Financial Contagion and Vulnerability of Asian Financial Markets[1]

Michael B. Devereux[2] and James Yetman[3]

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Abstract

The global experience of the last two years has shaken conventional beliefs in the benefits of unfettered financial markets. In response to the Asian crisis of a decade ago, most Asian economies had switched to an apparently more durable system of financing economic growth. But this did not prevent Asian countries from suffering considerably from the global financial crisis. Moreover, the spread of the crisis across countries seems to have been channelled more by financial linkages than conventional trade linkages. This raises questions about the future of financial integration among Asian economies and between Asia and the rest of the world. This paper first documents some features of the propagation of the global financial crisis. It then goes on to explore a two-country theoretical model in which there is a trade-off between the risk sharing benefits of international financial markets and the contagion effects of international financial interdependence. The key result of the model is to show that financial market integration in the presence of financial constraints can generate very high macroeconomic co-movement among economies, quite independent of international trade linkages.

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[2] University of British Columbia, CEPR and NBER, devm@interchange.ubc.ca
[3] Bank for International Settlements, Representative Office for Asia and the Pacific, Hong Kong, james.yetman@bis.org.

Standard economic theory predicts that international financial integration is a good thing. Financial markets allow for cross country risk sharing, increased investment and a more efficient allocation of resources across countries. Extending financial market integration from a region comprised of a small group of economies to a global arena encompassing all countries should offer welfare benefits to all economies and regions. Indeed, the rapid increase in capital flows across advanced and emerging economies in the last decade, often described as the process of 'financial globalization', has been associated with substantially higher economic growth rates as well as large increases in the volume of international trade. Going beyond anecdotal evidence of the benefits of liberalized financial markets to establish clear empirical evidence on the growth or risk sharing gains from financial integration has been more difficult, however. Kose et al (2009) provide an extensive review of the empirical evidence on the effects of financial integration and conclude that there is no clear-cut evidence that financial integration is beneficial.

One message from this literature is that the impact of financial integration depends not only on its presence or absence, but also on the type of integration. For instance, in the Asian region, the 1990's was a time of rapid growth combined with substantial financial integration through external capital inflows. The subsequent Asian crisis in 1997-1999 was judged to have been magnified partly because of the nature of financial imbalances built up during the early 1990's growth boom. East Asian economies found themselves with large outstanding liabilities in short term non-contingent foreign currency denominated bank loans – exactly the configuration likely to precipitate a panic-driven sudden stop in capital flows, and to exacerbate the effects of such an event.

The post 2000 experience of financial openness in East Asia has been much more successful. While Asian economies had large capital inflows of US dollar-denominated short-maturity bank lending in the 1990's, from 2000 onwards inflows were mainly in the form of equity investment and FDI. They also switched from running current account deficits to surpluses and building up stocks of international reserves. In most circumstances, this pattern of growth financing is likely to prove much more resilient than the previous episodes of capital inflows and debt financing (see Devereux and Sutherland, 2009). Indeed, even during the global financial crisis beginning in 2008, Asian financial markets had relatively little exposure to derivative products associated with the US subprime mortgage industry so that their banks and financial institutions suffered less than many of their European counterparts.

Nevertheless, Asian financial markets and real economies have still been deeply affected by the global financial crisis emanating from the US and Europe. Despite not being directly linked to toxic assets from the US that lay at the heart of the financial meltdown, Asian stock markets fell precipitously in late 2008 and Asian banks and corporations experienced large withdrawals of funds on the part of foreign banks and investors. This coincided with a rapid drop in investment spending, a drying up of trade financing and a subsequent collapse of exports for many Asian economies. Thus, while East Asian countries were well diversified according to the principles of portfolio diversification, there is a sense in which portfolio linkages themselves may lead to negative business cycle transmission during a crisis. That is, financial market interactions, through interdependent banks and financial institutions in many different countries, were associated with 'contagion' effects among economies. Rather than acting in the traditional manner as a stabilizing mechanism for sharing risk across regions and countries, it seems that the

interdependence of financial institutions acted as an international 'propagation mechanism' for the financial crisis.

This paper explores the role of financial markets as 'propagators' of international macro shocks, motivated by the experience of Asian financial markets and economies. The hypothesis we explore is that there is a fundamental trade-off between the efficiency benefits of international financial integration on the one hand, and the contagion effects of international financial market interdependence on the other hand. In an environment without financial market frictions, the international financial system would be fully efficient and would act so as to provide the maximum possible risk sharing and the best allocation of resources. But the presence of informational frictions and a lack of contract enforcement lead to substantial constraints on the operation of financial markets. A key friction, highlighted by many economists over the past decade, is the different natures of internal and external financing of investment. Because of informational and enforcement failures, many borrowers are constrained in the degree of borrowing and the maximum leverage of investment financing they can undertake. This means that movements in asset prices, by affecting borrower net worth, can have substantial effects on access to capital markets. Negative returns shocks, causing asset prices to fall, lead to a tightening of collateral constraints and result in a drying up of access to credit. This forces a process of 'de-leveraging', in which investors need to sell assets in order to satisfy capital or leverage constraints. In the international context, with inter-connected balance sheets among financial institutions across countries, shocks that cause a fall in asset prices in one country may precipitate de-leveraging affects which spill over into the balance sheets of institutions in other countries.

The paper first presents evidence on the extent of de-leveraging among financial institutions in the US in their Asian portfolio's during the recent crisis. As is clear from the data, foreign banks reduced their exposure to Asia in order to shore up their balance sheets in their home jurisdictions. We then show evidence that this financial de-leveraging may have acted as a powerful propagation mechanism in itself (see also Devereux and Yetman, 2010). Two types of evidence are brought to bear on this. First, we show that, during the crisis period, negative shocks to asset prices in the US have been associated with increased correlation of asset prices across countries. Using weekly, monthly and quarterly equity price data, the response of Asian markets to negative movements in US equity price movements were significantly greater (and more negative) after the beginning of the financial crisis relative to before the crisis. This is consistent with an implication of the model of international portfolio integration with leverage constraints.

The second piece of empirical evidence concerns the importance of financial linkages on the real economy. One of the basic hypotheses of the model is that financial linkages among countries may become very important during crisis periods in generating business cycle co-movement. We show that, empirically, the propagation of the recent global downturn has been more important for many economies with strong financial linkages than for those with trade linkages. This holds especially for countries that are financially 'vulnerable' in the sense that their sovereign bond ratings are lower.

We then move on to construct a theoretical model of international financial linkages in the presence of leverage constraints. The model emphasizes how a process of balance sheet contractions, generated by a downturn in one country, is spread around the globe through inter-connected 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 theoretical model illustrates the key message of the paper, which is that the combination of two features – financial market constraints and international financial linkages – gives rise to the possibility of very strong positive macroeconomic co-movement. In the absence of leverage constraints, standard theory suggests that financial market integration has relatively little implication for business cycle co-movements across countries, except for the degree of consumption co-movement. When leverage constraints are present and binding, but financial markets are nationally segmented, we show that international macroeconomic co-movement is actually *negative.* Shocks which reduce domestic consumption and investment will lead to increasing foreign consumption and investment. But the combination of binding leverage constraints *and* integrated international equity markets generates very high positive cross country co-movements in macroeconomic variables. The key reason is that financial integration leads to interdependence of portfolios across countries. With binding leverage constraints, the returns on portfolios affect net worth and therefore influence the degree of access to capital markets.

When leverage constraints are binding, and equity markets are integrated, the channel of business cycle transmission takes place through movements in asset prices. A large fall in asset prices in one country forces an immediate process of balance sheet contractions in that country's financial institutions. But the fall in asset prices leads to balance sheet deterioration in other countries that have internationally diversified asset portfolios, 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 the magnification of the initial shock, a

large fall in investment and highly correlated business cycles across countries during the resulting downturn.

We do not attempt to provide an integrated explanation of the recent financial crisis but instead highlight how the joint process of balance sheet constraints and portfolio interdependence generate an important cross-country propagation effect. We do this within the context of a two-country model 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 standard finance models, portfolio diversification is always beneficial. It allows for a diversification of consumption risk without affecting the nature of the risk. The portfolio diversification itself does not have any significant impact on cross-country co-movements of real variables. But in presence of leverage constraints this principle breaks down. When leverage constraints bind, moving from a environment without portfolio diversification to one where agents hold interdependent portfolios has a first order implication for real cross-country co-movements because movements in portfolio valuations affect leverage constraints and, by doing so, tend to generate the international propagation of shocks across countries.

This perspective on the effects of financial market integration raises a number of general issues regarding the benefits of financial integration. First, global financial integration may impose costs as well as benefits. On the one hand, increasing the extent of financial integration – for example, moving from regional integration to global integration – should bring in clear

welfare benefits in terms of enhanced risk sharing and more efficient capital allocation. But increasing portfolio linkages in the face of balance sheet constraints may expose regions in which financial institutions are fundamentally sound to the dangers of contagion from crises generated in other regions. If financial markets operated freely in an environment where portfolios were unconstrained this would not matter, since the basic gains from trade theorems would operate. But such gains are not guaranteed in the presence of leverage constraints. Thus there may be a genuine trade-off between regional and global financial integration. In the Asian context, as we have mentioned above, countries receiving substantial capital inflows from US banks were subject to rapid outflows during the crisis. The asset price ramifications of this (in the presence of financial frictions) may generate large real effects due to deleveraging. This suggests that a cautious approach to global financial integration is advisable.

A second implication of the model is that, as suggested by the theoretical literature, different types of financial integration may have very different implications for macroeconomic outcomes. As shown below, in the presence of leverage constraints the transmission of shocks between economies with integrated bond markets will be fundamentally different, both qualitatively and quantitatively, from that experienced between economies with integrated equity markets.

The model draws heavily on a number of separate literatures. First, and most importantly, we follow Kiyotaki and Moore (1997) and a large related literature in imposing leverage constraints on investors. This leads to a wedge between the effective returns faced by investors and savers, and can act as an amplification mechanism for business cycle shocks.[4] Second, we

[4] An alternative mechanism where balance sheets play a key role in business cycles is the 'financial accelerator' model of Bernanke et al. (1999). This has been extended to a multi-country setting by Gilchrist (2004).

emphasize 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).[5]

The paper is organized as follows. The next section provides some evidence of the importance of a financial channel in the recent business cycle downturn. We then develop 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 balance sheet adjustments in the propagation of business cycle shocks across countries. We then conclude.

2. Empirical Evidence on Financial Linkages and Leverage Constraints

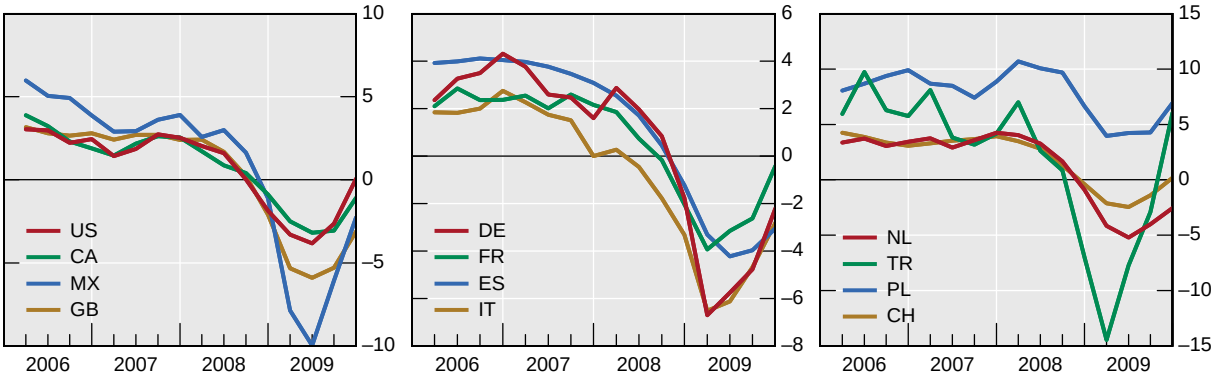
Here we present some suggestive evidence that supports the view that financial linkages were a key part of the transmission of the recent crisis. First, Figure 1 documents the global nature of the economic crisis. Figure 1a, for OECD countries, and Figure 1b, for economies in the Asia-Pacific, both show a remarkably synchronous collapse in economic growth rates. It is unlikely that trade linkages alone could account for the simultaneous downturns in all regions. The economies in the figures are very heterogeneous in their trade linkages and their sensitivity to trade with the US in particular varies greatly. This makes it reasonable to look for other areas of macroeconomic interdependence such as the strength of financial linkages.

[5] Dedola and Lombardo (2009) develop an interesting model similar to the present paper based on the financial accelerator model, incorporating endogenous portfolios as in the present paper. They emphasise a somewhat different type of transmission effect, unique to the financial accelerator model, coming from the direct connection between risk-premia across countries.

Figure 1a

Real GDP growth[1]

In per cent



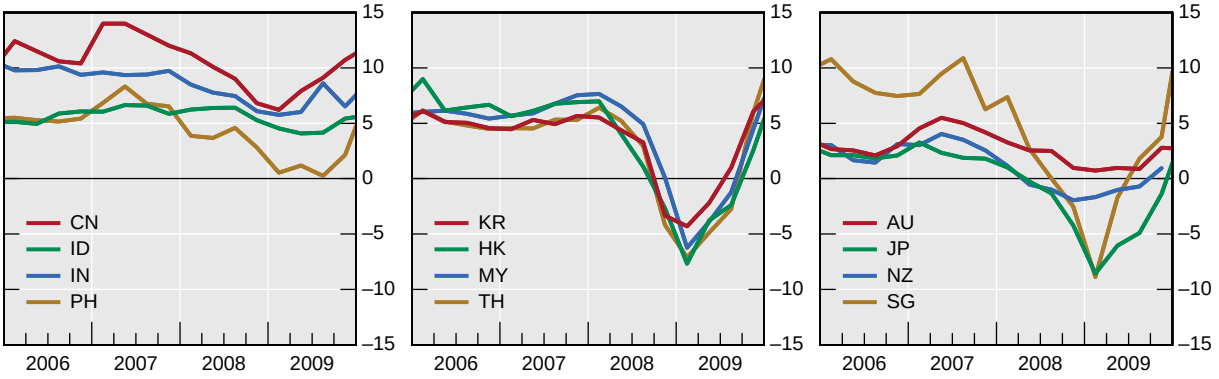
[1] Year-over-year changes in real GDP. US = United States, CA = Canada, MX = Mexico, GB = United Kingdom, DE = Germany, FR = France, ES = Spain, IT = Italy, NL = Netherlands, TR = Turkey, PL = Poland, CH = Switzerland.

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.

Table 1 presents more direct evidence on the process of deleveraging that took place during the financial crisis of 2008. It illustrates the growth rate of total short-term exposures of US banks to major Asian economies. This is the total stock among US reporting banks in the BIS International Banking Statistics of all loans to the destination economy with less than one year

remaining until maturity. A rapid decline in this stock in less than one year (for example, to Chinese Taipei between 2008Q2 and 2008Q4) implies little new issuance, and few loans being rolled over. Indeed, the average decline between 2008Q3 and 2008Q4 represents a 26 percent fall in total claims on Asia, demonstrating that US banks substantially deleveraged their balance sheets with respect to Asia during the run-up to the economic crisis.

Table 1. 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

Deleveraging and Asset Price Correlation

One feature of the deleveraging process is that asset prices become more correlated during crises. As negative shocks in one country lead to a deterioration of balance sheets through inter-connected portfolios, there is a deleveraging process that takes place in other countries and, as a result, a fall in asset prices that is highly correlated across countries. The empirical evidence strongly supports the view that asset prices became more highly correlated during the crisis. To illustrate this, we focus on equity markets as a proxy for asset markets more generally. We then show that links between equity prices in the United States and major Asia-Pacific economies strengthened during the crisis.

Table 2. Asia and Pacific Equity Price Indices

Economy	Index Name	Sample Period
Australia	All Ordinaries Index	02.01.1980-14.01.2009
China	Shanghai Stock Exchange A Share Index	04.01.1995-14.01.2009
Hong Kong	Hang Seng Index	02.01.1980-14.01.2009
Indonesia	Jakarta Composite Index	06.04.1983-14.01.2009
India	Bombay Stock Exchange Sensitive Index	02.01.1980-14.01.2009
Japan	Nikkei 225 Index	02.01.1980-14.01.2009
Korea	Korea Composite Stock Price Index	10.06.1987-14.01.2009
Malaysia	Kuala Lumpur Composite Index	02.01.1980-14.01.2009
New Zealand	New Zealand Exchange Limited 50 Free Float Total Return Index	03.01.2001-14.01.2009
Philippines	Philippine Stock Exchange Index	07.01.1987-14.01.2009
Singapore	Straits Times Index	01.09.1999-14.01.2009
Thailand	Stock Exchange of Thailand Index	08.07.1987-14.01.2009
United States	Standard and Poor's 500 Index	08.01.1980-13.01.2009

Our equity price data consists of the main equity price index for each of 12 Asia-Pacific economies, as well as the US, as given in Table 2. To illustrate changes in the strength of links between equity prices, we estimate equations of the form:

$$\Delta e_t^i = \beta_0^i + \beta_1^i D_t \Delta e_t^{US} + \beta_2^i (1 - D_t) \Delta e_t^{US} + u_t^i, \quad (1)$$

where $\Delta e_t^i = \ln(e_t^i) - \ln(e_{t-s}^i)$ is the change in the log of the level of the equity price index for economy i over interval s and D_t is a dummy variable that takes on a value of one before the financial crisis, and zero thereafter.

We consider two possible dates as representing the onset of the financial crisis. The first is 9 August 2007, which coincides with the announcement by BNP Paribas that it could not fairly value the underlying assets in three funds as a result of exposure to U.S. subprime mortgage lending markets. As a robustness check, we also consider 15 September 2008 when Lehman Brothers entered bankruptcy. We also consider three time-intervals ($s \in \{1, 4, 13\}$ in weeks), approximately corresponding to weekly, monthly, and quarterly frequencies.[6]

The estimation results for a break date of 9 August 2007 are outlined in Table 3. The results clearly show strong evidence consistent with a structural break in the relationship between US equity prices and those in the Asia-Pacific region. The coefficient on the importance of US equity prices as a driver of Asia-Pacific equity prices increased significantly in 30 out of 36 cases examined, increased insignificantly in a further 3 cases, and decreased insignificantly in

[6] The base data are weekly, taken from the close of business on Tuesday for the US series, and the close of business on Wednesday for Asia-Pacific economies.

each case involving Malaysia. These results are robust to the choice of sample starting point (for example, 1980 or 2000), and the choice of break point (9 August 2007 or 15 September 2008).[7]

Table 3. Estimation Results, Equation 1*									
	Weekly Data ($s=1$)			Monthly Data ($s=4$)			Quarterly Data ($s=13$)		
Economy	$\hat{\beta}_1^i$	$\hat{\beta}_2^i$	p-value	$\hat{\beta}_1^i$	$\hat{\beta}_2^i$	p-value	$\hat{\beta}_1^i$	$\hat{\beta}_2^i$	p-value
Australia	0.47	0.73	0.14	**0.52**	**0.79**	**0.00**	**0.53**	**0.84**	**0.00**
China	-0.02	0.15	0.41	**0.02**	**0.29**	**0.00**	**0.02**	**1.38**	**0.00**
Hong Kong	**0.76**	**1.20**	**0.00**	**0.80**	**1.00**	**0.00**	**0.92**	**1.91**	**0.00**
Indonesia	**0.02**	**0.90**	**0.00**	**0.08**	**0.31**	**0.04**	**0.39**	**0.94**	**0.00**
India	**0.10**	**1.21**	**0.00**	**0.19**	**1.33**	**0.00**	**0.42**	**1.31**	**0.00**
Japan	**0.41**	**1.08**	**0.00**	**0.40**	**0.83**	**0.00**	**0.43**	**1.13**	**0.00**
Korea	**0.48**	**0.79**	**0.03**	**0.58**	**1.17**	**0.00**	**0.73**	**1.17**	**0.00**
Malaysia	0.42	0.35	0.51	0.46	0.41	0.66	0.70	0.61	0.20
New Zealand	**0.22**	**0.40**	**0.07**	**0.31**	**0.56**	**0.00**	**0.36**	**0.64**	**0.01**
Philippines	**0.28**	**1.01**	**0.00**	**0.54**	**0.97**	**0.00**	0.90	0.98	0.37
Singapore	**0.61**	**0.87**	**0.05**	**0.63**	**1.42**	**0.00**	**0.95**	**1.29**	**0.00**
Thailand	**0.40**	**0.69**	**0.08**	**0.53**	**1.28**	**0.00**	**0.82**	**1.30**	**0.00**

* Reported p-values are for a test of $H_0: \hat{\beta}_2^i - \hat{\beta}_1^i = 0$. **Bold** indicates $\hat{\beta}_2^i$ is significantly greater than $\hat{\beta}_1^i$ at the 10% level.

If equity price shocks generate co-movement due to deleveraging during a crisis, it is more likely that this occurs for negative, rather than positive price shocks. This is because negative price shocks will tend to force collateral constraints to bind with greater frequency, as suggested by the model presented below. To that end, we estimate the following variant of our model:

$$(2)\ \Delta e_t^i = \gamma_0^i + \gamma_1^i D_t P_t \Delta e_t^{US} + \gamma_2^i D_t (1-P_t)\Delta e_t^{US} + \gamma_3^i (1-D_t) P_t \Delta e_t^{US} + \gamma_4^i (1-D_t)(1-P_t)\Delta e_t^{US} + u_t^i,$$

[7] The results are also robust to the Forbes and Rigobon (2002) correction to ensure that the results are not driven by increased shock variance between the two periods. Comparing correlation coefficients between the two sub-periods, the correlation for the second period is corrected using:

$$\rho_{iUS}^{kl\ *} = \frac{\rho_{iUS}^{kl}}{\sqrt{1+\left(\frac{\text{Var}(\Delta e_t^{US})_2}{\text{Var}(\Delta e_t^{US})_1} - 1\right)\left(1-\rho_{iUS}^{kl}\right)}},$$

where $\text{Var}(\Delta e_t^{US})_1$ and $\text{Var}(\Delta e_t^{US})_2$ are the variance of US equity returns over the pre-crisis period and crisis period respectively. Based on this correction, equity price correlations increased in 35 of the 36 cases presented in Table 3.

where P_t takes on the value 1 when US equity prices are rising ($\Delta e_t^{US} > 0$), and zero otherwise. Our test will take the form $H_0 : \hat{\gamma}_4^i - \hat{\gamma}_2^i = 0$. That is, we are testing if declines in US equity prices have a larger effect on equity prices in the Asia-Pacific since the beginning of the crisis. The results are presented in Table 4.

Table 4. Estimation Results, Equation 3*

	Weekly Data ($s=1$)			Monthly Data ($s=4$)			Quarterly Data ($s=13$)		
Economy	$\hat{\gamma}_2^i$	$\hat{\gamma}_4^i$	p-value	$\hat{\gamma}_2^i$	$\hat{\gamma}_4^i$	p-value	$\hat{\gamma}_2^i$	$\hat{\gamma}_4^i$	p-value
Australia	0.65	0.76	0.69	0.66	0.79	0.26	**0.54**	**0.85**	**0.00**
China	0.05	0.20	0.54	-0.02	0.20	0.31	**-0.02**	**1.36**	**0.00**
Hong Kong	**0.85**	**1.16**	**0.10**	0.87	1.07	0.17	**1.04**	**1.96**	**0.00**
Indonesia	**-0.01**	**0.90**	**0.00**	**-0.02**	**0.29**	**0.00**	**0.07**	**0.94**	**0.00**
India	**0.24**	**1.18**	**0.00**	**0.38**	**1.33**	**0.00**	**0.52**	**1.35**	**0.00**
Japan	**0.50**	**1.20**	**0.00**	**0.54**	**1.50**	**0.00**	**0.57**	**1.47**	**0.00**
Korea	0.48	0.75	0.15	**0.65**	**1.19**	**0.00**	**0.88**	**1.20**	**0.00**
Malaysia	0.58	0.37	0.17	0.57	0.39	0.17	0.65	0.60	0.44
New Zealand	0.34	0.53	0.14	**0.35**	**0.79**	**0.00**	**0.22**	**0.62**	**0.00**
Philippines	**0.39**	**1.12**	**0.00**	0.73	1.03	0.30	0.90	0.99	0.65
Singapore	0.78	0.88	0.51	**0.74**	**1.43**	**0.00**	**1.08**	**1.47**	**0.02**
Thailand	0.62	0.79	0.59	**0.53**	**1.31**	**0.00**	**0.85**	**1.31**	**0.03**

* Reported p-values are for a test of $H_0 : \hat{\gamma}_4^i - \hat{\gamma}_2^i = 0$. **Bold** indicates $\hat{\gamma}_4^i$ is significantly greater than $\hat{\gamma}_2^i$ at the 10% level.

As with the earlier results, there is clear evidence that declines in US equity prices have a larger negative effect on equity prices in the Asia-Pacific after the beginning of the crisis. In 22 out of 36 cases examined the coefficient on US equity prices increased significantly after the onset of the crisis. In a further 11 cases it has increased insignificantly, while it has decreased insignificantly in each case involving Malaysia.

In contrast, there is less evidence that an increase in US equity prices drives a larger positive change in Asia-Pacific equity prices since the beginning of the crisis. Examining the same 36 cases presented in Table 4, and testing $H_0 : \hat{\gamma}_3^i - \hat{\gamma}_1^i = 0$, there are 11 statistically

significant increases, 17 statistically insignificant increases, 5 statistically insignificant decreases and 3 statistically significant decreases (full results available from the authors).

Financial linkages versus trade linkages

The effects of global deleveraging shocks should be expected to vary by country. Countries are integrated both in trade and financial markets, and if portfolio inter-connectedness represents an important channel, then it should help to explain some of the co-movement among real activity, independent of direct trade linkages.

To compare the importance of balance sheet contractions spread through portfolio interdependence as a propagation mechanism for the crisis with that of trade linkages, we undertake the following analysis. As a rough measure of the international effect of the crisis, we use the change in the growth rate of real GDP between the year ended December 2007 and December 2008. To measure financial linkages we use total capital inflows from the US during 2007, as a percent of 2007 GDP, from US Treasury International Capital data (labelled TIC). Our sample includes all members of the OECD for which TIC data is available. To measure trade linkages, we use exports to the US in 2007 as a percent of 2007 GDP (X). Finally, we interact each of these variables with the sovereign credit rating of the economy (CR), to capture the idea that capital withdrawals are likely to affect lower rated economies more heavily than higher rated ones. Again, motivated by the model presented below, lower rated economies are more likely to be constrained in financial markets, so that balance sheet or leverage constraints are more likely to act as a propagation mechanism for macro shocks for these economies. Sovereign credit ratings are based on the Standards and Poor's sovereign foreign currency credit rating in December 2007.

Table 5. Explaining the slowdown: OECD countries[1]					
	(1)	(2)	(3)	(4)	(5)
X	-0.020 (0.844)	0.003 (0.982)			-0.043 (0.662)
CRX		-0.007 (0.775)			0.039 (0.144)
TIC			**-0.005** **(0.035)**	**-0.006** **(0.006)**	**-0.007** **(0.005)**
CRTIC				**-0.046** **(0.022)**	**-0.078** **(0.009)**
Adj. R^2	-0.036	-0.072	0.133	0.278	0.294
Obs.	29	29	27	27	27

[1] Dependent variable: real GDP growth rate in the year to 2008Q4, less the growth rate in the previous year. P-values are in parentheses; bold indicates significance at the 5% level. X equals exports to the US and TIC is gross capital inflows from the US, each as a percentage of GDP, in 2007. CRX and CRTIC are interactive terms, where CR is S&P sovereign foreign currency credit rating in 2007. CR=0 corresponds to a AAA-rating, 1 for AA+, and so on, to 12 for BB-.

We run these regressions for two separate samples. Table 5 reports the results for a group of 29 OECD countries, while Table 6 uses 12 Asia Pacific economies. For the OECD sample the results provide strong support for our argument that financial flows were a strong causal factor in the propagation of the crisis, while trade channels appear less important. First the export variables (X and CRX) are never economically or statistically significant, and sometimes enter with the wrong sign. Second, our measure of capital flows (TIC) is statistically significant in all cases. Third, when we include an interactive term between the credit rating and the size of capital inflows from the US this not only enters significantly, consistent with flight-to-quality, but it also further strengthens the statistical support for TIC. Finally, the size of the adjusted R-squared

statistics is supportive of capital inflows playing an important role in explaining the downturn, while trade channels are of less importance.

Table 6. Explaining the slowdown: Asia-Pacific economies[1]					
	(1)	(2)	(3)	(4)	(5)
X	**-.295** **(0.020)**	**-0.329** **(0.022)**			**-1.002** **(0.079)**
CRX		-0.020 (0.483)			0.137 (0.188)
TIC			**-0.023** **(0.088)**	-0.029 (0.221)	-0.103 (0.224)
CRTIC				-0.004 (0.751)	-0.027 (0.322)
Adj. R^2	-0.378	-0.348	0.190	0.110	0.354
Obs.	12	12	12	12	12

[1] Dependent variable: real GDP growth rate in the year to 2008Q4, less the growth rate in the previous year. P-values are in parentheses; bold indicates significance at the 5% level. X equals exports to the US and TIC is gross capital inflows from the US, each as a percentage of GDP, in 2007. CRX and CRTIC are interactive terms, where CR is S&P sovereign foreign currency credit rating in 2007. CR=0 corresponds to a AAA-rating, 1 for AA+, and so on, to 12 for BB-.

By contrast, for the Asia Pacific countries, trade channels are of more importance in accounting for the size of the slowdown. When the trade variable alone is included it is highly statistically significant and economically important. When the capital flows variable is included on its own it is significant at the 10 percent level, but it loses significance when both trade and capital flows are included. The interactive variable is never significant.

These results suggest that the impact of shocks originating in the US on other countries depends on the way in which these countries interact with the US. If these countries have significant capital flows from the US and, in addition, there exists financial fragility (as defined in our regressions), then capital flow linkages represent the primary channel of business cycle transmission. But if the countries have more robust financial sectors then trade linkages represent the predominant channel of transmission. In a rough sense, this is consistent with anecdotal evidence that Asian economies had little direct financial exposure to the type of structured financial products that lay at the heart of the initial financial crisis and their financial systems generally remained robust throughout the crisis.

3. A Model of Leverage Constraints and Portfolio Interdependence

We construct a very stripped-down model which illustrates the two main elements discussed in the introduction – the role of leverage or financial constraints in international transmission, along with the trade-off between the risk-sharing and contagion effects of financial integration. We take a two-country model in which there are financial markets both within and between countries.[8] Within countries there are borrowers (investors) and lenders (savers). Across countries there is trade in risk-free bonds and (in some versions of the model that we examine) trade in equities. The countries are called home and foreign. Within each country the investors and savers both use the same fixed asset and have infinite horizons. Investors purchase the fixed asset and rent it to production firms, receiving a risky return in exchange. We may think of this investment as the purchase of an equity claim on the production firm. Savers also make use of

[8] We do not explicitly distinguish between *regional* financial integration and *global* financial integration. As discussed in the introduction and conclusions however, we could think of *regional* Asian financial integration as corresponding to integration between financial systems which are not directly subject to leverage constraints (at least insofar as the recent crisis is concerned). Global financial integration then increases the exposure to financial systems in which leverage constraints magnify shocks.

the fixed asset in home production. 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, but they may engage in lending to or borrowing from foreign countries.

Investors in either country, however, may trade claims with investors in the other country so as to diversify their portfolio of equity holdings. Thus investors in each country hold levered investments, but may also have equity portfolios that are inter-connected across countries. We will look at the impact of financial integration in the form of a move from an equilibrium where there is a unified world market for non-contingent debt, but equity markets are segmented, to an equilibrium with integrated world bond and equity markets.

Finally, both investors and savers in each country supply a fixed quantity of labour to production firms.

Investors

We normalize the population of each country to unity, with a measure n of investors and $1-n$ savers. The representative investor in the home country maximizes:

$$E_t \sum_{s=t}^{\infty} \theta_s^I U(C_s^I), \tag{3}$$

where C_s^I is consumption of the final good. To keep the analysis solely focused on financial inter-linkages between countries, we assume that there is just one world good. Adding an endogenous terms of trade to the analysis would enrich the response, but would not fundamentally alter the cross-country transmission of balance sheet adjustments modeled here, so long as the elasticity of substitution across home and foreign goods is not close to unity.

We define the discount factor for investors such that:

$$\theta^I_{s+1} = \beta^I(\bar{C}^I_s)\theta^I_s, \quad \beta^I{}'(\bar{C}^I_s) \leq 0,$$

where $\bar{C}^I_s$ is the economy-wide average consumption of investors. Thus the investor's time preference is increasing in consumption, but the rate of time preference is taken as given by the individual investor. The assumption of endogenous time preference for investors plays the usual role of ensuring a stationary wealth distribution among groups, both within countries and across countries.

Investors receive income from their current holdings of domestic equity and, if they have access to international financial markets, from foreign equity also. In addition they receive labour income from working in the domestic production firm. They must repay their debts owed to savers, issue new debt, purchase equity claims on home (and, if financial markets are integrated, foreign) investments and consume. The home country investor's budget constraint in the case *without* international equity market integration is written as:

(4) $$C^I_t + q_{1t}k^I_{1t} = W^I_t + (q_{1t} + R_{1Kt})k^I_{1t-1} + B^I_t - R_{t-1}B^I_{t-1}.$$

If there are integrated cross-country equity markets, then the budget constraint is:

(4') $$C^I_t + q_{1t}k^I_{1t} + q_{2t}k^I_{2t} = W^I_t + (q_{1t} + R_{1Kt})k^I_{1t-1} + (q_{2t} + R_{2Kt})k^I_{2t-1} + B^I_t - R_{t-1}B^I_{t-1},$$

where q_{1t} and q_{2t} represent the price of the fixed asset (or equity) in the home and foreign country respectively, and k^I_{1t} and k^I_{2t} are the portfolio holdings of the fixed assets in each country held by the home investor. The fixed asset of the home (foreign) country earns a return R_{1Kt} (R_{2Kt}). W^I_t is wage income for the investor, who supplies one unit of labour. Finally, B^I_t is the debt issued to domestic or foreign savers and $R_{t-1}B^I_{t-1}$ is payment on previously incurred debt.

In order to generate heterogeneity in financial markets and the need for debt, we assume that only investors can purchase the fixed asset representing a claim on the output of final goods. As in Bernanke et al. (1999) we could assume that investors (or entrepreneurs, in their model) have some special capability for transforming a unit of the fixed asset into a usable factor of production that is rented to production firms. Lenders cannot do this, and so can gain from the investment only indirectly by lending to the investors.

In addition to constraint (4), we assume that investors face a constraint on total leverage due to an inability to commit to repayment. 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 either of the following two constraints. Without equity market integration, we have:

(5) $$B_t^I \leq \kappa q_{2t} k_{2t}^I .$$

When equity markets are integrated, investors in each country choose a portfolio comprised on equity of home and foreign firms. In this case the leverage constraint is described as:

(5') $$B_t^I \leq \kappa (q_{1t} k_{1t}^I + q_{2t} k_{2t}^I) .$$

The full leverage rate (the value of assets to capital) for investors is then $\frac{1}{1-\kappa}$ in the case where the leverage constraint (5) (or (5')) is binding.

Savers

Savers have preferences given by:

(6) $$E_t \sum_{s=t}^{\infty} \theta_s^S U(C_s^S).$$

Again, we define the discount factor such that $\theta_{s+1}^S = \beta^S(\bar{C}_s^S)\theta_s^S$, with $\beta^S{}'(\bar{C}_s^I) \leq 0$, where $\bar{C}_s^I$ is the economy-wide aggregate consumption of savers. We make the assumption that savers are inherently more 'patient' than investors, in the sense that:

(7) $$\beta^S(x) > \beta^I(x),$$

for all feasible values of x. Assumption (7) ensures that savers will lend to investors, and that investors will not have an incentive to build up enough wealth so as to be debt free.[9]

Savers purchase the fixed asset and lend to investors. They receive wage income from working in the final goods sector, and returns on their lending to investors. In addition they have a residual 'home production function' for use of the fixed asset. Thus an individual saver owning $k_{1,t}^S$ of the home fixed asset produces $G(k_{1,t}^S)$ in terms of home production, with $G'(k_{1,t}^S) < 0$. For simplicity we assume that home production is perfectly substitutable with the final good in savers preferences. With this assumption we may write the savers budget constraint as:

(8) $$C_t^S + q_{1t}k_{1t}^S = W_t^S + q_{1t}k_{1t-1}^S + G(k_{1t-1}^S) + B_t^S - R_{t-1}B_{t-1}^S.$$

[9] An alternative, but considerably more difficult, approach to achieving an equilibrium with levered investment is to assume that investors are less risk averse than savers. Solving a model with leverage based on risk preferences would be substantially harder than the approach we follow because we would need to solve the full stochastic model to a higher order of approximation. Adding habit persistence to the model would potentially allow for some time variation in risk aversion in a relatively simple way. We defer this for future work, however, in order to keep the analysis as transparent as possible.

Savers purchase only the domestic fixed asset. They do not have access to the same investment opportunity that investors have, and therefore they only demand the domestic fixed asset which is useful for their home production. In contrast, savers' purchases of debt from either home or foreign investors are unconstrained.

Optimality Conditions

Investors in the home country choose investment in equity and borrowing to maximize utility. In the case without international financial markets, the first order conditions for investors are:

$$U'(C_t^I) = E_t \beta^I (C_t^I) U'(C_{t+1}^I) \frac{(q_{1t+1} + R_{1Kt+1})}{q_{1t}} + \kappa \mu_t , \tag{9}$$

$$U'(C_t^I) = E_t \beta^I (C_t^I) U'(C_{t+1}^I) R_t + \mu_t . \tag{10}$$

Equation (9) is the optimal condition for choice of debt with a binding leverage constraint. The variable μ represents the shadow value of relaxing the leverage constraint by one unit. If this is positive, it means that the investor would like to borrow more, but is constrained by (5). Therefore current marginal utility is greater than expected future marginal utility times the return on investing in either the home or foreign country. Thus μ is a measure of the value of the opportunity to make a levered investment. To show this, put (5), (9) and (10) together to obtain:

$$\mu_t = E_t \beta^I (C_t^I) U'(C_{t+1}^I) \left[\frac{r_{1,t+1} - R_t}{1 - \kappa} \right], \tag{11}$$

where $r_{1,t+1} = (q_{1,t+1} + R_{1K,t+1}) / q_{1,t}$ is the return on the home equity. Equation (11) shows that, for a given distribution of excess returns and consumption, μ is higher the higher is the leverage rate.

It also implies that when $\mu > 0$ the expected return on the portfolio exceeds the cost of borrowing, up to the first-order.

When investors have access to international financial markets, choosing a portfolio of both home and foreign equity, we have the conditions:

$$U'(C_t^I) = E_t \beta^I (C_t^I) U'(C_{t+1}^I) \frac{(q_{1t+1} + R_{1Kt+1})}{q_{1t}} + \kappa \mu_t , \tag{12}$$

$$U'(C_t^I) = E_t \beta^I (C_t^I) U'(C_{t+1}^I) \frac{(q_{2t+1} + R_{2Kt+1})}{q_{2t}} + \kappa \mu_t , \tag{13}$$

$$U'(C_t^I) = E_t \beta^I (C_t^I) U'(C_{t+1}^I) R_t + \mu_t . \tag{14}$$

Although the leverage constraint may bind, with open international financial markets investors have an incentive to diversify their equity holdings across countries. In fact, we may put (12) and (13) together to get the standard portfolio selection condition:

$$E_t U'(C_{t+1}^I) \left(\frac{(q_{1t+1} + R_{1Kt+1})}{q_{1t}} - \frac{(q_{2t+1} + R_{2Kt+1})}{q_{2t}} \right) = 0 . \tag{15}$$

Given that the portfolio choice may be written in this form we may use standard methods to derive the optimal equity portfolio of each country's investors.

For savers, the first order conditions for the optimal choice of k_{1t}^S and B_t^S are simply:

$$U'(C_t^S) = E_t \beta^S (C_t^S) U'(C_{t+1}^S) \frac{(q_{1t+1} + G'(k_{1,t+1}^S)}{q_{1t}} , \tag{16}$$

$$U'(C_t^S) = E_t \beta^S (C_t^S) U'(C_{t+1}^S) R_t . \tag{17}$$

The return on the fixed asset for savers is determined by its marginal value in home production. Being unconstrained, savers will, up to a first order, choose a portfolio so as to equalize the return on debt and the total return on the fixed asset.

Production firms

Production firms in each country hire capital and fixed assets in order to produce. Firms are competitive, and maximize profits given the production function:

(18) $$Y_t = A_t F(L_t, K_t),$$

where L_t is effective employment and K_t is the firm's use of the fixed asset. Profit maximization then implies that:

(19) $$W_t^I = A_t F_1(L_t, K_t),$$

(20) $$W_t^S = A_t F_1(L_t, K_t),$$

(21) $$R_{1K,t} = A_t F_2(L_t, K_t).$$

Equilibrium

Equilibrium of the two-country world economy must satisfy market clearing for both the fixed asset and debt. Without international equity markets the condition for equity market clearing in the home economy is:

(22) $$nk_{1,t}^I + (1-n)k_{s,t}^S = 1.$$

In addition, the world bond market clearing condition is:

(23) $$nB_t^I + nB_t^{*I} + (1-n)B_t^S + (1-n)B_t^{*S} = 0,$$

where the asterisk represents the values of foreign variables.

In the case of open international equity markets, we replace (22) with the condition:

$$nk_{1,t}^{I} + nk_{1,t}^{*I} + (1-n)k_{s,t}^{S} = 1, \tag{24}$$

where $k_{1,t}^{*I}$ represents foreign country investor's real holdings of the home asset at the beginning of time $t+1$. In addition, the world market clearing condition must be satisfied:

$$\begin{aligned} &n(C_t^I + C_t^{*I}) + (1-n)(C_t^S + C_t^{*S}) = A_t F(1, n(k_{1,t}^I + k_{1,t}^{*I})) \\ &+ A_t^* F(1, n(k_{2,t}^I + k_{2,t}^{*I})) + (1-n)(G(k_{1,t}^S) + G(k_{1,t}^{*S})). \end{aligned} \tag{25}$$

This condition incorporates the fact that total labour supply of investors and savers is n and $1-n$, respectively, and total use of the fixed factor by final goods firms is equal to total holdings by domestic and foreign investors.

Definition of equilibrium

Without international equity markets, the equilibrium is described by conditions (4), (5), (8), (9) (10), (16), (17), (19)-(21) and (22) for the home economy, and the analogous conditions for the foreign economy, as well as conditions (23) and (24). This gives 24 equations in the 23 variables C_t^I, C_t^S, C_t^{*I}, C_t^{*S}, $k_{1,t}^I$, $k_{1,t}^S$, $k_{2,t}^{*I}$, $k_{2,t}^{*S}$, B_t^I, B_t^S, B_t^{*I}, B_t^{*S}, $q_{1,t}$, $q_{2,t}$, R_t, μ_t, μ_t^*, W_t^I, W_t^S, W_t^{*I}, W_t^{*S}, $R_{1K,t}$ and $R_{2K,t}$, with one equation being redundant by Walras' law.

With international equity markets, the equilibrium is described by conditions (4'), (5'), (8), (12), (13), (14), (16), (17), (19)-(21) and (22) for the home economy, and the analogous conditions for the foreign economy, as well as conditions (24) and (25). This gives 26 equations in the 25 variables C_t^I, C_t^S, C_t^{*I}, C_t^{*S}, $k_{1,t}^I$, $k_{2,t}^I$, $k_{1,t}^S$, $k_{1,t}^{*I}$, $k_{2,t}^{*I}$, $k_{2,t}^{*S}$, B_t^I, B_t^S, B_t^{*I}, B_t^{*S}, $q_{1,t}$, $q_{2,t}$, R_t, μ_t, μ_t^*, W_t^I, W_t^S, W_t^{*I}, W_t^{*S}, $R_{1K,t}$ and $R_{2K,t}$, again with one equation redundant by Walras' law.

Portfolio Choice

It is useful to provide a little more insight into the solution of the portfolio choice problem in this model. When investors can hold both domestic and foreign equity, they determine the optimal portfolio share using condition (15). But up to a first order, this condition just says that the return on the two equities must be equal. Thus, up to a first order, they would be indifferent between the two assets. In order to solve for the share of the portfolio in each country's equity, therefore, we must approximate (15) up to a second order. We do this following the method of Devereux and Sutherland (2009).

To illustrate the application of this method to the present model, the budget constraint for home country investors with integrated equity markets (4') may be rewritten as:

$$(26)\; C_t^I + NFA_t = W_t^I + R_{1Kt}\hat{k}_{1t-1}^I - q_{1t}(\hat{k}_{1t}^I - \hat{k}_{1t-1}^I) + r_{2t}NFA_{t-1} + r_{xt}\left[q_{1t-1}(k_{1t-1}^I - \hat{k}_{1t-1}^I)\right] + B_t - R_{t-1}B_{t-1},$$

where $\hat{k}_{1t}^I = k_{1t}^I + k_{1t}^{*I}$ represents the total stock of fixed capital in home production, NFA_t denotes net foreign assets and is defined as $NFA_t = q_{2t}k_{2t}^I - q_{1t}(\hat{k}_{1t}^I - k_{1t}^I)$, and we define r_{xt} as the *excess* return on the portfolio:

$$r_{xt} = r_{1t} - r_{2t} \equiv \left(\frac{q_{1t} + R_{1K,t}}{q_{1t-1}}\right) - \left(\frac{q_{2t} + R_{2K,t}}{q_{2t-1}}\right).$$

For given NFA_t, the portfolio choice may be described as the choice of $\alpha_t = q_{1t}(k_{1t}^I - \hat{k}_{1t}^I)$, which is the net holding of home country equity by home agents. It is easy to show that the first order condition that maximizes utility with respect to α_t gives equation (15). If $\alpha_t < 0$, the investors diversify in the sense that less than 100 percent of all home equity is owned by home investors. Equivalently, from (25), when $r_{xt} > 0$ due to a favourable return on the home equity, the investor

in the home country receives a negative *valuation* effect on his portfolio. This makes sense, since it implies that the investor is engaging in risk-sharing with investors from the foreign country.

Note that given the revised definition of net foreign assets, the leverage constraint for home country investors becomes:

$$B_t \leq \kappa(NFA_t + q_{1t}\hat{k}_{1t}^I) . \tag{27}$$

Thus, holding the home asset price constant, an increase in net foreign assets generated by either a current account surplus or a capital gain on the external portfolio will loosen the leverage constraint. But since $NFA_t + NFA_t^* = 0$, this will simultaneously tighten the leverage constraint facing foreign investors. Thus the degree to which leverage linkages govern the transmission of shocks across countries depends on the dynamics of net foreign assets, and these in turn are linked to portfolio choices made by home and foreign investors.

Calibration

We now explore the implications of the model for a number of alternative scenarios with respect to financial market integration, and the effect of leverage constraints. Clearly the model is a substantial simplification of reality. There are a number of standard features of DSGE models that are not included in the exercise. For instance, there is no endogenous capital accumulation and no variable labour supply. But the aim of the exercise is solely to explore the way in which financial leverage constraints affect the cross-country dynamics of asset prices, asset allocations and levered investments, and to investigate the affect of financial market integration within this environment. To do this, however, we need to choose parameter values for preferences, production technologies and the leverage constraint itself. Table 7 gives the set of parameter values used in the baseline model.

Table 7. Calibration			
Parameter	Value	Parameter	Value
n	0.5	ε	0.55
η	0.02	ω	0.25
ζ	Discount factors 0.985 and 0.94	σ	2
κ	0.75, 0.5	ρ	0.9

We assume that the measure of investors and savers is equal, so that $n = 0.5$. In the leverage constrained economy, this accords with the estimates of Campbell and Mankiw (1990) regarding the share of households that are subject to credit constraints in the US economy.

In the model with binding leverage constraints, total leverage (investment relative to capital) is equal to $1/(1-\kappa)$. The leverage ratio has a significant affect on the quantitative dynamics. We examine two alternatives. First we choose a relative low ratio of 2 ($\kappa = 0.5$), as in Bernanke and Gertler (1999). But given the high rates of leverage seen in the financial system in recent years we also explore the implications of a higher value of $\kappa = 0.75$, corresponding to total leverage of 4. When the leverage constraint is binding, the impact of shocks is greater for higher leverage. Qualitatively, however, the results are similar for both leverage ratios.

We assume a discount factor defined as:

$$\beta^i(C) = \zeta^i(1+C)^{-\eta}, \quad i = I, S.$$

Following Mendoza and Smith (2006) we set $\eta = 0.022$. We choose ζ for lenders to match an annual interest rate of 4 percent and for investors so that, in a steady state *without* binding leverage constraints, borrowing by investors is such that the leverage ratio matches that of the

economy with binding leverage constraints. In the case $\kappa = 0.75$ this requires that $\zeta^H = .985$ and $\zeta^I = .9735$. When $\kappa = 0.5$, we obtain $\zeta^H = .9825$ and $\zeta^I = .975$.

We assume a Cobb-Douglas final goods production technology, and let $F(L,K) = L^{\varepsilon} K^{1-\varepsilon}$. In order to have substantial propagation effects from leverage constraints, Kiyotaki and Moore (1997) require that production in the borrowing sector is linear in the fixed asset. Kocherlakota (2000) shows that, with a more conventional calibration allowing for decreasing returns, credit constraints have much less impact. We set $\varepsilon = 0.55$. Our choice of ε implies that fixed assets are slightly more important than conventional measures of capital's share in calibrations of the US economy.[10] Regarding the home production sector, we assume that $G = Z(k_1^S)^{\omega}$ and $\omega = 0.25$, implying that the fixed asset is less important in this sector.[11] We set $A = Z = 1$ in steady state. These assumptions, in combination with the other calibrated parameters, imply that 80 percent of the fixed asset is employed in final goods production in steady state.[12]

We follow the standard business cycle literature in setting an elasticity of intertemporal substitution equal to 0.5 so that $\sigma = 2$ in $U(C) = C^{1-\sigma}/(1-\sigma)$. Alternative values of σ change the volatility of asset prices, but have little qualitative effect on the results otherwise.

What are the appropriate shocks to focus on? While the recent crisis has raised the awareness of shocks to the financial system, our model lacks any detailed financial structure. It is not easy to pinpoint any key crisis-generating shock within the model. Instead, we follow the

[10] For many emerging market economies, however, estimates of capital share equal to 50 percent are quite common.
[11] Benhabib et al. (1991) calibrate the share of capital in home production equal to 0.08, but they do not include residential structures as capital.
[12] The equity portfolio positions taken in equilibrium with integrated equity markets are not reported directly in Table 7, since they are endogenous to the particular case that we focus on. In general we find that there is more diversification of equities in the model than seen empirically – the model does not explain the puzzle of 'home equity bias.' Devereux and Yetman (2010) introduce transactions frictions in financial markets which can generate home bias in equities. The results here would be qualitatively unchanged if we incorporated such frictions.

standard macro-RBC literature and look at the international propagation of productivity shocks in the final goods sector. The stochastic process for final goods productivity is modeled as:

$$\log(A_t) = \rho \log(A_{t-1}) + \upsilon_t \,, \tag{28}$$

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

4. Effects of productivity shocks

In this section we look at how the joint process of balance sheet constraints with portfolio interdependence affects the international propagation of shocks. The key result is that the two features of portfolio interdependence and leverage constraints together introduce substantial macroeconomic co-movement that is absent when these features are not both present.

Portfolio Autarky with Leverage Constraints

We first compare the effects of a 1 percent negative shock to the productivity of the fixed asset in final goods in the home country when leverage constraints are binding, but *without* international equity portfolio diversification. Figure 2 describes the impact of the shock on total consumption of final goods, aggregated across both savers and investors in each country, asset prices, lending by savers, asset allocation, the home country trade surplus and the world lending rate, in the environment where there is no portfolio diversification. The figure incorporates a high leverage rate, as described in the previous section.

The fall in the return on the productivity of final goods production has two immediate effects. It (temporarily) reduces wages for both investors and savers and, since the fall is persistent, it reduces the return on investment in the fixed asset for investors. With temporarily

lower income, ceteris paribus, both investors and savers would like to smooth out the impact on consumption by borrowing more, or saving less (note that because there is no *aggregate* investment there is no tendency for reduced overall spending on capital, as in the standard RBC model). At the same time, the fall in the return on the fixed asset will reduce the demand for investment funds by investors in the home economy. In a closed economy these two effects would lead to a fall in the price of the fixed asset and a reduction in investment in the fixed asset in final goods. The impact on the real interest rate depends on the degree to which the leverage constraint plays an important role. If there was no binding leverage constraint, the impact of the fall in A_t would lead real interest rates to rise, since both savers and investors have temporarily lower consumption, and the real interest rate should rise to eliminate the aggregate desire to smooth this consumption fall over time. But when the leverage constraint is binding, the fall in the asset price precipitated by the fall in the future return on investment in fixed assets causes a tightening of the constraint, reducing the amount that investors can borrow to invest. This leads to an amplification of the impact of the productivity shock on investment in the fixed asset. If the amplification is great enough then the fall in the demand for borrowing leads to a *fall* in the real interest rate rather than a rise.

With this explanation in mind, we may focus on the impact of the home country shock in Figure 2, where there is a unified world debt market (but no cross-country equity holdings). The figure is based on a high leverage rate. As a result, the amplification effect of asset prices is significant. Thus the fall in the productivity of the fixed asset in finals goods leads to significant tightening of the leverage constraint and a large forced reduction in borrowing to finance investment on the part of home country investors. This fall in borrowing is great enough that world real interest rates fall.

What does this imply for the international macroeconomic transmission of shocks? Figure 2 shows that in this case the co-movement of international macroeconomic aggregates is *negative*. The home country productivity decline reduces both aggregate home country consumption of final goods and investment in the final goods sector, driving down the home-country price of the fixed asset. But because the world real interest rate is lower, due to the amplified effect of the collateral reduction in the home economy, the cost of investment in fixed assets in the foreign country is reduced. Since equity markets are segmented across countries there is no balance sheet inter-connection across countries, so the fall in the home asset price has no direct effects on the foreign investor's leverage constraint. But, since the cost of borrowing is lower, there is an increase in borrowing and investment in the fixed asset on the part of foreign investors. Foreign total consumption rises as the fall in interest rates encourages an increase in spending, and the rise in foreign investment increases production of final goods in the foreign country.

The different responses of home and foreign investment lead asset prices to move in opposite directions in the two countries. There is an asset price decline in the home country, for reasons explained above. In the foreign country, by contrast, the increase in demand for the fixed asset raises the price of that asset.

Note also that the negative co-movement in asset prices is associated with pathological movements in the trade balance. The home country has temporarily lower output and, by standard reasoning, we would anticipate that it runs a trade deficit. But the large collateral related fall in wealth leads to a fall in aggregate consumption of final goods that is greater than the immediate fall in output, leading to a trade surplus. The foreign country, by contrast, experiences

a collateral-related expansion in wealth, and runs a trade deficit, even though it experiences a temporarily higher level of output (through an increase in investment in final goods).

Thus the end result is that consumption, investment and asset prices move in *opposite* directions in the two countries when there is an integrated world bond market but no equity market integration. Without integrated equity markets, the two countries interact in capital markets only through the world bond market. But in the presence of binding leverage constraints and a high level of leverage, productivity shocks drive real interest rates in a perverse way so that bond markets actually exacerbate the effects of the shock.

Figure 3 looks at the case with low leverage constraints, but again segmented financial markets. When leverage is set at 2, rather than 4, the impact of a home country productivity shock on the real interest rate is positive, since the collateral-related fall in borrowing is not large enough to overturn the initial desire to consumption smooth on the part of home agents. Thus, following the logic of the previous paragraphs, the rise in world interest rates leads to a reduction in the demand for borrowing in the foreign country, a fall in fixed investment and a fall in foreign consumption and asset prices. The home country then experiences a trade deficit rather than a surplus. So in this case of lower leverage, the cross country co-movement is positive. But, as we see below, the extent of co-movement is substantially less than is seen in the case of integrated international equity markets.

Equity Market Integration: Risk Sharing vs Contagion

The international macro transmission mechanism in Figure 2 strongly suggests the possibility of gains from international financial market integration. Productivity shocks in one country cause large collateral amplification effects, but have the opposite impact on the rest of

the world. Because all equity has to be held in domestic portfolios, there is no possibility of financial risk sharing so as to smooth the impact of macro shocks across countries. In this section, we illustrate the effects of equity market integration. We illustrate the effects of the same shock as before, but now allowing for equity market integration.

Figure 4 illustrates the high leverage case and shows that when equity markets are integrated there is a clear positive co-movement across the two countries in response to the home country productivity shock. Clearly we would anticipate that, due to the improved risk-sharing possibilities from equity trade, consumption movements would be more aligned across countries. But Figure 4 shows that the positive co-movement extends beyond consumption risk-sharing to the real economy. In contrast to Figure 2, the integration of equity markets leads to asset prices and investment becoming highly synchronized across countries.

The explanation for this positive co-movement is critically tied to the presence of binding leverage constraints in both the home and foreign countries. The home country productivity shock leads to a fall in the price of the home asset, as before, and, from the arbitrage condition (15), the foreign asset price also falls. Now, however, the home investor is hedged against the fall in the value of home equity. The optimal portfolio holding for the home investor is to have a negative net position in home equity (i.e. it divests some home equity in return for foreign equity), so that $\alpha_t < 0$. This, in conjunction with the fact that the home country productivity fall leads to a negative ex-post return on home equity (so that $r_{xt} < 0$), results in a positive portfolio gain for the home country following the shock, facilitating an *increase* in home NFA due to valuation effects. For the foreign country these valuation effects are negative, leading to a tightening of the leverage constraint on foreign investors. This forces foreign investors to reduce

borrowing and investment in the fixed asset. As before, the world interest rate on debt falls. But in contrast to the case without equity market, foreign investors cannot take advantage of lower world interest rates to increase their investment, since they find themselves less creditworthy due to tightened leverage constraints. The negative collateral impact of falling asset prices forces them to reduce their investment in fixed assets. Moreover, since equity markets immediately transmit wealth effects across countries, consumption falls in both the home and foreign countries.

A comparison of Figures 2 and 4 illustrates that, conditional on leverage-constrained investment, portfolio integration itself causes a dramatic qualitative shift in the international transmission process of productivity shocks. Absent equity market integration, shocks are transmitted negatively to consumption, asset prices and investment. There would thus be a clear incentive to diversify country specific risk through equity market diversification. But integrating equity markets in the presence of binding leverage constraints causes a sharp change in the nature of international transmission itself. Without leverage constraints there would be no such effects – real investment is entirely independent across countries in this basic model, and opening up financial markets in equity trade would have no effect on this co-movement whatsoever. But with these binding constraints, portfolio diversification leads to large shifts in net worth across countries in the face of country specific shocks. These net worth changes interact with leverage constraints to cause highly synchronized movements in investment demand across countries. Thus the ex-post gains to diversification, after financial integration, are diminished relative to the ex-ante 'perceived' gains, anticipated before equity market liberalization.

Equivalently we can observe that, while financial integration through equity markets allows for a positive gain from cross country risk-sharing, it also generates a 'contagion' effect in the presence of leverage constraints on investment. This contagion effect works through cross-country changes in net worth, affecting investment and increasing the degree of macroeconomic co-movement relative to that which would obtain in the absence of portfolio integration. As in standard models, portfolio diversification does enhance risk-sharing. But it does so at the cost of simultaneously increasing business cycle co-movement, because it generates interdependent movements in balance sheet positions. These movements, together with balance sheet constraints, affect the propagation of macro shocks. Thus portfolio diversification *increases* co-movement of business cycles. This is in stark contrast to the standard business cycle model, where increased risk sharing usually reduces the income effect of shocks and enhances the allocation of resources to their location of greatest returns, hence *reducing* business cycle co-movement.

Finally, Figure 5 shows the case of the same shock with equity market integration but lower leverage. Qualitatively, the effects are very similar to Figure 4. The main difference is that the amplitude of the effects of the shock is diminished since, in the case of lower leverage, the impact of asset price declines through the leverage constraint are lessened.

Conclusions

This analysis raises fundamental questions about the nature of the gains to financial market integration and how financial and regulatory policy should be designed in the light of these market failures. With inter-dependent financial market distortions across countries, it is not necessarily true that full financial liberalization is a first-best policy. Further, there may be an

optimal ‘sequencing’ of financial market opening that minimizes the risk of financial contagion. In broad terms, it is necessary to identify the financial structure that most efficiently exploits the trade-off between the gains from international portfolio diversification and the costs of ‘financial contagion’.

While this paper is primarily an academic study, it is possible to go beyond the narrow confines of the model and draw some more general implications for monetary and financial policy implied by the model. First, in so far as the contagion effects of financial markets are linked to excessive leverage within the financial system, the model suggests that financial regulatory policy which limits leverage may offer both domestic and international benefits. Consequently the model implies that there is a clear case for international coordination on financial regulatory policy. This is at odds with some views (e.g. Taylor, 2008) suggesting that regulation is best left to individual national policy-makers.

A further implication follows regarding regional versus global financial integration. As suggested above, it may be more desirable to pursue a more cautious approach to global financial integration when integration involves exposing domestic financial markets to foreign jurisdictions that exhibit excessive leverage or financial fragilities. By exposing domestic balance sheets to the risk of foreign asset price shocks, international financial integration may magnify business cycle risk. Moreover, this process is likely to be asymmetric. Negative shocks may have a bigger magnification effect than positive shocks, because they are more likely to push asset values down to the point where leverage constraints bind.

Finally, the model may have some implications for monetary policy coordination across countries. While there is no explicit monetary policy dimension to the model, and we maintain

the assumption of fully flexible prices throughout, there is a potential role for monetary policy in providing liquidity so as to avoid binding leverage constraints. In this situation again, as was the case for regulatory policy, there is a clear case for international coordination in the form of foreign exchange swaps and other liquidity enhancing reciprocal arrangements between central banks.

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Figure 2: The Impact of a Home Country Productivity Shock: Segmented Financial Markets

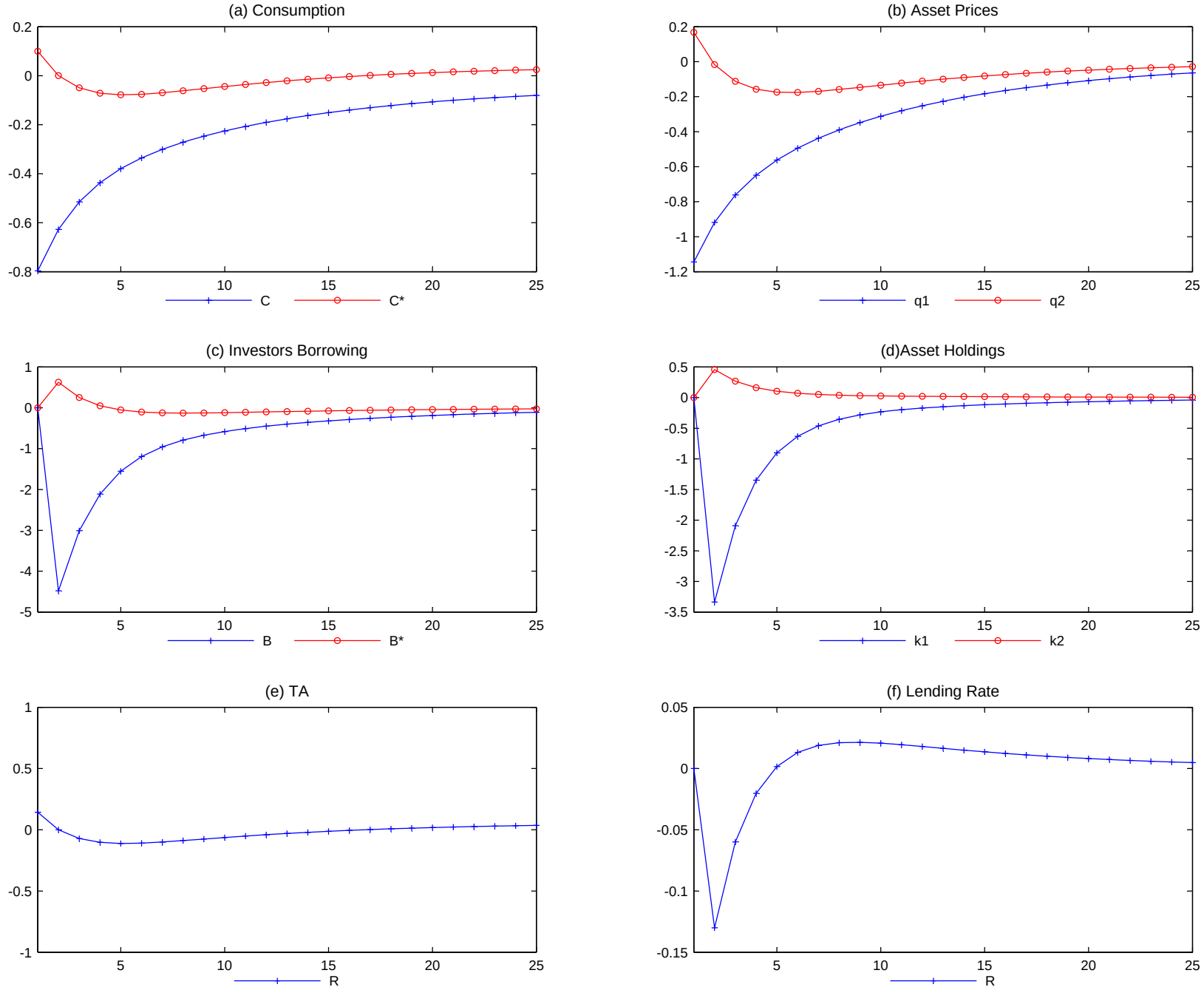


Figure 3: The Impact of a Home Country Productivity Shock: Segmented Financial Markets (Low Leverage)

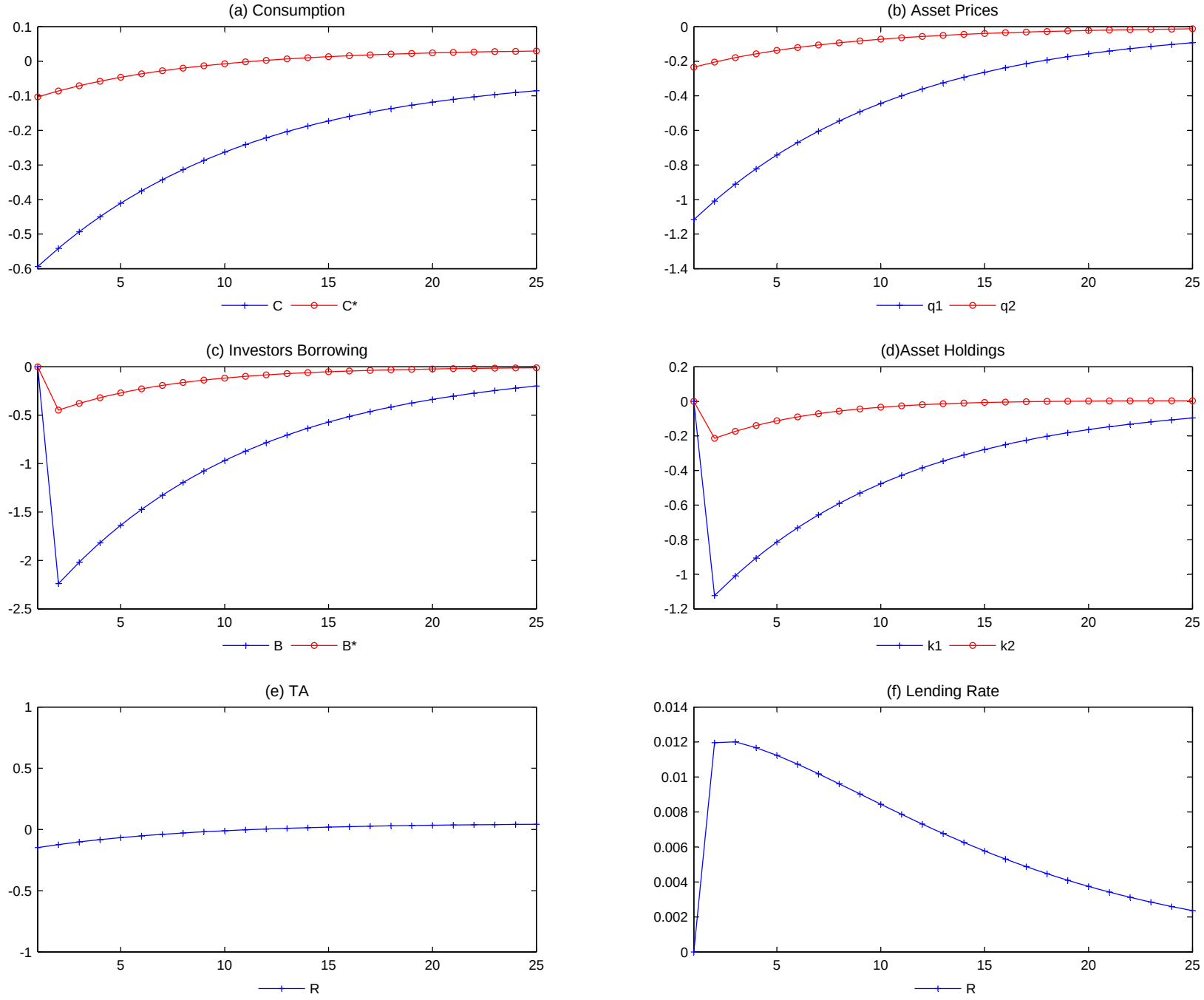


Figure 4: The Impact of a Home Country Productivity Shock: Integrated Financial Markets

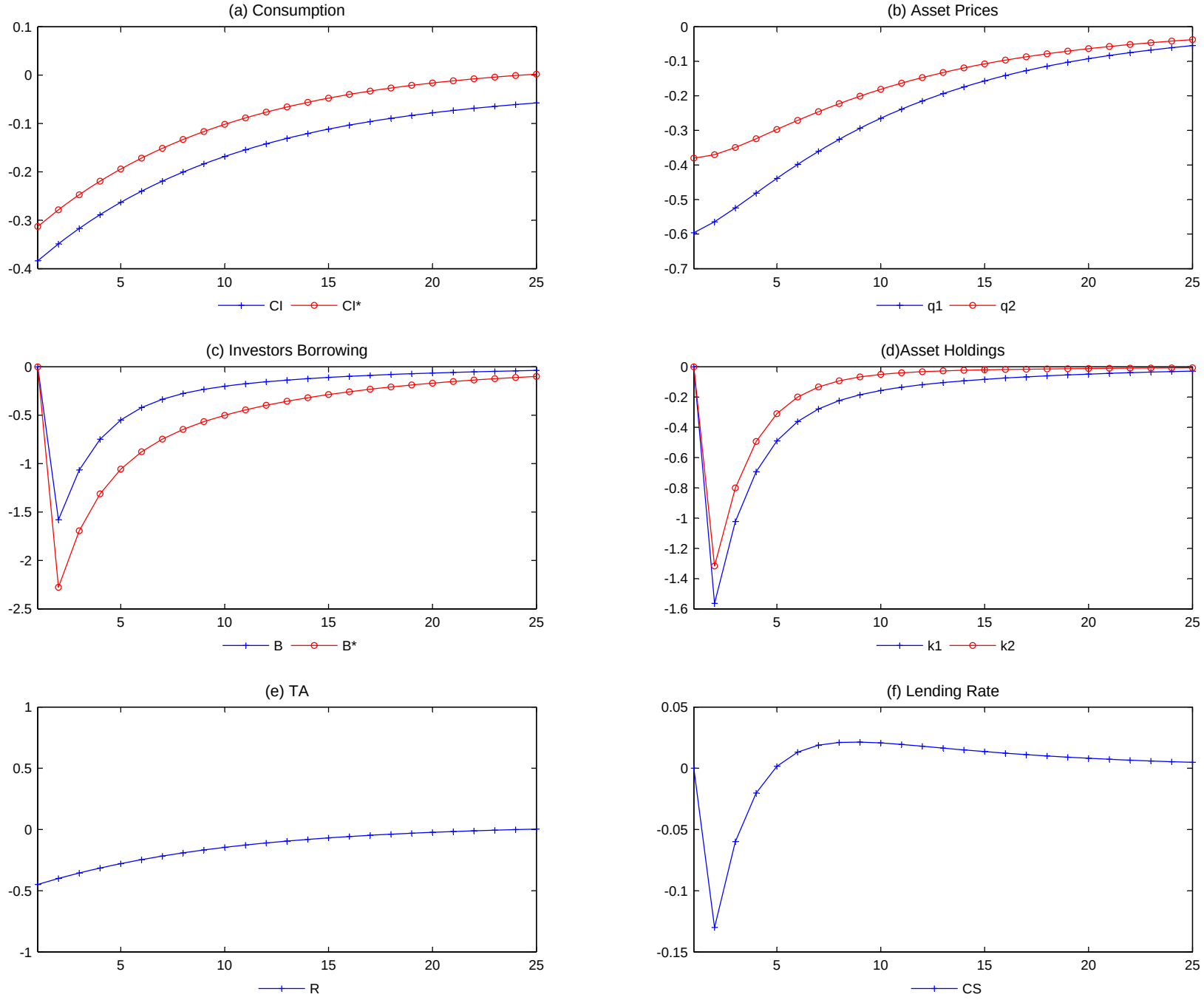


Figure 5: The Impact of a Home Country Productivity Shock: Integrated Financial Markets (Low Leverage)

