



# International business cycles with domestic and foreign lenders<sup>☆</sup>

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## Abstract

We examine the international transmission of business cycles in a two-country model where credit contracts are imperfectly enforceable. In our economy, foreign lenders differ from domestic lenders in their ability to recover value from borrowers' assets and, therefore, to protect themselves against contractual non-enforceability. The relative importance of domestic and foreign credit frictions changes over the cycle. This induces entrepreneurs to adjust their debt exposure and allocation of collateral between domestic and foreign lenders in response to exogenous productivity shocks. We show that such a model can explain the comovement of output across countries.

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## 1. Introduction

The role of credit market imperfections in explaining business fluctuations has been the object of analysis of a large literature in the last two decades. More recently, a number of studies have analyzed open economy models with financial frictions, finding that these models can explain important features of international business cycles (e.g. Kehoe and Perri, 2002; Baxter and Crucini, 1995, and the papers cited below). One shortcoming of these studies is that they are silent on the different weight that credit imperfections can have according to the nature—domestic and foreign—of lenders. Since credit imperfections are thought to stem from lack of information of lenders on borrowers, it appears reasonable that these imperfections differ according to the origin of the lenders. Foreign lenders are likely to have limited experience of local firms and laws, presumably because of a short history in lending to local firms.<sup>1</sup> More importantly, once credit imperfections are tied to the nature of the lenders, it is plausible that the *relative* importance of foreign versus domestic imperfections changes over the cycle. If the absolute importance of credit imperfections depends on aggregate variables, a change in aggregate variables is unlikely to leave unaffected the relative importance of credit imperfections.

This paper shows that changes in the relevance of foreign versus domestic credit imperfections and the resulting effects on the decision of firms as to which lenders to choose (domestic or foreign) can explain important aspects of international business cycles. In particular, the focus is on the comovement of output across countries.<sup>2</sup> In the data, for instance, it is generally observed that following a positive productivity shock in one country, output in the country hit by the shock *and* abroad rise. Standard open economy RBC models (see e.g. Backus et al., 1992) cannot replicate this pattern of the data: these models predict that when country *F* (foreign) is hit by a positive technology shock, output in country *H* (home) falls, especially as a result of a shift of resources towards the most productive economy.

We consider a two-country open economy model. In the model economy, entrepreneurs in both countries face restrictions in borrowing from domestic and foreign financiers, as in Gilchrist et al. (2002) and Faia (2002). To this story, the model adds two new dimensions: (i) the relative importance of the credit frictions that entrepreneurs face in borrowing from domestic or foreign lenders changes endogenously over the cycle and (ii) entrepreneurs can adjust their relative debt exposure in order to maximize their borrowing capacity.

In the model entrepreneurs face a quantity borrowing constraint à-la Kiyotaki and Moore (1997), i.e. they cannot borrow more than the value of the hard assets they pledge as collateral. Lenders, on the other hand, face a transaction cost in liquidating the collateral of borrowers. This transaction cost proxies for the cost in recovering collateral during bankruptcy procedures or in redeploying assets in the secondary market at the liquidation stage, and prevents entrepreneurs from borrowing up to the full value of their hard assets. Crucially, the liquidation technologies of domestic and foreign lenders differ. Domestic lenders face a transaction cost that is proportional to the collateral value. Foreign lenders face diseconomies to scale in recovering collateral: the fraction of value they lose in liquidation increases as the collateral value increases. The assumption of

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<sup>1</sup>Dell’Ariccia et al. (1999) argue that older banks may have a greater informational advantage if they have made loans to more borrowers than younger banks.

<sup>2</sup>For extensive evidence on the nature of this comovement, see Canova and Marrinan (1998).

diseconomies to scale in the liquidation technology aims at capturing the idea that foreign lenders have probably less experience than domestic lenders in recovering borrowers' assets and less knowledge of their best alternative uses. Experience and knowledge, in other words, represent a scarce local input such that, the higher is the value of the assets that foreign lenders recover and redeploy, the more their limited "liquidation ability" becomes strained.<sup>3</sup> This paper elaborates on this feature of the model offering examples and discussing related assumptions in the literature.

The transmission mechanism works as follows. Suppose that, at some date  $t$ , the foreign economy experiences a favorable productivity shock: in the foreign and in the domestic economy the value of entrepreneurs' productive assets (including the collateralizable ones) rises.<sup>4</sup> In the domestic economy, the increase in the value of collateralizable assets increases the average transaction cost that foreign lenders are expected to face if they have to liquidate the collateral of domestic entrepreneurs. As a result, domestic entrepreneurs have the incentive to relocate their collateral from foreign towards domestic lenders as they try to maximize their debt capacity. In turn, the increase in the relative importance of domestic borrowing (increased autarky) is associated with the incentive to increase real estate demand. In fact, real estate has value as collateral especially vis-à-vis domestic lenders (since they can liquidate more efficiently, and more willing to supply credit for each unit of real estate pledged). This induces further pressure in the domestic asset market, leading to a further increase of asset prices. The increase in real estate holdings and prices spurs the average transaction cost faced by foreign lenders further, and so forth. Overall, since rises in asset prices and holdings of entrepreneurs relax their borrowing constraints, domestic production increases more in our model than in the traditional international RBC model.

A growing literature emphasizes the role of credit market imperfections in explaining some of the features of international business cycles that cannot be explained by frictionless RBC models. Backus et al. (1992), Baxter and Crucini (1995) and Heathcote and Perri (2002) make the extreme assumption of financial autarky, i.e. countries cannot trade financial assets. These papers find that restrictions in the trade of financial assets can account for the positive output correlation across countries by reducing international capital mobility. In the presence of financial autarky, when a positive productivity shock hits country  $F$ , resources cannot flow from country  $H$  to country  $F$ . Hence, the reduction in investment in country  $H$  is not as severe as the one that would occur with perfect capital markets. In these papers credit frictions are exogenous, i.e. not tied to aggregate variables. Kehoe and Perri (2002) analyze a model in which the credit constraints that a country faces when borrowing from abroad change over the cycle. Building on the literature on sovereign debt imperfections (see Eaton and Gersovitz, 1981, for instance), they consider the case in which the debt capacity of a country is tied to the value that the country attributes to future access to international financial markets. The credit constraint requires that, in each period, allocations have a higher discounted utility than would prevail if the country were excluded from all further intertemporal and international trade. When country  $F$  is hit by a positive shock, its output cannot increase too much otherwise the value of defaulting would become higher than the penalty of being excluded from

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<sup>3</sup>Other local inputs that are limited for foreign lenders (e.g. personnel) can result into limited liquidation ability.

<sup>4</sup>The asset price comovement across countries derives directly from the propagation of the technological shock and indirectly from general equilibrium effects. This feature of the model is in common with other models on the financial accelerator in open economy (e.g. Gilchrist et al. (2002); Faia, 2002).

international financial markets in the future. Hence, the flow of capital from country  $H$  to country  $F$  must be limited: this helps to sustain the output rise in country  $H$ . As Kehoe and Perri stress, they “abstract completely from the difficulties of enforcing contracts between agents within a country (p. 908)”.<sup>5</sup> Hence, there is no room for changes in the relative importance of foreign versus domestic credit imperfections. Gilchrist et al. (2002) and Faia (2002) analyze models in which firms face a credit constraint in borrowing both home and abroad. The presence of generalized credit constraints amplifies the international transmission of shocks. They also allow for the degree of credit imperfections to differ across countries. However, there is no difference in credit imperfections according to the nature of lenders. Hence, only the *absolute* importance of credit frictions matters.

The paper is organized as follows. Section 2 describes the model. Section 3 presents the results. Section 4 concludes.

## 2. The model

The world consists of two symmetric, discrete-time countries. In each, entrepreneurs produce a unique final good (which is tradeable across countries) that is used for consumption. In each country, there is a fixed amount of a divisible, infinitely durable asset (which is not tradeable) that can be used either by entrepreneurs as input for production and collateral for loans or by households as a consumption good. We call this asset “real estate”. This modeling choice allows for fluctuations in the price of the pledgeable, productive asset. It also allows for changes in entrepreneurial real estate holdings which have first-order effects on economic activity.

Each economy is populated by the same measure of infinitely lived agents, households and entrepreneurs. Households rent labor to entrepreneurs, consume the final good and real estate; they also trade non-contingent one-period bonds issued by domestic entrepreneurs, foreign entrepreneurs and foreign households. Entrepreneurs consume and use labor and real estate to produce the final good; they can borrow and choose whether to borrow from domestic or foreign households. In borrowing, entrepreneurs face credit constraints.<sup>6</sup>

### 2.1. Borrowing constraints with endogenous liquidation costs

*The role of collateral:* Consider the problem of the representative domestic entrepreneur who wants to borrow from either domestic or foreign financiers. Credit contracts are imperfectly enforceable. We follow the literature, especially Kiyotaki and Moore (1997), in specifying this enforceability problem. In its simplest formulation, one can think that the entrepreneur can “walk away” with the funds borrowed. She will have no incentive to do so as long as the value of collateralized resources is at least equal to the funds borrowed. Alternatively, one can think that the entrepreneur’s human capital is specific to production and she cannot commit it at the contractual stage. This implies that ex-post, by threatening

<sup>5</sup>A world economy in which agents face endogenous credit frictions abroad but not domestically is not an extreme case of our economy. In such an economy, agents borrow up to the limit allowed by foreign financiers but do not face a meaningful choice in allocating pledgeable net worth (collateral) between foreign and domestic financiers.

<sup>6</sup>Households could face credit constraints, too. In the model we describe, given our assumption on the preferences, these constraints would not be binding in equilibrium, so we rule them out ex ante.

to withhold her human capital, the entrepreneur can trigger renegotiation of the contract and, if she has full bargaining power in renegotiation, force the repayment down to the collateral value. Regardless of the preferred specification, as in Kiyotaki and Moore (1997), the entrepreneur cannot borrow more than the expected present value of her pledgeable resources net of any recovery cost.<sup>7</sup> We assume that the entrepreneur can use only real estate  $h_t$  as collateral for the loan. The expected time  $t + 1$  price of real estate in terms of the final good is  $E_t q_{t+1}$ . The stochastic discount factor for the domestic financier is  $1/R_t^H$ , for the foreign financier is  $1/R_t^F$ .

*Lenders' liquidation technology:* In case of debt repudiation, financiers pay a transaction cost for disposing of the collateral (proxying for a bankruptcy or liquidation cost). The domestic lender expects to pay a proportional transaction cost  $E_t((1 - m_H)q_{t+1}h_t)$ . Hence, her expected recovery value is

$$E_t(q_{t+1}h_t - (1 - m_H)q_{t+1}h_t) = E_t(m_H q_{t+1}h_t). \quad (1)$$

The foreign lender expects to pay a convex cost  $E_t((1 - m_F)/qh(q_{t+1}h_t)^2)$ , i.e. her liquidation technology exhibits decreasing returns to scale.<sup>8</sup> Hence, her expected recovery value is

$$E_t\left(q_{t+1}h_t - \frac{1 - m_F}{qh}(q_{t+1}h_t)^2\right). \quad (2)$$

The main assumption of the model is the decreasing marginal ability of foreign lenders to extract value from entrepreneurs' assets (the quadratic specification is for computational simplicity). This assumption wants to capture the idea that foreign lenders have limited local experience, knowledge or physical inputs necessary for the activity of recovery and redeployment. In turn, these scarce local inputs can be put under more pressure than those of domestic lenders as the value of assets to be liquidated increases. In other words, the liquidation technology is such that, when a lender liquidates an asset, she has to employ some local physical input or some piece of knowledge about local insolvency procedures or about potential buyers in the secondary market. While domestic lenders have large availability of such inputs, foreign lenders possess these local inputs in a limited amount. Hence, as the value of collateral increases, the value they recover from liquidation may increase less than proportionally.

The specification of lenders' liquidation technology mirrors extant studies. For example, it replicates that used by Heaton and Lucas (1996) and Aiyagari and Gertler (1997) in describing transaction costs associated with trade of financial assets. Aiyagari and Gertler (1997) assume that, while "households" are not specialist and face quadratic costs in trading assets, "traders" are specialist and face proportional costs (normalized to zero). In what follows, we describe three circumstances in which the limited liquidation ability of foreign lenders can materialize.

(i) *Asset redeployment:* The limited ability of foreign lenders can occur at the redeployment stage. Consider an economy in which second-hand users have heterogenous efficiency in employing assets. The ability of a lender to identify efficient users is partly a by-product of the information gathered in credit relationships. Foreign lenders have

<sup>7</sup>What matters is the expected value of pledgeable resources. We are implicitly assuming that the opportunity to steal funds or to force renegotiation arises before any uncertainty on the value of collateral is resolved.

<sup>8</sup>The (steady state) value of  $qh$  in the denominator is a simple normalization.

generally a shorter history in lending to local firms (Dell’Ariccia et al., 1999), and hence knowledge of a smaller pool of second-hand users. Therefore, when they liquidate few assets they may address the efficient users they know, like domestic lenders. However, as they liquidate additional assets, they may have to address a pool of increasingly unknown users. Thus, they can make “mistakes” and address sub-optimal users.<sup>9</sup> A related argument follows Heaton and Lucas (1996). Assets can feature heterogenous liquidity and foreign lenders may be less able to identify liquid collateral than domestic. Thus, the collateral portfolio of domestic lenders may comprise highly liquid assets, while that of foreign lenders may comprise assets of heterogeneous liquidity. At the liquidation stage, foreign lenders will lose more and more value as they resell increasingly illiquid assets.

(ii) *Asset recovery*: The limited ability of foreign lenders can occur at the bankruptcy stage. Foreign lenders may understand local insolvency practices less than domestic lenders, especially when bankruptcy laws are poorly drafted (see Hermalin and Rose, 1999; Rajan and Zingales, 1998). For example, foreign lenders may count on a smaller pool of local officers acquainted with local bankruptcy procedures. Therefore, as they recover additional collateral, they may eventually have to resort to expensive local expertise, say hiring local lawyers (Hermalin and Rose, 1999).

(iii) *Information acquisition*: The examples thus far take lenders’ liquidation ability as given. This ability allegedly stems from information acquisition. It is reasonable that gathering additional information is more costly for foreign lenders than for domestic: that is, the technology for information acquisition of foreign lenders exhibits decreasing returns to scale. Indirectly, this would imply diseconomies to scale in their liquidation technology. In a similar vein, Hermalin and Rose (1999) argue that foreign lenders face higher marginal monitoring costs than domestic lenders so that their supply of funds is shifted inwards relative to the domestic one.

Our liquidation technology contains more information than the diseconomies to scale faced by foreign lenders. In fact, for small values of assets foreign lenders have a lower average liquidation cost. Otherwise, foreign lenders would be dominated by domestic and would never be chosen. This feature appears consistent with the pattern of international lending. Our analysis especially fits concentrated lenders, such as banks. For example, while concentrated lenders are directly involved in bankruptcy and liquidation procedures, dispersed financiers play a less active role, so that differences in their liquidation ability are likely to be less relevant. Internationally active financial institutions are on average larger<sup>10</sup> and probably count on better organized loan recovery offices than small ones. Domestic lenders consist instead of a mix of internationally active institutions and smaller ones. One can think that in our economy, if their local experience and knowledge were as abundant as for domestic lenders, foreign lenders would have a linear liquidation technology with a lower average liquidation cost than the domestic. Yet they suffer from diseconomies to scale. Hence, for sufficiently high values of collateral, the advantage due to their organized offices is offset by the disadvantage due to their limited local experience.

*Credit constraints*: Let  $\alpha_t$  be the share of real estate  $h_t$  used by the entrepreneur as domestic collateral and  $1 - \alpha_t$  the share used as international collateral. Let  $b_t^H$  and  $b_t^F$  be the amount of borrowing from domestic and foreign lenders, respectively. Given lenders’ liquidation costs in 1 and 2, the entrepreneur will face the following two borrowing

<sup>9</sup>Ramey and Shapiro (2001) stress the importance of search costs in asset redeployment.

<sup>10</sup>Tschoegl (2003) reports that the parent banks of US foreign subsidiaries are the largest banks domestically.

constraints:

$$R_t^H b_t^H \leq E_t(m_H \alpha_t q_{t+1} h_t), \tag{3}$$

$$R_t^F b_t^F \leq E_t \left( q_{t+1} (1 - \alpha_t) h_t \left( 1 - \frac{1 - m_F}{qh} (q_{t+1} (1 - \alpha_t) h_t) \right) \right). \tag{4}$$

It is clear that  $m_H$  and  $m_F$  can reflect the average efficiency of the liquidation technology of domestic and foreign lenders, respectively. Put differently,  $m_H$  and  $m_F$  can be thought of as proxies for the loan-to-value (LTV) ratios for domestic and foreign loans.

### 2.2. The full model

We now embed the above features in a dynamic general equilibrium model. As the two countries are symmetric, it suffices to describe the decisions in the domestic economy only.

Entrepreneurs consume the final good, which they produce using labor and real estate. They can borrow from domestic and foreign households, with their borrowing capacity being determined by the expected value of the assets (real estate) they pledge, respectively, to domestic and foreign households according to (3) and (4). The production function is Cobb–Douglas in domestically located labor  $l_t$  (immobile across countries and remunerated at  $w_t$ ) and real estate:

$$Y_t = A_t h_{t-1}^v l_t^{1-v}, \tag{5}$$

where  $A_t$  follows an AR(1) process in logs. Preferences are given by

$$E_0 \sum_{t=0}^{\infty} \gamma^t \ln c_t, \tag{6}$$

where  $c_t$  is consumption and  $\gamma$  is the discount factor. The flow of funds is

$$A_t h_{t-1}^v l_t^{1-v} + b_t^H + b_t^F = c_t + q_t \Delta h_t + R_{t-1}^H b_{t-1}^H + R_{t-1}^F b_{t-1}^F + w_t l_t, \tag{7}$$

where  $\Delta h_t \equiv h_t - h_{t-1}$ , and the domestic and foreign borrowing constraints are described by (3) and (4). Entrepreneurs choose labor demand, real estate holdings, domestic borrowing, foreign borrowing and the allocation of real estate (collateral) between domestic and foreign financiers. Denote with  $\lambda_t^H$  and  $\lambda_t^F$  the time  $t$  shadow values of the domestic and foreign borrowing constraint, respectively. The first-order conditions for optimal consumption require that

$$1/c_t = E_t(\gamma R_t^H / c_{t+1}) + \lambda_t^H R_t^H, \tag{8}$$

and

$$1/c_t = E_t(\gamma R_t^F / c_{t+1}) + \lambda_t^F R_t^F. \tag{9}$$

The optimal choice of  $\alpha_t$  equates the marginal benefit of domestic and foreign collateral:

$$\lambda_t^H m_H = \lambda_t^F E_t \tilde{m}_{t+1}^F, \tag{10}$$

where  $\tilde{m}_{t+1}^F \equiv 1 - 2(1 - m_F)(1 - \alpha_t) q_{t+1} h_t / (qh)$  is the extra borrowing allowed when collateral is pledged to foreign financiers. Efficient real estate demand requires

$$\frac{q_t}{c_t} = E_t \frac{\gamma}{c_{t+1}} \left( v \frac{y_{t+1}}{h_t} + q_{t+1} \right) + E_t [\lambda_t^H m_H \alpha_t q_{t+1} + \lambda_t^F (1 - \alpha_t) q_{t+1} \tilde{m}_{t+1}^F], \tag{11}$$

where the terms in square brackets denote the marginal benefit that real estate offers as collateral. Finally, labor demand is given by

$$w_t = (1 - v)y_t/l_t. \tag{12}$$

The consumption Euler equations and the real estate demand differ from the usual formulations because of the presence of the Lagrange multipliers on the borrowing constraint. In a neighborhood of the steady state equilibrium, the multipliers will be positive, so long as the entrepreneurial discount factor  $\gamma$  is lower than the households' discount factor  $\beta$ , which in turn prices bonds.

The household sector (denoted with a prime) is conventional. In each period, households enter with real estate  $h'_{t-1}$  and bonds coming to maturity. They derive utility from consumption  $c'_t$  and from real estate services proportional to the holdings  $h'_t$ . They rent labor  $l_t$  to domestic entrepreneurs, lend  $b_t^H$  to domestic firms,  $b_t^{F*}$  to foreign firms and lend  $b_t$  (or borrow  $-b_t$ ) to (from) foreign households, while receiving back the amount lent in the previous period times the agreed gross interest rates, respectively  $R^H$ ,  $R^{F*}$  and  $R$ . Preferences are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \ln c'_t + j \ln h'_t - \frac{\tau}{\eta} l_t^{\eta} \right), \tag{13}$$

where  $\beta$  is the discount factor. The flow of funds is

$$c'_t + q_t \Delta h'_t + b_t^H + b_t^{F*} + b_t = R_{t-1}^H b_{t-1}^H + R_{t-1}^{F*} b_{t-1}^{F*} + R_{t-1} b_{t-1} + w_t l_t. \tag{14}$$

where  $\Delta h'_t \equiv h'_t - h'_{t-1}$ . The solution to the household problem yields standard first order conditions for the choice of bonds, real estate and labor (see the technical appendix for the details).

### 3. Equilibrium and dynamic properties

Given bonds  $(b_{t-1}^H, b_{t-1}^F, b_{t-1}^{H*}, b_{t-1}^{F*}, b_{t-1})$ , real estate  $(h_{t-1}, h'_{t-1}, h_{t-1}^*, h'_{t-1}^*)$ , interest rates  $(R_{t-1}, R_{t-1}^H, R_{t-1}^F, R_{t-1}^{H*}, R_{t-1}^{F*})$  and technology  $(A_t, A_t^*)$ , a recursive competitive equilibrium is characterized by a path of asset prices  $(q_t, q_t^*)$ , interest rates  $(R_t, R_t^H, R_t^F, R_t^{H*}, R_t^{F*})$ , domestic collateral shares  $(\alpha_t, \alpha_t^*)$ , wages  $(w_t, w_t^*)$ , consumption  $(c_t, c'_t, c_t^*, c'_t^*)$ , real estate  $(h_t, h'_t, h_t^*, h'_t^*)$ , bonds  $(b_t^H, b_t^F, b_t^{H*}, b_t^{F*}, b_t)$ , labor  $(l_t, l_t^*)$ , output  $(y_t, y_t^*)$ , multiplier on credit constraint  $(\lambda_t, \lambda_t^*)$ , such that entrepreneurs and households maximize their utility and the bond, labor, real estate and world's final good markets clear.

In our economy, the key variable is  $\alpha_t$ , which determines entrepreneurs' relative debt exposure to domestic and foreign lenders. Using (10) and the no arbitrage conditions for the interest rates, one can solve for the optimal  $\alpha_t$  as a function of the value of real estate held by entrepreneurs:

$$\alpha_t = 1 - \frac{1 - m_H}{2(1 - m_F)} \frac{qh}{E_t(q_{t+1}h_t)}. \tag{15}$$

The optimal  $\alpha_t$ , the share of domestic collateral, is positively related to the domestic LTV ( $m_H$ ) and inversely related to the foreign LTV ( $m_F$ ). In addition, near the steady state,  $\alpha_t$  rises with real estate prices and holdings. That is, increases in the value of the entrepreneurial real estate will be associated with a switch from foreign to domestic



lenders. For example, consider a temporary increase in the expected value of real estate  $E_t(q_{t+1}h_t)$ , coming from, say, a positive shock to real estate productivity. Following the shock, transaction costs become relatively higher *at the margin* for the foreign lender. Hence, the amount of entrepreneurs' foreign borrowing rises in percentage less than the amount of domestic borrowing ( $\alpha$  rises).

In steady state, the equality of discount rates between domestic and foreign households would imply that the net foreign asset position  $b$  of domestic households vis-à-vis foreign is indeterminate and cannot be uniquely pinned down. In addition, the law of motion for households' bond holdings would not be a stationary variable. We work around this problem by imposing a very small quadratic cost on holding a quantity of household bonds  $b$  different from a symmetric level of 0.<sup>11</sup> The steady state and the complete linearized model are presented in the technical appendix.<sup>12</sup>

### 3.1. Allowing for variable capital

In the model above, although real estate changes hands between households and entrepreneurs, aggregate investment is zero because the total supply of the productive asset is fixed. It is straightforward to extend the model to allow for aggregate investment. Such an extension is valuable when one looks at the cyclical properties of the model, because it allows a more direct comparison of the model with the traditional two-country stochastic general equilibrium setup à-la Backus et al. (1992).

To do so, assume that entrepreneurs accumulate another asset,  $k$ , that can be reproduced from the final good. The technology is  $Y_t = A_t k_{t-1}^\mu h_{t-1}^v l_t^{1-\mu-\nu}$  and entrepreneurs own the entire variable capital stock which depreciates at rate  $\delta$ . Their flow of funds becomes:

$$A_t k_{t-1}^\mu h_{t-1}^v l_t^{1-\mu-\nu} + b_t^H + b_t^F = c_t + i_t + q_t \Delta h_t + R_{t-1}^H b_{t-1}^H + R_{t-1}^F b_{t-1}^F + w_t l_t, \quad (16)$$

where  $i_t = k_t - (1 - \delta)k_{t-1}$ . As for the properties of  $k$  as collateral, we adopt a flexible approach, by considering the cases both when variable capital cannot be used as collateral and when it can be used. In the latter case, symmetrically to real estate, we specify proportional (convex) liquidation costs for domestic (foreign) lenders, denoting the average domestic (foreign) LTV ratio associated with variable capital by  $z_H$  ( $z_F$ ) (see the technical appendix for details).

The modeling choice in which variable capital cannot be collateralized is interesting for a number of reasons. The first relates to the transmission mechanism. Our transmission mechanism is based on the interaction between prices and entrepreneurial holdings of collateralizable assets on the one hand and lenders' liquidation costs on the other. Unlike the price of real estate, in our economy the price of variable capital is fixed. Therefore, assuming that variable capital cannot be used as collateral better isolates our mechanism.

<sup>11</sup>See for instance Schmitt-Grohé and Uribe (2003) and our technical appendix.

<sup>12</sup>In steady state  $R = 1/\beta$ . Combining this result with the steady state entrepreneurial Euler equation for consumption yields:  $\lambda = (\beta - \gamma)/c$ . If  $\beta > \gamma$ ,  $\lambda > 0$  and the borrowing constraint will hold with equality near the steady state. However, if the variance of the shocks is very large or  $\gamma$  is very close to  $\beta$ , entrepreneurs might not borrow up to the limit after a long series of productivity shocks and decide instead to keep a buffer stock of resources to use in bad times to avoid the possibility of hitting the borrowing constraint. By assuming that the variance of the shocks is small and that  $\gamma$  is well below  $\beta$ , among other things, we can minimize the probability that credit constraints become non-binding in some states of the world.

In fact, for clarity of the argument, the analysis of [Kiyotaki and Moore \(1997\)](#) in a closed economy, with which we share some features of the transmission mechanism, assumes that variable capital cannot be used as collateral.

The second reason relates to the asymmetry in the liquidation technology, which constitutes a distinctive aspect of our environment. Allegedly, a typical feature of real estate markets is their idiosyncrasy. The organization of these markets, their liquidity and the type of active institutions sharply differ across countries. This implies that, when foreign lenders liquidate real estate, the experience built in their home market could be of little use. Hence, the assumption that foreign lenders have limited experience of the resale market for collateral appears realistic when collateral consists of real estate. Put differently, real estate is readily identifiable with countries.

The third reason relates to the fact that variable capital can also include inventories. For instance, an important strand of literature in financial economics argues that inventories may constitute a worse form of collateral than commercial property. In fact, unlike buildings, inventories can be absconded and continuously transformed ([Myers and Rajan, 1998](#); [Longhofer and Peters, 2004](#)).<sup>13</sup> Furthermore, the use of inventories as collateral is increasingly penalized by the international banking regulation. The norms of Basel II require periodic inspections by banks of inventories that are collateral. According to several practitioners this requirement can discourage banks from accepting this kind of collateral (European Association of Craft, Small and Medium-Sized Enterprises, 2003).<sup>14</sup>

### 3.2. Calibration

To show the basic workings of our model, we set variable capital aside for the moment. Likewise, we assume that productivity shocks are temporary and do not spillover across countries. Later, when considering the cyclical properties of the model, we allow for richer interactions between domestic and foreign shocks taking the parameters describing the evolution of the technology from [Backus et al. \(1992\)](#), who model productivity as highly persistent and allow for spillovers.

[Table 1](#) reports the calibrated parameters. The two countries are assumed to be symmetric, and our time period is a quarter:  $\beta = 0.99$ , implying an annual real interest rate of 4%;  $\gamma = 0.98$ , implying a steady state in which the return on entrepreneurial investment is 8%. Labor supply elasticity is set at 0.05, in the ballpark of several microeconomic studies (e.g. [Browning et al., 1999](#)): this way, the response of output to shocks depends almost entirely on the behavior of technology and on changes in entrepreneurs' real estate holdings. The elasticity of output to labor is 0.9 and the elasticity of output to real estate ( $\nu$ ) is 0.1. In the household utility function, the weight  $j$  on real estate is set equal to 0.1. These parameter choices imply that real estate is about equally split between households and entrepreneurs.

The parameters describing the average liquidation ability (the LTV ratios) are set equal to  $m_H = 0.9$  and  $m_F = 0.8$ . Given the liquidation technology, the steady state level of  $\alpha$ , the share of domestic collateral, is equal to 75%, whereas entrepreneurs' domestic debt and

<sup>13</sup>Clearly, other arguments work in the opposite direction. For example, inventories are generally quite liquid.

<sup>14</sup>This opinion is expressed in "Review of Capital Requirements: UEAPME's comments on the Third Consultative Document issued by the European Commission", October 22nd 2003.

Table 1  
Calibrated parameter values

Description	Symbol	Model		
		Basic	Extended $h$ collateral	Extended $h, k$ collateral
Household discount	$\beta$	0.99	0.99	0.99
Entrepreneur discount	$\gamma$	0.98	0.98	0.98
Domestic LTV for $h$	$m_H$	0.9	0.9	0.9
Foreign LTV for $h$	$m_F$	0.8	0.8	0.8
Domestic LTV for $k$	$z_H$	–	–	0.9
Foreign LTV for $k$	$z_K$	–	–	0.8
$h$ utility weight	$j$	0.1	0.1	0.1
$h$ share	$v$	0.1	0.1	0.1
Labor wage elasticity	$\frac{1}{\eta - 1}$	0.05	0.05	0.05
$k$ share	$\mu$	–	0.25	0.25
$k$ depreciation	$\delta$	–	0.03	0.03

Autocorrelation and variance covariance matrix of the shocks

$$\begin{bmatrix} \widehat{A}_{t+1} \\ \widehat{A}_{t+1}^* \end{bmatrix} = \Gamma \begin{bmatrix} \widehat{A}_t \\ \widehat{A}_t^* \end{bmatrix} + \varepsilon_t, \quad \Gamma = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}, \quad \Gamma = \begin{bmatrix} 0.9 & 0.09 \\ 0.09 & 0.9 \end{bmatrix}$$

$$E\varepsilon\varepsilon' = \Xi \quad \begin{bmatrix} 0.726 & 0 \\ 0 & 0.726 \end{bmatrix} \quad \begin{bmatrix} 0.726 & 0.187 \\ 0.187 & 0.726 \end{bmatrix}$$

foreign debt are, respectively, 150% and 50% of annual output.<sup>15</sup> Entrepreneurial real estate ends up being worth about 2 times annual output. In addition, entrepreneurs end up being highly levered and consume 3% of total output, whereas households consume the remaining fraction.

In the extended model, the elasticity  $\mu$  of output to variable capital is set equal to 0.25 (so that, with  $v = 0.1$ , the labor share is 65%) and the capital depreciation rate is 3%. When only  $h$  can be used as collateral, steady state investment to output equals 15%, households consume 73% of output, and entrepreneurs consume 12%. The steady state ratios of domestic and foreign entrepreneurial debt and asset prices to output are independent of  $\mu$ , and are the same as in the basic model. When both  $h$  and  $k$  can be used as collateral, we assume  $z_H = 0.9$  and  $z_F = 0.8$ . This way, the steady state ratios of domestic and foreign debt to output are larger, and equal 250% and 88% of annual output, respectively. Steady state investment to output is now 18%, households consume 78% of output, and entrepreneurs (being more levered) consume 4%.

<sup>15</sup>In 2002, the total liabilities (credit market instruments, trade payables, taxes payable and miscellaneous liabilities) of Nonfinancial Businesses in the US were 13.2 trillion dollars, that is 126% of GDP. The total liabilities of Households and Nonprofit Organizations were 8.7 trillion dollars, that is 84% of GDP (source: Federal Reserve, Flows of Funds of the United States, Tables L.100 and L.101). Moving to the foreign sector, the total amount of US-owned assets abroad was 6.5 trillion dollars (62% of GDP), which were split roughly equally between foreign direct investment, securities, and loans. The total amount of foreign-owned assets in the US was 9.1 trillion dollars, or 87% of GDP (source: BEA, Survey of Current Business, December 2003, Table G.1, lines 4 and 25). Although our model does not differentiate between the various liabilities, our values of 150% for domestic and 50% for foreign entrepreneurial debt are roughly consistent with these data.

3.3. Results

*Impulse responses:* Our transmission mechanism has two distinct aspects: on the one hand, the effect of changes in asset values on entrepreneurs’ debt capacity and asset demand (à-la Kiyotaki and Moore, 1997); on the other, the effect of changes in asset values on the relative efficiency of domestic and foreign lenders. We highlight the contribution of each channel by considering for simplicity the impact of a temporary shock to  $A_t^*$ , the foreign productivity.

The impulse responses of the basic model are in Fig. 1. To disentangle the contribution of the asymmetry between domestic and foreign lenders, we compare the responses with those obtaining when there is no difference (equal average and marginal liquidation costs) between domestic and foreign borrowing, so that the allocation of collateral across lenders becomes exogenous. That is, we consider an economy (exogenous- $\alpha$  economy, squared lines) where the initial levels of domestic and foreign entrepreneurial debt are the same as in our preferred model, but they increase in an equal proportion when the value of real

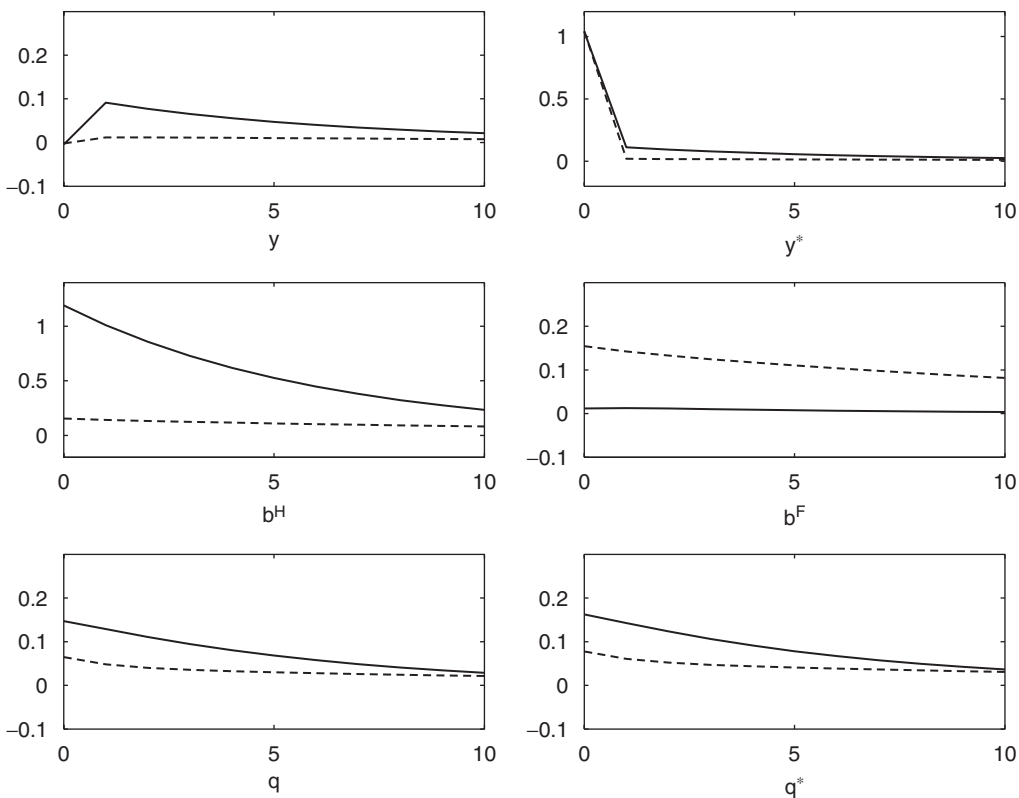


Fig. 1. Impulse responses to a temporary foreign productivity shock at time 0, model without variable capital. Solid lines: model with asymmetry between domestic and foreign lenders (endogenous  $\alpha$ ). Dashed lines: model with symmetric lenders (exogenous  $\alpha$ ). Ordinate: time horizon in quarters. Coordinate: % deviation from the baseline.

estate holdings rises. This version can be thought of as an extension of [Kiyotaki and Moore \(1997\)](#) to an international environment.<sup>16</sup>

In both countries, the shock to productivity elicits: (i) an increase in production; (ii) a rise in real estate prices; (iii) an increase in the relative importance of domestic versus foreign entrepreneurial borrowing. The positive impact of the shock is transmitted to the domestic economy generating a positive comovement of production in the two economies. Unsurprisingly, in period 0 output does not move at home while  $A^*$  has a direct effect on foreign output. However, the response of entrepreneurs' real estate holdings (not shown) is similar in the two countries, and is quite persistent despite the fact that the productivity shock only lasts one period. From period 1 on the countries experience deviations of output from steady state which are similar. In the exogenous- $\alpha$  economy, instead, the international transmission of the shock operates through the effect of asset values on credit constraints but not through changes in the relative debt exposure of entrepreneurs to foreign and domestic lenders. There is limited propagation of the shock to the domestic economy and the rise in the price and entrepreneurs' holdings of real estate is smaller.

How does the endogenous- $\alpha$  economy generate a stronger comovement? Our view is the following. After the positive technology shock in the foreign country, asset prices rise abroad and domestically. Without technology spillovers, a temporary foreign shock pushes domestic asset prices higher initially because of general equilibrium effects (mainly, the drop in the world interest rate drives up asset demand and prices both home and abroad).<sup>17</sup> In the model with technology spillovers, the increase in the productivity of domestic real estate will exert a direct pressure on domestic asset prices.<sup>18</sup> The rise in domestic real estate prices modifies the incentive for domestic firms to borrow from domestic versus foreign households. In fact, because of the increase in the value of real estate, the average liquidation cost faced by foreign lenders increases, while that of domestic lenders stays constant: the liquidation ability of foreign lenders becomes strained as the value of collateral rises. As domestic borrowing rises relative to foreign, entrepreneurs have a higher incentive to invest in real estate. In fact, real estate has a higher marginal value as collateral whenever the entrepreneur borrows from a more efficient marginal liquidator. Put differently, as entrepreneurs switch to domestic lenders, their real estate demand increases more, because they know that each additional unit of real estate will relax their credit constraints more. This induces further pressure in the domestic real estate market, leading to a further increase of real estate prices.<sup>19</sup> Overall, since increases in

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<sup>16</sup>[Paasche \(2001\)](#) extends the Kiyotaki and Moore framework to a model of contagion for two small economies that trade with a large economy but not with each other. In this model, propagation relies on terms of trade effects which are amplified by a collateral constraint.

<sup>17</sup>The interest rate drop also signals households to gradually consume the increase in production, starting from a large consumption today, and slowly returning to the baseline. For these standard effects see [King and Rebelo \(1999\)](#).

<sup>18</sup>The comovement of asset prices is a common feature of international business cycle models based on the financial accelerator (see [Gilchrist et al., 2002](#); [Faia, 2002](#)). Several empirical studies find a positive international correlation of asset prices. For example, analyzing commercial property values in 21 countries over the period 1987–1997, [Case et al. \(2000\)](#) find correlations within property types across countries that range between 0.33 and 0.44. The comovement of asset prices between the two economies is crucial for the mechanism of international transmission of cycles we describe, though it is not the main focus of the paper.

<sup>19</sup>Remember that entrepreneurs demand real estate both for its services as an input and as collateral. Moreover, the (marginal) usefulness of real estate as collateral depends on the (marginal) liquidation ability of the lender. The increase in real estate holdings and prices spurs the average liquidation cost faced by foreign lenders further, and so forth.

Table 2  
Business cycle properties of the model with variable capital

	Exo $\alpha$ <i>h</i> coll.	Endo $\alpha$ <i>h</i> coll.	Endo $\alpha$ <i>h, k</i> coll.	BKK baseline	BKK transport	BKK autarky	data
<i>Correlation of <math>y</math> with</i>							
$b^H$	0.81	0.77	0.76	na	na	na	0.52
$b^F$	0.81	-0.65	-0.65	na	na	na	-0.14
$q$	0.45	0.67	0.81	na	na	na	0.58
$C$	0.77	0.84	0.74	0.79	0.82	0.91	0.87
<i>Correlations between variables across countries</i>							
$y, y^*$	0.16	0.27	0.32	-0.18	0.02	0.11	0.51
$C, C^*$	0.95	0.95	0.96	0.88	0.91	0.73	0.32
$q, q^*$	0.95	0.95	0.96	na	na	na	0.50

*Notes:* All series are detrended using the HP filter.  $C$  ( $C^*$ ) denotes aggregate domestic (foreign) consumption. The correlations in column 5 are from Backus et al. (1992) baseline two-country international RBC model with a time-to-build structure. The correlations in column 6 are from Backus et al. (1992) model augmented with a cost for shipping goods across the border. The correlations in column 7 are from Backus et al. (1992) autarky model with no physical trade and no international borrowing. In the last column, the international correlations for  $y$ ,  $y^*$ ,  $C$  and  $C^*$  are calculated from US variables and an aggregate of 15 European countries and are from Kehoe and Perri (2002). Those of  $y$  with  $b^H$ ,  $b^F$ ,  $q$  and  $C$  and the international correlation of  $q$  with  $q^*$  are calculated using data on domestic loans, foreign loans, commercial real estate and Japan real estate (land) prices (all in real terms) as described in Iacoviello and Minetti (2003).

the entrepreneurs' real estate holdings and prices relax credit constraints, domestic output increases more than in the exogenous- $\alpha$  economy.

*Cyclical properties:* The results of the previous experiment are qualitatively similar when one allows for variable capital and persistent technology shocks which spill over across countries. We now derive a more precise measure of the interactions at stake, borrowing the properties of the technology from Backus et al. (1992), as reported in the last column of Table 1.

Table 2 shows the cyclical properties of our simulated economies in columns 2–4, reporting the contemporaneous correlations with home output of domestic and foreign entrepreneurial debt, asset prices and consumption. The table also shows the international output, consumption and asset price correlations. We report statistics for the exogenous- $\alpha$  economy with only  $h$  as collateral (column 2); for the endogenous- $\alpha$  economy with only  $h$  as collateral (column 3) and with both  $h$  and  $k$  as collateral (column 4). We compare our results with the data (last column). For ease of comparison with related literature, the table also reports the corresponding statistics in Backus, Kehoe and Kydland (open economy RBC model with time-to-build structure). The table reports statistics for their benchmark economy (column 5), for their economy with a transportation cost (column 6) and for their model with financial autarky and no international borrowing (column 7).

While our model cannot explain the full range of effects at stake, it is successful in turning the international output correlation from negative to positive. The exogenous- $\alpha$  model (with only  $h$  as collateral) predicts a positive correlation between  $y$  and  $y^*$  of 16%. The asymmetry between domestic and foreign lenders increases international output correlation to 27%. If one allows for collateralizable variable capital, the correlation between  $y$  and  $y^*$  grows larger, from 27% to 32%.

We now turn to the model predictions regarding the second moments of debt, asset prices and consumption. Both the endogenous and the exogenous- $\alpha$  economies predict positive correlations of domestic asset prices with domestic output and foreign asset prices. These features are consistent with the data. However, interestingly, only the endogenous- $\alpha$  economies capture the strongly procyclical pattern of the ratio domestic/foreign business debt observed in the data.<sup>20</sup> In Iacoviello and Minetti (2003), we derive a structural test for the predicted behavior of this ratio, by relating it to the expected value of firms' pledgeable assets: using US time-series data, we show that real estate values positively affect the importance of domestic versus foreign business loans.

Domestic and foreign consumption are more highly correlated in the model than in the data. This finding is neither new nor surprising. Households, who do *not* face financing constraints in the model, do most of the consumption in steady state. As found by Backus et al. (1992), in a context without frictions, the operation of the permanent income hypothesis generates an international correlation of consumption much higher than in the data. It would be worth exploring modifications to our modeling structure that preserve our key mechanism and can help to get around the differences between the theory and the data: this issue is left for future research.

#### 4. Conclusions

This paper has presented a two-country general equilibrium model in which the relative importance of credit frictions that entrepreneurs face vis-à-vis domestic and foreign lenders changes over the cycle. As a result, entrepreneurs endogenously adjust their allocation of collateral between domestic and foreign lenders in order to minimize the total cost of credit frictions. The endogenous interaction between relative credit frictions, domestic and foreign debt exposure and collateral values acts as a powerful international transmission mechanism of technology shocks, allowing to explain business cycle comovements across countries.

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<sup>20</sup>On the international correlation of property prices, see Case et al. (2000). On the procyclicality of the ratio domestic/foreign bank debt, see Dages et al. (2000) and Goldberg (2002).

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