that we would obtain a solution for Foreign house prices of the form $q^* = v'(h_1^*)/\bar{c}^*$.

[10]For simplicity, we assume global financial intermediaries are set up in the first period, and normalize to zero initial deposits and equity.

of liabilities whereby intermediaries always prefer to issue debt relative to equity. The budget constraint in the second period is:

$$c_2^* = p_{F2}^* y^* + R^d d + R^e e + \Pi, \tag{19}$$

where R^d and R^e are the real gross returns on deposits and equity, respectively, and Π stands for the profits of the global financial intermediary that the Foreign representative household owns.

The problem of the foreign representative household is to maximize (17) subject to (18) and (19). The first order conditions for the optimal choice of deposits and equities are:

$$1 = \beta^* R^d, \tag{20}$$

and

$$1 + \psi'(e) = \beta^* R^e. \tag{21}$$

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, which is increasing in the degree of convexity of the portfolio cost of adjustment function.

2.5 Global Financial Intermediaries

A representative financial intermediary (a global bank) operates in international credit markets and channels loans from patient Foreign lenders to impatient Home borrowers, funding its activity with a mix of equity and deposits raised in the Foreign country.[11]

Table 1 below summarizes the balance sheet of financial intermediaries in period 1. As discussed earlier, a given fraction η of their loan book is denominated in Home currency. Following Bräuning and Ivashina (2016), we assume that global financial intermediaries swap their exchange rate exposure by entering a contract with perfectly

[11] Obviously, this is oversimplification, as we abstract from domestic financial intermediation. The benefit of our assumption is that we can isolate the role of global banks and their interaction with the frictions on the demand side of domestic credit for the transmission of global financial shocks.

Table 1. Balance sheet of a typical global financial intermediary.

Assets		Liabilities	
Loans (Home currency):	b/s_1	Deposits:	d
Loans (Foreign currency):	f		
		Equity:	e

competitive specialized FX traders. These traders are endowed with a large amount of capital K and make zero profits. Using these swap contracts, global banks can ensure that only the total size of the asset side of their balance sheet matters, and not its currency composition.

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

$$\Pi = Rf + \frac{R^b b}{s_2} - R^d d - R^e e - \phi\left(\frac{b}{s_1}\right), \tag{22}$$

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 as much as possible. We assume that a capital requirement limits leverage and the size of their balance sheet:

$$e \geq \chi\left(\frac{b}{s_1} + f\right), \tag{23}$$

with $\chi \in (0, \bar{\chi})$.[12]

The problem for the representative global financial intermediary is to maximize (22) subject to the leverage constraint (23) and the balance sheet constraint. Using the no arbitrage condition (15) and the definition of the share of credit denominated in Home currency (12) introduced earlier, we can rewrite the problem of the representative global bank as:

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

[12] Gabaix and Maggiori (2014) obtain a similar constraint assuming that financiers can divert part of the funds intermediated through their activity.

subject to the balance sheet constraint:

$$(1+\eta)f = d + e, \tag{24}$$

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 capital constraint χ. We then map the results of this experiment into the identification of our 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 χ 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:

$$\Pi = \left[R - \chi R^e - (1-\chi)R^d\right](1+\eta)f - \phi(\eta f). \tag{25}$$

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

$$R = \chi R^e + (1-\chi)R^d + \frac{\eta}{1+\eta}\phi'(\eta f). \tag{26}$$

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 χ represents the weight on the return on equity: a tighter leverage constraint (a higher χ) 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 is the hedging cost of Home currency lending: for given f, the loan rate is increasing in the share of credit issued in Home currency. Similarly, for given η, 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.

2.6 Equilibrium

We characterize the equilibrium in terms of the quantity of credit denominated in Foreign currency f, for a given share of credit denominated in Home currency η, which we treat as a parameter. In equilibrium, the demand for housing within each country must equal the available supply, which is fixed and, without loss of generality, normalized 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 constraints;
3. Financial intermediaries maximize their profits subject to their balance sheet and leverage constraint;
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 as we assume in our empirical analysis in section 4.

3 The Small Open Economy Case: An Example

In our empirical analysis, 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. This case can be analyzed 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. This small open economy assumption implies that Home demand does not affect the equilibrium in the market for Foreign goods. In this case, we can solve for the real exchange as a function of the quantity of credit and the interest rate. The credit market then determines the entire equilibrium of the model.

3.1 The Exchange Rate and the Credit Market

Credit demand interacts with the goods market through the real exchange rate, which in period 1 and 2 is given by:[13]

$$s_1 = \left[\frac{\lambda y}{\lambda y^* + (1-\lambda)(1+\eta)f}\right]^{1-\lambda}, \tag{27}$$

$$s_2 = \left[\frac{\lambda y}{\lambda y^* - (1-\lambda)R(1+\eta)f}\right]^{1-\lambda}. \tag{28}$$

Intuitively, higher borrowing in period 1 implies higher Home demand, and hence an appreciation of the terms of trade (and consequently of the real exchange rate). However, higher borrowing in period 1 also means, higher interest repayments in period 2, and hence lower demand and a depreciation in period 2.

Credit supply

The credit supply schedule is upward-sloping in the $\{f, R\}$ space:

$$R = \frac{1 + \chi\psi'[\chi(1+\eta)f]}{\beta^*} + \frac{\eta\phi'(\eta f)}{1+\eta}, \tag{29}$$

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. In addition, as mentioned earlier, for a fixed share of Foreign (Home) currency credit in total credit, a larger balance sheet implies a higher hedging cost, which financial intermediaries pass on to borrowers. These two effects make credit supply increasing in the level of the interest rate.

The shock that we study originates from the balance sheet of global banks and is transmitted to individual countries through the international credit market. As equation (29) shows, an increase in the leverage of financial intermediaries (a reduction of the capital requirement parameter χ) shifts down the credit supply schedule. At any level of credit, the interest rate offered on loans issued to the Home country must fall. This mechanism is what underpins our identification assumptions in the VAR of section 4.

[13] The derivations of these equilibrium relations are reported in an supplement to the paper.

Credit Demand

The credit demand schedule differs depending on whether the collateral constraint binds or not. In particular, credit demand is a piecewise function with a kink at the level of credit where the borrowing constraint becomes binding:

$$R = \begin{cases} \dfrac{1}{\beta}\dfrac{s_1}{s_2} & \text{if } \ (1+\eta)s_1 f < \theta q \\ \dfrac{1}{\beta}\dfrac{s_1}{s_2}\left[\dfrac{\kappa}{(1+\eta)s_1 f} - \dfrac{1-\theta}{\theta}\right] & \text{if } \ (1+\eta)s_1 f = \theta q. \end{cases} \tag{30}$$

If the collateral constraint does not bind, the slope of the credit demand schedule is negative. In this region, the LTV level is irrelevant for the equilibrium. If the constraint binds, credit demand is downward-sloping for a sufficiently high level of the LTV ratio.[14]

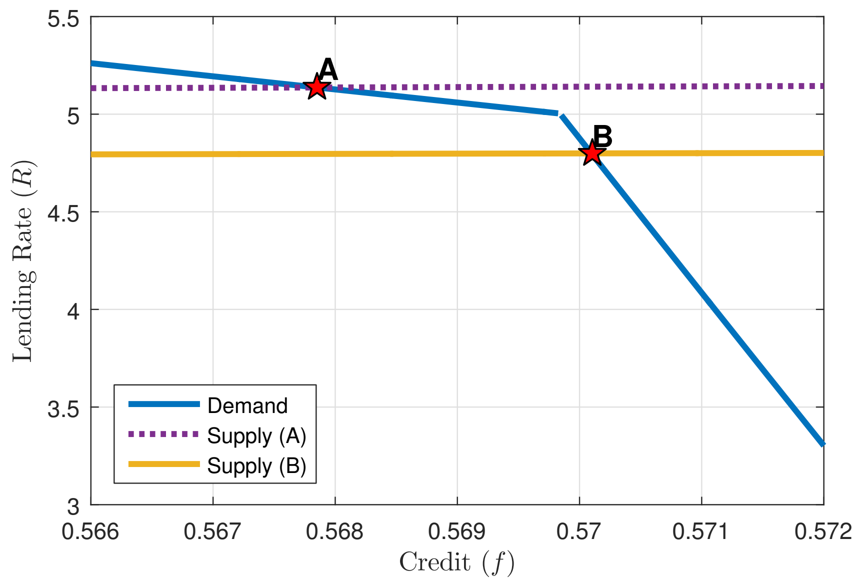
3.2 Equilibrium

Figure 3 plots the credit market equilibrium in the space $\{f, R\}$ for a reasonable choice of the parameters values. Starting with credit demand, which results from combining (27), (28), and (30), 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 a high value for $\theta = 0.9$, consistent with the observed (median) maximum LTV limit in our sample of countries, and $\eta = 0.43$ to match the median share of foreign currency liabilities from BIS data. 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 lending spread of about 100 basis points, whether the borrowing constraint is binding or not.

Focus next on the credit supply (equation 29). The parameters that pin down its shape are the capital requirement, the discount factor of country F, and 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. We set $\beta^* = 0.99$ to obtain $R^d = 4.1\%$ in annualized terms. We assume that the adjustment costs for equity holdings and the hedging cost are both quadratic and set

[14] See the appendix for the formal derivations of the slope of the credit demand schedule in the two regions.

Figure 3. International Credit Market Equilibrium.



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

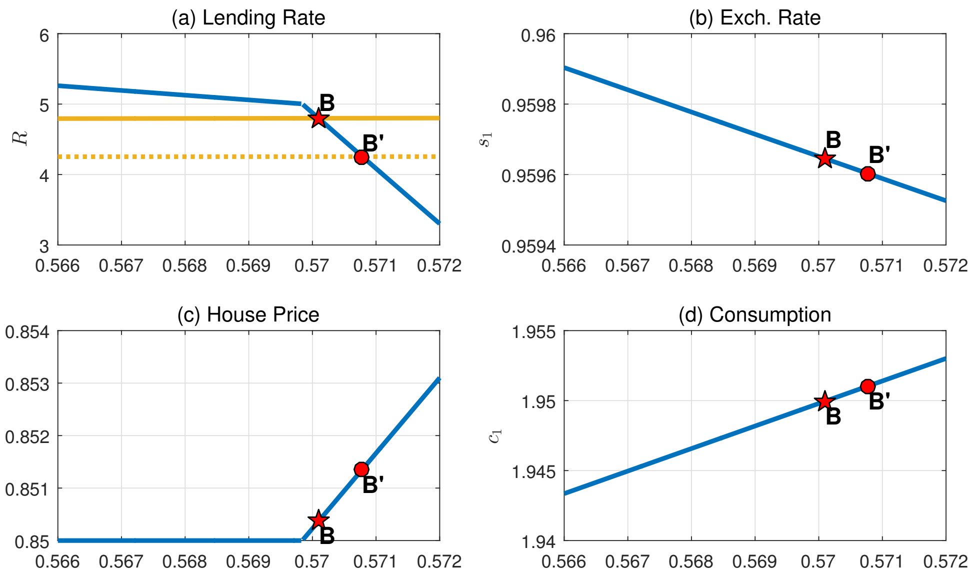
their parameters residually. Given the rest of the calibration, their values determine whether the borrowing constraint is binding or not, and the premium that bank equity pays over deposits.

Figure 3 displays the two types of credit market equilibrium that can arise in the model, depending on whether the constraint binds or not. For example, for a given cost of hedging, if the equity adjustment cost parameter is relatively high ($\zeta = 0.03$), financial intermediaries pay a large premium over the return on deposits (about ten and a half percentage points). In this case, the equilibrium is in the unconstrained region (point A), with a relatively high interest rate on loans of 5.2%. When the equity adjustment cost is relatively low ($\zeta = 0.02$), the equity premium is smaller (approximately seven percentage points), credit is abundant, and the interest rate on loans is lower at about 4.9%. In this case, given the LTV value, demand meets supply in the constrained region (point B).

3.3 The Transmission of a Leverage Shock

Figure 4 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

Figure 4. International Credit Supply Shock with Binding Borrowing Constraint.



Note. Change in χ from 0.1 to 0.02 (with leverage going from 10 to 50). Initial equilibrium: constraint is binding like in Point B in Figure 3. New equilibrium: Point B'. Credit volume on the horizontal axis.

(bottom-left panel), and consumption (bottom-right panel), to a reduction of χ from 0.1 to 0.02 in the region where the collateral constraint is binding.

We start from the same constrained equilibrium of Figure 3 (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 4), 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). While Figure 4 traces the impact of the shock for the particular set of parameter values discussed above, in appendix we show that the sign of theses derivatives is preserved as long as the model solution is approximated around a steady state in which the constraint is binding. A similar adjustment would occur if the economy experienced the same shock starting from point A in Figure 3. 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.[15]

4 An International Credit Supply Shock in the Data

In this section we identify an international credit supply shock empirically and discuss its impact on selected macroeconomic variables and asset prices of the receiving economies. 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 this transmission. As we shall see, most empirical findings are consistent with the predictions of our model.

4.1 A PVAR Model

The PVAR model includes the leverage ratio of US Broker-Dealers to identify an international credit supply shock and a small set of domestic variables that have a direct counterpart in the theoretical model. The set of domestic variables includes cross-border bank claims on financial and non-financial sector, real private consumption, real house prices, the real exchange rate vis-a-vis the US Dollar, and the current account balance as a share of country GDP. In the model, the private sector corresponds to households borrowing against housing collateral. For consistency, in the data, we do not distinguish between credit towards households and firms, and we focus on house prices as the key domestic asset price for the transmission of the exogenous shock. We do not include a price measure corresponding to the credit variable selected because quarterly time series for interest rate on loans are not available for our large country panel. Nonetheless, below we use the model to link the response of house prices and the real exchange rate, which are observables, to the interest rate on loans.

The specification for each country i is:

$$x_{it} = a_i + b_i t + c_i t^2 + F_{1i} x_{i,t-1} + u_{it}, \tag{31}$$

where x_{it} is the vector of endogenous variables, a_i is a vector of constants, t and t^2

[15] Starting from point A, with a large enough shock, the economy could also move from the unconstrained to the constrained equilibrium. The adjustment in this case would be similar to that depicted in Figure 4.

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 Σ_{iu}. All variables considered enter in log-levels, except for the current account, which is expressed in percentage of country GDP. [16] 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 data-congruent specification for all 50 countries in our 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 with a later starting date, depending on data availability.

We estimate the model using the mean group estimator of Pesaran and Smith (1995) and Pesaran et al. (1996), as pooled estimators are not consistent in 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 initially in our event study.[17]

4.2 Identification

We want to identify a shock to the international supply of credit as in the model presented in previous section. The model shows that changes in leverage of international financial intermediaries lead to an international credit supply expansion. In the PVAR model, we use innovations to US Broker-Dealers' leverage as a source of exogenous variation in the international supply of credit, and cross-border claims of BIS reporting banks as our measure of international credit.[18] Leverage of US Broker-Dealers can be readily measured from US Flow of Funds data. These institutions are also a good proxy for the global financial intermediaries that we considered in the theoretical analysis.

Consistent with the small open economy assumption in our model, our key assumption is that leverage of US Broker-Dealers is not contemporaneously affected by

[16] The country VAR system can be consistently estimated in levels with OLS even if it contains some unit roots (see Sims et al., 1990). See the paper's supplement for robustness to using Local Projections as in Jorda (2005).

[17] 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.

[18] Bruno and Shin (2015) also show that changes in the leverage of US Broker-Dealers have a well-defined theoretical and empirical linkage with changes in BIS cross-border claims.

conditions in individual countries outside the United States. In the estimation of the country-specific VARs, however, we can allow for lagged feedback of the domestic economy into the leverage equation. Proceeding in this way does not compromise either the consistency or the efficiency of estimates obtained given that we do not use country-specific standard errors to construct the variance of the mean group estimator. For robustness, however, we compute also a restricted specification of the VAR in which we eliminate this lagged feedback. Since the leverage of US Broker-Dealers is endogenous to the US business cycle, we do not include the US in the sample, leaving us with 50 countries.

In practice, we obtain the impulse responses of all other variables in the country VAR systems to an international credit supply shock from the Cholesky decomposition of the variance-covariance matrix of the estimated reduced-form residuals, with leverage ordered first in the system.[19] The orthogonalized leverage innovations for each of the country-specific models (light solid lines) together with their cross-country average (dark solid line) and standard deviation (straight dotted lines) are plotted in Figure 5. The shocks differ slightly across countries because of the lagged feedback from the rest of the system to leverage equation and the fact that models are estimated over different sample periods (depending on data availability).

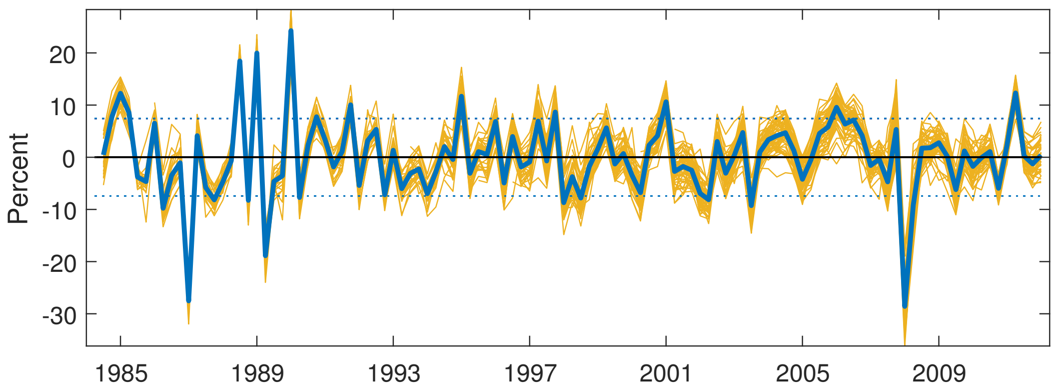
While leverage of the international financial intermediaries is exogenous in our model, in the data various factors can affect the leverage of US Broker-Dealers. Long-term determinants include financial regulations and innovation (e.g., Boz and Mendoza (2014)), liquidity conditions and systemic risk, as well as the state of the business cycle (see, for example, Bruno and Shin, 2015, Rey, 2013, Bekaert et al., 2013).

Table 2 reports regressions of the average orthogonalized residual in Figure 5 on these underlying, more structural determinants of US Broker-Dealers' leverage. For monetary policy, we consider both the raw change in the Federal Funds Rate (ΔFFR_t), capturing the systematic component of monetary policy, as well as its surprise component (ϵ_t^{MP}) measured with Romer and Romer (2004) monetary policy shocks. We also include the slope of the yield curve ($R_t^L - R_t$) that contain information about the state of the US business cycle and term risk premia. Finally, we consider the VIX volatility index (VIX_t) as a raw measure of systemic risk.

Consistent with the available evidence, leverage tends to increase when US policy

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

Figure 5. Estimated International Credit Supply Shock.



Note. The light solid lines are the orthogonalized leverage innovations for each of the country-specific models. The dark solid line is the cross-country average of the country-specific leverage innovations. The dotted lines are the average of the one-standard deviation bands, equal to 7.5 percent per quarter.

rates and volatility are falling, and to a lesser extent, when the term premium declines. In fact, the term premium is only marginally significant statistically, and drops out when we enter these variables jointly in the regression. Note, however, that the adjusted R-squared of the regressions is quite low, approaching 10 percent only when VIX index and Fed Funds Rate changes are entered together. This suggests that they would be relatively weak instruments.

For our purposes we do not need to take a stand on the underlying structural sources of cyclical change in the leverage data. As long as country-specific, domestic pull factors do not affect leverage of US Broker-Dealers, we can treat changes in leverage as an exogenous push shock to capital flows that increases the international credit supply like in our model. Thus, to make sure that leverage is not affected by common shocks to many small open economies, as a robustness, in our PVAR model, we will control for world GDP and world equity prices that have a strong forward looking component, rather than instrumenting leverage with its structural determinants above.[20]

[20] Cesa-Bianchi et al. (2015) used these variables as instruments for cross-border claims in a similar set up, along with US Broker-Dealers' leverage, applying the external instrument approach of Mertens and Ravn (2013) and Stock and Watson (2012). Their optimal instrument selection procedure chooses leverage as preferred instrument for most countries, but the F-statistics is often below the threshold value to avoid weak instruments problems. They obtain very close results by using the instrumental variables directly in the PVAR as exogenous variables and applying the Cholesky decomposition as done in this paper.

Table 2. Brokers-Dealers' Leverage Innovations and Their Underlying Determinants.

x_t	(1)	(2)	(3)	(4)	(5)
ΔFFR_t	-2.477**				-2.613**
	[-2.364]				[-2.536]
ϵ^{MP}		-0.0497			
		[-0.650]			
$R_t^L - R_t$			-0.900		
			[-1.642]		
VIX_t				-0.00182**	-0.00195**
				[-2.057]	[-2.252]
Obs.	111	91	111	111	111
Adj. R^2	0.049	0.005	0.024	0.037	0.091

Note. The Table reports a regression of the leverage innovations in Figure 5 (average across countries) on their possible determinants: $\epsilon_t^{LEV} = \beta x_t$. ΔFFR_t is the first difference of the real (ex-post) federal fund rate; ϵ^{MP} is Romer and Romer (2004) monetary policy shock; $R_t^L - R_t$ is the slope of the US yield curve; VIX_t is the VIX index. The regressions also include a constant and world GDP (not reported).

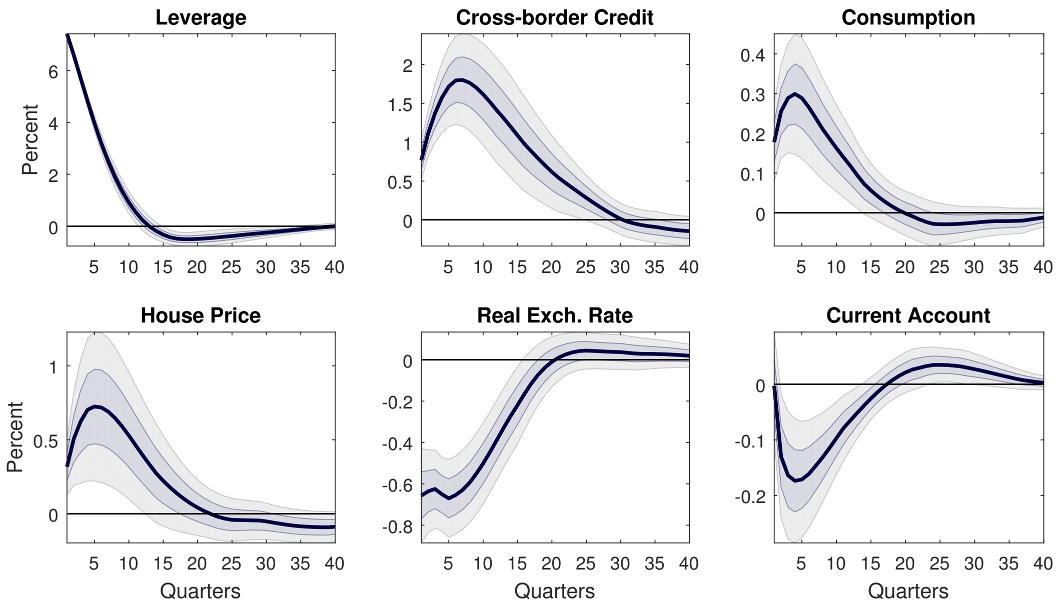
4.3 Response of a Typical Small Open Economy

Figure 6 reports the impulse response to the identified international supply of credit.[21] The size of the shock is one-standard deviation of the leverage residuals, which is equal to 7.5% per quarter on average across all countries (e.g., leverage going from 10 to 10.075). We censor the responses included in the computation of the mean group estimator at the 10% level (5% each side) to eliminate the possible influence of any outliers. The dark and light shaded areas represent the one- and two-standard deviation confidence intervals, respectively, computed based on scaled variance of the country responses across countries, which is a consistent estimates of the true cross section mean impulse response.

The estimated impulse responses are consistent with the transmission in our theoretical model. In the typical small open economy (represented here by the average response in the cross-section) the leverage shock leads to a statistically significant and

[21]We use a simple average of the country-specific estimates to construct the mean-group estimates. Results are robust to using a weighted average because of the large number of countries in the sample.

Figure 6. Impulse Responses to an International Credit Supply Shock



Note. Mean group estimate of the impulse responses to a one standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are one- and two-standard deviation confidence intervals, respectively.

persistent increase in cross-border claims, real consumption, and house prices; to a real exchange rate appreciation, and a deterioration of the current account balance.[22] These responses are in accordance with the behavior of a constrained economy in our model whereby house prices respond to increased demand for collateral following the credit shock. The responses are also consistent with the the exchange rate collateral and the endowment valuation effects dominating the (contractionary) debt valuation effect of the appreciation. Therefore, both the exchange rate appreciation and the house price increase possibly amplify the initial effect of the shock.

Note also that, like in our model, in the medium term (about 4-5 years after the shock) the exchange rate goes through a period of depreciation, before reverting completely to its long-run value. The depreciation is associated with falling consumption and house prices, and a current account surplus. The amplitude of the bust-phase,

[22]Note here that these are conditional responses to a particular shock. In the data, the current account balance should add up to zero globally only unconditionally (and ignoring the global discrepancy), but not conditional on particular shocks. Even unconditionally, the current account does not add up to zero globally if scaled relative to country GDP.

however, is much smaller than the boom-phase, even though it has the same duration. In contrast, in the theoretical model (and the episodes reported in Figure 1), the two phases have not only similar duration, but also comparable amplitude.

Quarterly data on interest rates on loans, either in domestic or foreign currency, are not available for a large and long panel data set like ours. The model, however, helps us connect the response of house prices to these interest rates. For simplicity, assume the LTV parameter θ is equal to one. The first order conditions for credit (14) and house prices (16) can be combined to give:

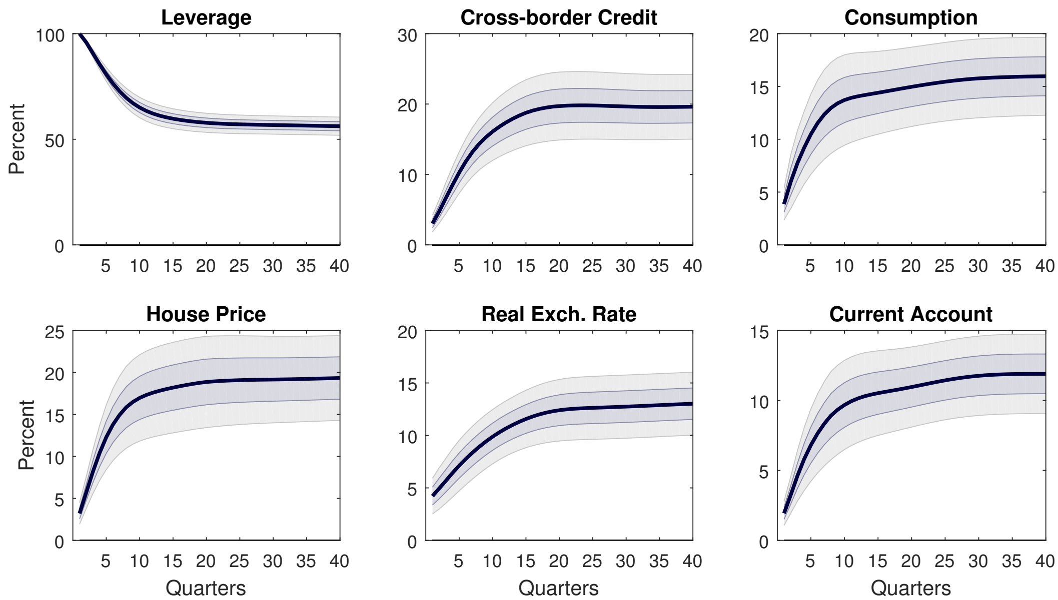
$$\beta R^b = \frac{\kappa}{q} \qquad \text{and} \qquad \beta R \frac{s_2}{s_1} = \frac{\kappa}{q}.$$

These two expressions equalize the cost of borrowing, in domestic and foreign currency, respectively, to the return on housing. Housing returns in domestic currency must fall in line with declining lending rates when the international supply of credit expands. Given a constant marginal utility of housing, this adjustment must happen via an increase in house prices that erodes returns as the boom triggered by the shock propagates.

The model, therefore, predicts that returns on other "risky" assets fall in response to the international credit supply shock like 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 return on housing via an asset price boom. In the data, the net effect of capital inflows will depend on the balance between the falling returns in local currency and the appreciating real exchange rate that make those lower returns more attractive to foreign investors. The fact that, in the data, the current account swings into deficit in response to the shock means that cross-border claims co-move closely with total net capital inflows. This observation in turn suggests that the exchange rate component of the total return may be dominating the underlying return decline in domestic-currency from the perspective of foreign investors.

The effects of the international credit supply shock are quantitatively sizable. Cross-border bank claims display a hump-shaped response, with an impact response of slightly less than 1% percent and a peak response just below 2% percent. This corresponds to an impact increase of about USD250 billions if this multiplier is applied to all countries in the sample, relative to the post global financial crisis global average of USD25 trillions. Consumption and real house prices increase by about 0.3% percent and 0.75% percent,

Figure 7. Share of Variance Explained by International Credit Supply Shock.



Note. Mean group estimate of the forecast error variance decomposition due to the international credit supply shock. The dark and light shaded areas are one- and two-standard deviation confidence intervals, respectively.

respectively, above their long-run levels within a year. The real exchange rate vis-a-vis the US Dollar appreciates on impact by about 0.6% percent, arguably driven by the nominal exchange rate, strengthens some more, and then reverts very slowly toward its equilibrium level. Finally, the current account turns into a deficit, with a trough of more than 0.15% percentage points of GDP. Ignoring the fact that the VAR model responses may not be accurate to evaluate a large change in leverage, the estimated elasticities imply a consumption drop during the global financial crisis of about 4-5 percentage points in the typical economy, compared to the 7 percent registered by the United States during the NBER-dated phase of the great recession, with leverage falling by 15 times.

Figure 7 reports the mean group estimate of the share of variance explained by the international credit supply shock. The shock we focus on is important for the dynamics of the data as it explains a sizable portion of the variance of all variables in the VAR system. At the same time, US Broker-Dealers' leverage is explained mostly by shocks to itself within the first a year or so, consistent with the identification assumptions made. Our leverage shock accounts for 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 exceed the share of forecast error variance that is typically explained by domestic monetary policy shocks.

As we report in Figures (D.2-D.7) of the paper supplement, these results are fairly robust. We have findings similar to the baseline when we condition on contemporaneous world GDP in the VAR systems. When we exclude lagged country variables from the leverage equation, we find stronger effects, while the effects of the shock are qualitatively similar, but quantitatively weaker when we condition on world equity prices, possibly reflecting the fact that world equity prices incorporate information, like risk premia, also captured by the leverage variable.[23] When we drop from the sample Japan, Germany, the United Kingdom, and Switzerland, economies that are relatively large in economic or financial terms like the United States, we find exactly the same results. Finally, when we estimate the model with averages of the Local Projections following Jorda (2005), constructed like our mean group estimates, we find essentially the same results for all variables except the exchange rate for the forecast step 3, 4 and 5. And even in the case of the exchange rate response, the results are essentially the same with LPs if we use the real effective exchange rate, rather than the bilateral rate vis-a-vis the US dollar, which is less volatile.

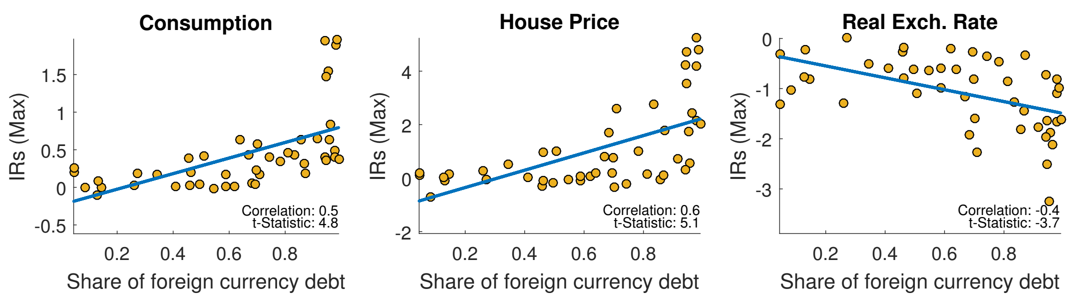
5 Understanding Cross-Country Differences

The error bands in Figure 6 for the responses of consumption, house prices, 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 are associated with 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 suggests that the intensity of the country responses to the credit

[23]The reason why these additional controls do not alter the results significantly is that the reduced form residuals of the country VARs are weakly correlated across countries. For example, in the case of the consumption equation, the average pairwise correlation across countries of the reduced form innovations is a mere 0.075 in the baseline. Conditioning on world equity prices, it falls only to 0.06.

Figure 8. Cross-country Differences in Response to International Credit Supply Shock: Share of Foreign Currency Liabilities.



Note. The three panels plot the peak impulse response of consumption (left panel), house prices (middle panel) and the real exchange rate (right panel) to the international credit supply shock (vertical axis, *IRs (Max)*) against the share of foreign currency liabilities (horizontal axis, $1/(1+\eta)$). An exchange rate increase is a depreciation. See the Data Appendix on data sources and definitions.

shocks may be affected by the share of foreign currency liabilities and the maximum LTV limit prevailing in that country.

5.1 Share of foreign currency credit

As the share of foreign currency debt increases, the collateral exchange rate effect of a binding borrowing constraint becomes stronger. A higher share of foreign currency debt, however, strengthens also the debt valuation effect that, all else equal, is contractionary. The endowment valuation effect instead is unaffected by this country characteristic in the model.

Country differences in the share of foreign currency liabilities can account for two additional expansionary effects in the model. First, a higher share of foreign currency denominated debt decreases the interest rate burden of debt as global financial intermediaries transfer a smaller cost of hedging onto domestic borrowers. Second, a higher share of foreign currency denominated debt increases the sensitivity of the real exchange rate to variations in the level of credit via the demand channel in equation (27).

Figure 8 provides evidence consistent with our conjecture. 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

$(1/(1+\eta)$, horizontal axis). The correlations are particularly strong for consumption and house prices (about 0.5 and 0.6, respectively). The correlation is slightly weaker (-0.4), but clearly statistically significant also for the real exchange rate.

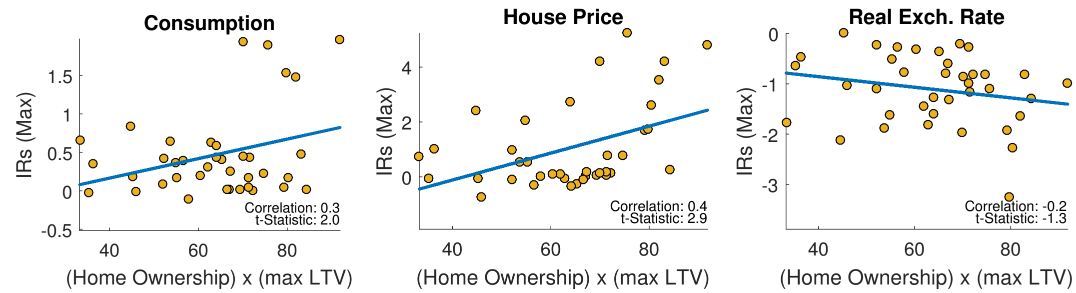
In general, it is not possible to characterize analytically the sign of the net effect associated with a higher share of foreign currency denominated debt in the model. However, in the numerical example discussed in Figure 4, the combination of the effects above implies that consumption, house prices, and the real exchange rate are more sensitive to international credit supply shocks the higher the share of debt denominated in Foreign currency. Therefore, we interpret the empirical correlations in Figure 8 as supportive evidence that the expansionary effects discussed in the model dominate. Of course, in the data, other channels will be at work that are absent from our model. These include the traditional expenditure switching effect of exchange rate changes (which would normally be contractionary, but is muted in our model because of the absence of production), and the wealth effect of any non-zero, net foreign asset position. Nonetheless, the scatter plots in Figure 8 suggests that a higher share of foreign currency debt amplifies the expansionary effect of the international credit supply shock.

5.2 Maximum LTV

A second candidate interpretation of the heterogeneous sensitivity to the international credit supply shock is country variation in the LTV ratio, which is a key determinant of leverage in the domestic financial system. For given asset prices, if the borrowing constraint is binding, a higher maximum LTV ratio allows for additional borrowing, which contributes to push up house prices, further relaxing the borrowing constraint. The model predicts that, as long as the borrowing constraint is binding, higher LTV ratios will increase consumption and house prices more, and lead to a larger appreciation of the real exchange rate. In the model, because of our strong assumptions on preference and technology, if the borrowing constraint is not binding, a higher LTV ratio is irrelevant for the response of the economy to the credit supply shock, and there is no association between the LTV ratio and the sensitivity of the economy to the shock.

Figure 9 plots 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 lever-

Figure 9. 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* $\times$ *max LTV*). Data Appendix on data sources and definitions.

age 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 shock should be lower according to our model.[24]

Figure 9 is consistent with the mechanism stressed in our model. This correlation is economically and statistically significant for house prices (about 0.4) and consumption (about 0.3), but weaker (about -0.2) and not statistically significant for the real exchange rate. Notice here that an upward sloping association between the LTV ratio and the house price response like the one found in the data, in our model, implies that the marginal borrower is constrained in most of these economies, as we assumed in deriving the transmission of the shock.

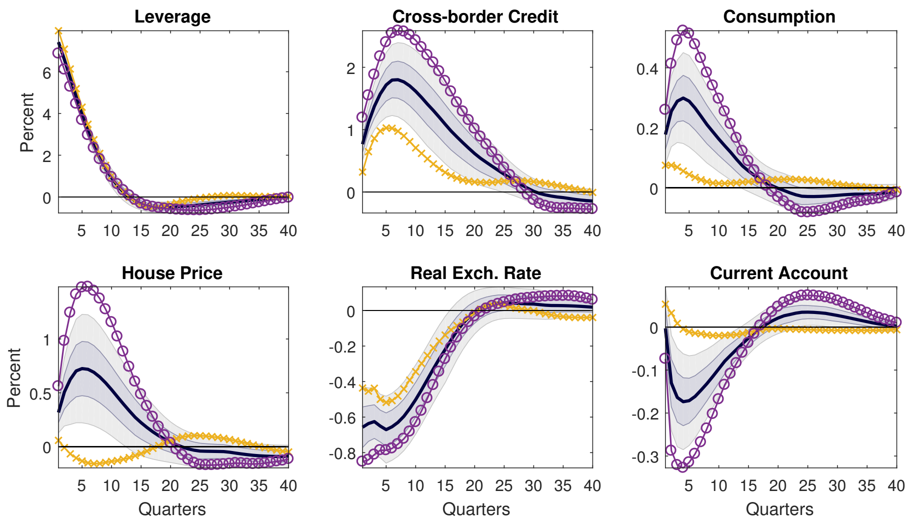
6 Robustness

The results reported in 8 and 9 are robust to using the average response over the first 4 quarters, or the share of variance of these variables explained by the credit supply shock during the first year.[25]

[24]High home-ownership alone may be a reflection of pervasive cash transactions and an inflation-hedging demand for housing which is not in our model.

[25]These robustness exercises, although not reported here, are available on request.

Figure 10. IMPULSE RESPONSES: HIGH AND LOW SHARE OF FOREIGN CURRENCY LIABILITIES



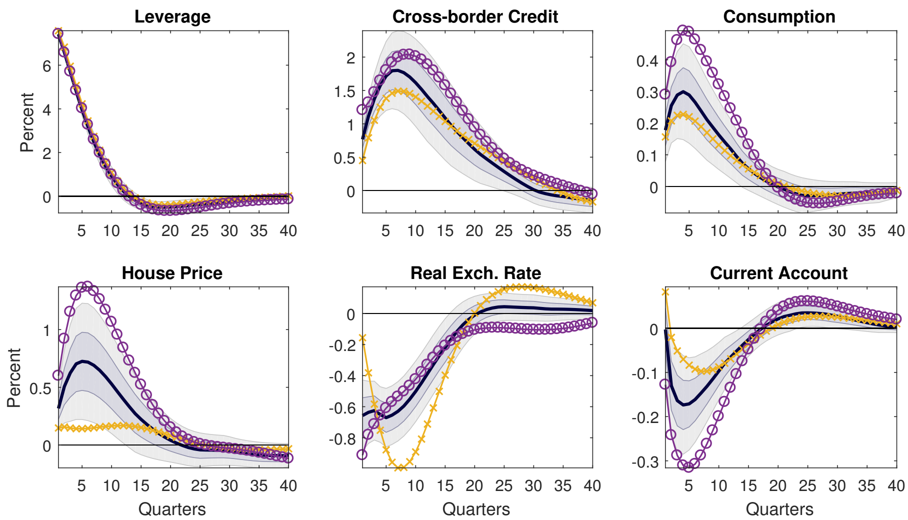
NOTE. Mean group impulse responses to a one standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively. The solid line with crosses and circles plot the mean group estimate for 'Low' and 'High' share of foreign currency liabilities, respectively.

An alternative way of looking at the heterogeneity in the effects of the international credit supply shock is to estimate our panel VAR model on different groups of countries, or 'bins', based on the country characteristics. Given the large number of countries, we can split the sample in two, while preserving the consistency of the mean group estimates. We create these two sub-samples of 25 countries by grouping 'above' or 'below' the median value of each characteristic (labeled 'high' and 'low') and recomputing the mean group estimates within the subsample.

Figure 10 and 11 report the results for the max LTV limit weighted by home ownership and the share of foreign currency liabilities, respectively. Each Figure plots the baseline impulse responses to the leverage shock, together with the mean (sub)group estimate for the 'low' (solid line with crosses) and 'high' (solid line with circles) value of the characteristics.

As we can see, the results for the share of foreign currency liabilities and the max LTV limit give the same message conveyed by the scatter plots in Figure 8 and 9. But notice here that a lower share of foreign currency liabilities is associated with a

Figure 11. Impulse Responses: High and Low Maximum LTV



Note. Mean group impulse responses to a one standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively. The solid line with crosses and circles represents the mean group estimate for 'Low' and 'High' maximum LTV (weighted by Home ownership), respectively.

much smoother responses than with a lower maximum LTV limit, with consumption and the current account almost flat in the former case—and thus suggesting that one characteristics might be more important than the other.

6.1 Alternative Interpretations of Cross-Country Heterogeneity

The intensity of the country responses to the international credit supply shock seems to be closely associated with the share of foreign currency liabilities ($1/(1+\eta)$) and the maximum LTV limit (θ). We focused on these two characteristics because they have a clear counterpart in the model, which helps interpreting the mechanisms at work. But it is reasonable to consider that there might be other relevant characteristics.

For instance, Table 3 reports the correlation between the cross-country peak responses of consumption, house prices, and the real exchange rate and a small set of additional country characteristics, including a measure of exchange rate flexibility (from the annual fine classification of Ilzetzki et al. (2010), averaged over the 2000-2010 pe-

Table 3. Cross-country differences in the Incidence of the International Credit Supply Shock: Alternative Interpretations.

	Consumption	House Price	Exch. Rate
Max Loan to Value	0.32	0.44	-0.21
Foreign currency liability	0.53	0.54	-0.39
Exch. Rate flexibility	-0.40	-0.41	0.16
Capital controls (inflows)	0.23	0.32	-0.28
Mortgage debt / GDP	-0.31	-0.42	0.25

Note. Correlation between the peak impulse response of selected variables (columns) and country characteristics (rows). See the appendix on data definition and sources.

riod), a '*de iure*' measure of controls on capital inflows (from Fernandez et al. (2016), averaged over the 1995-2013 period), and the mortgage credit over GDP (from Warnock and Warnock (2008), averaged over the 2001-2005 period).

Table 3 illustrates that higher exchange rate flexibility is associated with a lower consumption and house price response to the international credit supply shock, in line with the notion that a flexible exchange rate can help absorb external shocks. The result is even starker in Figure D.8 in the supplement, where we plot the impulse response by sub-groups of 'low' and 'high' exchange rate flexibility countries, and find that more flexible regimes are less vulnerable to the shock.

Table 3 also shows that controls on capital inflows correlate positively with the incidence of the shock, possibly suggesting that more vulnerable countries may adopt more controls on inflows. Notice however that there is a strong correlation between the share of foreign currency liabilities and the tightness of capital controls on inflows (0.56). So, the positive correlation between capital controls and the consumption response might be picking up the correlation between the consumption response and the share of foreign currency liabilities.

Finally, mortgage debt over GDP is negatively associated with the consumption responses. But without the aid of a model it is more difficult to assess whether this reflects better domestic risk sharing opportunities associated with a more developed financial system or other less intuitive mechanisms.

7 Conclusions

In this paper we set up a model of collateralized borrowing in domestic and foreign currency with international financial intermediation. Consistent with this model, we then identify a shock to the international supply of credit in a panel VAR framework. We find that the identified shock in the data has a transmission consistent with that implied by the model. International credit supply shocks trigger a consumption boom, house price inflation, and real exchange rate appreciation, as well as a current account deterioration. The shock also explains a non-negligible share of the variance of these variables.

We find that these effects are quantitatively stronger the higher the share of foreign currency liability in total liabilities and the maximum LTV limit in the domestic credit market. In the paper we also show that other country characteristics might be associated with this heterogeneity, including particularity the flexibility of the exchange rate regime. We leave the detailed exploration of the role of the exchange rate regime in explaining the countries difference that we uncover for future research.

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A Appendix: Episodes of Boom-Bust in Capital Flows

In this appendix 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 as reported in Figure 1 in the introduction. 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) as this is the measure of international credit that we use in our empirical analysis in the paper.[26] 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:

$$KF_{it} = \sum_{j=1}^{N} KF_{ij,t} \quad \forall j \neq i, \tag{A.1}$$

where $j = 1, ..., N$ indexes the aggregate of all BIS reporting banks in country j.

We consider a slightly wider set of variables than those studied in the theoretical and the VAR models. They include: 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 (while in our VAR analysis we use quarterly data). We use annual data to work with the longest time series available. A description of the variables and their sources is reported in the appendix below.

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).[27] The peak (trough) is defined as the last period

[26] Consistent with the empirical analysis, in the model, a representative household sector borrows directly from international financial intermediaries.

[27] This procedure is similar to the one used in the literature, e.g., Gourinchas et al. (2001), Mendoza and Terrones (2008). 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 or pick a threshold for the amplitude, which introduces spurious variation over time in the analysis.

Table A.1. Summary Statistics of Boom-Bust Episodes.

ALL	Number	Duration	Max	Min	Amplitude
booms	2.4	7.3	32.6	5.0	131.6
busts	1.4	4.4	-4.2	-20.4	-53.2
boom-bust	0.9	12.7	36.3	-21.8	103.5
AE	Number	Duration	Max	Min	Amplitude
booms	2.5	8.8	28.5	3.7	130.1
busts	1.1	3.7	-4.6	-17.5	-36.9
boom-bust	0.8	13.4	29.5	-19.2	115.7
EM	Number	Duration	Max	Min	Amplitude
booms	2.3	6.1	35.9	5.9	132.8
busts	1.6	4.8	-4.1	-21.9	-61.3
boom-bust	0.9	12.4	40.5	-23.5	96.0

Note. Summary statistics of boom-bust episodes computed over the full sample of countries (ALL), and splitting the sample in advanced (AE) and emerging economies (EM).

within the episode in which the annual rate of growth of cross-border credit is positive (negative). 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. Figure 1 in the paper reports the results. The summary statistics for these episodes (such as duration and amplitude) are reported in Table A.1 below. Note that, of the 50 boom-busts, only 20 started after 1994 and about 33 ended by 2005; in the case of the booms, 76 started by 1994 and 83 ended by 2004. Thus, these statistics suggest that the bulk of the episodes identified are not concentrated in the run up to, or during, the global financial crisis.

B Appendix: Data 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 collected The data set includes the 1970:Q1 – 2012:Q4 (subject to 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 B.1.

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

Nominal exchange rate vis-à-vis US dollar. US dollars per unit of domestic currency (a decline is a depreciation). Source: Datastream. Real bilateral exchange rate obtained by adjusting with CPI indexes.

Real effective exchange rate. Index such that a decline 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. Average over the 2005-2014 period. Source: Housing Finance Information Network (HOFINET).

Maximum LTV ratios. For the vast majority of countries, the maximum LTV corresponds to its legal limit (when such limit exists). Source: Cerutti et al. (2015).

Shares of foreign currency liabilities over total liabilities. Authors' calculations based on a confidential version of the *Total cross-border bank lending* data described above. The share is computed as cross-border bank claims in foreign currency over total cross-border bank claims. The correlation between these shares and those of Lane and Shambaugh (2010) is 0.78. Source: BIS.

Table B.1. House Price Data: Definitions and Sources

Country	Definition	Source
Argentina	House Apartments in Buenos Aires City, average price per sqm (USD).	Arklems
Australia	House Price Indexes: Eight Capital Cities.	OECD
Austria	Residential property prices, new and existing dwellings.	OECD
Belgium	Residential property prices, existing dwellings, whole country.	OECD
Brazil	Residential Real Estate Collateral Value Index.	Central Bank
Bulgaria	Residential property price, existing flats (big cities), per sqm.	BIS
Canada	Average existing home prices.	OECD
Chile	HPI general, houses and apartments.	Central Bank
China	House price index.	OECD
Colombia	House Price Index.	Central Bank
Croatia	House price index	Dallas FED
Czech Rep.	Residential property prices, existing dwellings, whole country.	OECD
Denmark	Price index for sales of property.	OECD
Estonia	Residential property prices, all dwellings, per sqm.	BIS
Finland	Prices of dwellings.	OECD
France	Indice trimestriel des prix des logements anciens.	OECD
Germany	Residential property prices in Germany.	OECD
Greece	Prices of dwellings.	OECD
Hong Kong	Residential property price, all dwellings, per sqm.	BIS
Hungary	Residential property price, all dwellings, per sqm.	BIS
Iceland	Residential property price, all dwellings (Reykjavk), per sqm.	BIS
India	Residex.	National Housing Bank
Indonesia	Residential property prices, new houses (big cities), per dwelling.	BIS
Ireland	Residential property price index.	OECD
Israel	Prices of dwellings.	OECD
Italy	Residential property prices, existing dwellings, whole country.	OECD
Japan	Urban Land Price Index.	OECD
Korea	House price index.	Dallas FED
Latvia	Residential property prices, new and existing flats, whole country.	ECB
Lithuania	Residential property price, all dwellings, per sqm.	BIS
Luxembourg	House price index.	Dallas FED
Malaysia	Residential property prices, all dwellings, per sqm.	BIS
Malta	Property Prices Index (based on advertised prices).	Central Bank
Mexico	Residential property prices, all dwellings, per dwelling.	BIS
Morocco	Residential property prices, existing dwellings, per sqm.	BIS
Netherlands	House Price Index for existing own homes.	OECD
New Zealand	House price index.	OECD
Norway	House price index.	OECD
Peru	Residential property prices, per sqm.	BIS
Philippines	Residential and commercial property prices, flats (Makati), per sqm.	BIS
Poland	Residential property prices, (big cities), per sqm.	BIS
Portugal	Residential property prices, new and existing dwellings.	BIS
Russia	Residential property prices, existing dwellings, per sqm.	BIS
Serbia	Average prices of dwellings in new construction, per sqm.	National Stat. Office
Singapore	Average prices of dwellings in new construction, per sqm.	BIS
Slovak Rep.	Residential property prices, existing dwellings.	OECD
Slovenia	House price index.	OECD
South Africa	Residential property price.	BIS
Spain	Precio medio del m2 de la vivienda libre (> 2 anos de antiguedad).	OECD
Sweden	Real estate price index for one and two dwelling buildings for permanent living.	OECD
Switzerland	Real estate price indices.	OECD
Taiwan	National House Price Index.	Synyi
Thailand	Residential property prices, average of all detached houses, per sqm.	BIS
Ukraine	Average Price of Apartments, Kiev, per sqm (USD).	Blagovest
UK	Mix-adjusted house price index.	OECD
US	Purchase and all-transactions indices.	OECD
Uruguay	Precio promedio del metro cuadrado de compraventas, Montevideo (USD).	National Stat. Office

Note. See Cesa-Bianchi, Cespedes, and Rebucci (2015) for more details and the sources of house price series extended with historical data.

C Supplement: Model Derivations

This appendix reports the full set of equilibrium conditions of the model. It then derives expressions for the terms of trade and the credit market equilibrium, discusses the slope of the credit demand, and finally analyzes the response to a change in χ for the small open economy case that is relevant to support the VAR identification and interpret the empirical results.

C.1 Equilibrium Conditions

A competitive equilibrium for our 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:

$$\begin{aligned} 1 - \mu &= \beta R^b, \\ 1 - \mu &= \beta R \frac{s_2}{s_1}, \\ (1 - \mu\theta) q &= \kappa, \\ (1 + \eta) s_1 f &\leq \theta q, \\ c_1 &= \tau_1^{\alpha - 1} y + (1 + \eta) s_1 f, \\ c_2 &= \tau_2^{\alpha - 1} y - (1 + \eta) s_2 R f, \end{aligned}$$

   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:

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

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

leverage constraints:

$$
\begin{aligned}
R &= \chi R^e + (1-\chi)R^d + \phi'(\eta f), \\
(1+\eta)f &= d + e, \\
e &= \chi(1+\eta)f.
\end{aligned}
$$

4. Goods market clear in every period:

$$
\begin{aligned}
ny &= n\alpha\tau_1^{1-\alpha}c_1 + (1-n)\alpha^*\tau_1^{1-\alpha^*}c_1^*, \\
ny &= n\alpha\tau_2^{1-\alpha}c_2 + (1-n)\alpha^*\tau_2^{1-\alpha^*}c_2^*, \\
(1-n)y^* &= n\,(1-\alpha)\,\tau_1^{-\alpha}c_1 + (1-n)\,(1-\alpha^*)\,\tau_1^{-\alpha^*}c_1^*, \\
(1-n)y^* &= n\,(1-\alpha)\,\tau_2^{-\alpha}c_2 + (1-n)\,(1-\alpha^*)\,\tau_2^{-\alpha^*}c_2^*.
\end{aligned}
$$

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

$$
s_1 = \tau_1^{\alpha-\alpha^*} \qquad\qquad s_2 = \tau_2^{\alpha-\alpha^*}.
$$

There are 18 equations for 16 variables. Two goods market equilibrium conditions (one in each period) are redundant by Walras's Law.

C.2 Small Open Economy Case

We now 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.

C.2.1 Goods Market and the Terms of Trade

We start from the goods market equilibrium:

$$
\begin{aligned}
ny &= n\alpha\tau^{1-\alpha}c + (1-n)\alpha^*\tau^{1-\alpha^*}c^*, &\text{(C.1)} \\
(1-n)y^* &= n\,(1-\alpha)\,\tau^{-\alpha}c + (1-n)\,(1-\alpha^*)\,\tau^{-\alpha^*}c^*, &\text{(C.2)}
\end{aligned}
$$

where we dropped the time subscript as these expressions are static and have the same form in both periods. Rewrite these conditions as

$$y = \alpha \tau^{1-\alpha} c + \frac{1-n}{n} \alpha^* \tau^{1-\alpha^*} c^*, \tag{C.3}$$

$$y^* = \frac{n}{1-n} (1-\alpha) \tau^{-\alpha} c + (1-n)(1-\alpha^*) \tau^{-\alpha^*} c^*. \tag{C.4}$$

Next, use the relationship between the consumption shares, the country size, and the degree of openness ($\alpha = 1 - (1-n)\lambda$ and $\alpha^* = n\lambda$) to obtain

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

$$y^* = \frac{n}{1-n} (1-n)\lambda \tau^{(1-n)\lambda - 1} c + (1-n\lambda) \tau^{-n\lambda} c^*. \tag{C.6}$$

Simplifying and taking the limit for n that goes to zero, the previous expressions yield

$$y = (1-\lambda)\tau^{\lambda} c + \lambda \tau c^*, \tag{C.7}$$

$$y^* = c^*, \tag{C.8}$$

which imply 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

$$c_1 = \tau_1^{1-\lambda}(1+\eta)f + \tau_1^{-\lambda} y, \tag{C.9}$$

where we have used the relation above between the real exchange rate and the terms of trade. Now 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

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

Intuitively, higher credit 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 is

$$c_2 = \tau_2^{-\lambda} y - \tau_2^{1-\lambda}(1+\eta)Rf.$$

Substitute again into the goods market equilibrium to obtain the terms of trade

$$\tau_2 = \frac{\lambda y}{\lambda y^* - (1-\lambda)(1+\eta)Rf}, \tag{C.11}$$

and and hence the real exchange rate

$$s_2 = \left[\frac{\lambda y}{\lambda y^* - (1-\lambda)(1+\eta)Rf}\right]^{1-\lambda}. \tag{C.12}$$

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

C.2.2 Credit Market

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

Credit Supply. We start with the 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

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

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 the credit demand. Start from the optimal choice of housing services. If the borrowing constraint is not binding ($\mu = 0$), the equilibrium conditions for domestic households reduce to to $q = \kappa$ (the first order condition for housing services), $(1+\eta)s_1 f < \theta q$ (the non-binding collateral constraint), and the consumption Euler equation

$$R = \frac{1}{\beta}\frac{s_1}{s_2}.$$

Consider now the equilibrium with binding borrowing constraint ($\mu > 0$). In this case, we can solve for the Lagrange multiplier from the Euler equation to yield

$$\mu = 1 - \beta R \frac{s_2}{s_1}. \tag{C.13}$$

Substituting this expression into the housing pricing equation we have

$$\left(1 - \theta + \theta \beta R \frac{s_2}{s_1}\right) q = \kappa. \tag{C.14}$$

And solving for q and substituting into the borrowing constraint with equality yields

$$(1+\eta) s_1 f = \frac{\theta \kappa}{1 - \theta + \theta \beta R s_2 / s_1}, \tag{C.15}$$

which can be solved to obtain

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

C.3 Slope of Credit Demand

Debt valuation effects associated with the real exchange rate may generate a credit demand function with a segment is not downward sloping. So here we study the conditions under which it is well-behaved.

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

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

Now define the function

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

so that we can apply the implicit function theorem. In particular, we have that

$$\frac{\partial R}{\partial f} = -\frac{\partial G_1 / \partial f}{\partial G_1 / \partial R}. \tag{C.16}$$

The derivative at the numerator is

$$\frac{\partial G_1}{\partial f} = -\frac{1}{\beta}\left(\frac{s_1}{s_2}\right)^{\lambda} \frac{\lambda y^*(1+\eta)(R+1)}{[\lambda y^* + (1-\lambda)(1+\eta)f]^2} < 0.$$

The derivative at the denominator is

$$\frac{\partial G_1}{\partial R} = -\left[1 + \frac{1}{\beta}\left(\frac{s_1}{s_2}\right)^{\lambda} \frac{(1+\eta)f}{\lambda y^* + (1-\lambda)(1+\eta)f}\right] < 0.$$

As both numerator and denominator of (C.16) are negative, in the region where the collateral constraint does not bind, the credit demand function will be negatively sloped.

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

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

The slope of credit demand if the collateral constraint binds is

$$\frac{\partial R}{\partial f} = -\frac{\partial G_2/\partial f}{\partial G_2/\partial R}. \tag{C.17}$$

And the derivative at the numerator is

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

while the derivative at the denominator is

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

So in the limiting case of 100 percent LTV, credit demand continues unequivocally to be downward sloping. A simple continuity argument suggests that the result carries through for high enough values of θ. Indeed, in our numerical example in which we set θ to the high value of 92% (close to the average maximum LTV in our country sample of about 90%), credit demand is downward sloping when the collateral constraint binds.

C.4 The Transmission of an International Credit Supply Shock

This appendix derives analytically the approximate response of the economy to a change in χ. We focus on the region in which the collateral constraint binds. For small enough changes in χ, a log-linear approximation provides an accurate description of the impact of the credit supply shock.[28]

Start from the expression (C.10) for the real exchange rate in period 1 that can be rewritten as

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

The linear approximation around a steady state with binding constraint is

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

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

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

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

$$\hat{s}_1 = -\frac{(1-\lambda)^2}{\lambda y}\bar{s}_1^{\frac{1}{1-\lambda}}(1+\eta)\bar{f}\hat{f}. \tag{C.18}$$

Now consider period 2 and rewrite s_2 as

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

The linear approximation around the steady state is

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

[28] We denote the steady state value of a generic variable x with $\bar{x}$ and the log-deviation from steady state as $\hat{x} \equiv (x-\bar{x})/\bar{x}$.

Using the expression for s_2, we can write the last expression as

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

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

$$\hat{s}_2 = \frac{(1-\lambda)^2}{\lambda y} \bar{s}_2^{\frac{1}{1-\lambda}} (1+\eta)\bar{R}\bar{f}\left(\hat{R} + \hat{f}\right). \tag{C.19}$$

The credit demand schedule can be rewritten as

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

And its linear approximation is

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

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

$$\hat{R} = -\frac{1}{\beta\bar{R}}\left[\frac{\kappa}{(1+\eta)\bar{s}_2\bar{f}}\left(\hat{s}_2 + \hat{f}\right) + \frac{1-\theta}{\theta}\frac{\bar{s}_1}{\bar{s}_2}\left(\hat{s}_1 - \hat{s}_2\right)\right]. \tag{C.20}$$

Finally, the expression for credit supply is

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

and its linear approximation is

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

where ψ' and ψ'' 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

$$\hat{R} = \frac{\bar{\chi}}{\beta^*\bar{R}}[\psi' + \bar{\chi}(1+\eta)\psi''\bar{f}]\hat{\chi} + \frac{\bar{f}}{\beta^*\bar{R}}\left[\bar{\chi}^2\psi''(1+\eta) + \frac{\eta^2\phi''}{1+\eta}\right]\hat{f}. \tag{C.21}$$

Expressions (C.18)-(C.21) constitute a linear system of four equations in four unknowns $\{\hat{s}_1, \hat{s}_2, \hat{R}, \hat{f}\}$ that also depend on $\hat{\chi}$. Thus, 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

$$\begin{aligned}
a_{14} &\equiv \frac{(1-\lambda)^2}{\lambda y}\bar{s}_1^{\frac{1}{1-\lambda}}(1+\eta)\bar{f} > 0 \\
a_{23} = a_{24} &\equiv -\frac{(1-\lambda)^2}{\lambda y}\bar{s}_2^{\frac{1}{1-\lambda}}(1+\eta)\bar{R}\bar{f} < 0 \\
a_{31} &\equiv \frac{1}{\beta\bar{R}}\frac{1-\theta}{\theta}\frac{\bar{s}_1}{\bar{s}_2} > 0 \\
a_{34} &\equiv \frac{\kappa}{\beta\bar{R}\bar{s}_2(1+\eta)\bar{f}} > 0 \\
a_{44} &\equiv -\frac{\bar{f}}{\beta^*\bar{R}}\left[\bar{\chi}^2\psi''(1+\eta) + \frac{\eta^2\phi''}{1+\eta}\right] < 0
\end{aligned}$$

and the non-zero coefficient of the vector B is

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

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

$$\begin{aligned}
\hat{s}_1 &\equiv \frac{a_{14}b_{41}(a_{23}-1)}{d}\hat{\chi} \\
\hat{s}_2 &\equiv -\frac{b_{41}a_{23}(1-a_{24}+a_{14}a_{31})}{d}\hat{\chi} \\
\hat{R} &\equiv \frac{b_{41}(a_{23}-a_{34}+a_{14}a_{31})}{d}\hat{\chi} \\
\hat{f} &\equiv -\frac{b_{41}(a_{23}-1)}{d}\hat{\chi},
\end{aligned}$$

where

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

In the limit, for $\theta \to 1$, we have that $a_{31} = 0$ and hence $d < 0$. In this case it is easy to see that

$$\frac{\partial \hat{s}_1}{\partial \hat{\chi}} > 0 \qquad \frac{\partial \hat{R}}{\partial \hat{\chi}} > 0 \qquad \frac{\partial \hat{f}}{\partial \hat{\chi}} < 0.$$

Therefore, in response to a positive international credit supply shock (a fall in χ), the real exchange rate appreciates, the real lending rate falls, and the amount of credit extended to the Home economy 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 $a_{14} > 1$; a condition that is always satisfied for large enough levels of credit over GDP.

Finally, the response of consumption to the credit shock is

$$\frac{\partial c_1}{\partial \chi} = (1+\eta)\bar{s}_1\frac{\partial f}{\partial \chi} + \left[(1+\eta)\bar{f} - \frac{\lambda}{1-\lambda}\bar{s}_1^{-\left(1+\frac{\lambda}{1-\lambda}\right)}y\right]\frac{\partial s_1}{\partial \chi}$$

A positive international credit supply shock increases consumption, both directly (the first term in the expression above) and indirectly 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.

D Supplement: Additional Empirical Results and VAR Robustness

This Supplement (not for publication) reports additional stylized facts and empirical results, including a a battery of robustness checks on the panel VAR results.

D.1 Time-varying share of foreign currency liabilities

In the model we assume that the share of foreign currency credit ($1/(1+\eta)$) is constant over time. In fact, $1/(1+\eta)$ is an equilibrium variable that may vary over time in response to shocks. At the country level, however, there is relatively little time variation. To illustrate this, we divide our sample in two sub-samples and we plot the average share of foreign currency credit during the first period through the Asian financial crisis (the 1985-1999 period) against the average share thereafter (the 2000-2015 period).

Figure D.1 shows that most country data points are close to the 45 degree line, suggesting that the shares have not changed much over time. Specifically, the correlation between the two set of shares is 0.9 and highly statistically significant.

D.2 VAR Robustness

In this section, we analyze the robustness of our empirical results. First, we consider a specification in which both contemporaneous and lagged domestic variables are excluded from the leverage equation. Second, we consider specifications in which we control for the possible presence of common country-specific shocks that could invalidate our identification assumption. The US and international business cycle are interrelated and both can affect US Broker-Dealer leverage. To control for common shocks, we augment our baseline specification with world GDP or would equity prices, ordering these two variables before leverage in the system. We consider world equity prices as this is a forward looking variable.

The results from these experiments (reported in in figures D.2-D.3, respectively) show that our baseline results are fairly robust. Both the impulse responses and the forecast error variance decompositions remain close to the baseline, with some quantitative differences. In particular, we find stronger impacts of the shock when we restrict the feedback from the lagged country variables to the leverage equation, and slightly weaker effects when we control for world GDP and especially world equity prices. We note here that world equity prices capture a broad set of factors, including risk premia also captured by leverage. It is therefore remarkable that they affect the results only quantitatively.

In the baseline PVAR model, the identification of the leverage shock rests on a small open economy assumption that might not apply to larger economies like Germany, the United Kingdom, Japan, and Switzerland (like the United States, which for this reason is excluded from the analysis). In Figure D.5 we we drop these larger economies from the sample and, for comparison, we also plots our baseline impulse responses (solid line with circles). The results are virtually unchanged.

D.3 VARs vs. Local Projections

While VARs provide a rich set of statistics on the dynamic properties of a system, they might be misspecified along multiple dimensions. The Local Projection (LP) methodology, developed by Jorda (2005) and applied in a similar setting to ours in Jorda et al. (2015) provides a more limited set of statistics is more robust. As we noted earlier, in the context of a PVAR model with a large number of countries, lag selection is particularly challenging.

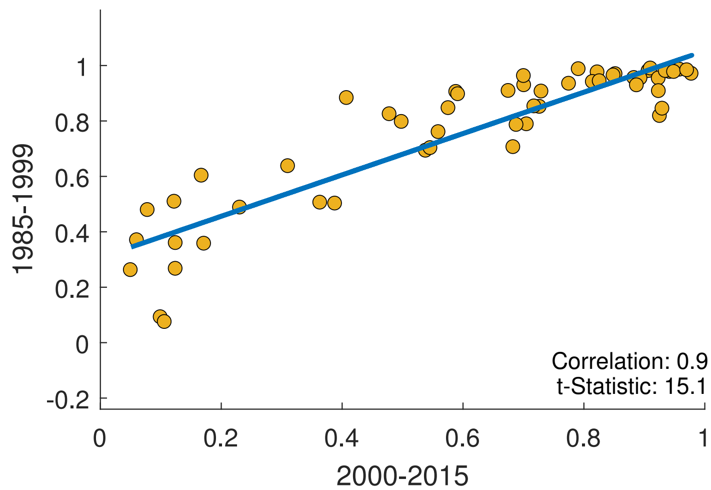
To check robustness on our results in this direction, we compute the LPs for each country, and each variable in our VAR, based on a specification in which Broker-Dealer leverage is treated as exogenous variable from the perspective of the small open economy. We then compute a mean group LP as the average of the country LPs like in the case of the VARs. The LP, in fact, is a dynamic regression, and coefficient heterogeneity would render a pooled estimate inconsistent like in a standard dynamic panel data model context (e.g., Pesaran and Smith (1995)

Figure D.6 reports the results and shows that the LP methodology yields essentially the same results over the relevant projection horizons for all variables except the exchange rate at forecast step 3, 4, and 5. And if we use the real effective exchange rate rather than the bilateral exchange rate vis-a-vis the US dollar, the results are the essentially the same also in the case of the exchange rate response (Figure D.7) because the response of the effective rate is less volatile than the bilateral real exchange rate.

D.4 VARs on Different Groups of Countries ('bins'): The Role of Exchange Rate Flexibility

In this section, we report the results we obtain from estimating our panel VAR model on different groups of countries, or 'bins', focusing on the role of exchange rate flexibility. As we explain in the main text, this is an alternative way of looking at the heterogeneity in the effects of the international credit supply shock. The impulse responses are reported in Figure D.8.

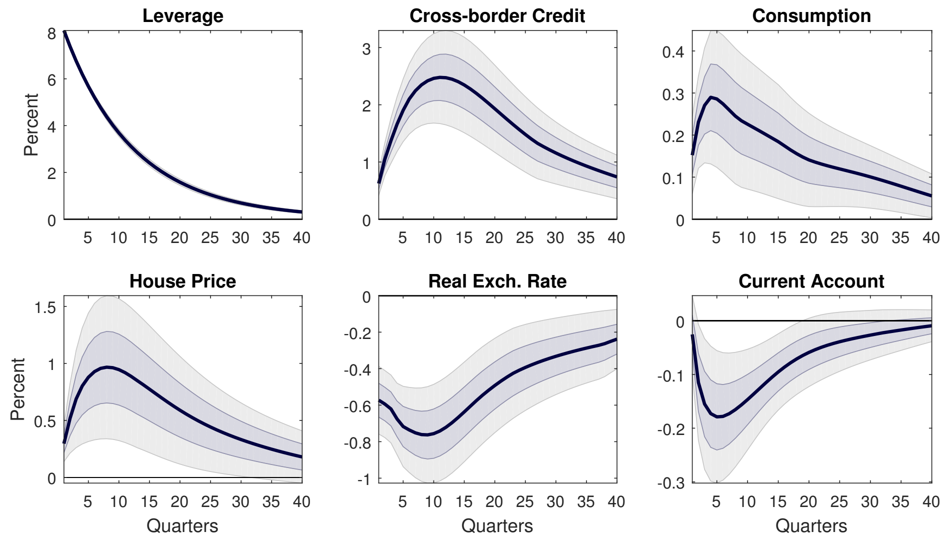
Figure D.1. Shares of Foreign Currency Liabilities Before and After the Asian Crisis Over Subsamples.



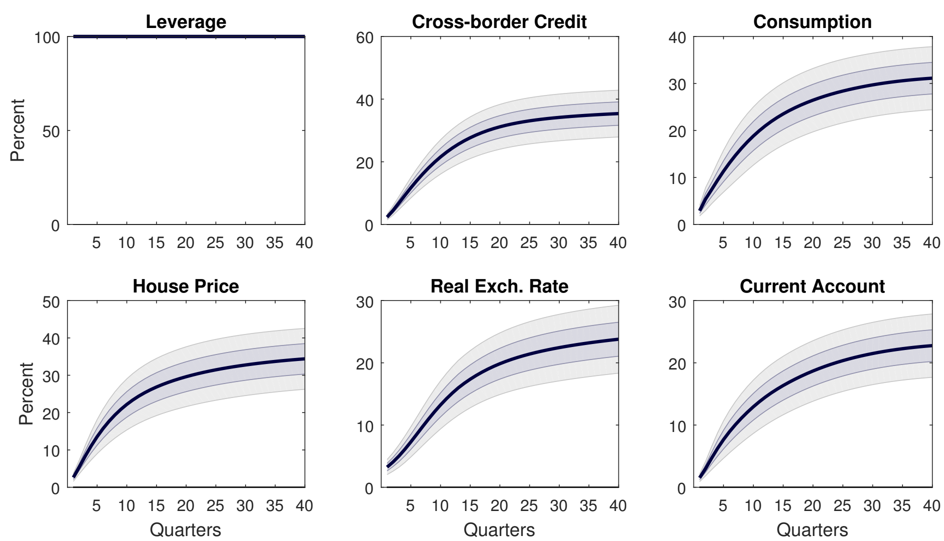
Note. Shares of foreign currency liabilities over total liabilities computed over the 1985-1999 sample (y-axis) and the 2000-2015 sample (x-axis). The shares are computed using the currency breakdown of cross-border bank claims (the data used in the baseline VAR in the paper) provided by the BIS.

Figure D.2. Impulse Responses and Forecast Error Variance Decompositions: Restricted Model.

(A) Impulse responses



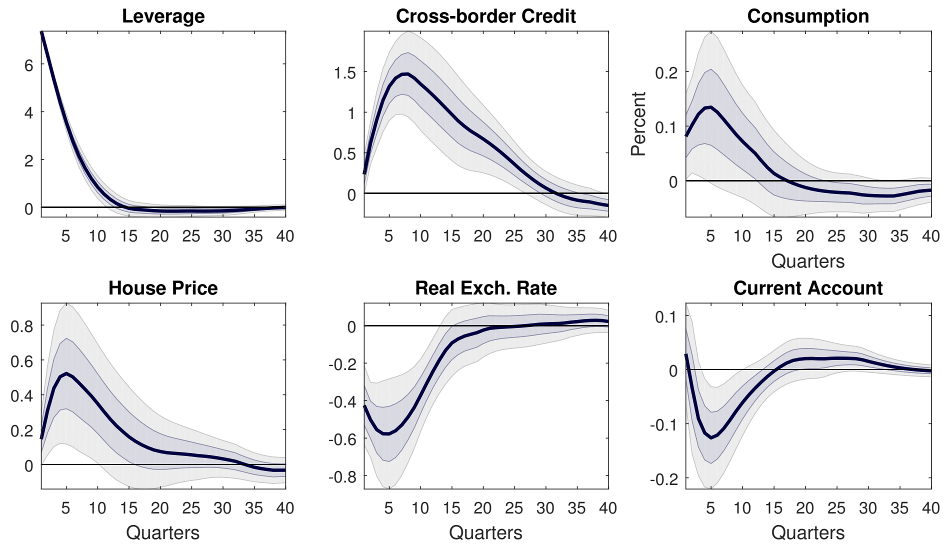
(B) Forecast error variance decompositions



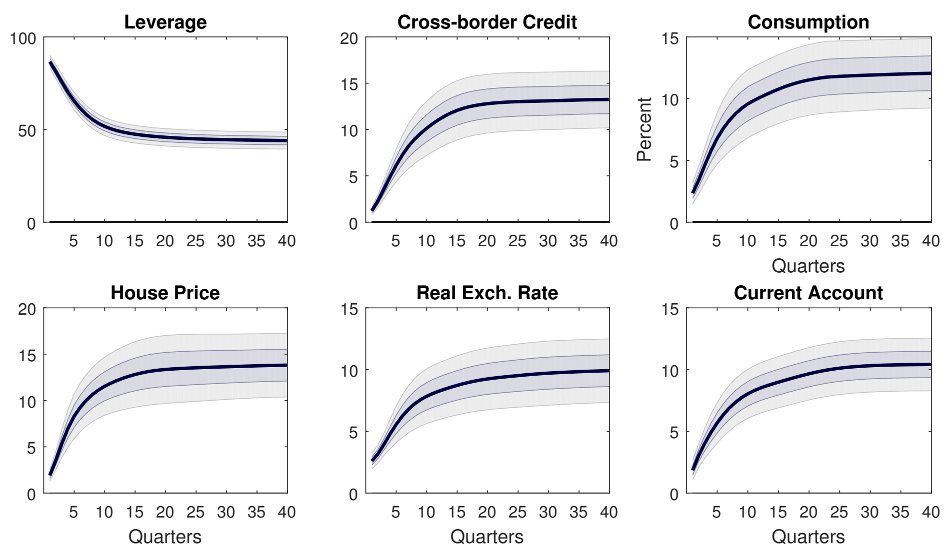
Note. Mean group impulse responses and forecast error variance decompositions to a one standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively. No lagged country variable enters the leverage equation.

Figure D.3. Impulse Responses and Forecast Error Variance Decompositions: Controlling for World GDP.

(A) Impulse responses



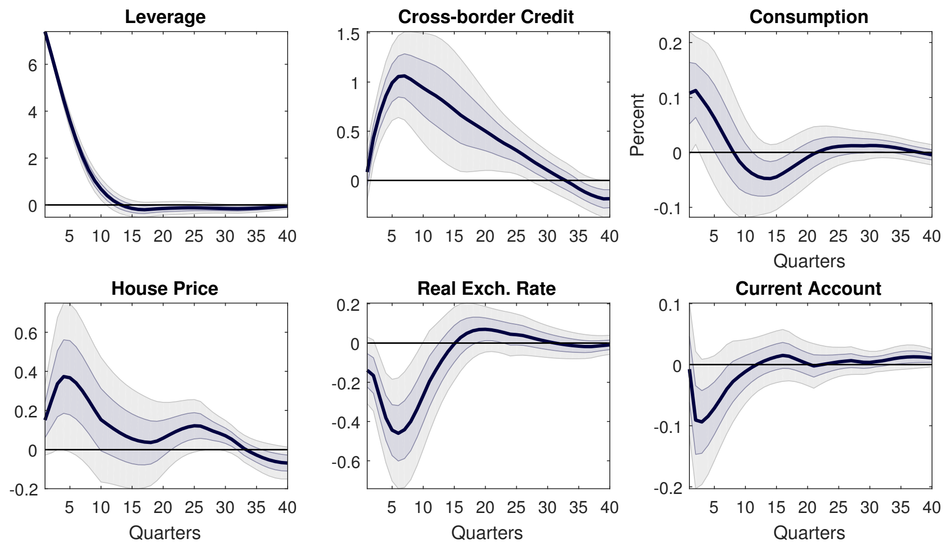
(B) Forecast error variance decompositions



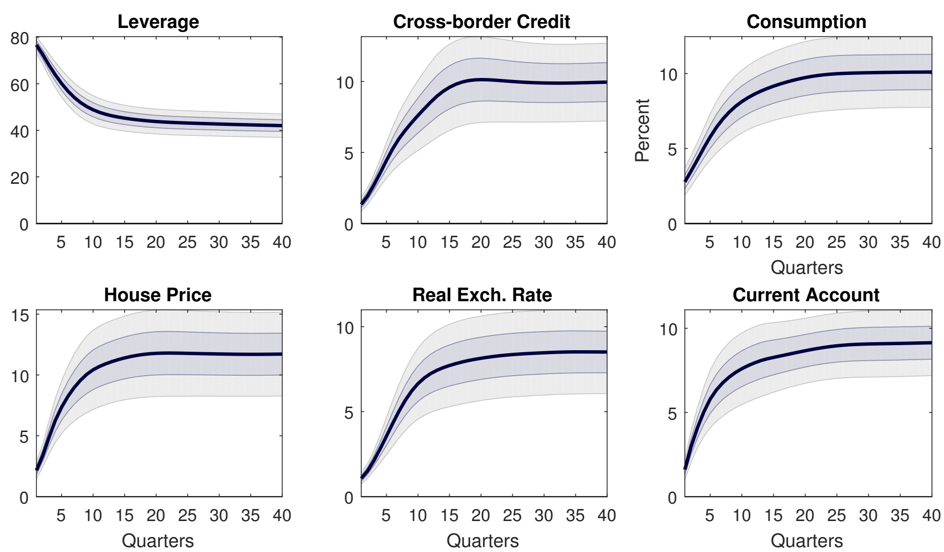
Note. Mean group impulse responses and forecast error variance decompositions to a one standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively. World GDP added to the country VARs and ordered first in the system.

Figure D.4. Impulse Responses and Forecast Error Variance Decompositions: Controlling for World Equity Prices.

(A) Impulse responses

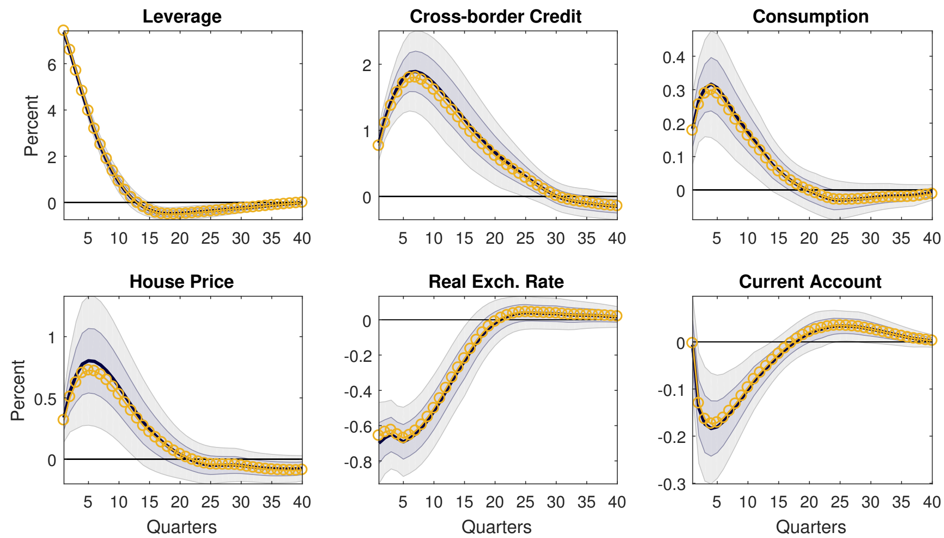


(B) Forecast error variance decompositions



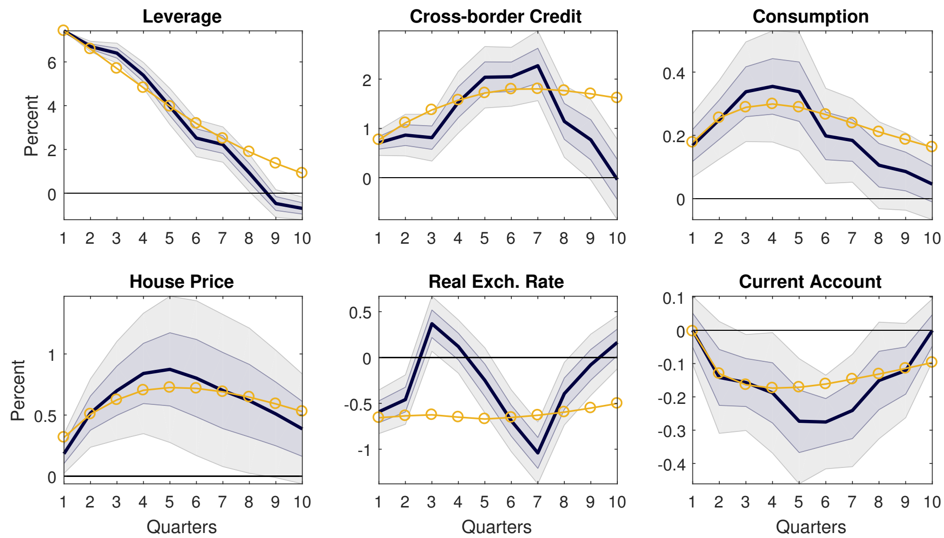
Note. Mean group impulse responses and forecast error variance decompositions to a one standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively. World equity prices added to the country VARs and ordered first in the system.

Figure D.5. Impulse Responses to an International Credit Supply Shock Excluding Larger Economies.



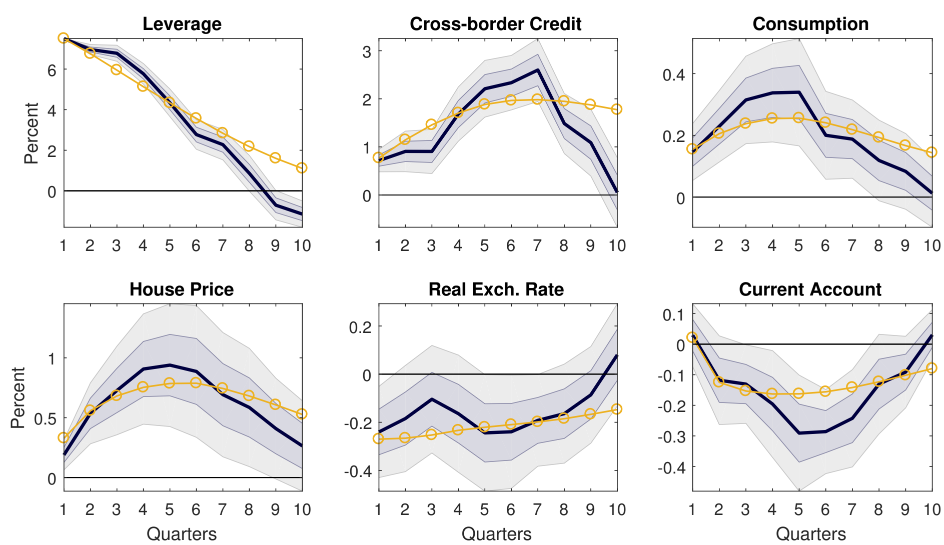
Note. Impulse responses to a one standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively. Countries dropped: Germany, the United Kingdom, Japan, and Switzerland. The line with circles is the baseline estimate reported in the paper.

Figure D.6. VARs vs. LPs with Bilateral Exchange Rate.



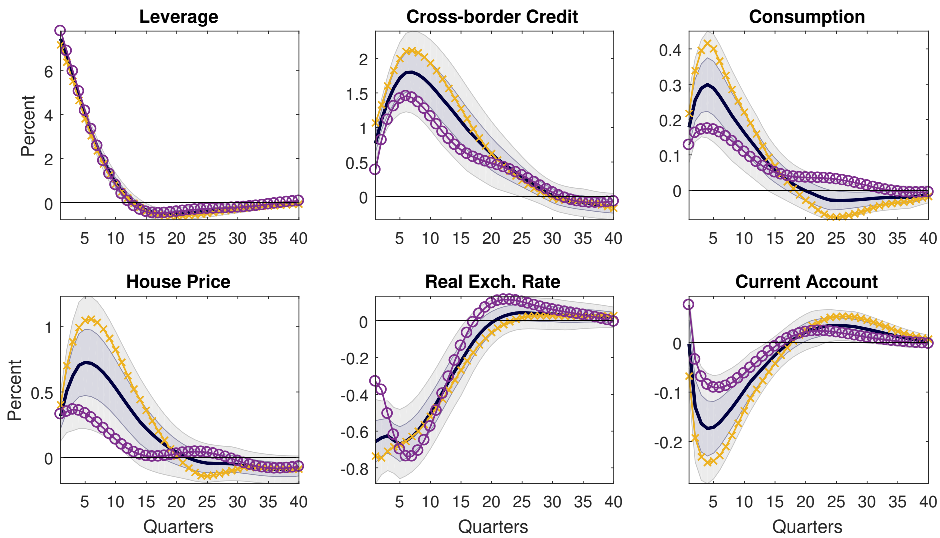
Note. LPs onto a one-standard deviation (7.5%) increase in US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals. The solid line with circles is the impulse response from our baseline PVAR specification. Both LPs and VARs are mean group estimates.

Figure D.7. VARs vs. LPs with Effective Exchange Rate.



Note. LPs onto a one-standard deviation (7.5%) increase in US Broker-Dealers. The dark and light shaded areas are the one- and two-standard deviation confidence intervals. The solid line with circles is the impulse response from the baseline PVAR. Both LPs and VARs are mean group estimates.

Figure D.8. IMPULSE RESPONSES: HIGH AND LOW EXCHANGE RATE FLEXIBILITY.



NOTE. Mean Group impulse responses to a one-standard deviation (7.5%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one- and two-standard deviation confidence intervals, respectively. The solid line with crosses and circles represents the mean group estimate for 'Low' (below median value) and 'High' (above median value) exchange rate flexibility from the annual "fine" classification of Ilzetzki et al. (2010) (average over the 2000-2010 period).