Financial deleveraging and the international transmission of shocks

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1. Introduction

The current international financial crisis has highlighted the critical role of financial markets in the propagation of business cycle shocks, both in transmitting shocks from one country to another and in magnifying the effects of shocks. A relatively minor (on a global scale) deterioration in the US subprime mortgage market led to a much larger collapse in the asset values of major US investment banks, which in turn quickly precipitated a major crisis affecting financial institutions across the globe.

It is widely agreed that high financial leverage – high ratios of assets to underlying capital – was a critical factor in the magnifying effects of the crisis. As asset values declined, highly leveraged financial institutions found their net worth sharply eroded, and were forced to shed assets to avoid unacceptable risks of insolvency. This process of "deleveraging" drove asset values down further, impairing the balance sheets of other institutions. While the financial dynamics of balance sheet deleveraging have been widely discussed elsewhere, it is less well understood how this process affects macroeconomic outcomes or that financial deleveraging alone may generate an immediate and powerful international transmission of shocks.

A clear prerequisite for deleveraging to have powerful macroeconomic effects is the presence of some type of financial friction or distortion in credit markets. After all, in a frictionless, undistorted world, leverage is irrelevant. Thus, in order to capture the dynamics of the financial meltdown, financial frictions will be of critical importance.

Many existing models do a poor job of explaining international spillovers during the recent crisis. Most models of business cycle transmission still rely on the international linkage of countries through trade flows. While global trade has been growing at remarkable rates over the past two decades, it is still the case that the major world regions – the United States, Asia and Europe – are to a large extent "closed" economies, with the export share from one region to another representing only a small proportion of overall GDP. This perspective led many to believe in the prospects for a 'de-coupling' of the rest of the world from a US recession. But the rapid deterioration in economic activity in almost all regions of the world during the current crisis appears to be much larger than would have been anticipated based on trade linkages alone. Krugman (2008) suggests that traditional multi-country business cycle models lack a critical "international finance multiplier" by which financial shocks in one country affect investment both in the original country and in other countries through financial or balance sheet linkages.

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This paper discusses a theoretical model of a balance sheet channel for the international transmission of shocks. The model emphasises how a process of financial deleveraging, generated by a downturn in one country, is spread around the globe through interconnected portfolios. In the presence of leverage constraints, we show that this gives rise to a separate financial transmission mechanism of business cycle shocks that is completely independent of trade linkages. In fact, we work with a highly stripped down "one world good" model in which, in steady state, there are no trade linkages across countries at all.

The paper's main contribution is to compare how macro shocks are transmitted under two financial market structures. The model contains two countries in which investors borrow from savers in each country, and invest in fixed assets. Investors also diversify their portfolios across countries, and hold equity positions in the assets of the other country as well as their own. Investors cannot commit to repay savers, however, and in order to enforce payment, may face limits on the maximum amount of leverage on their balance sheets. In an environment where leverage limits do not bind, the Modigliani-Miller theorem applies, and the international transmission of shocks is quite limited. Specifically, there is no international transmission due to deleveraging. A negative productivity shock which leads to a fall in the value of assets in one country will cause financial institutions to sell some assets and reduce their debt exposure, but this does not affect other countries. In fact, in other countries, investors increase their borrowing. More broadly, business cycle fluctuations across countries are essentially uncorrelated in the absence of limits on leverage.

When leverage constraints are binding, however, there is a powerful transmission of shocks across countries. A fall in asset values in one country forces an immediate process of deleveraging in that country's financial institutions. But the deterioration in asset values leads to a worsening of leverage constraints in other countries as well, causing a sell-off in assets and a forced reduction in borrowing around the globe. This, in turn, drives a further sell-off in the first country, establishing a feedback loop. The end result is a large magnification of the initial shock, a big fall in investment, and highly correlated business cycles across countries during the resulting downturn.

The model draws heavily on a number of separate literatures. First, and most importantly, we follow Kiyotaki and Moore (1997) in imposing leverage limits on investors. Second, we emphasise the linkages among countries through the presence of inter-connected portfolios. Portfolio linkages, in a somewhat different context, have for some time been seen as important in the contagion effects of financial shocks (see Rigobon 2003 and Pavlova and Rigobon 2008, for example). Finally, we introduce endogenous portfolio interdependence through the recently developed techniques of Devereux and Sutherland (2009).

The paper is organised as follows. The next section provides some evidence of the importance of financial deleveraging in the recent business cycle downturn. We then discuss the key components of the basic two-country model in which investors and savers interact, but investors may be limited by leverage constraints. In Section 4 we explore the effects of a negative productivity shock in one country, and demonstrate the role of deleveraging in the propagation of business cycle shocks across countries. We then conclude.

2. Empirical evidence

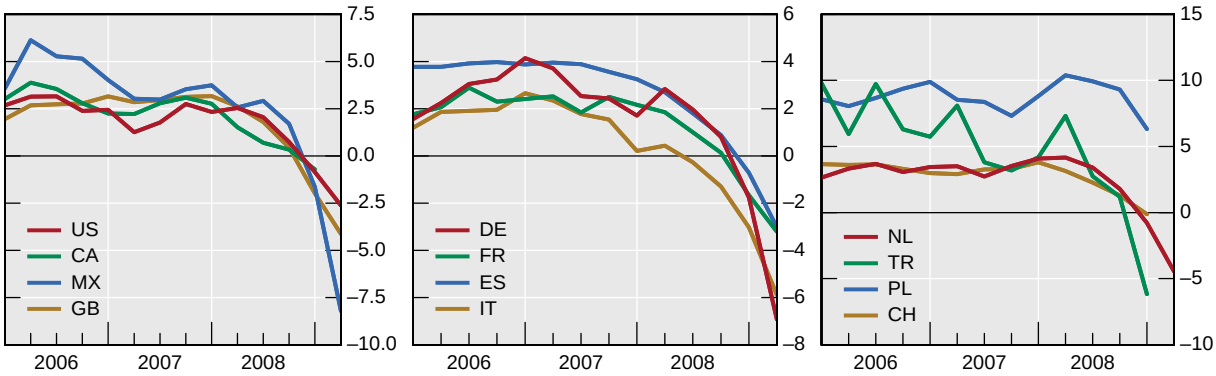
We present some empirical evidence that supports our contention that global deleveraging may have been an important propagation mechanism for the crisis. First, Figure 1 documents the global nature of the economic crisis. Figure 1a, for OECD countries, and Figure 1b, for economies in the Asia-Pacific, both show a remarkably synchronous collapse in economic growth rates. It is unlikely that trade linkages alone could account for the simultaneous downturns in all regions. If we take the US economy as the ultimate source of the financial crisis then it would be easy to explain the scale of the downturn in Mexico, for instance. But

Figure 1a illustrates dramatic reductions in economic growth in many European economies, only marginally linked to the US through trade flows. A similar picture emerges from the Asian economies in Figure 1b.

Figure 1a

Real GDP growth[1]

In per cent



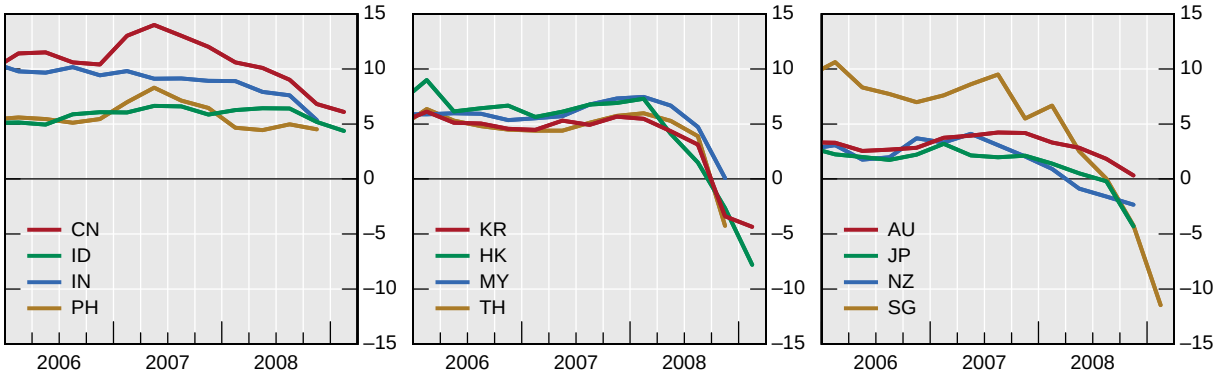
[1] Year-over-year changes in real GDP. US = United States, CA = Canada, MX = Mexico, GB = United Kingdom, DE = Germany, FR = France, ES = Spain, IT = Italy, NL = Netherlands, TR = Turkey, PL = Poland, CH = Switzerland.

Source: national data.

Figure 1b

Real GDP growth[1]

In percent



[1] Year-over-year changes in real GDP. AU = Australia, CN = China, HK = Hong Kong, IN = India, ID = Indonesia, JP = Japan, KR = South Korea, MY = Malaysia, NZ = New Zealand, PH = Philippines, SG = Singapore, TH = Thailand.

Source: national data.

In addition there is clear evidence that deleveraging by banks has reduced the supply of credit in Asia. Table 1a contains the stock of short-term exposures of US banks to major Asian economies. This is the total stock among US reporting banks of all loans to the destination economy with less than one year remaining until maturity. Under normal circumstances, in each quarter new claims are issued and many maturing existing claims are rolled over. A rapid decline in less than one year (for example, to Chinese Taipei between 2008Q2 and 2008Q4), then, implies little new issuance, and few loans being rolled over. Indeed, the average decline between 2008Q3 and 2008Q4 represents a 26% fall in total

claims on Asia, demonstrating that US banks have substantially deleveraged their balance sheets with respect to Asia since the beginning of the crisis.

Table 1a

Short-term claims of US banks on Asian economies

$US millions

Destination of funds	2007Q4	2008Q1	2008Q2	2008Q3	2008Q4
Hong Kong	10,079	10,066	12,900	11,366	8,837
Singapore	17,007	16,966	15,196	11,778	10,188
China	13,192	11,635	14,795	12,693	6,498
Chinese Taipei	7,845	9,689	8,929	7,155	3,795
India	25,722	20,779	16,582	17,093	13,801
Indonesia	6,007	5,902	5,286	6,782	5,313
Malaysia	3,345	3,431	4,054	2,201	1,997
Philippines	1,370	2,060	1,923	1,579	1,547
South Korea	26,254	27,435	28,027	29,873	21,518
Thailand	794	860	534	692	869

Source: BIS International Banking Statistics

Further evidence for deleveraging by US banks is presented in Table 1b, for all OECD countries for which data is available. While the evidence here is more mixed, there is a clear pattern overall that the largest OECD economies (by size of claims) have experienced a substantial fall in US bank claims during 2008. In particular, France, Germany Ireland, Italy, Korea and Luxembourg, the largest recipients of US bank claims, all experienced major withdrawals over 2008. Further, total claims across all countries declined by more than 20%, with half of that decline occurring in the final quarter.

Aside from bank balance sheets, we can also find clear evidence consistent with deleveraging in other instruments. Equities in particular were believed by many policymakers to be a vector of contagion, as the following remark by Rakesh Mohan, Deputy Governor of the Reserve Bank of India, indicates:

> "Our problems are mainly due to the sell-off by foreign institutional investors in the domestic equity markets leading to a sharp reduction in net capital inflows and the sharp slowdown in global economic activity and external demand." (Mohan 2009)

This view is consistent with the data on international capital flows captured by the Treasury International Capital System (Figure 2). The crisis has seen a fall in both inflows and outflows of capital from the US, at the aggregate level. The scale of the fall in flows in early 2009 is unprecedented over the full sample of aggregate TIC data going back to 1980. In the model we will see that this type of deleveraging, when combined with binding leverage constraints among financial institutions, can impart an independent international transmission of shocks.

Table 1b

Short-term claims of US banks on OECD economies

$US millions

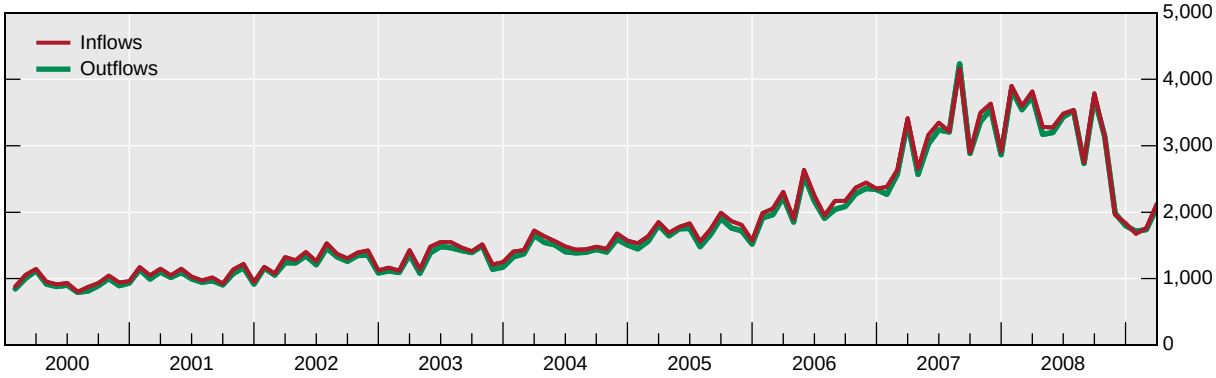
Destination of funds	2007Q4	2008Q1	2008Q2	2008Q3	2008Q4
Austria	4,179	4,207	4,841	3,574	2,256
Belgium	8,742	13,911	17,453	15,762	15,567
Czech Republic	527	716	798	894	518
Finland	3,191	2,837	2,386	3,024	2,928
France	57,952	69,098	41,790	44,355	55,287
Germany	56,910	65,933	48,407	41,295	39,266
Greece	3,947	4,857	3,005	2,310	2,428
Hungary	894	1,003	900	1,113	491
Ireland	28,317	27,471	28,082	27,767	23,550
Italy	25,180	25,521	26,215	18,617	17,243
Korea	26,254	27,435	28,027	29,873	21,518
Luxembourg	26,050	24,730	22,826	21,650	11,943
Mexico	6,492	7,752	7,497	6,784	7,734
Netherlands	43,132	46,995	52,071	47,617	37,230
Poland	2,356	2,254	2,279	2,308	2,521
Portugal	2,861	2,331	2,054	1,740	1,226
Spain	28,267	28,367	25,370	18,719	18,420
Turkey	7,320	6,916	7,014	6,010	5,107

Source: BIS International Banking Statistics

Figure 2

US capital inflows and outflows

In billions of US dollars



Source: US Department of Treasury.

Financial linkages versus trade linkages

The effect of global deleveraging should be expected to vary by country. Some economies are more dependent on capital inflows than others, and countries with low credit ratings may suffer more from a sudden reduction in flows than higher rated countries, for example. Evidence of the effects of deleveraging should account for the difference in vulnerabilities across countries.

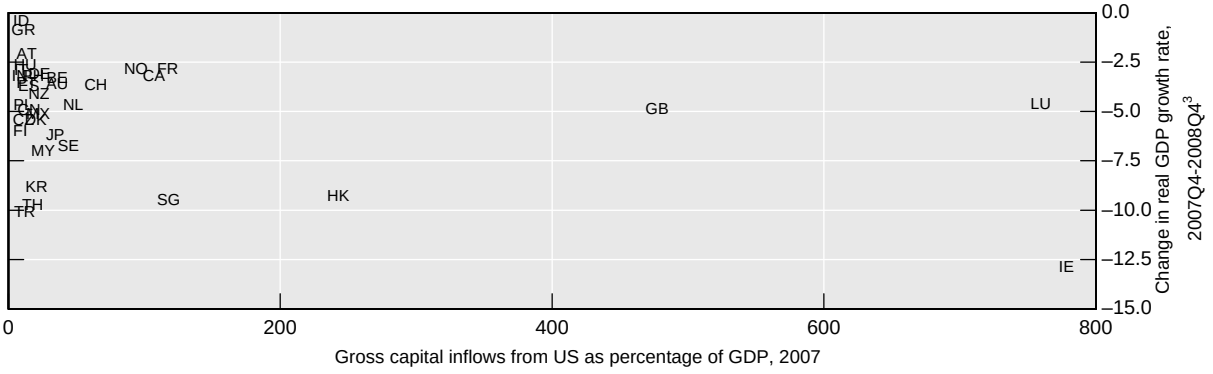
We demonstrate the importance of deleveraging as a propagation mechanism for the crisis using a simple graphical approach. As a rough measure of the international effect of the crisis, we use the change in the GDP growth rate between the year ended December 2007 and December 2008. The vulnerability of countries to a sudden outflow of capital is calculated as total gross sales by foreigners to US residents of long-term securities during 2007, as a percent of 2007 GDP, using US Treasury International Capital (TIC) data. Our sample includes all members of the OECD for which TIC data is available, as well as some additional Asian economies (China, Hong Kong, India, Indonesia, Malaysia, Philippines, Singapore and Thailand).

The results in the top panel of Figure 3 suggest no clear relationship between the slowdown and international capital flows. However, this does not account for difference in credit ratings across economies. It also does not separate international financial centres, which are likely to be affected differently by the crisis than other economies, and Ireland, which is an extreme outlier.

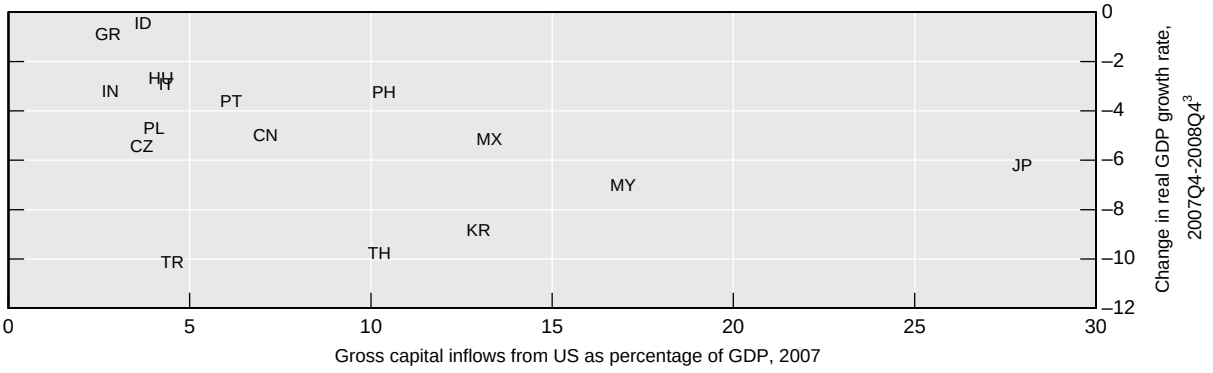
Figure 3

Decline in GDP as a function of capital inflows from US[1]

All countries



Credit rating < AA[2]



[1] Labels are 2-digit ISO country codes. [2] Sovereign foreign currency credit rating, S&P, 2007. [3] Real GDP growth rate in year to December 2008 less growth rate in year to December 2007.

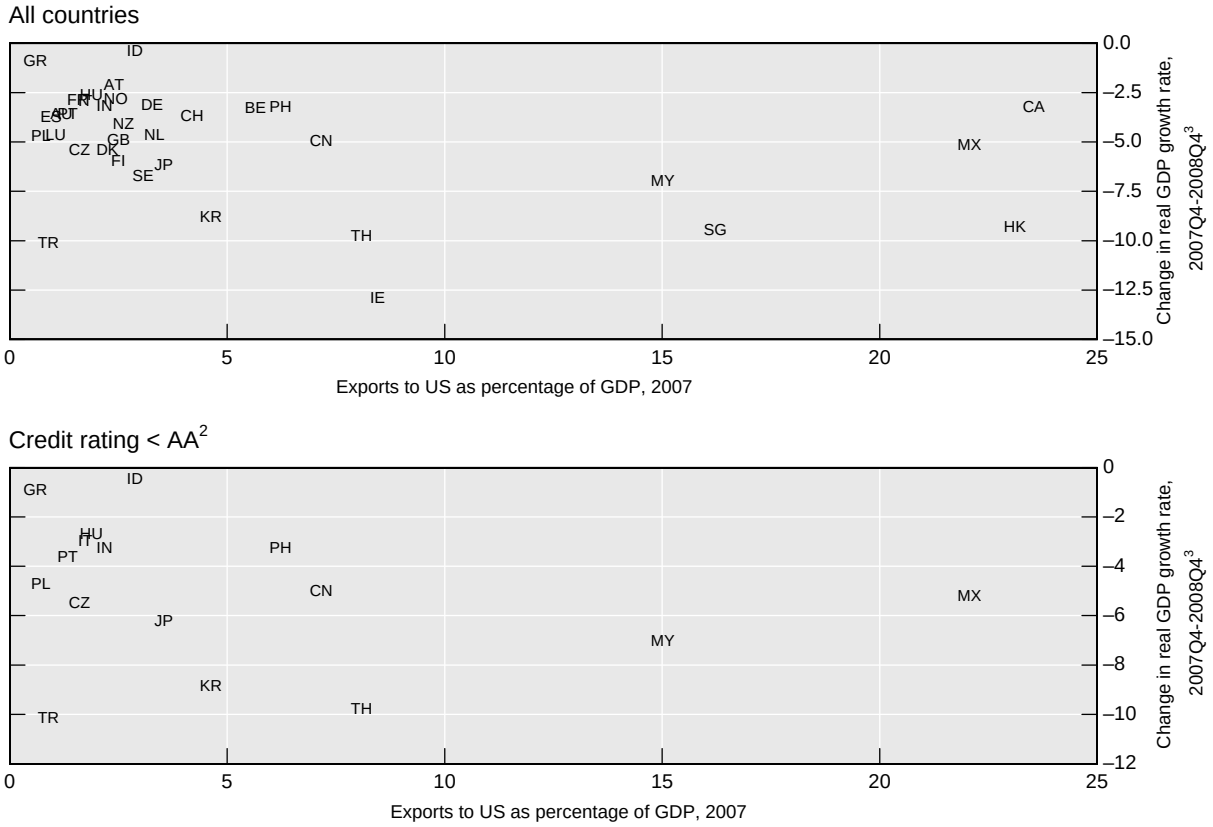
Source: Treasury International Capital System; International Financial Statistics; national data.

The lower panel repeats the analysis, including only those countries with a sovereign foreign currency rating lower than AA by S&P in 2007. Now there is a clearer negative relationship. Lower-rated economies that had previously enjoyed large capital inflows from the United States saw particularly severe declines in GDP.

The evidence for trade as a propagation mechanism for the crisis, using similar methods, is a little more mixed. Figure 4 repeats the analysis for the same samples of countries, substituting exports to the United States in 2007 as a percent of GDP from the IMF's Direction of Trade statistics in place of capital flows. There may be a negative relationship between trade and the downturn, but Mexico and Canada stand out as outliers with relatively minor declines in output, despite exports to the United States that exceed 20% of GDP.

Figure 4

Decline in GDP as a function of exports to US[1]



[1] Labels are 2-digit ISO country codes. [2] Sovereign foreign currency credit rating, S&P, 2007. [3] Real GDP growth rate in year to December 2008 less growth rate in year to December 2007.

Source: Treasury International Capital System; International Financial Statistics; national data.

In summary, this evidence suggests the possibility that a financial channel may be important for the international propagation of shocks, in addition to the normal trade-related channels. Moreover, it is difficult to explain the scale and synchronicity of the global downturn based on trade alone.

3. The model

In this section we describe a basic two-country model with leveraged borrowers and lenders in each country. The model contains many standard elements, which are only outlined briefly.[3] Within each country, there are investors and savers. Both have infinite horizons, supply labor inelastically to production firms and purchase the same fixed asset. Investors rent the fixed asset to competitive production firms, receiving a risky return in exchange, while savers use it in home production. Investors are more impatient than savers, so they will borrow from savers in order to invest in the fixed asset. Savers therefore choose a portfolio in which they hold the debt of investors and the fixed asset. By assumption, savers do not hold domestic or foreign equity.

Investors in either country trade claims with investors in the other country so as to diversify their portfolio of equity holdings. Thus they hold leveraged investments, but also have equity portfolios that are interconnected across countries.

Focusing on the key assumptions of the model, we define the discount factor as:

$$\theta_{t+1}^{i} = \beta^{i}(\bar{C}_{t}^{i})\theta_{t}^{i}, \quad \beta^{i}{}'(\bar{C}_{t}^{i}) \leq 0, \tag{1}$$

Where $\bar{C}_{t}^{i}$ is the economy-wide average consumption of agents of type i, and $i \in \{I, S\}$ indicates savers or investors. The specific functional form we assume is $\beta(C) = \zeta C^{-\eta}$.

Investors face a constraint on total leverage due to an inability to commit to repayment, as in Kiyotaki and Moore (1997). Total debt is assumed to be restricted to be no greater than κ times the market value of equity assets, where $\kappa < 1$. Thus home investors' choices are constrained by:

$$B_{t}^{I} \leq \kappa(q_{1t}k_{1t}^{I} + q_{2t}k_{2t}^{I}), \tag{2}$$

where q_{1t} and q_{2t} represent the price of the fixed asset (or equity) in the home and foreign country respectively, k_{1t}^{I} and k_{2t}^{I} are the portfolio holdings of the fixed assets in each country held by the home investor and B_{t}^{I} is the debt issued to domestic savers. Leverage constraints in the form of (2) have been used quite widely in the literature on asset prices (Aiyagari and Gertler 1999), emerging market crises (Mendoza and Smith 2006), borrowing in a small open economy (Uribe 2006) and monetary policy with credit frictions (Iacoviello, 2005).

Investors in the home country choose investment in the home equity and the foreign equity, as well as borrowing, to maximise their expected utility subject to their budget constraint and leverage constraint, giving the standard portfolio selection condition:

$$E_{t}U'(C_{t+1}^{I})\left(\frac{(q_{1t+1} + R_{1Kt+1})}{q_{1t}} - \frac{(q_{2t+1} + R_{2Kt+1})}{q_{2t}}\right) = 0. \tag{3}$$

Given that the portfolio choice may be written in the form (3), we can use the recent methods described in Devereux and Sutherland (2009) to derive the optimal equity portfolio of each country's investors.

We also follow Tille and Van Wincoop (2007) in also extending (3) to allow for transactions costs of international financial trade that effectively limit international portfolio diversification

[3] For full model details, see Devereux and Yetman (2010).

to generate home equity bias in equilibrium. In particular, we assume that an "iceberg" cost factor given by $\exp(-\tau) \leq 1$ reduces the returns that home investors receive from foreign investment so that condition (3) becomes:

$$E_t U'(C^I_{t+1}) \left(\frac{(q_{1t+1} + R_{1Kt+1})}{q_{1t}} - \frac{(q_{2t+1} + R_{2Kt+1})}{q_{2t}} \exp(-\tau) \right) = 0 . \quad (4)$$

As we will show, when leverage constraints are not binding, the dynamic paths of asset allocations are independent across countries. This holds despite the fact that, up to a first order, expected returns on all assets are equalised both within and across countries. However, when leverage constraints bind, asset allocation in the each country will depend on the level of productivity in both countries, because productivity shocks to one country will affect the tightness of leverage constraints across all financial markets.

Because the model is such a stripped down representation of a full-scale DSGE framework lacking capital accumulation and dynamics in the labour supply and containing only a single world good, there are many dimensions in which the model's predictions will depart from reality. The aim of the exercise is rather to explore the way in which financial leverage constraints affect the cross-country dynamics of asset prices, asset allocations and leveraged investments, and to investigate the international transmission of deleveraging. To do this, however, we need to choose parameter values for preferences, production technologies and the leverage constraint itself. Table 2 gives the set of parameter values used in the baseline model.

Table 2

Calibration

Parameter	Value	Parameter	Value
n	0.5	ε	0.5
η	0.01	ω	0.36
ζ	Discount factors 0.96 and 0.94	σ	5
κ	0.8	ρ	0.9

We focus on shocks to the productivity of final goods in each country. The stochastic process for final goods productivity is modeled as:

$$\log(A_t) = \rho \log(A_{t-1}) + \upsilon_t , \quad (5)$$

where $\rho = 0.9$, $E_{t-1}\upsilon_t = 0$ and $\sigma^2_\upsilon = 0.02^2$. We assume that foreign productivity is driven by the same process, and foreign and domestic productivity shocks are uncorrelated.

4. Deleveraging effects of productivity shocks

No leverage constraints

We first examine the impact of a 1% negative productivity shock in the home country, in the environment without leverage constraints. Figures 5 and 6 describe the impact of the shock on consumption of investors, asset prices, lending by savers, asset allocation, the internal lending rate and the consumption of savers. Figure 5 represents the case where portfolio diversification is restricted by second order transactions costs as described in (4), while

Figure 6 describes the case of unrestricted portfolios, as in (3). In the unrestricted case, home investors have a bias against home equities. Investors are exposed to non-diversifiable risk from wage income, which is positively correlated with the return on home equity. With an unrestricted portfolio, they will hedge this risk by taking a larger position in foreign equity than home equity, as discussed in Baxter and Jehrmann (1997). Given the calibration of the model, in an unrestricted equilibrium $k_1^I = .2\hat{k}_1^I$. That is, home investors would hold only 20% of total home equity (i.e. 20% of the fixed assets which are invested in the home final goods technology), with foreign investors holding the remaining 80%.

Figure 5

No leverage constraints, partial diversification

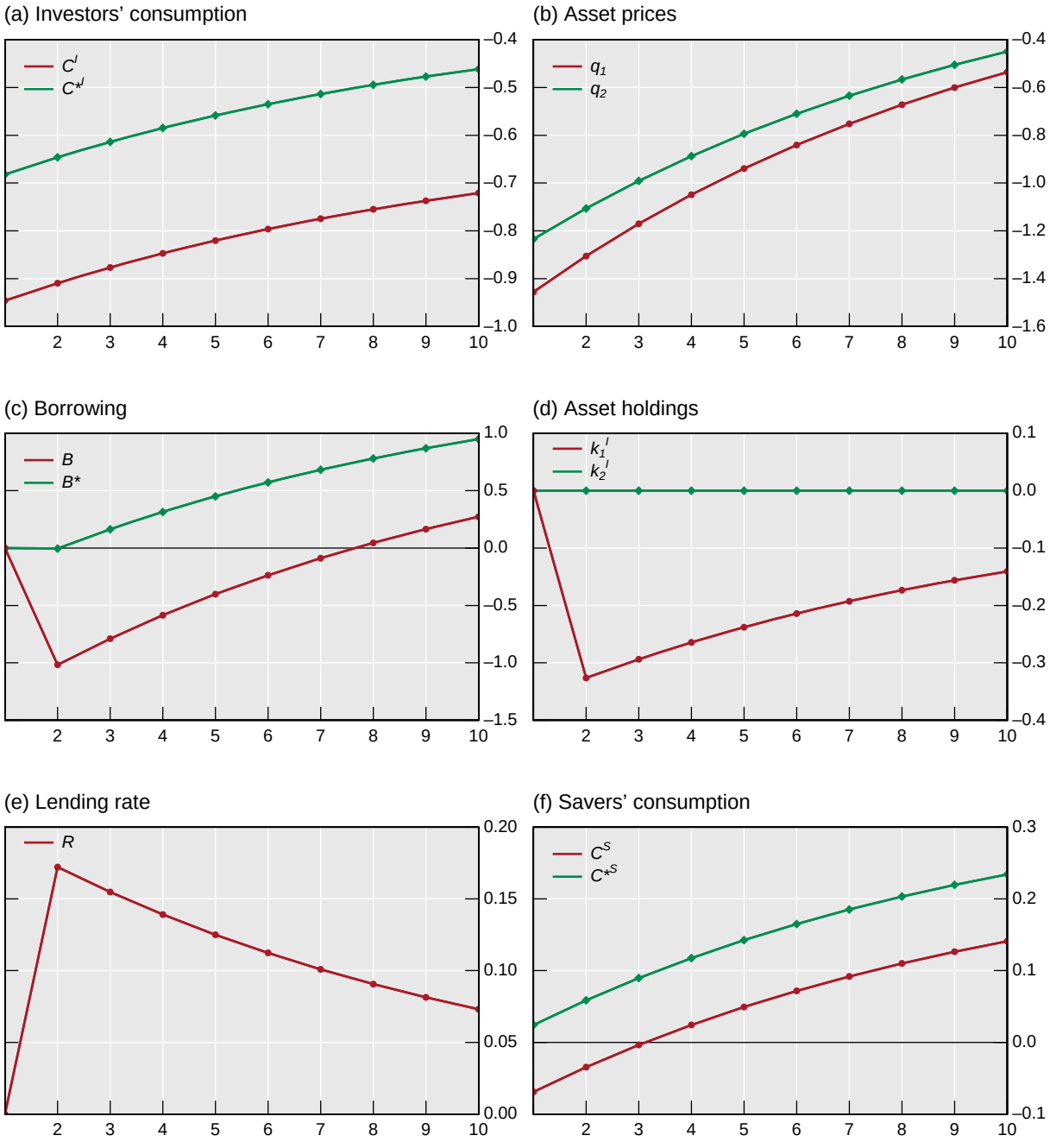
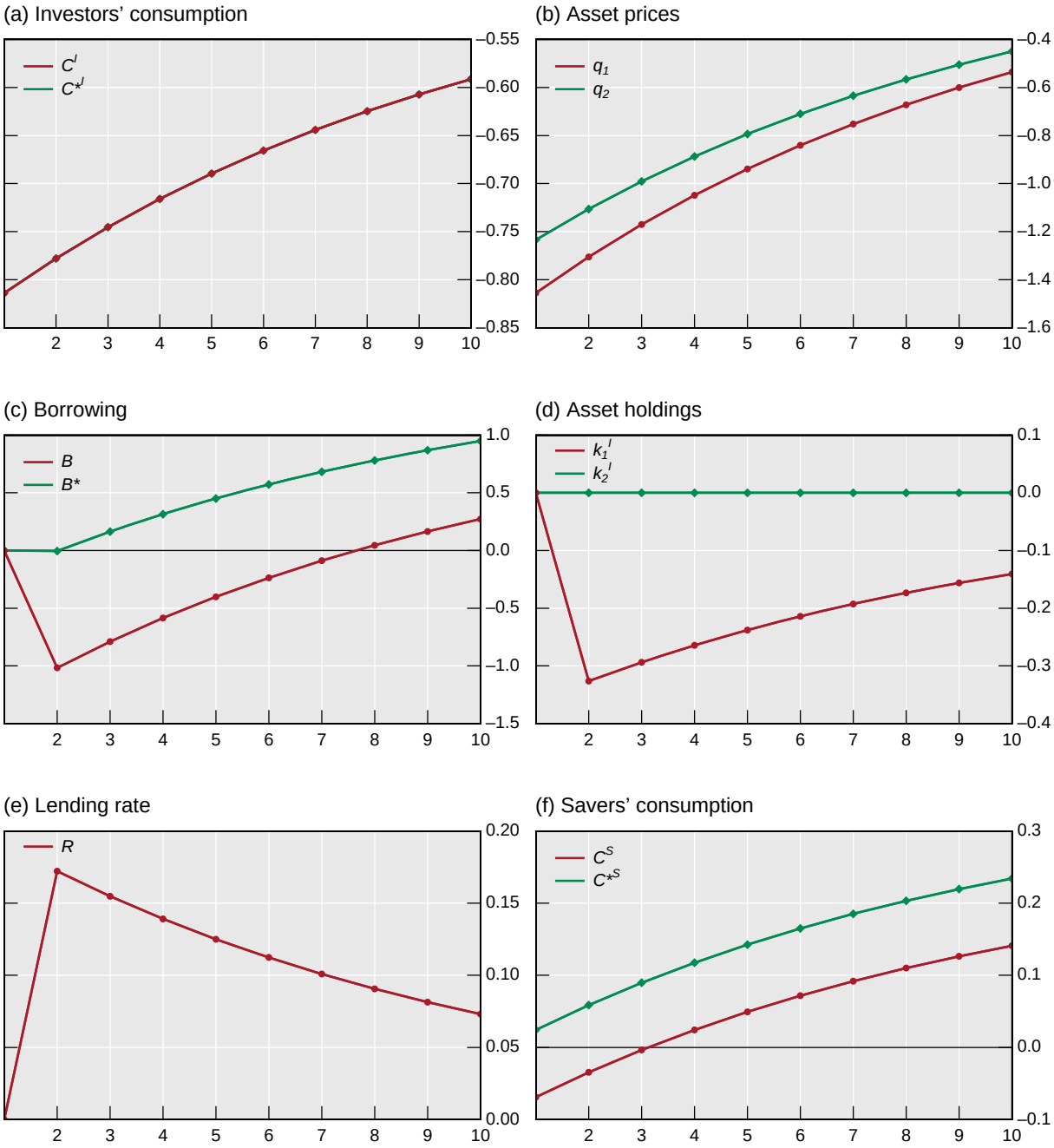


Figure 6

No leverage constraints, full diversification



Since this is clearly counterfactual, we use the iceberg cost variable τ as a crude mechanism to match the optimal portfolios more closely with observed home bias in equity holdings. In Figure 5 τ has been chosen so that $k_1^I = .75\hat{k}_1^I$, implying that home investors hold 75% of home equity.

The response to a productivity shock is quite similar in each of the figures. Without leverage constraints, the impact of a fall in home country productivity is to reduce consumption of investors globally, by identical amounts in the case of unrestricted diversification. The shock represents a temporary fall in the consumption of investors in both countries. But since consumption is expected to increase in the future, real interest rates must rise. The

combination of a persistently lower return on the home asset and rising real interest rates means that the home asset price must immediately fall.

Without leverage constraints, all returns are equalised, at least up to a first order approximation, for investors to be willing to hold all assets in their portfolios. Thus the price of foreign assets must also fall. That is, arbitrage implies that the rate of return to lenders rises by the same amount in both countries, even though lenders do not directly engage in international borrowing or lending. But the pattern of lending moves in completely different directions in the two countries, as do lenders' portfolios. In the home country, there is a fall in investment in the fixed asset in the final goods sector simply because this sector has suffered a persistent negative technology shock. This leads to an increase in the holdings of the fixed asset by lenders. They shift the composition of their portfolios from debt towards increased holdings of the fixed asset. Thus lending falls in the home country. In the foreign country, by contrast, there is no change at all in the allocation of the fixed asset. But lending in the foreign country actually rises, as investors borrow more from lenders in order to cushion against the temporary fall in their investment income.

A different way to see this is that in the foreign country, lenders are offered a higher rate of return on their lending, and are willing to purchase more debt from foreign investors. Either way we look at it, lending rises in the foreign country, while it falls in the home country. In this sense, there is no international transmission of deleveraging.

The impact of the shock on lenders' consumption in the two countries also moves in opposite directions. Lenders in the home country lose, since they suffer a direct fall in their wage income. Lenders in the foreign country gain, since they lend more at higher interest rates, and their wage income and holdings of the fixed asset are unaffected. Clearly lenders cannot achieve full consumption risk-sharing, since they cannot directly hold a claim on the equity of the other country.

In the economy without leverage constraints, then, the international transmission of shocks is limited, and clearly counterfactual, relative to the discussion of the empirical evidence of financial spillovers in Section 2. A negative productivity shock in the home country leads to domestic deleveraging, as investors reduce both their borrowing and holdings of fixed assets. But there is no foreign deleveraging. Investment in fixed assets is completely unaffected in the foreign country, and foreign investors actually increase their borrowing. More critically, there is no international transmission of the shock to GDP at all. Since the foreign asset allocation is unaffected by the domestic shock, foreign output is unchanged. Thus, in the absence of credit market imperfections, the possibility for the international transmission of shocks through balance sheet deleveraging is limited.

Leverage constraints and international transmission

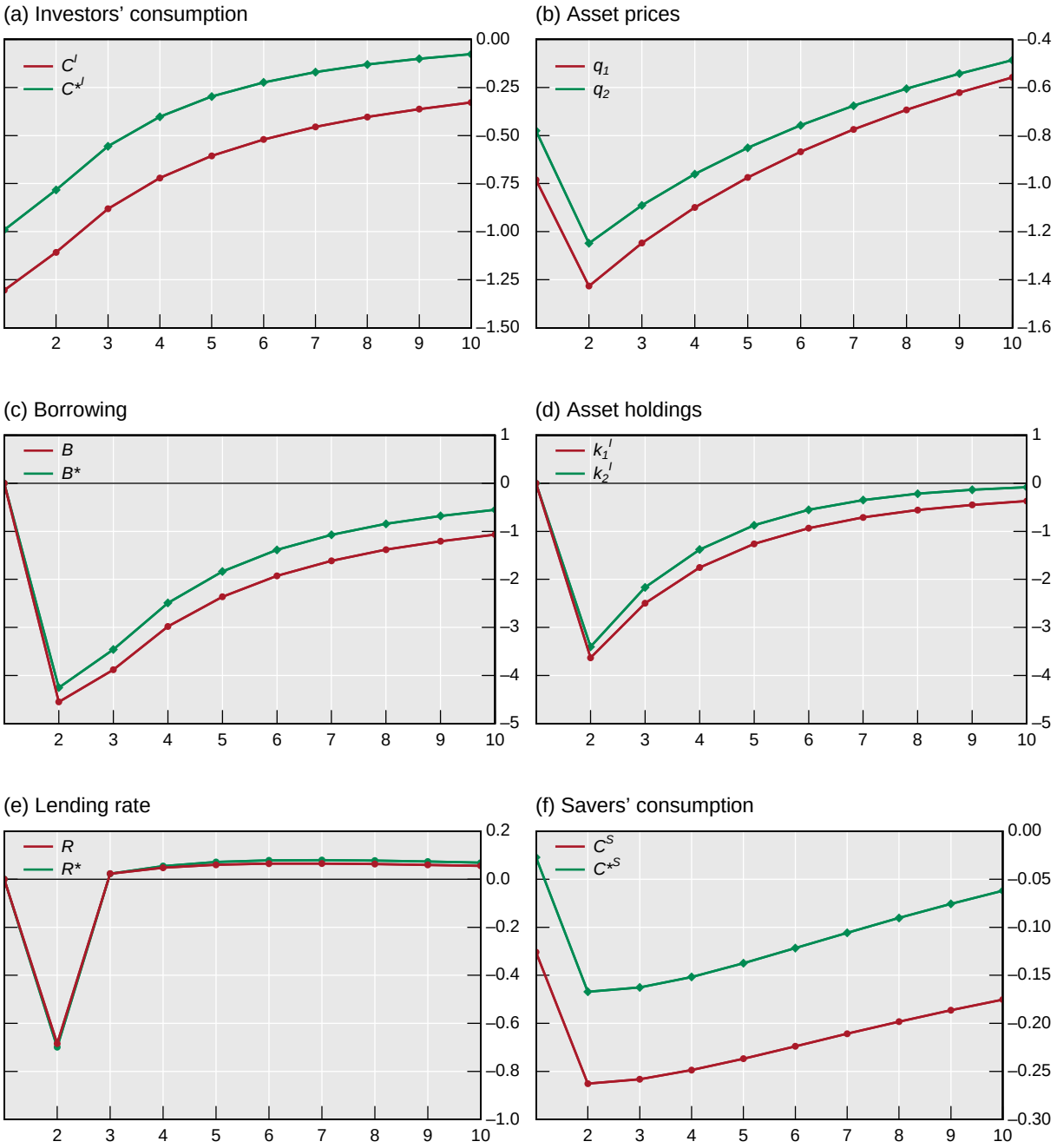
Figures 7 shows the impact of a negative productivity shock in the home country in the model when leverage constraints bind in both countries, when investors' portfolios are only partly diversified due to the presence of transactions costs.[4]

We saw before that without leverage constraints, a fall in home country productivity leads to a fall in asset prices in both countries, and a fall in investors' consumption. With leverage constraints, the fall in asset prices leads to a tightening of the constraint, in both countries. The result is a reduction in borrowing by investors, and a consequent reduction in investment in fixed assets. Note that, for the foreign country, there is no direct fall in the productivity of the domestic final goods sector.

[4] Results are qualitatively similar with lower levels of leverage or with full diversification.

Figure 7

Binding leverage constraints, partial diversification



In addition, the price of foreign equity falls. But in spite of there being no direct shock to foreign equity returns, and a fall in the price of the asset, there is still a fall in demand for the asset by investors in both countries. This is the essence of the "inverted demand curve" for assets that characterises episodes of deleveraging, as emphasised by Aiyagari and Gertler (1999). Here it is taking place as a spillover from one levered investor to another, as emphasised by Krugman (2008). That is, a fall in the price of the asset held by one investor leads to a tightening of leverage constraints and a fall in demand for both the original asset and other assets held in the portfolio.

Even in the case where portfolios are only partly diversified, there is a very high correlation across countries in borrowing and investment. The decline in leverage is so great that the internal lending rate in each country immediately falls. Again, note that this is in response to

a temporary shock so that future consumption of investors is expected to increase. But because investors are subject to leverage constraints, the path of their consumption is de-linked from the path of interest rates.

The fall in asset prices is of a similar order of magnitude in the leverage-constrained economy as in the unconstrained economy. Asset prices display a V-shaped response, however, falling by less immediately than in the second period. This is due to the fall in lending rates. Since lenders are unconstrained, the fall in returns on lending must be accompanied by a fall in the expected returns on the lenders holding fixed assets for home production. Hence, immediately following the shock, asset prices are expected to fall further.

Note that there is a distinct difference between the constrained and unconstrained economy, not just in the direction of international transmission of shocks, but also in the scale. In the unconstrained economy, a one percent decline in final goods' sector productivity leads to an approximately one percent fall in borrowing from lenders, but only a 0.3% reduction in fixed asset investment. Not only is there an absence of transmission via international deleveraging, but the domestic impact of the shock is also relatively mild. By contrast, the response of the constrained economy is larger by orders of magnitude. Borrowing falls by almost 5% in the home economy, and investment in fixed assets by almost 4%. Even in the foreign economy the deleveraging multiplier is very large – investment falls by more than 3% and borrowing falls by 4%. In both countries, the response to the shock is proportionally much larger than the shock itself, due to the interaction of asset price declines and binding leverage constraints.

Consumption of home and foreign investors also falls by more in the constrained economy than in the unconstrained economy, although the decline is less persistent with leverage constraints. Also, in contrast to the economy without constraints, consumption falls for both for investors and lenders, in both countries.

Unconditional moments

Table 3 reports the unconditional moments of the model under the assumption that productivity shocks in both countries follow identical but uncorrelated distributions, given by (5).

Table 3

Unconditional moments

Leverage constraints	**None**	**None**	**Binding**	**Binding**
Diversification	Partial	Full	Partial	Full
$\mathrm{SDEV}(C^I)$	2.9	3.0	3.9	4.0
$\mathrm{SDEV}(C^S)$	0.4	0.5	0.8	0.9
$\mathrm{SDEV}(q)$	4.7	5.2	4.7	4.9
$\mathrm{SDEV}(R)$	0.6	0.7	2.0	2.0
$\mathrm{SDEV}(\hat{k}^I)$	0.8	0.9	11.0	11.3
$\mathrm{CORR}(q_1, q_2)$	0.98	0.99	0.99	0.99
$\mathrm{CORR}(\hat{k}_1^I, \hat{k}_2^I)$	0.02	0.04	0.99	0.98
$\mathrm{CORR}(R, R^*)$	–	–	0.99	0.99

As is evident from the figures, the model with binding leverage constraints displays substantially more overall volatility than the model where leverage constraints are absent. Consumption of investors is 50% more volatile, and consumption of savers is twice as volatile. Asset price volatility is relatively unchanged with and without leverage constraints but investment volatility is vastly higher, as is clear from a comparison of Figures 5 and 7. Investment correlation across countries is essentially zero in the economy without leverage constraints, but almost perfect in the economy with leverage constraints. Table 3 therefore underscores the main message of the paper. In the presence of credit market imperfections, balance sheet linkages across financial institutions can generate a very powerful mechanism for the international transmission of business cycle shocks.

5. Conclusions

This paper has provided empirical evidence on the importance of financial deleveraging in propagating business cycle shocks across countries. Financial interdependence, combined with binding leverage constraints, can open a channel for the transmission of shocks that may be as important as standard trade linkages. We have used this evidence to construct a simple two-country model in which highly leveraged financial institutions hold inter-connected portfolios, and may be limited in their investment activity by capital constraints. The combination of portfolio interdependence and capital constraints leads a negative shock in one country to precipitate an episode of global deleveraging and disinvestment. In this sense, our model may be seen as a formal general equilibrium representation of Krugman (2008), who suggests that interconnections in financial markets may give rise to an "international finance multiplier". In our model, we find that with high initial levels of leverage, the global effects of the shock may be substantially magnified.

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