International Credit Supply Shocks[☆]

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Abstract

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

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1 Introduction

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

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

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

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

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

The model we use embeds two blocks of different characteristics. One block is small but financially integrated with the rest of the world. In this economy, households are relatively impatient and subject to a standard borrowing constraint (Kiyotaki and Moore, 1997). The other block is large and is the source of the global supply of credit. Households of the foreign economy own financial intermediaries that operate globally and channel funds to the borrowing country. Financial intermediaries are subject to an exogenous capital requirement as in Brunnermeier and Sannikov (2014) and He and Krishnamurthy (2013).[1]

When the capital requirement constraint on intermediaries is relaxed, the international supply of credit expands as we document in the event study and we assume in the VAR analysis. The shock leads to a consumption boom, an appreciation of the real exchange rate and house prices inflation (while the expected return on these assets falls), like in the event study. If the collateral constraint is binding, house prices expand households' borrowing capacity. Similarly, when credit is denominated in foreign currency and the constraint is binding, the real exchange rate can boost the domestic borrowing capacity in the model. Movements in the real exchange rate, however, imply valuation effects also when the borrowing constraint is not binding and hence might have additional roles in the transmission of the credit shock. In particular, the value of the domestic endowment increases while the value of borrowing decreases if credit is denominated in foreign currency.

Finally, we investigate empirically the transmission and the relative importance of our international credit supply shock, as well as the cross country differences in its impact. We do so by

[1] In practice, several factors, such as regulation, financial innovation, risk appetite, and monetary policy, can determine a change in the leverage constraint. We do not take a stand on the ultimate cause of this shift. Instead, we focus on its consequences for the international supply of credit and the transmission to foreign economies.

specifying a Panel Vector Autoregression model (PVAR) for about 50 countries between 1985 and 2012. Following the insight of the theoretical model that we develop, we augment the PVAR model with the leverage of US Broker-Dealers, and then focus on a shock to this variable.

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

The VAR analysis, also, reveals a significant degree of heterogeneity in the transmission mechanism across countries. The the impact of the shock is much stronger in economies with larger share of liabilities denominated in foreign currency and high loan-to-value ratios, also consistent with the model we set up. We show in the model that both the tightness of this constraint (the LTV ratio) and the share of foreign currency liability can potentially affect the transmission of the international credit supply shock consistent with the cross country differences in the vulnerability to shock.

Our paper relates to three strands of literature. A first set of contributions explore how US monetary or regulatory policy stance, innovations in the financial system, and risk taking behavior can affect leverage of international financial intermediaries and the global financial cycle, both from an empirical (Rey, 2013, 2016, Forbes et al., 2016) and theoretical (Bruno and Shin, 2015, Boz and Mendoza, 2014) perspective. We take this ideas one step further and investigate, both empirically and theoretically, possible mechanism of transmission to macroeconomic variables in individual countries. We investigate the next chain in the transmission of such shocks—from the leverage of US Broker-Dealers to macroeconomic dynamics in economies at the receiving end of capital inflows and also study the cross country distribution of these effects.

The second strand consists of papers that studied the role of international capital flows in fueling the US housing boom and subsequent crash—see, among others, Justiniano et al. (2015), and Favilukis et al. (2017).[2] In this paper, we explore the role of house prices and exchange rates

[2] Aizenman and Jinjarak (2009) investigate empirically the impact of shocks to house prices for the current account.

for the transmission of capital flow shocks emanating at the center of the international financial system and potentially affecting the to the periphery.

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

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

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

In this section we document the behavior of asset prices and the real economy associated with episodes of boom-bust in international capital flows in a large sample of advanced and emerging markets. We focus on a specific component of capital flows, namely BIS reporting banks' cross-

See Gete (2009) and Ferrero (2015) for models that rationalize this direction of causality.

border claims to all sectors of the receiving economy (i.e. finacial and non-financial). For example, if $KF_{ij,t}$ is cross-border bank claims from country j to country i in period t, our capital flows variable for country i is defined as:

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

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

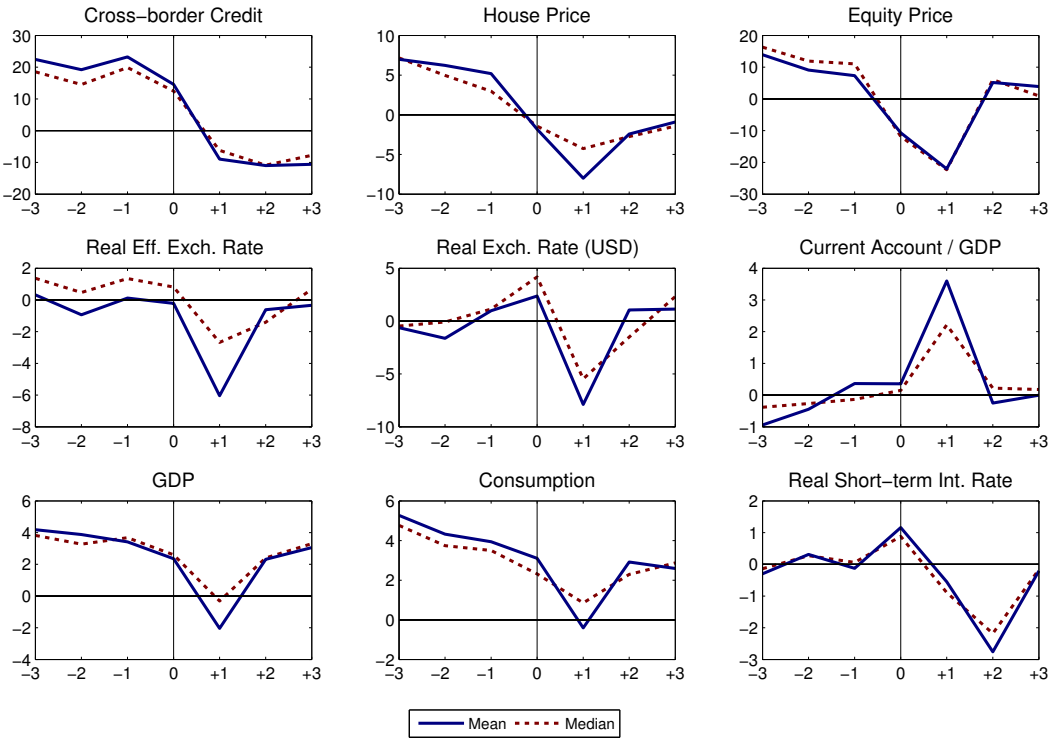
We focus on the behavior of asset prices and the real economy around boom-bust episodes in cross-border claims. To identify boom-bust episodes we define a boom (bust) as a period longer than or equal to three years in which annual cross-border claim growth is positive (negative).[3] The peak (trough) is defined as the last period within the episode in which the annual rate of growth of cross-border credit is positive (negative). We use annual data to avoid seasonal and other noisy components in quarterly data. We then define "boom-bust" episodes as episodes of booms followed by a bust.

This procedure identifies 134 booms, 81 busts, and 50 boom-bust episodes.[4] We then plot the behavior of other macro and financial variables around the identified boom-bust episodes. Figure 1 reports the results. It plots the mean and the median (solid line and dotted line, respectively) across all episodes, using a 6-year window that goes from three year before the peak to three years after the peak. In each panel, time 0 marks the peak of the boom-bust cycle in cross-border bank claims (i.e., the last period of a boom in which cross-border bank claims display a positive growth rate), which is also depicted with a vertical line. All variables are expressed in percentage changes, with the exception of the short-term interest rate and the current account over GDP which are

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

[4]The summary statistics for these episodes (such as duration and amplitude) are reported in the Appendix.

Figure 1 Event Study: Boom-Bust Episodes In Cross-border Lending



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

expressed in percentage point changes.

Figure 1 shows that a boom in cross-border banking claims is associated with an economic expansion, as both GDP and consumption display positive and elevated rate of growth (of about 3-5 percent per year). The boom is also accompanied by very fast growing house and equity prices. Real interest rates increase only the year before the peak and are associated with a fall in asset prices and a slowdown in economic activity. On average, the real effective exchange rate seems unaffected by the capital inflow, but we can see an appreciation vis-a-vis the US dollar during the last year of the boom episode. Moreover, about half of the episodes are associated with large real appreciations. The current account deteriorates sharply for most episodes, and it starts to adjust gradually in about half of them during the last year of the expansion.

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

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

3 Model

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

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

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

3.1 Goods Markets

The representative Home household consumes a Cobb-Douglas basket of Home and Foreign goods:

$$c = \frac{c_H^{\alpha} c_F^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}, \tag{2}$$

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

$$\alpha \equiv 1-(1-n)\lambda,$$

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

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

$$c_H = \alpha \left(\frac{P_H}{P}\right)^{-1} c \qquad \text{and} \qquad c_F = (1-\alpha)\left(\frac{P_F}{P}\right)^{-1} c, \tag{3}$$

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

$$P = P_H^{\alpha} P_F^{1-\alpha}. \tag{4}$$

The representative household in the Foreign block has a symmetric consumption bundle, with $\alpha^* \equiv n\lambda$ representing the Foreign consumption share of imported goods. The demand for Home and Foreign goods by the Foreign representative household are symmetric to (3), with the only difference that an asterisk denotes Foreign variables.

3.2 Exchange Rates and Relative Prices

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

$$P_H = \mathcal{E} P_H^* \qquad \text{and} \qquad P_F = \mathcal{E} P_F^*, \tag{5}$$

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

[5] The size of home bias decreases with the degree of openness and disappears when $\lambda = 1$. In the limit for $n \to 0$, the Home block becomes a small open economy. We will study this special case in details below.

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:

$$\tau = \frac{\mathcal{E}P_F^*}{P_H}. \tag{6}$$

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:

$$p_H = \tau^{\alpha-1} \qquad \text{and} \qquad p_F = \tau^{\alpha}, \tag{7}$$

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

$$p_H^* = \tau^{\alpha^*-1} \qquad \text{and} \qquad p_F^* = \tau^{\alpha^*}. \tag{8}$$

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

$$s \equiv \frac{\mathcal{E}P^*}{P}. \tag{9}$$

An increase in 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:

$$s \equiv \frac{\mathcal{E}P^*}{P} = \frac{\mathcal{E}P_F^*}{P_H} \times \frac{p_H}{p_F^*} = \tau^{\alpha-\alpha^*}. \tag{10}$$

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

3.3 Home Households

A continuum of measure $n \in [0,1]$ of households populate the Home economy. All households are identical and relatively impatient. We denote by c_1 and c_2 their consumption in the two periods. In addition, in period 1, the household decides once and for all the amount of housing services to purchase, which we assume to be proportional to the housing stock h_1.[6] Lifetime utility therefore is:

$$\mathbb{U} = u(c_1) + \beta u(c_2) + v(h_1), \tag{11}$$

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

Households are endowed with y units of Home goods in each period and h_0 initial units of housing, and can obtain credit f, denominated in Foreign currency.[7] Thus, the budget constraint in period 1 is:

$$c_1 + qh_1 - s_1 f = p_{H1} y + qh_0, \tag{12}$$

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

$$c_2 = p_{H2} y - s_2 R^b f. \tag{13}$$

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

$$s_1 f \leq \theta q h_1. \tag{14}$$

The parameter θ represents a limit that lenders impose on borrowers to mitigate issues related

[6] For simplicity, we abstract from construction and assume that housing is in fixed supply (land).

[7] We discuss the case of borrowing partially denominated in domestic currency in section 5.4 and describe the extension of the model that includes this feature in the Appendix.

to asymmetric information. In practice, 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.

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

Equation (14) shows that, when the collateral constraint binds, a real exchange rate appreciation amplifies exogenous shocks in the same vein as an increase in house prices, thereby expanding households' borrowing capacity and their consumption (collateral valuation effect). But the effects of changes in the real exchange rate are not limited to the case in which the collateral constraint binds. On the one hand, an appreciation of the domestic currency boosts the value of the endowment. This "endowment valuation effect" positively contributes to the purchasing power of Home households. On the other hand, since borrowing is denominated in Foreign currency, an appreciation reduces the purchasing power in terms of Home goods of a given amount of debt. This "debt valuation effect", which is extreme in the absence of debt denominated in domestic currency, constitutes a drag on demand by Home households.[8] On balance, an appreciation of the real exchange rate is likely to be expansionary. The reason is that the debt valuation effect can prevail only at high level of foreign indebtedness. In this case, however, the borrowing constraint is more likely to bind. Therefore, the collateral valuation effect is likely to reinforce the endowment valuation effect, thus resulting in an expansion of domestic demand in the aftermath of an appreciation.

The problem for the domestic representative household is to maximize (11) subject to (12), (13), and (14). Let $\mu\bar{c}$ be the Lagrange multiplier on the borrowing constraint, normalized by the

[8] In a dynamic context, the debt valuation effect would trade off the lower purchasing power of a given amount of debt contracted in the current period with the lower repayment on credit obtained in the past.

marginal utility of consumption. The first order condition for the optimal demand of credit is:

$$1 - \mu = \beta R^b \frac{s_2}{s_1}, \tag{15}$$

with $\mu > 0$ when $s_1 f = \theta q h_1$. Expression (15) is the consumption Euler equation under risk neutrality. This equation shows that, when binding, a tighter borrowing constraint (i.e., a higher μ) reduces the cost of forgone consumption today.

The Euler equation for the choice of housing services is:

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

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

3.4 Foreign Households

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

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

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. 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.[9]

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

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

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

where $\psi(\cdot)$ represents a convex cost of changing the equity position.[10] The equity adjustment cost creates a "pecking" order of liabilities whereby intermediaries always prefer to issue debt relative to equity. As in Jermann and Quadrini (2012), we assume that this function and its first two derivatives are positive, with $\psi'(0) = \zeta > 0$. 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 for the foreign representative household is to maximize (17) subject to (18) and (19). The first order conditions for the optimal choice of deposits and equity 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.

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

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

Assets		Liabilities	
Loans:	f	Deposits:	d
		Equity:	e

3.5 Global Financial Intermediary

The representative global financial intermediary channels loans from patient foreign lenders to impatient domestic borrowers, funding its activity with a mix of equity and deposits. The balance sheet of financial intermediaries (summarized in Table 1) is denominated in Foreign goods to capture the idea that global financial intermediaries do not bear the costs of currency exposure by matching the denomination of assets and liabilities.[11]

The profits of a generic financial intermediary are the difference between the total return on loans, and the payouts to depositors and equity holders:

$$\Pi = R^b f - R^d d - R^e e. \tag{22}$$

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

$$e \geq \chi f, \tag{23}$$

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:

$$f = d + e. \tag{24}$$

[11] When we allow for some loans to be denominated in Home currency in section 5.4 below, we will assume that financial intermediaries hedge their foreign currency positions, passing the costs on to borrowers, to retain the idea that global banks do not bear currency risk on their balance sheet.

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

The main theoretical experiment that we focus on in the model is a one-time change in the capital constraint χ. We will then map the results of this experiment into the identification of an international credit supply shock in the VAR analysis of the next section. For this purpose, we will focus on an equilibrium in which the capital constraint is binding. If the capital constraint were slack, financial intermediaries would become irrelevant, and changing its value would have no effect on macroeconomic variables.

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

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

Competition among intermediaries pushes profits to zero and implies that the lending rate is a weighted average of the funding costs:

$$R^b = \chi R^e + (1-\chi)R^d, \tag{26}$$

where the capital constraint χ represents the weight on the return on equity. We note here that 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.

3.6 Equilibrium

As the Home household is relatively impatient, in equilibrium, the Home country borrows from Foreign country at the prevailing interest rate. Home agents use credit, together with their endowment, to buy non-durable consumption goods and housing services. In equilibrium, the demand for housing within each country must equal the available stock, which, without loss of generality, is 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 constraint.

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

4. Goods market clear in every period.

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

4 The Small Open Economy Case: An Example

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

In this case, the credit supply schedule becomes horizontal. But the assumed functional form for the equity adjustment cost preserves an explicit role for changes in the capital requirements/leverage ratios in the equilibrium. The credit demand schedule differs depending on whether the borrowing constraint for domestic households binds. The small open economy assumption also implies that Home demand does not affect the equilibrium in the market for Foreign goods. Conversely, Foreign demand remains relevant for the Home goods market equilibrium. As we show in the Appendix, the model equilibrium can then be summarized by the credit market equilibrium:

1. **Credit supply:**

$$R^b = \frac{1+\zeta\chi}{\beta^*}, \tag{27}$$

2. **Credit demand:**

$$R^b = \begin{cases} \frac{1}{\beta}\frac{s_1}{s_2} & \text{if } \; s_1 f < \theta q \\ \frac{1}{\beta}\frac{s_1}{s_2}\left(\frac{\kappa}{s_1 f} - \frac{1-\theta}{\theta}\right) & \text{if } \; s_1 f = \theta q, \end{cases} \tag{28}$$

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

$$s_1 = \left[\frac{\lambda y}{\lambda y^* + (1-\lambda) f}\right]^{1-\lambda}, \tag{29}$$

$$s_2 = \left[\frac{\lambda y}{\lambda y^* - (1-\lambda) R^b f}\right]^{1-\lambda}. \tag{30}$$

Equation (27) expresses the interest rate offered by intermediaries as a function of the capital requirement and the cost of adjusting the equity position. An increase in the leverage of the financial intermediaries (a reduction of the capital requirements) shifts down the credit supply schedule and reduces the interest rate offered on loans issued to the Home country. This mechanism is what underpins our identification assumptions in the VAR of section 5.[13]

Equation (28) describes the credit demand schedule, which is a piecewise function with a kink at the level of credit where the borrowing constraint becomes binding. Inspection of expressions (28), (29), and (30) clearly shows that, unlike in Justiniano et al. (2015), credit demand is downward-sloping if the borrowing constraint does not bind, because of the endowment and debt valuation effects associated with the real exchange rate discussed above. In the Appendix, we show analytically that credit demand is downward-sloping also in the region where the borrowing constraint binds, at least locally.

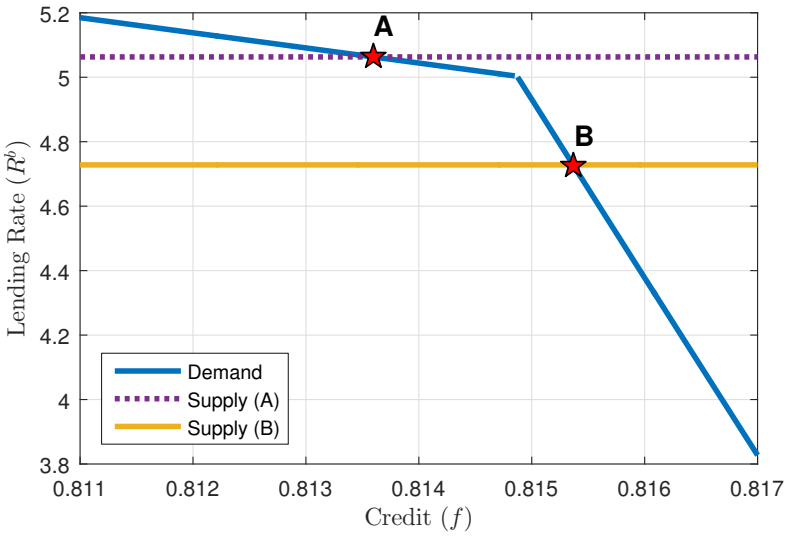
If the constraint is not binding, neither house prices nor the LTV ratio affect credit. The offered rate pins down the expected real exchange rate depreciation. In this region, we can solve for the equilibrium quantity of credit supplied to the Home country f_u to get:

$$f_u = \frac{\lambda y^* \left[1 - \left(\beta R^b\right)^{\frac{1}{1-\lambda}}\right]}{(1-\lambda)\left[R^b + \left(\beta R^b\right)^{\frac{1}{1-\lambda}}\right]}. \tag{31}$$

If the borrowing constraint is binding, the equilibrium quantity of credit depends on both the real exchange rate and house prices. In the limiting case in which the LTV ratio equals 100% ($\theta = 1$), the quantity of credit that global financial intermediary channel to the Home country f_c

[13] Because the Home country is small, the quantity of credit issued does not enter expression (27). Under a more general calibration whereby the Home country is not atomistic relative to the rest of the world, the international supply of credit becomes increasing in the quantity of credit, as in the closed economy case of Justiniano et al. (2015).

Figure 2 : International Credit Market equilibrium.



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

solves the following non-linear equation:

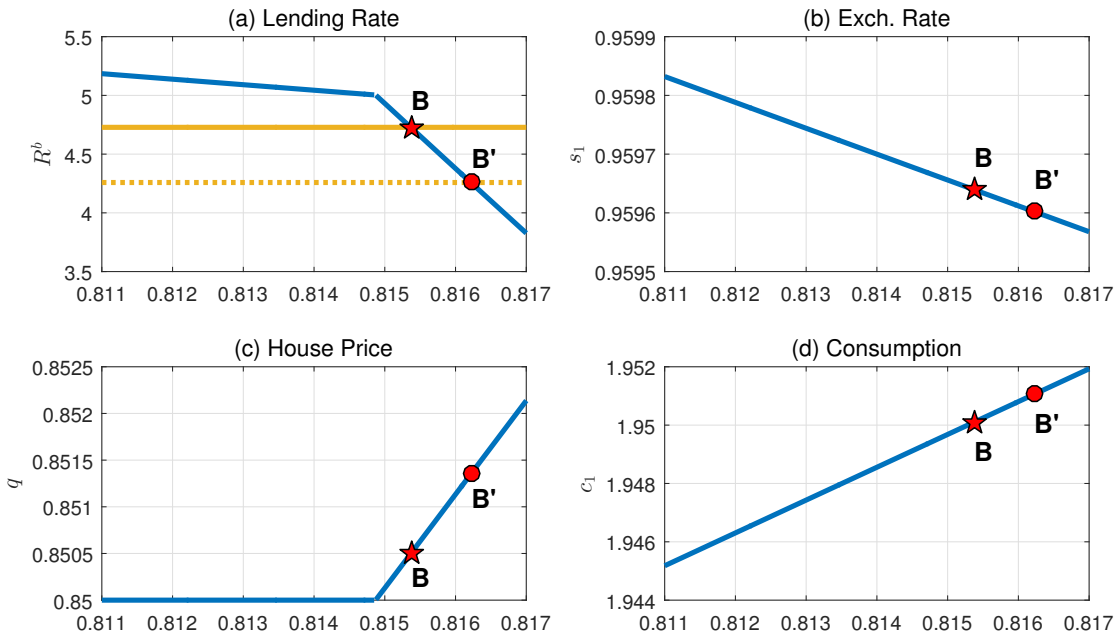
$$\lambda y \left(\frac{\beta R^b}{\kappa}\right)^{\frac{1}{1-\lambda}} f_c^{\frac{1}{1-\lambda}} + (1-\lambda) R^b f = \lambda y^*. \tag{32}$$

More generally, the LTV ratio also affects the demand of credit and an analytical solution is not possible. Therefore, in what follows, we characterize numerically the credit market equilibrium in the space $\{f, R^b\}$ for reasonable parameter values.

Let us focus first on the credit demand, which results from combining (28), (29), and (30). We normalize the endowment in both countries to $y = y^* = 1$ and the marginal utility of housing in units of marginal utility of consumption $\kappa = 1$. We set $\theta = 0.92$, consistent with the observed (average) maximum LTV limit in our sample of countries. We pick a value for the openness parameter ($\lambda = 0.8$) slightly larger than in Gali and Monacelli (2005) but within the range discussed in the literature. Finally, we set the domestic discount factor to $\beta = 0.9$ to yield a reasonable value for the real interest rate in the credit market, whether the borrowing constraint is binding or not.

The supply of credit (equation 27) is pinned down by three parameters: β^*, χ, and ζ. We assume a leverage ratio of 10 ($\chi = 0.1$), a value that is close to the average leverage of US commercial banks in the data. As common in the literature, we set $\beta^* = 0.99$ to obtain $R^d = 4.1\%$ in annualized

Figure 3 : International Credit Supply Shock with Binding Borrowing Constraint.



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

terms. We treat the choice of the equity adjustment cost parameter ζ residually. Given the rest of the calibration, its value determines whether the equilibrium is in the region where the borrowing constraint is binding or not.

Figure 2 displays the two types of credit market equilibrium that can arise in this model. If the equity adjustment cost is relatively high ($\zeta = 0.023$), financial intermediaries pays a large premium over the return on deposits (approximately ten percentage points), and the interest rate on credit is roughly 5%. In this case, the equilibrium is in the unconstrained region (point A) . Conversely, when the equity adjustment cost is relatively low ($\zeta = 0.015$), the equity premium is not as large (about six percentage points), and the interest rate on credit is around 4.7%. In this case, the equilibrium is in the constrained region (point B).

Consider now an increase in international credit supply obtained by reducing χ from 0.1 to 0.025. We start from the same constrained equilibrium of Figure 2 (point B) with low equity premium. The reduction in capital requirements of global banks increases the international supply of credit. The credit supply schedule shifts downward, and the new credit market equilibrium

occurs in point B' (top-left panel of Figure 3), with higher credit and a lower interest rate. The higher availability of credit pushes up house prices (bottom-left panel). As demand rises in the Home country, the real exchange rate also appreciates (top-right panel) and consumption increases (bottom-right panel).

If a similar shock were to take place in the unconstrained region (point A in Figure 2, the response of the exchange rate and consumption would be similar. The main difference would be that, for a small enough shock, house prices would not respond because the borrowing constraint is not binding. However, if the credit supply shock is large enough, the economy could move from the unconstrained to the constrained region, so that again house prices would increase.

The next section studies the response of macroeconomic variables and asset prices to an identified international credit supply shock in the data using a large panel of vector autoregressions.

5 The Impact of an International Credit Supply Shock

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

5.1 A PVAR Model

The PVAR model includes a small set of variables which have a direct counterpart in the theoretical model. We include the leverage ratio of US Broker-Dealers (described below), cross-border bank claims to all sectors, real GDP, real private consumption, real house prices, the real (ex-post) short-term interest rate, the real exchange rate vis-a-vis the US Dollar, and the current account balance over GDP. To keep the size of the VAR model as small as possible, we do not include inflation and nominal interest rate separately. Thus, the real ex-post short-term interest rate is meant to reflect the monetary policy stance. A stabilizing monetary policy response should manifests itself with a change in the real short-term interest rate.

The specification for each country i is:

$$x_{it} = a_i + b_i t + c_i t^2 + F_{1i} x_{i,t-1} + u_{it}, \tag{33}$$

where x_{it} is the vector of endogenous variables, a_i is a vector of constants, t and t^2 are vectors of deterministic trends, F_{1i} is a matrix of coefficients, and u_{it} is a vector of reduced form residuals with variance-covariance matrix Σ_{iu}. All variables considered enter in log-levels, except for the interest rate, which enters in levels.[14] The empirical model is the same for all countries to avoid introducing differences in country responses due to different specifications, and because it would be difficult to find a perfectly data-congruent specification for all countries in the sample. In particular, somewhat arbitrarily, but mindful of the relatively short sample period for some of the emerging economies, we include one lag of each variable in every system. The full sample period is 1985:Q1-2012:Q4, but some country models are estimated starting later depending on data availability.

We estimate the model using the mean group estimator of Pesaran and Smith (1995) and Pesaran et al. (1996).[15] In the estimation, we drop all countries which have less than 40 observations or have unstable dynamics (i.e., with eigenvalues larger than 1). This selection leaves us with 51 out of the 57 countries originally in our event study.[16]

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

[14] We estimate the VAR systems in levels allowing for implicit cointegration among variables. Sims et al. (1990) show that, if cointegration among the variables exists, the system's dynamics can be consistently estimated in a VAR in levels.

[15] Pooled estimators are inconsistent in a dynamic panel data model with slope coefficients varying across countries.

[16] 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.

5.2 Identification

We want to identify a push shock to the international supply of credit as in the model of the previous section. The model shows that changes in leverage of international financial intermediaries lead to an increase in the international supply of credit. Thus, in the PVAR model, we use innovations to US Broker-Dealers leverage as a source of exogenous changes in the international supply of credit to our collection of small open economies.[17] Leverage of US Broker-Dealers is readily available from the data (US Flow of Funds), and these institutions are a good proxy for the global financial intermediaries that we considered in the theoretical analysis.

Consistently with the model, our key assumption is that changes in the leverage of US Broker-Dealers lead to a shift in the international supply of credit, but leverage of US Broker-Dealers is not affected by conditions in individual countries outside the United States.[18]

Various factors can affect US Broker-Dealers' leverage, including US monetary policy, financial regulation, financial innovation, and shifts in risk appetite (see, for example, Bruno and Shin, 2015, Rey, 2013, Bekaert et al., 2013). For our purposes, we do not need to take a stand on the underlying structural sources of shifts in leverage. As long as country-specific, domestic pull factors do not affect leverage, we can treat changes in this variable as a proxy for an exogenous push shock to capital flows, or an international credit supply shock like in our model above.

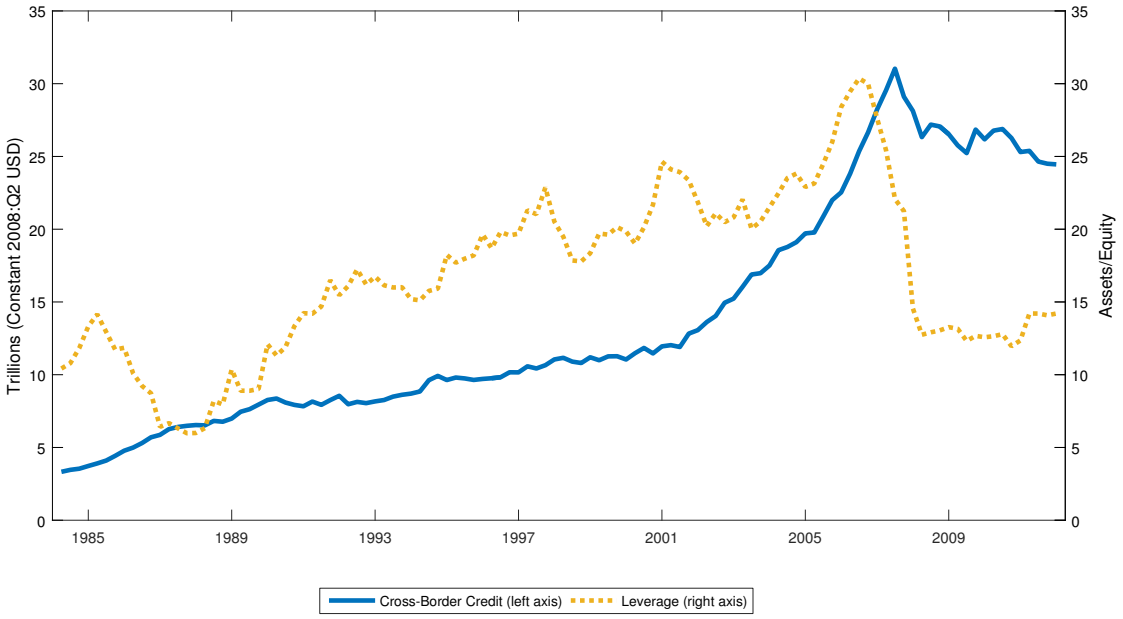
Figure 4 plots the sum cross-border bank claims over all countries in our sample (solid blue line) and the leverage of US Broker-Dealers (dashed yellow line). The two series share a secular upward trend as well as cyclical variations at relatively low frequency. Albeit to a different degree and with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

In practice, we obtain the impulse responses of all other variables in the system to a shock to

[17] Since the leverage of US Broker-Dealers is endogenous to the US, we do not include the US in the sample, leaving us with 50 countries.

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

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



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

US Broker-Dealers' leverage from the Cholesky decomposition of the variance-covariance matrix of the estimated reduced-form residuals of each country-specific VAR, with leverage ordered first in the system. [19]

5.3 The Typical Response of a Small Open Economy

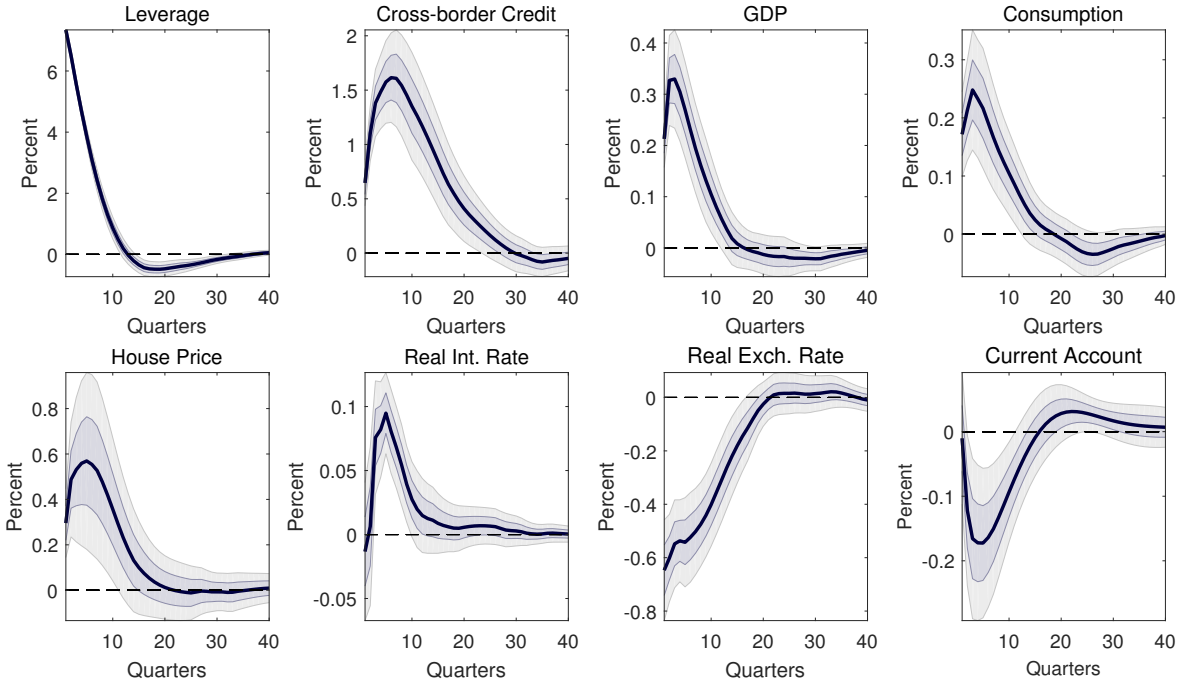
Figure 5 reports the impulse response to the exogenous shift in the international supply of credit.[20] The size of the shock is set equal to the standard deviation of the residuals of the leverage equation, which—on average across all countries—is equal to 7.3%. We censor the responses included in the computation of the mean group estimator at the 10% level (5% each side) to eliminate the possible influence of any outliers on the cross-country average. The dark and light shaded areas represent the one- and two-standard deviation confidence intervals, respectively.

The impulse responses from the VAR are consistent with the findings in our event study, and

[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.

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

Figure 5 : Impulse Responses to an International Credit Supply Shock

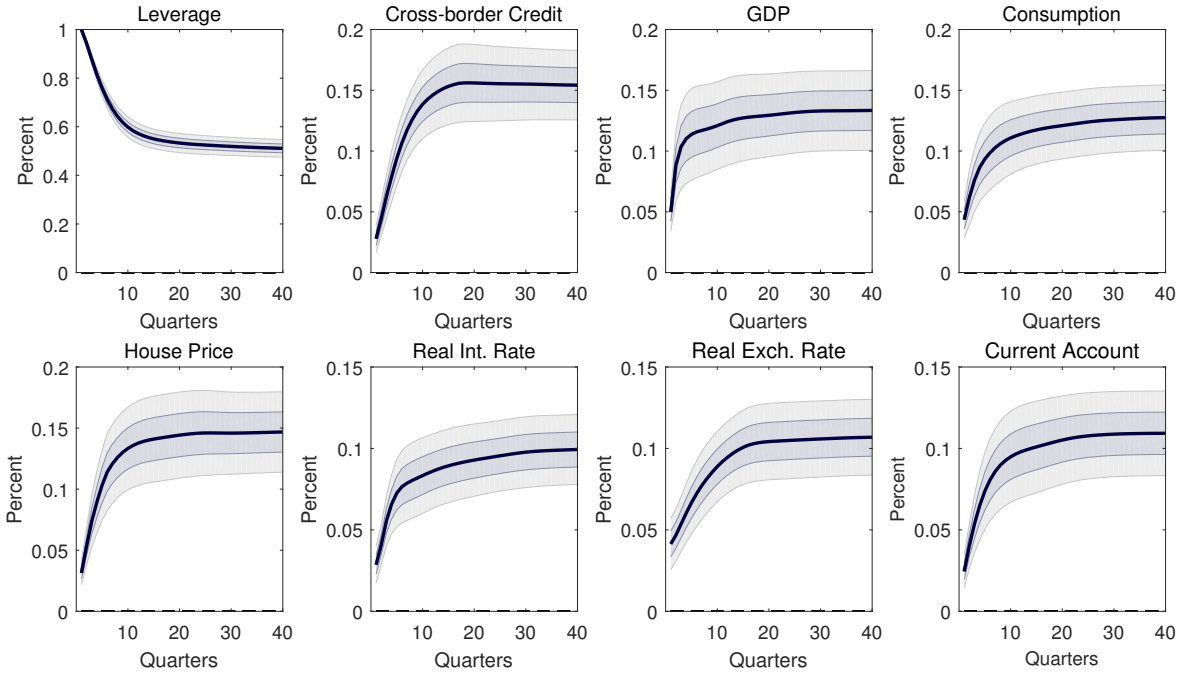


Note. Impulse responses to a one standard deviation (7.3%) increase in the leverage of US Broker-Dealers. The dark and light shaded areas are the one and two standard deviation confidence intervals, respectively.

with the mechanisms at work in the model. In the typical small open economy represented here, our leverage shock leads to a statistically significant and persistent increase in cross-border claims, real GDP, real consumption and real house prices, a hump shaped response of real interest rate, a prolonged real exchange rate appreciation, and a deterioration of the current account balance. Cross-border bank claims display a hump-shaped response, with an impact response of 0.6% and a peak response of 1.5%. Similarly, consumption and real house prices increase by about 0.2% and 0.5% above their long-run levels, respectively, within a year. The real exchange rate vis-a-vis the US Dollar appreciates on impact by about 0.6%, arguably driven by the nominal exchange rate, and then reverts very slowly to its equilibrium level. The response of the short-term real interest rate is initially muted. The real interest rate then increases more slowly than consumption and house prices, but steadily for about two years, peaking at about 10 basis points above its long-run level. Overall, the shock to US Broker-Dealers' leverage generates expansionary effects consistent with the trasmission of our model.

Figure 6 reports the mean group estimates of the variance share of the international credit

Figure 6 : Share of Variance Explained by International Credit Supply Shock



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

supply shock. The shock explains a significant share of variance of all other variables in the system. At the same time, leverage is explained largely by shocks to itself within the first a year or so. The shock can explain about fifteen percent of the forecast error variance of cross-border credit, house prices, GDP, and consumption; and a slightly smaller share for the remaining variables. These magnitudes are economically meaningful and exceed the share of forecast error variance that is typically explained by monetary policy shocks. For example, in our PVAR, a US monetary policy shock explains roughly 5% of the forecast error variance of cross-border bank claims, consumption, house prices and exchange rates (i.e., between half and one third less than the global liquidity shock.[21]

[21]To conduct this exercise, we identified a shock to US monetary policy relying on high-frequency US monetary policy surprises, constructed by Gurkaynak et al. (2005) also used by Gertler and Karadi (2015) in a monetary VAR for the US. Relative to Gertler and Karadi (2015), we construct a series of monetary surprises based on the 3-month Euro-Dollar futures (*ED4*) that covers a longer sample period.

5.4 Understanding Cross-Country Differences

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

We conjecture that the observed cross-country differences may depend on the interaction between the amplification that asset prices generate in response to an international credit supply shock and certain features of the economies in our sample. In particular, our model suggests that the intensity of the country responses to the credit shocks may be affected by the share of foreign currency liabilities and the maximum LTV limit prevailing in that country.

Consider first the share of foreign currency liability. If we generalize the model to allow for credit to be partly denominated partly in Home currency, we show in Appendix that the borrowing constraint becomes:

$$b + s_1 f \leq \theta q h_1,$$

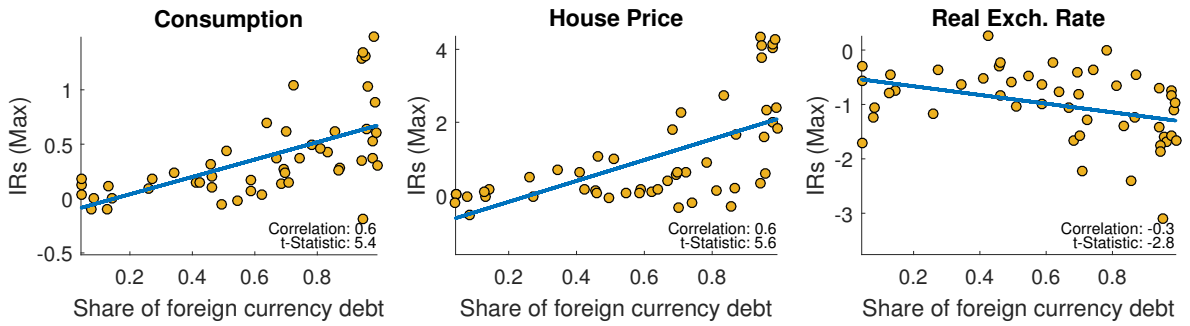
where b is the amount of credit denominated in Home currency extended by global financial intermediaries.[22] As the share of foreign currency debt increases, the collateral valuation channel associated with a binding borrowing constraint becomes stronger. Everything else equal, an appreciation of the real exchange rate relaxes the borrowing constraint more because effectively the purchasing power in domestic currency of credit obtained from global financial intermediaries increases.

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

Figure 7 provides evidence consistent with this hypothesis. The figure plots the cross-country

[22] As the Appendix shows, this equilibrium can be characterized in terms of the share of debt issued in Home currency. As this share goes to zero, the model converges to the baseline specification discussed earlier.

Figure 7 Cross country differences in response to international credit supply shock: Share of foreign currency liabilities.



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 share of foreign currency liabilities computed using BIS banking data (horizontal axis).

peak responses of consumption (left panel), house prices (middle panel), and the real exchange rate (right panel) against the share of foreign currency liabilities computed using BIS banking data (horizontal axis).[23] The correlations are particularly strong for consumption and house prices (about 0.6). The correlation is slightly lower (-0.3) but nevertheless statistically significant also for the real exchange rate.[24]

A second candidate explanation to account for the heterogeneity of the impulse responses across countries is variation in the LTV ratio. For given asset prices, if the borrowing constraint is binding, a higher LTV ratio allows for additional borrowing. The model predicts that, as long as the borrowing constraint is binding, higher LTV ratios typically increase consumption and house prices and lead to an appreciation of the real exchange rate.[25] Obviously, if the borrowing constraint is not binding, a higher LTV ratio is irrelevant for the response of the economy to the credit supply shock.

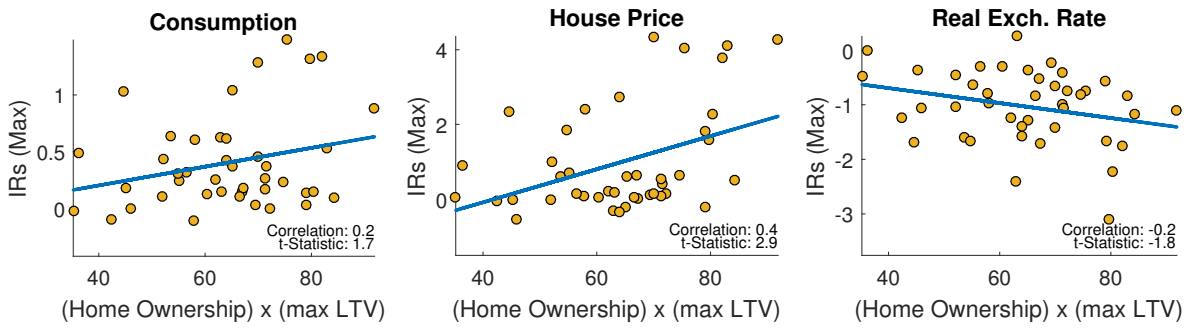
Figure 8 is also consistent with this explanation of the different intensities of the country responses to the international credit supply shock. In this figure, we plot the peak impulse responses of consumption (left panel), house prices (middle panel), and the real exchange rate (right panel)

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

[24]The results are robust to using the average response over the first 4 quarters or the share of variance of this variables explained by the credit supply shock during the first year.

[25]See the Appendix for sufficient conditions under which this result holds.

Figure 8 Cross country differences in response to international credit supply shock: LTV ratios.



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

from the VAR (vertical axis) against the maximum LTV ratio interacted with the homeownership rate (horizontal axis).[26] The LTV ratio is weighted with the homeownership ratio to capture both leverage in the local financial system and the availability of housing collateral. Indeed, if high leverage is permitted, but homeownership 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. The correlation is quite strong for house prices (about 0.4) but weaker for consumption and the real exchange rate (plus and minus 0.2, respectively). Nevertheless, all correlations are statistically significant at least at the 10% confidence level.

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

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

6 Conclusions

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

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

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

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

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A Appendix. Data Sources

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

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

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

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

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

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

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

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

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

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

Consumer prices. Consumer price index. Source: OECD, IMF IFS, Bloomberg.

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

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

Home-ownership. HOFINET

Table A.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 the extended appendix on the sources of house price series extended with historical data.

B Appendix: Model Derivations

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

B.1 Equilibrium

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

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

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

   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, so that in the aggregate we have:

$$\begin{aligned} R^b &= \chi R^e + (1-\chi) R^d, \\ nf &= (1-n)(d+e), \\ (1-n)e &= \chi n f. \end{aligned}$$

4. Goods market clear in every period:

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

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. By Walras's Law, two goods market equilibrium conditions (one in each period) are redundant.

B.2 Goods Market and the Terms of Trade

We start from the goods market equilibrium:

$$ny = n\alpha\tau^{1-\alpha}c + (1-n)\alpha^*\tau^{1-\alpha^*}c^*, \tag{B.1}$$

$$(1-n)y^* = n\left(1-\alpha\right)\tau^{-\alpha}c + (1-n)\left(1-\alpha^*\right)\tau^{-\alpha^*}c^*, \tag{B.2}$$

where, for simplicity, we dropped the time subscript as these two expressions are static. We can rewrite these conditions as

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

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

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

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

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

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

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

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

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

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

$$c_1 = \tau_1^{1-\lambda} f + \tau_1^{-\lambda} y, \tag{B.9}$$

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

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

and thus

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

Intuitively, higher foreign debt implies higher Home demand, and hence an appreciation of the terms of trade (and consequently of the real exchange rate).

In period 2, the budget constraint of the Home representative household gives

$$c_2 = \tau_2^{-\lambda} y - R^b \tau_2^{1-\lambda} f.$$

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

$$\tau_2 = \frac{\lambda y}{\lambda y^* - (1-\lambda) R_1^b f}, \tag{B.11}$$

and for the real exchange rate

$$s_2 = \left[\frac{\lambda y}{\lambda y^* - (1-\lambda) R^b f} \right]^{1-\lambda}. \tag{B.12}$$

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

B.3 Credit Market

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

B.3.1 Credit Supply

We start with credit supply. Substituting the expressions for the return on deposit and the return on equity in the zero profit condition for financial intermediaries, together with the binding capital

constraint, yields an expression for credit supply

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

As we take the limit for $n \to 0$, we use the assumption about the first derivative of the equity adjustment cost function ($\psi'(0) = \zeta > 0$) and obtain

$$R^b = \frac{1+\zeta\chi}{\beta^*}.$$

B.3.2 Credit Demand

We start from the optimal choice of housing services. If the borrowing constraint is not binding ($\mu = 0$), the equilibrium conditions for domestic households boil down to $q = \kappa$, $s_1 f < \theta q$ and

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

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

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

We plug this expression into the house price equation to obtain

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

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

$$s_1 f = \frac{\theta\kappa}{1 - \theta + \theta\beta R^b s_2/s_1}. \tag{B.15}$$

We solve this equation for the return on loans to get

$$R^b = \frac{1}{\beta}\frac{s_1}{s_2}\left(\frac{\kappa}{s_1 f} - \frac{1-\theta}{\theta}\right).$$

C Appendix: Log-Linear Approximation

In this section we show that, in the small open economy model, the credit demand schedule is downward sloping about a steady state in the region where the collateral constraint is binding, which in turn implies a positive level of credit.[27]

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

C.1 Goods Market and the Terms of Trade

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

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

The linear approximation around the steady state is

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

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

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

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

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

Now consider period 2 and rewrite s_2 as

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

The linear approximation around the steady state is

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

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

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

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

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

C.2 Credit Supply

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

$$R^b = \bar{R}^b + \frac{\zeta}{\beta^*} (\chi - \bar{\chi})$$

which we can write in lod-deviations from the steady state as

$$\frac{R^b - \bar{R}^b}{\bar{R}^b} = \frac{\zeta\bar{\chi}}{\beta^*\bar{R}^b}\frac{\chi - \bar{\chi}}{\bar{\chi}}$$

or

$$\hat{R}^b = \frac{\zeta\bar{\chi}}{1+\zeta\bar{\chi}}\hat{\chi}.$$

C.3 Demand

We consider the binding region only ($s_1 f = \theta q$). The demand function can be rewritten more conveniently as

$$R^b = \frac{1}{\beta}\left(\frac{\kappa}{s_2 f} - \frac{s_1}{s_2}\frac{1-\theta}{\theta}\right)$$

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

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

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

$$\hat{R}^b = -\frac{\kappa}{\beta\bar{R}^b}\frac{1}{\bar{s}\bar{f}}\left(\hat{f} + \hat{s}_2\right) - \frac{1}{\beta}\frac{1-\theta}{\theta}\left(\hat{s}_1 - \hat{s}_2\right).$$

To summarize, when the borrowing constraint is binding in the Home economy (in log-linear terms, $\hat{s}_1 + \hat{f} = \hat{q}$), the equilibrium in the international credit market is determined by:

1. SUPPLY

$$\hat{R}^b = \frac{\zeta\bar{\chi}}{1+\zeta\bar{\chi}}\hat{\chi}. \tag{C.1}$$

2. DEMAND

$$\hat{R}^b = -\frac{\kappa}{\beta\bar{R}^b}\frac{1}{\bar{s}\bar{f}}\left(\hat{f} + \hat{s}_2\right) - \frac{1}{\beta}\frac{1-\theta}{\theta}\left(\hat{s}_1 - \hat{s}_2\right) \tag{C.2}$$

3. REAL EXCHANGE RATE

$$\hat{s}_1 = -\frac{(1-\lambda)^2}{\lambda y}\bar{s}^{\frac{1}{1-\lambda}}\bar{f}\hat{f} \tag{C.3}$$

$$\hat{s}_2 = \frac{(1-\lambda)^2}{\lambda y}\bar{s}^{\frac{1}{1-\lambda}}\bar{R}^b\bar{f}\left(\hat{f} + \hat{R}^b\right) \tag{C.4}$$

We can plug the expression for $\hat{s}_2$ in the demand function to recover an expression for the demand function in the $\{\hat{R}^b, \hat{f}_1\}$ space. To get a cleaner expression, we make a further simplifying assumption and take the limiting case where $\theta \to 1$. If θ is high enough, the approximation remains

valid. Solving for $\hat{R}^b$ yields

$$\hat{R}^b = -\left(\frac{\kappa}{\beta \bar{R}^b \bar{s} \bar{f}}\right)\left[\frac{\beta\lambda y + \beta\left(1-\lambda\right)^2 \bar{f}\bar{R}^b \bar{s}^{\frac{1}{1-\lambda}}}{\beta\lambda y + \kappa\left(1-\lambda\right)^2 \bar{s}^{\frac{\lambda}{1-\lambda}}}\right]\hat{f}.$$

As the two terms in parenthesis in the last expression are always positive, the demand schedule, in a neighborhood of the steady state with binding collateral constraint, is downward sloping in the space $\{\hat{R}^b, \hat{f}\}$.

D Appendix. The Share of Foreign Currency Liabilities

So far we have assumed that all credit issued to the Home country is denominated in Foreign currency. This assumption simplifies the analysis and allows us to demonstrate the main forces at work in the model. In practice, however, some credit is issued in domestic currency, either directly by global banks or through domestic financial intermediation. In this section, we extend the model to incorporate this feature, which will become relevant in the empirical analysis below.

We maintain the assumption that the Home country bears the currency risk. Global financial intermediaries continue to issue credit to the Home economy, but we allow for some fraction of their loan book to be denominated in Home currency. The intermediaries are able to hedge their currency exposure via swap contracts issued by perfectly competitive specialized FX operators. We do not pin down the currency composition of total credit available to the Home economy. Instead, we parameterize the share of foreign currency debt and analyze the role of this share for the equilibrium.

The representative household in the Home economy still maximizes (11) but now the budget constraint in period 1 and 2 are

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

and

$$c_2 = p_{H2} - Rb - s_2 R^b f,$$

where R denotes the gross real interest rate that global financial intermediaries require on credit denominated in Home currency b. Accordingly, the borrowing constraint now includes debt denominated in both currencies:

$$b + s_1 f \leq \theta q h_1.$$

Using the same notation as before for the Lagrange multiplier on the borrowing constraint, the first order condition with respect to b is:

$$1 - \mu = \beta R.$$

The remaining first order conditions for the Home representative households are unchanged. Combining the last expression with the first order condition for credit denominated in Foreign currency yields:

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

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

In what follows, it will be convenient to define the ratio between credit in Home and Foreign currency as

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

so that $1+\eta$ represents the inverse of the share of Foreign currency liabilities from the perspective of the Home country. If $\eta = 0$, the model corresponds to the baseline case in which all credit is denominated in Foreign currency. As η increases, more and more debt is denominated in Home currency, and the collateral valuation effect becomes less severe. This consideration is evident from the borrowing constraint at equality, which with the new notation can be written as

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

An appreciation of the real exchange rate (a fall in s_1) has a smaller amplification effect when η is very large because little debt is denominated in Foreign currency.

As mentioned, we will treat η as a parameter. In equilibrium, consumption in the two periods is:

$$\begin{aligned} c_1 &= p_{H1} y + (1+\eta) s_1 f, \\ c_2 &= p_{H2} y - (1+\eta) R f. \end{aligned}$$

Following Bräuning and Ivashina (2016), we assume that global financial intermediaries can hedge their currency exposure by entering a swap contract with perfectly competitive FX operators. These operators are endowed with a large amount of capital K and make zero profits. Using swaps, banks can ensure that only the total asset size of their balance sheet matters for their activity. We assume that the cost of swapping the total amount of credit denominated in Home currency is $\Gamma(nb/s_1)$, with $\Gamma'(\cdot) > 0$.

The balance sheet identity for global financial intermediaries is now

$$n(1+\eta) f = (1-n)(d+e), \tag{D.1}$$

while the capital requirement becomes

$$(1-n)e \geq \chi n (1+\eta) f. \tag{D.2}$$

The representative global bank chooses the amount of credit that maximizes its profits subject

to the balance sheet constraint (D.1) and the capital requirement (D.2):

$$\max_f \Pi = R^b n(1+\eta)f - R^d(1-n)d - R^e(1-n)e - \Gamma(\eta n f).$$

As in the baseline formulation, we focus on the case in which the capital constraint is binding. After rearranging, the first order condition for the optimal choice of f becomes:

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

The presence of credit denominated in Home currency introduces an extra cost, due to hedging, that global financial intermediaries pass on to their customers in the form of a higher interest rate on loans. Obviously, as $\eta \to 0$, we retrieve our baseline case in which all credit is denominated in Foreign currency.

In the small open economy case, as $n \to 0$, because of the assumption on the cost of hedging, we obtain

$$R^b = \frac{1+\chi\zeta}{\beta^*} + \frac{\eta\gamma}{1+\eta},$$

where $\gamma \equiv \Gamma'(0)$. If the borrowing constraint is not binding, so that $(1+\eta)s_1 f < \theta q$, the credit demand equation is identical to the baseline case. When the borrowing constraint does bind, however, the presence of some credit denominated in Home currency implies that

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

Finally, in the goods market, we obtain the solution for the terms of trade:

$$\begin{aligned} \tau_1 &= \frac{\lambda y}{\lambda y^* + (1-\lambda)(1+\eta)f}, \\ \tau_2 &= \frac{\lambda y}{\lambda y^* - (1-\lambda)(1+\eta)R^b f}. \end{aligned}$$

AF: Review the predictions of the model and state them in terms of high share of foreign currency liability (lower η)

A positive share of credit denominated in Home currency increases the interest rate that borrowers face because of the cost of hedging incurred by global financial intermediaries. When the collateral constraint binds, the presence of debt denominated in Home currency reduces the amplification effect of a real exchange rate appreciation. In addition, a higher share of credit denominated in Foreign currency reduces the sensitivity of the real exchange rate on impact to variations in the level of credit. To see this last effect, we compute the cross-derivative of the terms of trade in period 1 with respect to credit and the share of debt denominated in Home currency:

$$\frac{\partial^2 \tau_1}{\partial f \partial \eta} = -\frac{\lambda y(1-\lambda)[\lambda y^* - (1-\lambda)(1+\eta)f]}{[\lambda y^* + (1-\lambda)(1+\eta)f]^3} < 0. \tag{D.3}$$

The result follows from the fact that the terms of trade must be positive in all periods. Therefore, if $\tau_2 > 0$, the term in square bracket at the numerator of the last expression is also positive.

E Appendix. The Effect of Changes in LTV Ratios

In this section we investigate the effects of a change in the LTV ratio on the small open economy equilibrium. Equations (27)-(30) show that the LTV ratio only affects the equilibrium through credit demand in the region in which the collateral constraint is binding. This observation should be intuitive. The small open economy assumption implies that the interest rate on loans is constant and only affected by changes in the capital constraint. Moreover, if the collateral constraint is not binding for the Home economy, the LTV ratio is irrelevant. When the collateral constraint is binding, however, changes in the LTV ratio affect the equilibrium both directly and indirectly through the effect of the amount of credit on the real exchange rate in the two periods.

In order to derive an expression for the effect of changes in the LTV ratio on the equilibrium quantity of credit, we construct the function $G(f, \theta)$ from the portion of credit demand (28) in which the collateral constraint is binding:

$$G(f,\theta) = \frac{\kappa}{\beta s_2 f} - \frac{1}{\beta}\left(\frac{1-\theta}{\theta}\right)\frac{s_1}{s_2} - R^b.$$

By the implicit function theorem, the effect of a change in the LTV is

$$\frac{df}{d\theta} = -\frac{\partial G/\partial\theta}{\partial G/\partial f}. \tag{E.1}$$

The numerator of the last expression is easy to compute:

$$\frac{\partial G}{\partial \theta} = \frac{1}{\beta\theta^2}\frac{s_1}{s_2} > 0.$$

The denominator is more involved because we need to take into account the effects of changes in the quantity of credit on the real exchange rate in the two periods:

$$\frac{\partial G}{\partial f} = -\frac{\kappa}{\beta s_2 f^2}\left(1 + \frac{\partial s_2}{\partial f}\frac{f}{s_2}\right) - \frac{1}{\beta s_2}\left(\frac{1-\theta}{\theta}\right)\left(\frac{\partial s_1}{\partial f} - \frac{s_1}{s_2}\frac{\partial s_2}{\partial f}\right). \tag{E.2}$$

The effect of a change in the quantity of credit available to the Home country on the real exchange rate in the first period is:

$$\frac{\partial s_1}{\partial f} = -\frac{(1-\lambda)^2 s_1^{1+\frac{1}{1-\lambda}}}{\lambda y} < 0.$$

Similarly, the effect in the second period is:

$$\frac{\partial s_2}{\partial f} = \frac{(1-\lambda)^2 R^b s_2^{1+\frac{1}{1-\lambda}}}{\lambda y} > 0.$$

If $\partial G/\partial f < 0$, a higher LTV ratio increases the Home demand of credit. Expression (E.2) shows that this result, which seems intuitive, clearly holds in the limiting case $\theta \to 1$, that is, an environment in which the private sector can borrow up to the full value of collateral. More generally, the effect remains positive as long as

$$\frac{\kappa}{s_1 f}\left[\frac{\lambda y}{f} + (1-\lambda)^2 R^b \tau_2\right] > \left(\frac{1-\theta}{\theta}\right)\left[\frac{(1-\lambda)^2 \lambda y}{\lambda y^* + (1-\lambda) f} + (1-\lambda)^2 R^b \tau_2\right].$$

The square bracket on the left-hand side of the last inequality is always bigger than the square bracket on the right-hand side. Therefore, for high enough values of $\theta < 1$, the limiting argument above still applies.

The model, therefore, predicts that countries with higher LTVs (especially at high levels) will demand (and receive) more credit. On impact (first period in the model), their real exchange rate appreciates, before depreciating in the long run (second period), as the Home country needs to pay back its debt. In the constrained region, house prices are given by

$$q = \frac{\kappa}{1-\theta\mu}.$$

Therefore, the effect of a change in the LTV ratio on house prices is

$$\frac{dq}{d\theta} = \frac{\kappa\mu}{(1-\theta\mu)^2}\left(1 + \frac{d\mu/\mu}{d\theta/\theta}\right).$$

We can show formally that the effect of an increase in the LTV parameter on the multiplier is negative:

$$\frac{d\mu}{d\theta} = -\frac{\beta R^b}{s_1}\left(\frac{ds_2}{d\theta} - \frac{s_2}{s_1}\frac{ds_1}{d\theta}\right) < 0,$$

where we have used the partial derivatives of the real exchange rate above

$$\frac{ds_1}{d\theta} = \frac{\partial s_1}{\partial f}\frac{\partial f}{\partial \theta} > 0 \qquad \text{and} \qquad \frac{\partial s_2}{\partial f}\frac{\partial f}{\partial \theta} < 0,$$

as long as $\partial f/\partial\theta > 0$. If the direct effect of being able to borrow more prevails on the reduction of the shadow value of housing, an increase in the LTV parameter leads to an increase in house prices when the collateral constraint binds. Finally, in the short run, Home consumption is given by

$$c_1 = \tau^{-\lambda}(\tau f + y).$$

The effect of an increase in the LTV ratio on consumption is:

$$\frac{dc_1}{d\theta} = \tau_1^{-\lambda}\left[(1-\lambda)f - \lambda\tau_1^{-1} y\right]\frac{\partial \tau_1}{\partial f}\frac{\partial f}{\partial \theta} + \tau_1^{1-\lambda}\frac{\partial f}{\partial \theta}.$$

Provided the level of credit is not too high, at high enough values of the LTV (so that $\partial f/\partial\theta > 0$),

the last expression is positive. To summarize, credit, house prices, and consumption should all be increasing in the level LTV ratio.