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Global banks and crisis transmission ☆

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ABSTRACT

We study the effect of financial integration (through banks) on the transmission of international business cycles. In a sample of 18/20 developed countries between 1978 and 2009 we find that, in periods without financial crises, increases in bilateral banking linkages are associated with more divergent output cycles. This relation is significantly weaker during financial turmoil periods, suggesting that financial crises induce co-movement among more financially integrated countries. We also show that countries with stronger, direct and indirect, financial ties to the U.S. experienced more synchronized cycles with the U.S. during the recent 2007–2009 crisis. We then interpret these findings using a simple general equilibrium model of international business cycles with banks and shocks to banking activity. The model suggests that the relation between integration and synchronization depends on the type of shocks hitting the world economy, and that shocks to global banks played an important role in triggering and spreading the 2007–2009 crisis.

1. Introduction

A central question in international macroeconomics is how financial integration affects the international transmission of country-specific shocks. This question is at the heart of the debate on how the 2007–2009 global financial crisis spread and on the implications of cross-border financial linkages for business cycles within the Euro area. Yet, both the empirical and theoretical literatures give ambiguous, and sometimes conflicting, answers.

Empirically the literatures on the correlates of business cycle synchronization and on how contagion spreads evolved separately. On the one hand, the business cycle synchronization literature focuses on long-term averages trying to identify the effect of financial integration, and other (mostly bilateral) factors, on business cycle synchronization using cross-country (and cross-country-pair) variation. This literature in general finds a positive relation between financial integration and synchronization independent on whether the sample includes financial crisis episodes.[1] Yet, recent work by Kalemli-Ozcan et al. (2012) shows that in a sample of developed countries before the pre-2007 crisis when financial crises were rare (or absent for most countries), within country-pair increases in cross-border financial linkages are associated with less synchronized output cycles.[2] The contagion literature, on the other hand, limits its focus on crisis periods, primarily in emerging markets, studying how financial shocks spread via trade or financial links. Overall this body of work provides compelling evidence that crises spread contagiously from the origin mostly via financial linkages.[3]

Theoretical models make opposing predictions on the effects of financial integration (through banks) on the synchronization of economic

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[1] See Otto et al. (2001), Baxter and Kouparitsas (2005), Kose et al. (2004), Imbs (2006), Rose (2009).
[2] See also Kalemli-Ozcan et al. (2001) and Garcia-Herrero and Ruiz (2008).
[3] See, among others, Kaminsky and Reinhart (2000); Kaminsky et al. (2003); Cetorelli and Goldberg (2011).

activity, depending on whether real or financial shocks are the dominant source of aggregate fluctuations. Suppose that, in a financially integrated world, firms in certain countries are hit by a negative real (say, productivity) shock. Global banks would decrease lending in the affected countries and increase lending in the non-affected countries, thereby causing a further divergence of output growth.[4] In contrast, if the negative shock is to the efficiency of the banking sector in some countries, globally operating banks would be hit and they would pull out funds from all countries, including the ones not hit by the shock. This transmits the financial shock internationally, making international business cycles more synchronized.[5]

Our paper aims to contribute to both the empirical and the theoretical debates on the relation between financial integration on the synchronization.

1.1. Empirical contribution

Our main empirical contribution is to show that the relation between business cycles correlation and financial/banking integration is different in "tranquil" (no financial crisis) times and in times of financial turmoil (crises). For our analysis we use a unique bilateral panel data-set of cross-border banking linkages from the Bank of International Settlements (BIS) and data on business cycles for 18/20 developed economies over the period 1978–2009; hence our analysis covers several episodes of financial crises, including the 2007–2009 global financial crisis. Importantly our data allows us to measure not only direct cross-border banking linkages (e.g. the exposure of U.K.-based banks in the U.S.) but also indirect ones (U.K. banks holding U.S. assets both directly but also through the Cayman Islands).

Our first finding is that during "tranquil" times there is a significant negative association between banking linkages and the synchronization of output cycles within pairs of countries. This result is in line with the recent evidence in Kalemli-Ozcan et al. (2012). Our second, and most novel, finding is that the association between banking integration and business cycle synchronization, conditional on being in a financial crisis, is much closer to zero, suggesting that a financial crisis is an event that induces co-movement among more financially integrated countries. This is true both for the recent global 2007–2009 financial crisis and also during previous crises, such as the banking crisis in Finland and Sweden in the early 1990s and in Japan in the mid/late 1990s. Third, we find that during the recent financial crisis there has been a positive association between output synchronization and exposure to the U.S. financial system. Importantly, however, the positive correlation between output synchronization and financial linkages to the U.S. emerges only when, on top of direct links to the U.S., we also consider indirect links via the Cayman Islands, the main off-shore financial center of the U.S. economy.

These empirical findings bridge the literatures on business cycle synchronization and on contagion as they show that financial crises spread in a contagious way through banking linkages and that this spread manifests in a higher business cycle synchronization for country pairs that are more financially connected. Our findings are also in line with the conventional wisdom that the during the 2007–2009 crisis a negative credit shock in the U.S. capital markets spread to the rest of the world via financial — banking in particular — linkages. We find our results interesting especially because the existing empirical evidence on whether the crisis spread via financial linkages from the U.S. to the rest of the world is, so far, inconclusive. In particular Rose and Spiegel (2010, 2011) find no role for international financial linkages in transmitting the crisis both for developed countries and for emerging markets.[6] The lack of systemic evidence linking financial globalization with output decline during the past years has even led some authors to argue that financial factors might not be an important driver of this crisis (e.g. Chari et al. (2008); Mulligan (2009)).

A key challenge in identifying a correlation between financial integration and output synchronicity during the 2007–2009 global crisis is to isolate the effect of bilateral financial linkages from a (potential) large common to all advanced countries shock. For example Imbs (2010) shows that the degree of international correlation in national business cycles since the end of 2008 is unprecedented in past three decades, suggesting the presence of a common shock. Focusing on the asset backed commercial paper market, Acharya and Schnabl (2010) show that *all* big international banks had positions with similar risk profiles before the crisis, making the roll-over of their debt quite hard when they started experiencing losses, and hence causing a large common financial shock. Since common shocks and contagion are quite often observationally similar, it is quite hard to separate out one from another in an empirical setting (see Reinhart and Rogoff, 2009a).

In our analysis we try to isolate the effect of financial linkages on business cycles from the role common shocks using the richness of our data. First the panel structure allows us to condition on common to all countries shocks. Second since our data goes back to the late 1970s we can investigate the effect of financial integration on output synchronization during financial crises in advanced economies that did not have massive global implications. Third, having a better measure of financial integration (that includes both direct and indirect through small financial off-shore center linkages between countries) we can identify more precisely the role of financial integration on business cycle synchronization.

1.2. Theoretical contribution

On the theoretical side our contribution is to develop a stylized dynamic stochastic general equilibrium model of international banking. The first objective of the model is to illustrate a concrete mechanism through which exogenous changes in financial integration affect business cycle synchronization, and to study how this mechanism works under both real and financial shocks. We find that the model's can reproduce the empirical relation between financial integration and business cycle synchronization quite well, suggesting that our empirical findings are qualitatively and quantitatively consistent with the hypothesis that exogenous changes to financial integration have significant effects on business cycle synchronization, both during tranquil times (where more integration leads to less co-movement) and during crises periods (where more integration leads to more co-movement). The second purpose of the model is to use our empirical findings to identify the underlying sources of aggregate output fluctuations. Our theoretical model implies that the sign and the magnitude of the estimated relation between financial integration and output synchronization crucially depends on the nature of shocks hitting the economy; as a consequence the estimated relation can be used to identify the shocks. In particular the evidence on the change of the relation during the period 2007–2009 suggests that aggregate fluctuations during that period were mostly driven by shocks to financial intermediation rather than to firms' productivity. Our model is related to the theoretical contributions in a series of recent papers that study co-movement and financial integration in the 2007–2009 crisis. In particular see, among others, the recent works

[4] See, among others, Backus et al., (1992), Obstfeld (1994), Holmstrom and Tirole (1997), Morgan et al. (2004) and Heathcote and Perri (2004).

[5] See, among others, Holmstrom and Tirole (1997), Morgan et al. (2004), Calvo (1998), Calvo and Mendoza (2000), Allen and Gale (2000), Mendoza and Quadrini (2010), Olivero (2010), Devereux and Yetman (2010).

[6] In contrast, Cetorelli and Goldberg (2011) find that lending supply in emerging markets was affected through a contraction in cross-border lending by foreign banks. Employing global VARs, Helbling et al. (2010) find that the U.S. credit market shocks have a significant impact on the evolution of global growth during the latest episode. Chudik and Fratszcher (2011), again using a global VAR approach, find that while the tightening of financial conditions was a key transmission channel for advanced economies, for emerging markets it was mainly the real side of the economy that suffered due to the collapse of worldwide economic activity.

by Dedola and Lombardo (2010), Devereux and Yetman (2010), Devereux and Sutherland (2011), Kollmann et al. (2011) and Perri and Quadrini (2011). Its main innovation relative to these contributions lies in the way we model banks, banking shocks and their effect on economic activity, which allows for a flexible yet simple illustration of the relation between financial integration and co-movement.

Overall our theoretical and empirical results suggest that financial integration has an important effect on the transmission of business cycles, and that this effect changes, depending on the nature of shocks. They also suggest that the least part of the 2007–2009 world recession was the outcome of a credit shock in the U.S. capital markets that spread contagiously to other industrial countries with strong linkages with the U.S. and its main off-shore center, the Cayman Islands.

1.3. Structure

The remainder of the paper is structured as follows. Section 2 presents the empirical methodology and discusses our data on output synchronization and international banking linkages. Section 3 reports the empirical results. Section 4 lays out the theoretical framework. Section 5 presents the quantitative results. Section 6 concludes.

2. Methodology and data

2.1. Specification

The goal of our empirical analysis is to uncover the association between business cycle synchronization and banking integration, and see how this relation has potentially changed during times of financial crises. To do so we estimate variants of the following regression equation:

$$Synch_{i,j,t} = \alpha_{i,j} + \lambda_t + \beta Linkages_{i,j,t-1} + \gamma Post_t \times Linkages_{i,j,t-1} + X'_{i,j,t}\Phi + \epsilon_{i,j,t}.$$

$Synch_{i,j,t}$ is a time-varying bilateral measure reflecting the synchronization of output growth between countries i and j in period (quarter) t; GDP data to construct growth rates come from OECD's statistical database. $Linkages_{i,j,t-1}$ measures cross-border banking activities between country i and country j in the previous period/quarter. $Post_t$ is an indicator variable for the crisis period that switches to one in all quarters after $2007:q3$, when the financial crisis in the U.S. mortgage market started unfolding.[7] In all specifications we include country-pair fixed-effects ($\alpha_{i,j}$), as this allows to account for time-invariant bilateral factors that affect both financial integration and business cycle synchronization (such as trust, social capital, geography, etc.).[8] We also include time fixed effects (λ_t), to account for common to all countries shocks. In some specifications we replace the time fixed-effects with country-specific time trends ($trend_i$ and $trend_j$), to shed light on the importance of common global shocks versus country-specific shocks. We also estimate specifications including both time fixed effects and country-specific time trends to better capture common shocks and hard-to-observe country-specific output dynamics. We control for other factors, such as the level of income, population, bilateral trade, etc.[9] Yet since most of the usual correlates of output synchronization are either time-invariant (distance, information asymmetry proxies) or slowly moving over time (similarities in production, bilateral trade), with the exception of lagged GDP per capita and population, no other variable enters the specification with a significant point estimate.

In many specifications we augment the empirical specification with measures reflecting the banking exposure of each country-pair to the U.S. financial system both before and during the recent financial crisis. This allows us to examine whether synchronization has increased during the recent crisis between pair of countries that were strongly exposed to the U.S. In contrast to most previous works, we examine the effect of both direct and indirect via financial center exposure to the U.S. financial system. As argued in detail by Milesi-Ferretti et al. (2010), most available data on bilateral external positions (and our data) are based on the concept of residence, the guiding principle of balance of payments statistics; as such they overstate exposure to and from small financial centers and understate exposure to the U.S. and the U.K.[10] To deal with indirect exposure to the U.S. via financial centers, we construct a lower and upper bound for the exposure to the U.S. As a lower bound we use direct banking linkages between each country-pair and the U.S. As an upper bound we add exposure to the direct exposure linkages to the Cayman Islands (since we have data going back in the early 1980s).

2.2. Output synchronization

We measure business cycle synchronization ($Synch$) with the negative of divergence in growth rates, defined as the absolute value of GDP growth differences between country i and j in quarter t.

$$Synch_{i,j,t} \equiv -\left|\left(\ln Y_{i,t} - \ln Y_{i,t-1}\right) - \left(\ln Y_{j,t} - \ln Y_{j,t-1}\right)\right|. \quad (1)$$

This index, which follows (Giannone et al., 2010), is simple and easy-to-grasp. Moreover, it is not sensitive to the various filtering methods that have been criticized on various grounds (see Canova, 1998, 1999). In contrast to correlation measures that cross-country studies mainly work with, this synchronization index does not (directly at least) reflect the volatility of output growth and, therefore, allows us to identify the impact of banking integration on the covariation of output growth. Another benefit of this index is that, as we do not have many post crisis observations, the rolling average correlation measures are not very well estimated (see Doyle and Faust, 2005).[11]

[7] We also estimated models where the $Post_t$ indicator switches to one after the collapse of Lehman Brothers in the third quarter of 2008. The results are similar. Since we do not have many post crisis observations, we prefer for our baseline estimates the earlier timing.

[8] Kalemli-Ozcan et al. (2012) show that accounting for country-pair fixed-factors is fundamental. Working in a similar to our sample of advanced economies during tranquil times (i.e. non crisis years), they show that the typical cross-sectional positive correlation between financial integration and output synchronization changes sign when one simply accounts for time-invariant country-pair factors. Including country-pair fixed-effects is needed because both the literature on the correlates of cross-border investment (e.g. Portes and Rey (2005); Guiso et al. (2009); Buch (2003); Papaioannou (2009)) and the literature on the determinants of output co-movement (e.g. Baxter and Kouparitsas (2005)) show that time-invariant factors, related to geographic proximity, trust, and cultural ties are the key robust correlates of financial integration and output synchronization.

[9] In all panel specifications we cluster standard errors at the country-pair level, so as to account for arbitrary heteroskedasticity and autocorrelation within each country pair (Bertrand et al., 2004).

[10] Data on ultimate exposures can in principle be constructed only for bank assets (creditor side) for a limited set of countries by comparing our locational statistics to the consolidated statistics that are also reported by BIS and nets out lending by affiliates. See Milesi-Ferretti et al. (2010) and Kubelec and Sá (2010) for such an exercise. There are still remaining issues though such as position vis-a-vis non-banks and the issue of non-affiliate banks. See McGuire and von Peter (2009).

[11] For robustness and for comparability with the work of Morgan et al. (2004) on the impact of banking integration on the evolution of business cycles across states in the U.S., we also experimented with an alternative (though similar) synchronization measure finding similar results. To construct the (Morgan et al., 2004) synchronization index we first regress GDP growth separately for country i and j on country fixed-effects and period fixed-effects and take the residuals that reflect how much GDP (and its components) differs in each country and year compared to average growth in this year (across countries) and the average growth of this country over the estimation period. The absolute value of these residuals reflects fluctuations with respect to the cross-country and the across-year mean growth. Second we construct the business cycle synchronization proxy as the negative of the divergence of these residuals taking the absolute difference of residual growth.

2.3. International banking linkages

To construct the bilateral financial linkages measures we utilize proprietary data from the Bank of International Settlements' (BIS) Locational Banking Statistics Database. The database reports investments from banks located in up to 40 countries (the "reporting area") into more than 200 countries (the "vis a vis area") at a quarterly basis from the late 1970s till present. Yet the data for around 20 "reporting area" countries are available only in the past decade or so. We thus limit our attention to a homogenous group of 18/20 advanced economies that we have (almost) complete coverage since 1978. These countries are: Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, Portugal, Sweden, and the United States.[12] Thus we have a rich bilateral panel dataset on banks' positions spanning from the first quarter of 1978 to the last quarter of 2009.

The data is originally collected from domestic monetary authorities and supervisory agencies and includes all of banks' on-balance sheet exposure as well as some off-balance sheet items. The database follows the locational principle and, therefore, also includes lending to subsidiaries and affiliates. Thus the Locational Banking Statistics reflect more accurately the international exposure of countries (and banks) than the consolidated statistics database of the BIS that nets out lending and investment to affiliate institutions. The statistics capture mainly international bank to bank debt instruments, such as inter-banks loans and deposits, credit lines, and trade-related lines of credit. The data also covers bank's investment in equity-like instruments as well as foreign corporate and government bonds. [13]

While not without drawbacks, our data offers important advantages compared to other international investment databases that are essential for understanding the impact of financial globalization on the transmission of the recent crisis. First, the BIS statistics have by far the most extensive time coverage from all similar database on cross-border investment holdings (as a comparison to the IMF CPIS database that reports bilateral cross-border financial flows and stocks after 1999). Second, the data reports bilateral financial linkages between each country in the world and the U.S., where the crisis originated. This allows us to investigate the direct impact of the credit shock in the U.S. on the rest of the world. Third, the data includes information on banking activities between almost all countries in the world and some key financial off-shore centers. As a sizable bulk of the U.S. financial transactions are channeled via the Cayman Islands (as well as some other off-shore financial center), this allows us to better measure the exposure of countries to the U.S. Fourth, while the data mostly cover banking activities, according to most commentators and anecdotal evidence banking linkages played a prominent role in the international transmission of the 2007–2009 financial crisis.

The main limitation of our dataset is that it reports the aggregate international exposure only of the banking system.[14] As such our dataset does not include portfolio investment by mutual funds and the shadow financial system (hedge funds), foreign direct investment and other international transactions (see Lane and Milesi-Ferretti, 2007). Yet, cross-border banking activities have been by far the largest component of cross-border investment in the 1980s and the 1990s, and even nowadays it consists of the bulk of international finance. The country-level aggregate statistics of Lane and Milesi-Ferretti (2008) indicate that the stock of cross-border banking is more than 50% of the overall amount of international holdings (that includes also FDI and portfolio investment). For the 1980s and 1990s banking activities were more than two-thirds.

As long as there is a high correlation between international banking and other forms of portfolio investment (equity flows, FDI, and debt flows), our estimates will not be systematically biased. According to the latest vintage of the Lane and Milesi-Ferretti data-set of aggregate (at the country-level) foreign holdings, the correlation of total debt, portfolio debt, banking, FDI and equity in levels (either expressed as a share of total assets or as a share of GDP) is the range of 0.75–0.99. Other country-pair datasets on foreign capital holdings also suggest a strong correlation of the various types of international investment. For example, Kubelec and Sá (2010) document that the correlation between our BIS data and IMF's CPIS (Coordinated Portfolio Investment Surveys) bilateral debt data, which has a broader coverage of debt assets and liabilities, is 80%.

We measure cross-border banking activities/linkages ($Linkages_{i,j,t-s}$) in two ways. First, we use the sum of bilateral assets and liabilities between countries i and j standardized with the sum of the two countries GDP in each quarter.[15]

$$\left[Linkages/GDP = \frac{Assets_{i,j,t} + Liabilities_{i,j,t} + Assets_{j,i,t} + Liabilities_{j,i,t}}{\left(GDP_{i,t} + GDP_{j,t}\right)}\right].$$

Second, we use bilateral assets and liabilities between countries i and j over the sum of the total external assets and liabilities of each country in each quarter.

$$\left[Linkages/TotalLinkages = \frac{Assets_{i,j,t} + Liabilities_{i,j,t} + Assets_{j,i,t} + Liabilities_{j,i,t}}{Tot\_Assets_{i,t} + Tot\_Liabilities_{i,t} + Tot\_Assets_{j,t} + Tot\_Liabilities_{j,t}}\right].$$

We finally measure banking exposure to the U.S. financial system with the sum of bilateral assets and liabilities of each country-pair vis a vis the U.S. divided by the sum of the two countries' GDP in each quarter (variable U.S. Linkages/GDP in Table 1 below). Since we have complete data coverage for the international banking activities with the Cayman Islands, we also construct a broader indicator of linkages to the U.S. where we also add to the exposure of each country-pair to the U.S. the exposure to the Cayman Islands (variable U.S. broad linkages/GDP in Table 1 below).[16] Table 1 gives descriptive statistics for the variables employed in the empirical analysis.

3. Empirical results

In this section we first present some preliminary evidence on the relation between integration and business cycle correlation during the recent crisis and then report the results of our empirical analysis in the period 1978–2009. We then examine whether financial linkages to the U.S. have affected the synchronicity of output during the

[12] In most empirical specifications we exclude Luxembourg and Switzerland, because these countries have exceptionally large financial systems and international financial linkages. The results are almost identical if we were to include these two financial hubs in our analysis (see Table 2, for example).

[13] Assets include mainly deposits and balances placed with non-resident banks, including bank's own related offices abroad. They also include holdings of securities and participation (i.e. permanent holdings of financial interest in other undertakings) in non-resident entities. Data also include trade-related credit, arrears of interest and principal that have not been written down and holdings of banks own issues of international securities. They also cover portfolio and direct investment flows of financial interest in enterprizes.

[14] Another limitation is that the BIS does not distinguish between traditional banking activities, equity investment, and holdings of international debt. As such we cannot examine the effects of the different types of financial integration on output synchronization.

[15] We have also experimented with gross flows, finding similar results. We prefer working with stocks, because theoretically it is more appealing. Note that changes in stocks may not solely reflect increased/decreased investment, as stocks (assets and liabilities) may change due to valuation effects arising from movements in the exchange rate or the market value of international investment.

[16] For robustness we also constructed broader indicators of exposure to the United States using data from Panama, Bermuda, and Virgin Islands. Yet since we do not have complete coverage from these off-shore centers we decided to report results of exposure to the U.S. financial system simply adding to the U.S. numbers the exposure to and from the Cayman Islands.

Table 1
Descriptive statistics.

	N	Mean	sd	Min	Max	p1	p5	p25	p50	p75	p95	p99
Pairwise corr. of GDP	25,061	.1757	.2963	−.8462	.9698	−.5085	−.3066	−.0278	.1708	.3815	.6664	.8578
Synch. of GDP	27,911	−4.303	4.587	−45.66	−.0007	−22.37	−12.90	−5.638	−2.93	−1.320	−.2571	−.0511
Linkages/GDP	18,192	.0187	.0418	0	.6444	.0000	.000	.0011	.0046	.0170	.0809	.2316
Linkages/total linkages	18,183	.0260	.0348	0	.2478	.0002	.000	.0042	.0118	.035	.0980	.1702
U.S. linkages/GDP	15,322	.1324	.1615	.0061	1.486	.0095	.0171	.0419	.0850	.145	.4591	.8783
U.S. broad linkages/GDP	13,156	.1846	.2054	.0099	1.853	.0195	.0309	.0707	.1203	.2078	.6110	1.099

Notes: The pairwise correlation of GDP is the correlation of real GDP growth estimated using 16 quarterly observations. The GDP synchronization index is the one defined in Eq. (1). All other variables are defined in this section.

recent crisis. We conclude the empirical part of our analysis investigating whether the association between output synchronization and banking integration during the 2007−2009 crisis is similar to previous financial turmoil episodes that have hit advanced economies.

3.1. Preliminary evidence before and after the recent financial crisis

To get a first-pass on the data patterns on the correlation between financial integration and output synchronization, we run simple difference-in-difference type specifications in the period just before and during the recent financial crisis. Specifically, focusing on a group of 20 advanced economies over the period 2002–2009, we split the sample into two 4-year periods and for each time-span we estimate the correlation of real per capita GDP growth between each country-pair using quarterly data (over 16 quarters). We then regress the correlation in output growth on a bilateral index of banking integration based on the total assets and liabilities of banks in the two countries in the beginning of each period (in 2006 and in 2002) allowing the coefficient on the banking integration measure to differ in the two periods. As we condition on country-pair fixed-effects, these specifications examine whether within country-pair increases in banking integration are associated with a lower or a higher degree of business cycle synchronization; by allowing the coefficient on the banking integration to differ in the beginning of each period, we examine whether this association has changed during the recent crisis.

Table 2
Bilateral financial linkages and output correlations.

Dependent variable: pairwise GDP growth correlations			
	(1)	(2)	(3)
Sample	All	All	No Luxembourg, Switzerland
Crisis indicator	0.4390***	0.5344***	0.6316***
	(0.0627)	(0.0852)	(0.0930)
	7.00	6.27	6.79
Linkages/GDP	−0.1107***	−0.0914**	−0.1202***
	(0.0379)	(0.0384)	(0.0440)
	−2.92	−2.38	−2.73
Linkages/GDP × Crisis		0.0263**	0.0340***
		(0.0121)	(0.0129)
		2.18	2.63
Country-pair fixed	Yes	Yes	Yes
R-squared (within)	0.813	0.801	0.806
Observations	340	340	287

Notes: The table reports panel (country-pair) fixed-effect coefficients estimated in two non-overlapping 4-year periods, in the period 2002q1–2005q4 and the period 2006: q1–2009q4, using 20 × 19 country-pairs. The dependent variable is the pair-wise correlation of real GDP per capita between country *i* and country *j* in each of the two periods. The crisis indicator equals one for the second period (and zero in the first-period). Financial integration is measured by the log of the share of the stock of bilateral assets and liabilities between countries *i* and *j* in quarter t relatively to the sum of the two countries' GDP in the beginning of each period (linkages/GDP). Column (3) omits Luxembourg, and Switzerland. All specifications also include the log of the product of the two countries' GDP in the beginning of each period and the log of the product of the two countries population. Heteroskedasticity robust standard errors are reported in parenthesis and corresponding t-stats are below. * denotes significance at the 90% confidence level, ** denotes significance at the 95% confidence level, *** denotes significance at the 99% confidence level.

Table 2 reports the results from our preliminary empirical analysis. Some noteworthy patterns emerge. First, the coefficient on the second period time effect (the crisis dummy) that captures the effect of the financial crisis on output synchronization is positive and highly significant. This reflects the fact that during the period 2007–2009 correlations have increased tremendously (see also Perri and Quadrini, 2011). Our estimate suggests that output growth correlations increased by around 0.4−0.5 during the recent crisis period (as compared to the four year period just before). Second, the coefficient on banking integration in the simple specification in column (1) is negative and highly significant. This suggests that conditional on common to all countries' shocks, within country-pair increases in banking integration are associated with less synchronized output cycles. Third, when we allow the coefficient on banking integration to differ in the two 4-year periods (which most likely are characterized by different types of shocks), we find a positive and significant coefficient of the interaction between banking linkages and second period dummy: this implies that country pairs that were strongly integrated via the international banking system at the start of the 2007–2009 crisis (in the beginning of 2006) experienced more synchronized contractions during the crisis. Notice that, while the partial effect of financial integration on output synchronization during the recent crisis is positive, the total effect is negative. So the crisis makes the relation between financial integration and output synchronization *less* negative.

3.2. Financial integration and output synchronization

Table 3 reports our benchmark estimates on the effect of financial integration on output synchronization in the period 1978–2009. The estimates in column (1) are in line with the simple difference-in-difference estimates reported in Table 2, where we used the correlation of GDP growth as the dependent variable and focused on the period just before and during the recent financial crisis (2002–2009). In tranquil times, there is a significantly negative association between banking integration and output synchronization. Note that this association does not necessarily means that integration causes low synchronization, as it is conceivable that causality runs from synchronization to integration.[17] To control for this (and other endogeneity) concerns, (Kalemli-Ozcan et al., 2012), for the period 1978–2006, use instrumental variables using an exogenous structural index of financial integration based on legislative/regulatory harmonization policies in financial services as an instrument for cross-border banking linkages (see also Kalemli-Ozcan et al., 2010). They show that reverse causation is not quantitatively important. Unfortunately, however, the structural index of financial integration is not available for the recent crisis period, and as such we cannot implement their proposed panel instrumental variables approach.

The coefficient on banking integration changes sign when we focus on the recent financial crisis period. The estimate on the interaction term between bilateral banking activities and the recent crisis

[17] As the benefits of international diversification are larger when the output cycles of two countries are asynchronous, the negative correlation could reflect causality running from output divergence to financial integration (see Heathcote and Perri, 2004 for a theoretical exposition).

Table 3
Bilateral financial linkages and GDP synchronization.

Dependent variable: GDP growth synchronization								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Linkages/GDP	−0.2479***	−0.3022***	−0.2200***	−0.2212***				
	(0.0638)	(0.0675)	(0.0645)	(0.0685)				
	−3.88	−4.48	−3.41	−3.23				
Linkages/GDP × Crisis	0.2645***	0.1931***	0.1233**	0.1241**				
	(0.0326)	(0.0425)	(0.0496)	(0.0495)				
	8.12	4.54	2.49	2.51				
Crisis indicator	−0.1148				−0.1972			
	(0.1666)				(0.1656)			
	−0.69				−1.19			
Linkages/total linkages					−0.1615**	−0.3549***	−0.1408**	−0.1376*
					(0.0689)	(0.0760)	(0.0666)	(0.0700)
					−2.34	−4.67	−2.11	−1.97
Linkages/total linkages × Crisis					0.2739***	0.1370***	0.0878	0.0890
					(0.0366)	(0.0514)	(0.0590)	(0.0588)
					7.48	2.67	1.49	1.51
Trade				−0.0394				−0.0538
				(0.0598)				(0.0589)
				−0.66				−0.91
Country-pair _xed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time _xed	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Country trends	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Di_erence (t-stat)	0.25	−1.57	−1.34	−1.29	1.57	−2.75	−0.7	−0.62
R-squared (within)	0.095	0.166	0.187	0.186	0.093	0.166	0.187	0.185
Observations	14,328	14,328	14,328	13,567	14,328	14,328	14,328	13,567

Notes: The table reports panel (country-pair) fixed-effect coefficients estimated over the period 1978:q1–2009:q4, using 18 × 17 country-pairs omitting Luxembourg and Switzerland. The dependent variable (GDP Synchronization) is minus one times the absolute value of the difference in the growth rate of GDP between countries *i* and *j* in quarter *t*. In columns (1)–(4) financial integration is measured by the log of the share of the stock of bilateral assets and liabilities between countries *i* and *j* in the previous quarter relatively to the sum of the two countries' GDP in the previous period (linkages/GDP). In columns (5)–(8) financial integration is measured by the log of the share of the stock of bilateral assets and liabilities between countries *i* and *j* in the previous quarter relatively to the sum of the two countries' external assets and liabilities in the entire world in the previous period (linkages/total linkages). The crisis indicator variable equals one in all quarters after 2007:q3 (and zero before that). All specifications also include the log of the product of the two countries' GDP in the beginning of each period and the log of the product of the two countries population. The specifications in columns (4) and (8) also include the sum of the logs of real bilateral exports and imports between countries *i* and *j* in the previous quarter (trade). The specifications in columns (1) and (5) include country-specific linear time-trends. The specifications in columns (2) and (6) include time fixed-effects. The specifications in columns (3), (4), (7), and (8) include time fixed-effects and country-specific linear time-trends. Standard errors adjusted for panel (country-pair) specific auto-correlation and heteroskedasticity and corresponding t-statistics are reported below. * denotes significance at the 90% confidence level, ** denotes significance at the 95% confidence level, *** denotes significance at the 99% confidence level.

period implies that during the 2007–2009 years an increased degree of banking integration was followed by more synchronized cycles. In column (2) we include time (quarter) fixed-effects to account for common global shocks, while in column (3) we include time fixed-effects and country-specific time trends. In both specifications, the coefficient on banking integration continues to enter with a negative and significant estimate; the coefficient changes sign and turns positive (and significant) in the recent crisis period. In column (4) we control for bilateral trade in goods.[18] The coefficient on goods trade is small and statistically indistinguishable from zero. Most importantly conditioning on goods trade does not affect the coefficient on banking integration both during tranquil periods and during the recent financial crisis.[19]

The total effect of financial integration ($\beta+\gamma$) on output synchronization is negative, with the exception of specifications (1) and (5), where we do not account for common shocks with the inclusion of time fixed effects. This is important since, as we argued above, our results can be interpreted as the negative effect of financial integration on synchronization being weakened during the 2007–2009 crisis. This is not the case in columns (1) and (5), where the total effect ($\beta+\gamma$) is positive. However this positive effect is spurious since it is driven by the simple fact that all boats sinked together, something not accounted for in these permutations. This indicates the utmost need to include time fixed effects so as to separate the effect of financial contagion, if there is any, from the impact of common shocks. As shown in the tables, with the exceptions of three columns, the difference between the two coefficients is not significantly different than zero most times though.

The estimates in Table 3 imply an economically significant effect. Since the banking integration measure is expressed in logs and the dependent variable is in percentage points, the estimates are semi-elasticities. The coefficient in column (3) implies that for a typical rise in bilateral integration from the 50th percentile to the 75th percentile of the distribution, which is similar to the increase in integration between Italy and Portugal during our sample (a tripling), is followed by an average decrease in GDP synchronization of 0.6 percentage points of these two countries in tranquil times. Yet during the crisis for the same pair the effect of banking integration on output synchronization turns positive; a 0.3 percentage point increase in synchronization. Given the median degree of synchronization (2.7%) these are significant effects. The effects are also sizeable from the perspective of changes. The actual average increase in synchronization is 1% during the crisis period of 2007–2009. Thus, our estimates can explain up to 30% of the actual changes in output convergence during the crisis.[20]

In columns (5)–(8) we report estimates that are otherwise similar to the ones in columns (1)–(4) using the alternative banking integration index, the log of the share of bilateral banking assets and liabilities to the total amount of external banking assets and liabilities of each pair. The results are similar to the ones in columns (1)–(4). In

[18] The bilateral trade index is the sum of the logs of real bilateral exports and imports between the two countries in each quarter. Data come from OECD monthly statistical database on trade.

[19] A priori it looks important to account for differences in bilateral trade, as previous works show that trade in goods and financial services tend to move in tandem (e.g. Rose and Spiegel, 2004citealtac07) and that trade has a significantly positive effect on business cycle synchronization. Yet in the high-frequency quarterly dimension there is no significant within country correlation between goods trade and business cycle synchronization.

[20] There are some outliers in the dependent variable (GDP growth divergence exceeding 15%; see Table 2). We thus re-estimated all models windsorizing the dependent variable at the 1% and 5%. The estimates are similar to the ones reported in the main tables.

Table 4
Bilateral financial linkages, U.S. financial linkages, and GDP synchronization.

Dependent variable: GDP growth synchronization						
	(1)	(2)	(3)	(4)	(5)	(6)
Linkages/GDP	−0.3096***	−0.3272***	−0.2460***	−0.3012***	−0.2422***	−0.2066***
	(0.0667)	(0.0755)	(0.0655)	(0.0698)	(0.0664)	(0.0697)
	−4.64	−4.61	−3.76	−4.31	−3.65	−2.96
Linkages/GDP × Crisis	0.2321***	0.2182***	0.1284**	0.1663***	0.1737***	0.1176**
	(0.0525)	(0.049)	(0.0555)	(0.0503)	(0.0484)	(0.0553)
	4.42	4.41	2.31	3.30	3.59	2.13
U.S. Linkages/GDP	0.2298	0.1177	0.0204			
	(0.1556)	(0.1563)	(0.1425)			
	1.48	0.83	0.13			
U.S. Linkages/GDP × Crisis	0.2251*	0.0196	0.1263			
	(0.1322)	(0.1178)	(0.1344)			
	1.70	0.17	0.94			
Crisis indicator	0.0044			0.5409***		
	(0.1911)			(0.1840)		
	0.02			2.94		
U.S. broad linkages/GDP				−0.7337***	−0.0191	−0.4836***
				(0.1518)	(0.1560)	(0.1705)
				−4.83	−0.12	−2.84
U.S. broad linkages/GDP × Crisis				0.5613***	0.2277*	0.4075**
				(0.1483)	(0.1343)	(0.1580)
				3.79	1.70	2.58
Country-pair fixed	Yes	Yes	Yes	Yes	Yes	Yes
Time xed	No	Yes	Yes	No	Yes	Yes
Country trends	Yes	No	Yes	Yes	No	Yes
R-squared (within)	0.097	0.194	0.194	0.076	0.156	0.170
Observations	12,452	12,452	12,452	10,847	10,847	10,847

Notes: The table reports panel (country-pair) fixed-effect coefficients estimated over the period 1978:q1–2009:q4. The dependent variable (GDP Synchronization) is minus one times the absolute value of the difference in the growth rate of GDP between countries *i* and *j* in quarter *t*. Financial integration is measured by the log of the share of the stock of bilateral assets and liabilities between countries *i* and *j* in the previous quarter relatively to the sum of the two countries' GDP in the previous period (Linkages/GDP). In columns (1)–(3) we measure U.S. linkages by the log of the share of the stock of bilateral assets and liabilities between each country and the U.S. in the previous quarter relatively to the two countries' GDP in the previous period (U.S. Linkages/GDP). In columns (4)–(6) we measure U.S. linkages by the log of the share of the stock of bilateral assets and liabilities between each country-pair and the U.S. and the Cayman Islands in the previous quarter relatively to the two countries' GDP in the previous period (U.S. Broad Linkages/GDP). The Crisis indicator variable equals one in all quarters after 2007:q3 (and zero before that). All specifications also include the log of the product of the two countries' GDP in the beginning of each period and the log of the product of the two countries population. The specifications in columns (1) and (4) include country-specific linear time-trends. The specifications in columns (2) and (5) include time fixed-effects. The specifications in columns (3) and (6) include time fixed-effects and country-specific linear time-trends. Standard errors adjusted for panel (country-pair) specific auto-correlation and heteroskedasticity and corresponding t-statistics are reported below. * denotes significance at the 90% confidence level, ** denotes significance at the 95% confidence level, *** denotes significance at the 99% confidence level.

tranquil times a higher degree of banking linkages is associated with less synchronized, more divergent, output cycles. The negative association between banking integration and output synchronization during the recent financial crisis is attenuated during the 2007–2009 crisis period.

3.3. U.S. exposure and crisis transmission

The recent financial crisis started with the problems in the U.S. sub-prime market in the summer of 2007 and intensified in 2008 when Bear Stearns and Lehman Brothers (and many other banking institutions) experienced massive losses. Many commentators and policy makers have argued that financial linkages enabled the quick transmission of the crisis from a corner of the U.S. capital markets to the rest of the world. Yet, recent works fail to find evidence for the importance of financial ties to the U.S. for the severity of the crisis (e.g. Rose and Spiegel, 2010).

In Table 4 we examine whether output synchronization during the recent financial crisis has been stronger among country-pairs that had stronger linkages to the U.S. banking system relative to the pairs that have weaker connections. Controlling for direct exposure to the U.S. has no major effect on our evidence in Table 3. The coefficient on bilateral banking linkages between the two countries is negative and significant, implying that in tranquil times an increase in banking linkages is followed by more divergent output cycles. The coefficient on bilateral banking linkages changes sign and becomes positive and significant during the recent financial crisis. In contrast to the bilateral banking integration measures that enter with stable and significant coefficients, columns (1)–(3) show that direct U.S. banking linkages variable enters with an insignificant coefficient both before and after the recent financial crisis. The insignificant coefficient on U.S. banking linkages during the recent financial crisis is in line with the recent work of Rose and Spiegel (2010), who, using alternative (cross-sectional) techniques and data also fail to find a systematic correlation between international linkages to the U.S. and the magnitude of the recessions across countries in 2007–2009.

In columns (4)–(6) of Table 4 we report otherwise similar to columns (1)–(3) estimates, but we now use a broader measure of exposure to the U.S. that incorporates not only banking activities of each country-pair with the U.S., but also linkages to the Cayman Islands.[21] Accounting for indirect links to the U.S. financial system appears fundamental. The coefficients on the U.S. linkage measures that were insignificant in the analogous specifications in columns (1)–(3) enter now with significant estimates. In all three permutations the post crisis estimate on the U.S. linkages variable—that now incorporates assets and liabilities in the U.S. and the Cayman Islands—is positive and statistically significant at standard confidence levels. This implies that country-pairs with strong linkages to the U.S. financial system experienced more synchronized cycles during the recent crisis period. Most importantly this effect seems to work on top of the positive effect of bilateral banking activities on output synchronization during the 2007–2009 crisis and the total effect becomes positive for the countries that are tightly linked to U.S., when we add all the coefficients. This appears consistent with the transmission of the crisis from the U.S. to the pairs that are highly

[21] The results are similar if we also add Bermuda, Panama, and the Channel Islands. We prefer the estimates only with the Cayman Islands because the BIS database records these transactions since 1983. In contrast data for the other financial centers are available only after 2000.

Table 5
Financial linkages and output synchronization in tranquil and turbulent times.

Dependent variable: GDP growth synchronization				
	(1)	(2)	(3)	(4)
Previous crises	RR	RR	LV	LV
Linkages/GDP	−0.2179***	−0.1889***	−0.2321***	−0.2138***
	(0.0616)	(0.0672)	(0.0613)	(0.0643)
	−3.54	−2.81	−3.79	−3.32
Linkages/GDP × Crisis	0.1817***	0.1107**	0.2056***	0.1285**
	(0.0491)	(0.0532)	(0.0506)	(0.0531)
	3.70	2.08	4.06	2.42
Linkages/GDP × Previous crises	0.1467***	0.1035***	0.1857***	0.1866***
	(0.0254)	(0.0295)	(0.0246)	(0.0256)
	5.78	3.51	7.55	7.29
U.S. broad linkages/GD	0.0600	−0.4074**	0.0965	−0.3467**
	(0.1444)	(0.1663)	(0.1447)	(0.1704)
	0.42	−2.45	0.67	−2.04
U.S. broad linkages/GDP × Crisis	0.2400*	0.3691**	0.2072	0.3547**
	(0.1323)	(0.1500)	(0.1350)	(0.1468)
	1.81	2.46	1.53	2.42
Country-pair fixed	Yes	Yes	Yes	Yes
Time fixed	No	Yes	No	Yes
Country trends	Yes	Yes	Yes	Yes
R-squared (within)	0.160	0.171	0.164	0.176
Observations	10,847	10,847	10,847	10,847

Notes: The table reports panel (country-pair) fixed-effect coefficients estimated over the period 1978:q1–2009:q4. The dependent variable (GDP synchronization) is minus one times the absolute value of the difference in the growth rate of GDP between countries *i* and *j* in quarter *t*. Financial integration is measured by the log of the share of the stock of bilateral assets and liabilities between countries i and j in the previous quarter relatively to the sum of the two countries' GDP in the previous period (Linkages/GDP). We measure U.S. linkages by the log of the share of the stock of bilateral assets and liabilities between each country-pair and the U.S. and the Cayman Islands in the previous quarter relatively to the two countries' GDP in the previous period (U.S. broad linkages/GDP). The crisis indicator variable equals one in all quarters after 2007:q3 (and zero before that). The previous crisis indicator variable equals one when a major financial turmoil episode is present in country i or j in period/quarter t. In columns (1)–(2) we identify previous crises using the Reinhart Reinhart and Rogoff (2008) classification of main financial turmoil episodes, while in columns (3)–(4) we use the Laeven and Valencia (2010) classification that includes both systemic and non-systemic banking crises. All specifications also include the log of the product of the two countries' GDP in the beginning of each period and the log of the product of the two countries' population. Standard errors adjusted for panel (country-pair) specific auto-correlation and heteroskedasticity and corresponding t-statistics are reported below. * denotes significance at the 90% confidence level, ** denotes significance at the 95% confidence level, *** denotes significance at the 99% confidence level.

exposed to the U.S. and in turn to other countries. Moreover, the negative and significant coefficient on U.S., banking linkages in column (6) suggests that increases in financial integration between a country-pair and the U.S. financial system in tranquil periods are followed by more divergent cycles.

3.4. Is this time different?

Our finding that during the recent financial crisis period the negative relation between banking integration and output synchronization is weakened raises the question on whether a similar pattern was present during previous financial crisis episodes. While we focus on a group of advanced economies in a period of relative financial stability up until the recent crisis of 2007 − 2009, there were some episodes of systemic banking crises in our sample. Reinhart and Rogoff (2008) argue that the 2007–2009 financial crisis has been comparable (to some at least degree) to some previous banking crises episodes in other advanced economies, namely Spain (1977 − 1985), Finland (1991–1994), Sweden (1991–1994), and Japan (1997–2001).[22]

We thus estimated specifications allowing the effect of banking integration to differ when one of the two countries in each pair was under a major banking crisis in each quarter before the 2007–2009 crisis. Table 5 reports the results. In columns (1) and (2) we use the Reinhart and Rogoff (2008) banking crisis classification, while for robustness in columns (3) and (4) we use the banking crisis chronology of Laeven and Valencia (2010). The effect of banking integration on output synchronization is positive during banking crises, even before 2007, although the total effect is still negative. The coefficient is estimated quite precisely, and appears significant at the 99% confidence level in all permutations. The coefficient in column (2) where besides including country-pair fixed-effects and time-effects, we also include linear country trends (−0.10) implies that a doubling in the degree of financial integration leads to an increased synchronization of output by one percentage point. The magnitude of the coefficient is also quite similar with the coefficient on banking integration during the recent financial crisis (in column (2) is −0.11), thus suggesting that the mechanisms under play during the 2007–2009 crisis were not fundamentally different than that of previous financial crises. In all specifications we cannot reject the null hypothesis that the two coefficients on banking integration during financial crisis episodes are the same.

Note that once we control for the previous crisis, the total effect of financial integration on synchronization is positive in the case of the current crisis for the pairs of countries that are strongly tied to the U.S. (conditional on time fixed effects and country-specific trends). This is an extremely strict specification, since we can separate contagion from the common shock. To the best of our knowledge this result is the first evidence that shows transmission as a result of financial/banking integration for pairs of countries that are strongly integrated with the U.S. financial system.

4. A model of international business cycles with banks

In this section we develop a simple international business cycle model where global banks intermediate funds from households/consumers/savers to firms/borrowers. There are two types of shocks driving economic fluctuations: a standard productivity shock and a shock that affects the value of risky assets held by banks and, through this channel, their ability to intermediate funds. We refer to the latter shocks interchangeably as credit or banking shocks.

The model serves two purposes. The first is to precisely spell a causal link between financial integration and business cycle synchronization. Our empirical section documents a relationship between the

[22] Reinhart and Rogoff (2009b) also list Norway's banking crisis in the late 1980s as comparable, but Norway is not included in our sample.

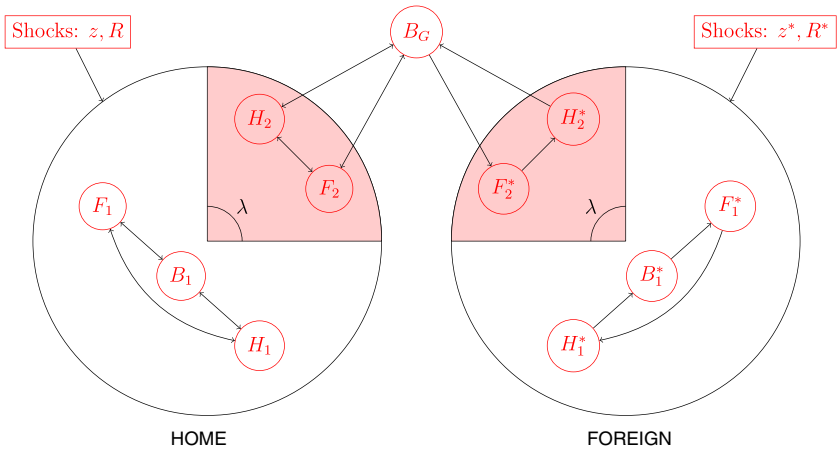

Fig. 1. The economy.

two that changes during crisis times, but does not speak about the mechanism and the direction of causation. Here we will use the model to derive quantitative results that show how the empirical findings are indeed consistent with the hypothesis that exogenous changes to financial integration have significant effects on business cycle synchronization, and that the magnitude of these effects depends on the structural shocks hitting the economy. The second purpose of the model is to show that our empirical findings can be used to identify sources of output fluctuations, and thus to shed light on the causes of the triggering and spreading of the 2007–2009 crisis. Our framework is similar in spirit to recent models that introduce global banks in an international business cycles set-up (see, for example, Kollmann et al., 2011). One innovation of our set-up is that it models the relation between banking integration and co-movement in a very simple fashion; as such the set-up is well-suited to analyze the effects of cross-border banking integration on business cycle synchronization, under different types of shocks.

4.1. The economy

We consider a two-countries, two-sectors, one-good world. Fig. 1 contains a stylized representation of the economy. In each country (foreign country variables are denoted by *) and in each sector (denoted by $i=1,2$) there are households (H_i and H_i^*), which supply labor to firms and save with banks in the same sector. Firms (F_i and F_i^*) hire labor, make investment decisions, and pay dividends and wages to households in their sector, which in turn borrow from banks in the same sector. Finally there are banks which intermediate funds between households and firms. The difference between the two sectors is banking integration. Sectors 1 in each country (denoted in Fig. 1 by the white areas in the circles) are financially separated from the rest of the economy and banks in that sector ((B_1, B_1^*) in Fig. 1) intermediate only between consumers and firms within the sector. Sectors 2 (denoted in Fig. 1 by the shaded areas in the circles) are financially integrated; all consumers and firms in sector 2 in both countries have financial transactions through the same set of banks (B_G). Banks in sectors 2 are global banks as, since the sectors are integrated, their national identity does not matter. The two sectors have size $1-\lambda$ and λ, respectively, so λ is a stylized measure of the degree of banking/financial integration. Note that for the extreme value of $\lambda=0$ the model nests the case of financial autarky in which all banks only operate domestically and there are no financial flows between the two countries. At the other extreme (when $\lambda=1$ there is a maximum level of financial integration) all banks are global and intermediation markets are fully integrated between the two countries. Besides financial integration the two sectors in each country are identical in every respect; they are subject to the same country-specific shocks to productivity (z and z^*) and to credit (R and R^*).

In the rest of subsection we first describe the consumers/workers problem; we then describe the firms' problem, and conclude with the description of the banking sector. Our model of banks is highly stylized: our objective is not to provide a detailed description of how the world banking system operates and of the underlying forces of banking shocks, but to provide a simple set-up in which shocks to banking activities can have real repercussions in multiple countries. Moreover our modeling of banking/financial integration is simplified as the degree of internationalization of the banking system is captured by the exogenously given parameter, λ.

4.1.1. Households

In each country and in each sector there is a continuum of identical infinitely lived households whose preferences are given by

$$E\sum_{t=0}^{\infty}\beta^t U(c_{it}, l_{it}), \qquad i=1,2 \tag{2}$$

where E represents expectations across time and possible states of the world, c_{it} denotes consumption, l_{it} is labor effort, $0<\beta<1$ is the discount factor and $U(.,.)$ is a standard utility function. Households in each sector enter each period with an amount of bank deposits, D_{it}, carried over from the last period; they also receive labor income $w_{it}l_{it}$ (where w_{it} is the wage rate), and dividends d_{it} from firms in their sector.[23] In each period consumers allocate resources between consumption and savings in the form of domestic bank deposits, which yield a gross rate of return R_{it}. Consumers' budget constraints in the two sectors are

$$c_{it}+\frac{D_{it+1}}{R_{it}}=w_{it}l_{it}+d_{it}+D_{it}, \quad i=1,2. \tag{3}$$

Consumers' problem is to choose sequences for consumption, labor, and bank deposits to maximize Eq. (2) subject to Eq. (3) taking as given the sequences for bank deposit rates, wages, and dividends, as well as the initial conditions for bank deposits. Consumers in country 2 solve an analogous problem. Financial integration implies that consumers in sector 2 can shop for banks in the two countries so

[23] Throughout this paper we assume 100% home bias in equity markets. The results presented below are not dependent on this assumption.

the deposit rate for sector 2 consumers is equalized across countries i.e.

$$R_{2t} = R^*_{2t}, \quad \text{for all } t.$$

Notice that in this simple set-up deposits are effectively constituted by physical goods, set aside by consumers in banks, so we can think of them (and also refer to them) as banking capital.

4.1.2. Firms

Firms in both sectors and both countries operate, on behalf of consumers in that sector, a constant return to scale technology $F(.,.)$, which uses capital (k_{it}) and labor (l_{it}) to produce a consumption good. Production in each sector is subject to stochastic, country specific, but common across sectors, productivity shocks z_t and z^*_t. The crucial assumption that connects banks with the real economy is that firms, in order to undertake production, need to borrow from banks an amount of working capital equal to the wage bill. This assumption is usually motivated by a timing structure in which firms need to pay workers before they receive the proceeds from their sales (see, for example, Christiano and Eichenbaum (1992) or Neumeyer and Perri (2005). Firms in sector i pay a gross lending rate R^e_{it} on bank loans. As it will become clear later, due to the intermediation process, the lending rate R^e_{it} is not, in general, equal the deposit rate R_{it}. Firms' dividends d_{it} are thus given by the value of production minus the wage bill (including interests) and minus investment:

$$d_{it} = e^{z_t} F(k_{it}, l_{it}) - R^e_{it} w_{it} l_{ibvt} - x_{it} \tag{4}$$

where x_{it} represents investment in physical capital. The capital stock evolves according to

$$k_{it+1} = (1-\delta)k_{it} + x_{it} - \phi k_{it}\left[\frac{x_{it}}{k_{it}} - \delta\right]^2, \qquad i = 1,2 \tag{5}$$

where δ is the depreciation rate and ϕ determines the magnitude of capital adjustment costs. Finally we assume that the log of productivity follows a bivariate auto-regressive process

$$\begin{bmatrix} z_t \\ z^*_t \end{bmatrix} = A_z \begin{bmatrix} z_{t-1} \\ z^*_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon^z_t \\ \varepsilon^{z^*}_t \end{bmatrix} \tag{6}$$

where A_z is a 2×2 matrix and $[\varepsilon^z_t, \varepsilon^{z^*}_t]$ is a vector of *i.i.d* innovations with mean 0, standard deviation σ^z_ε and correlation ρ^z_ε. Firms' problem in country 1 and sector i is

$$\begin{aligned} &\max_{l_{1t}, k_{1t}, x_{1t}} E\sum_{t=0}^{\infty} d_{it} Q_{it} \\ &s.t. \\ &(4), (5), (6) \quad k_{i0} \text{ given} \end{aligned}$$

where $Q_{it} = \beta^t U_c(c_{it}, l_{it})$ is the marginal rate of substitution of domestic consumers in sector i (which are the owners of the firm). The problem of firms in both sectors of country 2 is analogous. In the financially integrated sectors firms can shop for banks in both countries. So lending rates will be equalized.

$$R^e_{2t} = R^{e*}_{2t}.$$

4.1.3. Banks

To complete the model we now describe how banks intermediate funds from consumers to firms/managers. In each sector there is a continuum of identical competitive banks. Banks in the financially segmented sector raise deposits $\frac{D_{1t}}{R_{1t}}$ and $\frac{D^*_{1t}}{R^*_{1t}}$, respectively from consumers in those sectors. Banks in the financially integrated sectors are "global banks" and raise deposits/banking capital from consumers in the financially integrated sector in both countries, i.e. global banks' deposits are given by $\frac{D_{2t+1}+D^*_{2t+1}}{R_{2t}}$. We assume that the activity of raising deposits is costly and banks need to pay a fraction ι of deposits to cover intermediation costs. Banks allocate deposits to two types of assets: country-specific risky technologies (which are intended to capture returns on assets held by banks and not explicitly modeled here, such as mortgages or stocks), and risk-free loans to firms, as described above. In sector 1 banks only lend to firms in that sector and in that country and only invest in the risky technology of that country. In sector 2 (the global banks sector) banks lend to firms in both countries and invest in a diversified international fund, which contains equal shares of the risky technologies of both countries.[24] We denote with R^m_t and R^{m*}_t the stochastic gross returns on risky technologies in the two countries, which we assume to have equal mean in each country. Banks first, without knowing the realizations of returns R^m_t, R^{m*}_t, decide how much to invest in the risky asset. We assume that the expected return on the risky asset is always high enough so that each bank invests in it the maximum share of its deposits allowed by bank regulation i.e. $0<\bar{m}<1$.[25] After returns R^m_t, R^{m*}_t are observed (but not cashed in), banks compete offering loans to firms in their sector. Since firms borrow to finance the wage bill, equilibrium loans of banks L_{it} and L^*_{it} are given by

$$\begin{aligned} L_{1t} &= w_{1t} l_{1t}, L^*_{1t} = w^*_{1t} l^*_{1t} \\ L_{2t} &= w_{2t} l_{2t}, L^*_{2t} = w^*_{2t} l^*_{2t}. \end{aligned}$$

At the end of the period banks receive the proceeds from lending to firms and from risky investments; banks also pay back deposits plus interests to consumers and intermediation costs. Competition between banks insures that equilibrium interest rate on loans is such that bank profits are 0.

To complete the description of the banking problem we have to specify a process for shocks to the return to risky assets: we assume that they follow a bivariate auto-regressive process given by

$$\begin{bmatrix} R^m_t \\ R^{m^*}_t \end{bmatrix} = \begin{bmatrix} \bar{R}^m \\ \bar{R}^m \end{bmatrix} + A_R \begin{bmatrix} R^m_{t-1} \\ R^{m^*}_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon^R_t \\ \varepsilon^{R^*}_t \end{bmatrix}$$

where A_R is a 2×2 matrix and $[\varepsilon^R_t\ \varepsilon^{R^*}_t]$ is a vector of *i.i.d.*innovations with mean 0, standard deviation σ^R_ε and correlation ρ^R_ε.

4.1.3.1. Caveat. We have modeled banks portfolio decision in a rather stark fashion, basically assuming that banks invest a constant fraction of their portfolio in risky assets. Obviously in reality bank can, and do, change the composition of their portfolio. If, however, one interprets our model as a representation of the entire financial sector then the assumption that the proportion of risky and safe assets is rather constant through time is not too far-fetched. The crucial ingredient in our theory is that banks are always exposed to some additional risk that interferes with their lending to firms; the assumptions that the size of this risk is constant and that the loans to firm are risk free are made for analytical simplicity.

4.2. Equilibrium

An equilibrium, for an exogenously given level of financial integration (size of the two sectors) λ, is a collection of price sequences, R^e_{it}, R_{it}, w_{it}, Q_{it}, R^{e*}_{it}, R^*_{it}, w^*_{it}, Q^*_{it}, exogenous shock processes z_t, R^m_t,z^*_t, R^{m*}_t, and quantities c_{it}, l_{it}, k_{it}, x_{it}, d_{it}, D_{it},L_{it},c^*_{it}, l^*_{it}, k^*_{it}, x^*_{it}, d^*_{it}, D^*_{it}, L^*_{it} such that

[24] This is a very simple way of capturing the idea that in general global banks will be affected by shocks in the risky technology in both countries.

[25] This assumption seems to be empirically valid as in almost all countries banks hold (close to) the minimum regulatory amount of capital in safe assets.

Table 6
Functional forms and baseline parameter values.

Functional forms	
Utility	$U(c,l)=\log(c)-Al$
Production	$F(k,l)=k^{\alpha}l^{1-\alpha}$
Preference parameters	
Discount factor	$\beta=0.99$
Weight of labor	$A=2.3$
Technology parameters	
Capital share	$\alpha=0.36$
Depreciation rate	$\delta=0.025$
Productivity process	$A_z=\begin{pmatrix}0.95 & 0.0\\ 0.0 & 0.95\end{pmatrix}, \rho_{\varepsilon}^{z}=0.3,\ \sigma_{\varepsilon}^{z}=\begin{cases}0.7\%\ \text{Prod. only}\\ 0.48\%\ \text{Prod \& Credit}\end{cases}$
Adjustment cost	$\phi=0.43$
Banking parameters	
Degree of integration	$\lambda=15\%$
Share of risky assets in banks portfolio	$\bar{m}=18\%$
Credit shocks process	$_{AR}=\begin{pmatrix}0.95 & 0.0\\ 0.0 & 0.95\end{pmatrix}, \rho_{\varepsilon}^{R}=0.3, \sigma_{\varepsilon}^{R}=3\%,\ \bar{R}^{m}=1.06(1-0.95)$
Intermediation costs	$\iota=4\%$

1. Given prices and shocks, consumers and firms solve their problems, banks invest a share $\bar{m}$ in the risky portfolio and make zero profits in each period and in each sector i.e.

$$\bar{m}R_t^{m}+(1-\bar{m})R_{1t}^{e}=R_{1t}+\iota \quad \text{for all } t. \tag{7}$$

$$\bar{m}R_t^{m^*}+(1-\bar{m})R_{1t}^{e^*}=R_{1t}^{*}+\iota \quad \text{for all } t. \tag{8}$$

$$\bar{m}\left(\frac{1}{2}R_t^{m}+\frac{1}{2}R_t^{m^*}\right)+(1-\bar{m})R_{2t}^{e}=R_{2t}+\iota \quad \text{for all } t. \tag{9}$$

The right hand sides of Eqs. (7)–(8) represent banks' costs (per unit of deposit) in the segmented sectors in the two countries; the right hand side in Eq. (9) represents the cost of the typical global bank. Similarly the left hand sides of Eqs. (7)–(8),sent revenues (per unit of deposit) from risky capital and revenues from lending to firms in the segmented sectors; and the left hand side of Eq. (9) represents the global banks revenues.

2. Goods markets clear, i.e.

$$c_{1t}+x_{1t}+(D_{1t+1}-D_{1t})=e^{z_t}F(k_{1t},l_{1t})+\frac{D_{1t+1}}{R_{1t}}\left(\bar{m}\left(R_t^{m}-1\right)-\iota\right) \quad \text{for all } t. \tag{10}$$

$$c_{1t}^{*}+x_{1t}^{*}+(D_{1t+1}^{*}-D_{1t}^{*})=e^{z_t^{*}}F\left(k_{1t}^{*},l_{1t}^{*}\right)+\frac{D_{1t+1}^{*}}{R_{1t}^{*}}\left(\bar{m}\left(R_t^{m^*}-1\right)-\iota\right) \quad \text{for all } t. \tag{11}$$

$$c_{2t}+c_{2t}^{*}+x_{2t}+x_{2t}^{*}+(D_{2t+1}-D_{2t})+(D_{2t+1}^{*}-D_{2t}^{*})=e^{z_t}F(k_{2t},l_{2t})+e^{z_t^{*}}F(k_{2t}^{*},l_{2t}^{*})+\frac{(D_{2t}^{*}+D_{2t})}{R_{2t}}\left(\frac{\bar{m}}{2}\left(R_t^{m}+R_t^{m^*}-2\right)-\iota\right) \quad \text{for all } t. \tag{12}$$

The left hand side of the market clearing equilibrium conditions includes, besides consumption c_{it}, c_{it}^{*} and investment in physical capital x_{it}, x_{it}^{*}, investment in banking deposits $(D_{it+1}-D_{it})$ $(D_{it+1}^{*}-D_{it}^{*})$, which are used either as working capital or as investment in the risky technology. The right hand side includes production by firms $e^{z_t}F(k_{it},l_{it})$, $e^{z_t}F(k_{it}^{*},l_{it}^{*})$ and resources generated by the risky technology, net of the intermediation costs $\frac{D_{it}}{R_{it}}\left(\bar{m}\left(R_i^{m}-1\right)-\iota\right)$ and $\frac{D_{it}^{*}}{R_{it}^{*}}\left(\bar{m}\left(R_i^{m^*}-1\right)-\iota\right)$.

3. Financial intermediation markets clear. In each period in the segmented sectors the demand for working capital from the firms in the sector is equal to the supply of loans in that sector; while for the global banks the demand for working capital in both countries is equal to the global supply of loans.

$$L_{1t}=(1-\bar{m})\frac{D_{1t}}{R_{1t}} \quad \text{for all } t. \tag{13}$$

$$L_{1t}^{*}=(1-\bar{m})\frac{D_{1t}^{*}}{R_{1t}^{*}} \quad \text{for all } t. \tag{14}$$

$$L_{2t}+L_{2t}^{*}=(1-\bar{m})\frac{(D_{2t}+D_{2t}^{*})}{R_{2t}} \quad \text{for all } t. \tag{15}$$

4.3. Parametrization

The equilibrium described above does not admit analytical solution. So to characterize its properties we need to assign functional forms to utility and production, numerical values to the various parameters and then derive a numerical solution using standard linearization techniques. Functional forms for utility and production, preference and technology parameters are set in a standard fashion in this literature, so to match long run zero growth in hours worked, constant shares of labor income and volatility of investment relative to GDP. They are reported in Table 6 below. The productivity process is also standard but, as we consider two versions of the model, one with only productivity shocks, the other with productivity and banking shocks, we consider two values for the variance of innovation of productivity: the two values are chosen such that the two versions of the model have the same volatility of GDP growth (to facilitate comparison across them).

Since the parameters characterizing the banking sector are less standard, we briefly describe how we set them. The parameter λ, which determines the degree of financial integration between the two countries and $\bar{m}$, which determines the share of assets banks invest in the risky technology are set so that model with only productivity shocks generates volatility of net exports (relative to the percentage volatility GDP) roughly equal to 40% and a correlation of net exports and GDP which is about −0.4: these values are consistent with statistics computed for U.S. and other developed countries.[26]

Next regarding the stochastic process for credit shocks we assume that innovations to credit and productivity shocks are uncorrelated, that the transition matrix of the stochastic process for banking shocks and the correlation of the innovations in credit shocks are the same as the ones for the process for productivity (i.e. $A_R=A_z$ and $\rho_{\varepsilon}^{R}=\rho_{\varepsilon}^{z}$).[27] When we consider the version of the model with two types of shocks

[26] It is easy to see how the parameter λ affects directly the volatility of net exports, as when λ is 0 the economies are closed and the volatility of net exports is 0. Why does the parameter $\bar{m}$ affect the correlation between net exports and output? The parameter $\bar{m}$, even in absence of banking shocks, affects the sensitivity of domestic lending rates R^{e} to changes in the deposit rates R (see Eq. 16). The larger $\bar{m}$, the more R^{e} raises in response to an increase in R due to a productivity shock. This implies that firms do not hire much in response to higher productivity and hence do not invest much. This in turns implies that the country as a whole imports less goods to finance investment and that makes the correlation between net exports and output less negative than in the model with low $\bar{m}$.

[27] We recognize that these are rather arbitrary assumptions. Our key results on the impact of integration under two different types of dominant shocks are robust to significant perturbations in these assumptions.

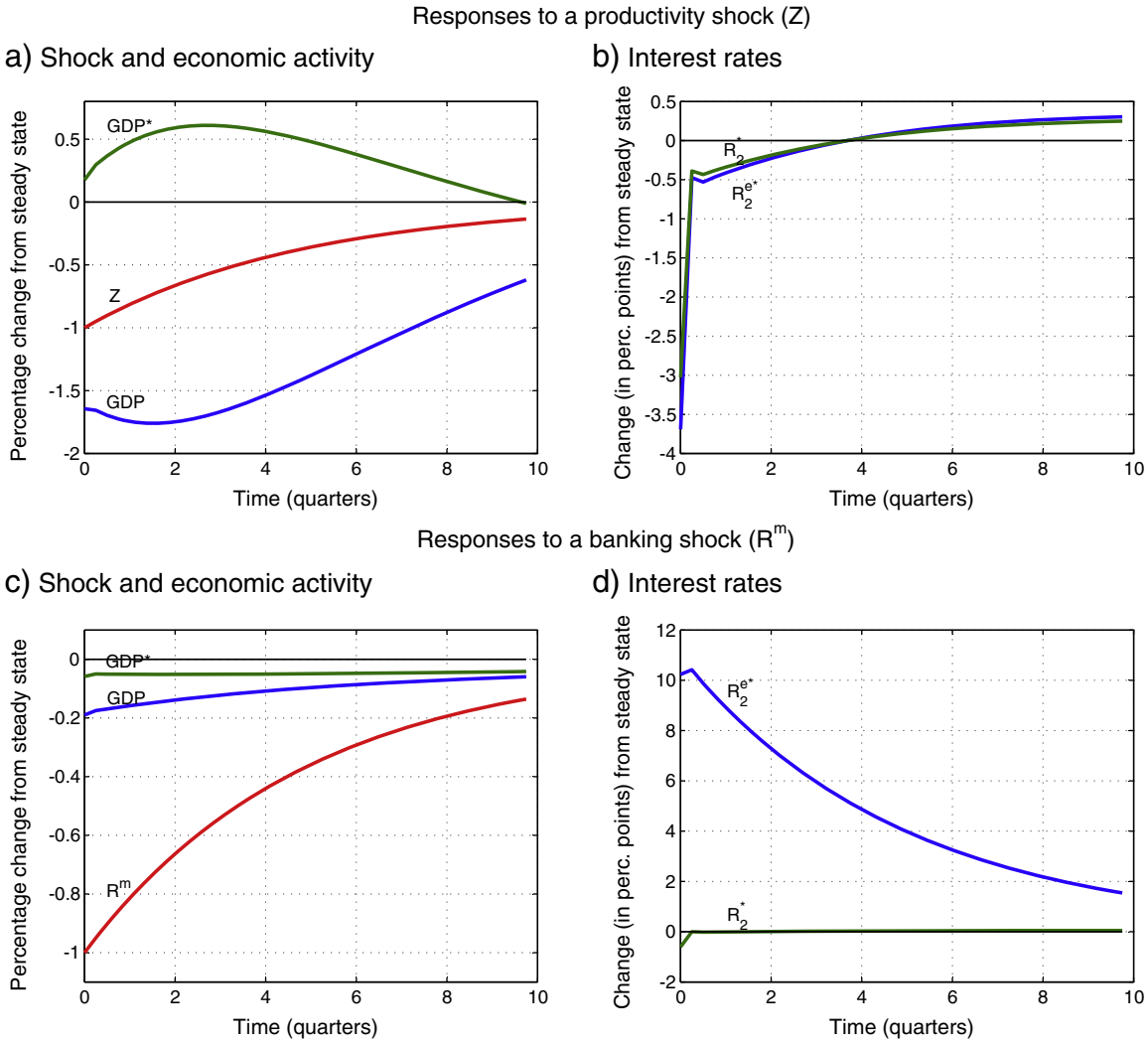

Fig. 2. Impulse responses to productivity and banking shocks.

we set the standard deviation of the innovations to banking shocks σ_R^ε so that banking shocks alone are responsible for a standard deviation of growth rate of GDP of about 0.3%. To obtain this number we have observed that the standard deviation of quarterly growth rate of U.S. GDP increased from about 0.5% in the period 1984–2006 to about 0.8% in the period 2007 − 2010 and so, attributing the entire increase in U.S. volatility to credit shocks, yields the target number.

This simple procedure yields a value of $\sigma_R^\varepsilon = 3\%$. It is obviously hard, in such a stylized model, to identify the data equivalent of returns on risky investments undertaken by the banking sector and the volatility of returns on these risky investments. The simple calibration approach though suggests that in order for these shocks to explain a significant fraction of GDP volatility, the volatility of returns on these risky investments in the banking/financial sector has to be large: much larger than the volatility of productivity shocks and comparable to the volatility of stock returns.

We finally set the average return on risky assets in the model, $\bar{R}^m$, to match an average real return on observed risky assets (such as stocks) of around 6%, and set the banking intermediation cost $\iota = 4\%$ of deposits so, in the model with banking shocks the spread between lending and deposit rate is 3% on average and positive 95% of the times.[28]

[28] We experiment with several values of these last two parameters, in particular with the returns on risky assets ranging from 2% to 10% and the intermediation costs ranging from 0% to 8%. The business cycle statistics produced by the model vary very little within this range.

4.4. The effects of shocks

4.4.1. Productivity shocks

Productivity shocks in this model operate as in a standard two country real business cycle model. Consider, for example, a negative productivity shock in the home country. In sector 1 (the segmented one) the shock lowers labor demand and investment and hence output at home, but, absent spillovers in the productivity itself, has no effects abroad. In sector 2 (the financial integrated one) a negative domestic productivity shock reduces labor demand and output but also reduces global demand for credit, which causes a fall in the (common across countries) deposit and lending rates. The fall in the lending rate causes an increase in labor demand and employment abroad and the fall in the deposit rate induces an increase in investment abroad. The larger the financially integrated sector (i.e. the larger λ) the more inter-connected the two economies are; as such the more a negative productivity shock at home has an expansionary effect abroad and hence the less the economies are correlated. By enabling resource flows from the less productive to the more productive country, financial integration reduces the output correlation between the economies. The top two panels of Fig. 2 show the impulse responses of a negative domestic productivity shock. The home country GDP contracts and foreign country GDP expands (panel *a*). The foreign economy expands because interest rates in the financially integrated sector (the lines R_2^* and R_2^{*e} in panel *b*) fall.

4.4.2. Credit shocks

Credit shocks are shocks to returns on risky bank assets R_t^m and $R_t^{m^*}$. To get some intuition on how these work it is useful to first focus on the segmented sector, say, in the home country. Recall that the two key interest rates, R_{1t}, the rate depositors receive, which determines the cost of raising funds for banks, and R_{1t}^e, the lending rate banks charge to firms, will not be equalized. The reason why these two rates differ in equilibrium, even though banks make zero profits, is that banks make losses or gains on investment in the risky technology. These gains/losses plus the zero profit conditions drive a wedge between $R_t+\iota$ and R_t^e. And this wedge, through the working capital channel, has an effect on economic activity. To see this solve for R_{1t}^e in Eq. (7) to get

$$R_{1t}^e = \frac{1}{1-\bar{m}}(R_{1t}+\iota) - \frac{\bar{m}}{1-\bar{m}}R_t^m. \tag{16}$$

Eq. (16) shows that

1. Unless $\bar{m}=0$ (i.e. banks are prohibited to invest in risky assets) or $R_t^m = R_{1t}+\iota$ (i.e. the return on the risky technology is the same as the equilibrium deposit rate plus intermediation costs), the rate banks charge to firms is different from the depositors rate plus intermediation costs. The presence of the intermediation costs guarantees that, on average, the spread between lending and deposit rate, $R_{1t}^e - R_{1t}$ is positive.
2. Negative shocks to the return to the risky asset (rate) increase the spread between depositor rate and lending rate.
3. The larger the share invested in risky assets, $\bar{m}$, the more sensitive is the lending rate to shocks in the risky rate. Banks make up for losses on risky assets by charging a high interest rate to firms. If bank portfolio contains a large share of risky assets interest the rate hikes necessary to cover the losses are larger.

4.4.3. Graphical illustration of the impact of credit shocks

To further understand the effect of a financial shock Fig. 3 represents equilibrium in the financially segmented sector. The positively sloped line *ZP* represents combinations of deposit rates and lending rates that yield zero profit for banks (Eq. (16)), for a given level of k_1, z, and R^m. The line is positively sloped because a high deposit rate induces, *ceteris paribus*, a high lending rate so that banks break even. The negatively sloped line represents the locus of lending and deposit rates that constitute an equilibrium in intermediation markets (Eq. (13)). It is negatively sloped because a higher R_1 induces a higher supply of deposits D_{1t} and thus requires a lower R_1^e to induce a high demand for credit from the firms. The graph allows to easily understand the effect of shocks. Consider for example a fall in R^m. The fall lowers revenues for banks and thus implies a shift up of the zero profit condition from *ZP* to *ZP*′. In equilibrium this will result in a fall in deposit rates from R_1 to R'_1 and an increase in lending rates from R_1^e to $R_1^{e'}$. Higher lending rates, through the working capital channel, reduce firms labor demand and hence equilibrium employment. Consequently, as a result of the shock to the risky revenues of the banking sector, economic activity falls.

The effects of a negative shock to R^m in the financially integrated sector are similar, with the difference that the shock now gets transmitted in the financially integrated sector abroad through the common interest rate. Since financially integrated sectors share both deposit rates and lending rates, the rate changes that caused the reduction of economic activity at home also cause a reduction of economic activity abroad. The bottom panels in Fig. 2 show how in response to an adverse credit shock economic activity in both countries contracts (in panel *c* both *GDP* and *GDP** fall). In the home country economic activity contracts in both sectors, because lending rates in both sectors raise; in foreign country economic activity contracts because the lending rate in the financially integrated sector, R_2^{e*}, increases (see panel d). One important thing to notice is that, in response to a credit shock, interest rates in the model raise substantially. Again this is due to the stylized nature of our model: in the real world besides the interest rates additional conditions in credit markets, such as borrowing restrictions or bank failures (as well as monetary policy), are likely to manifest in credit markets as a result of shocks. Since our model completely abstracts from those additional variables, interest rates need to be volatile for credit conditions to have sizeable effect on economic activity.

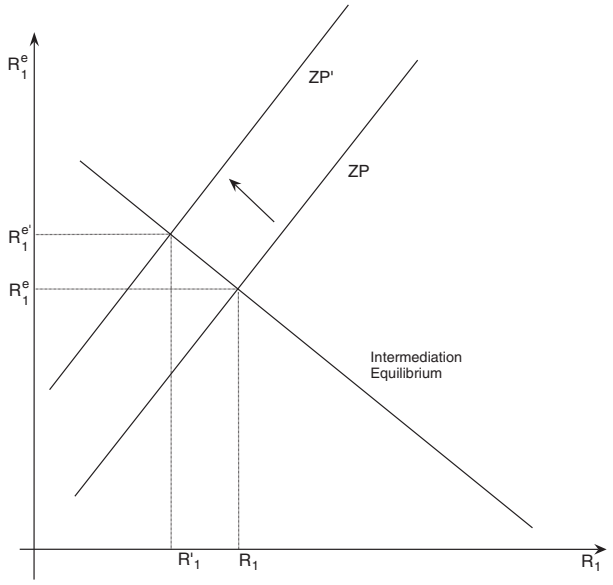

Fig. 3. Equilibrium interest rates and the effect of credit shocks.

5. Quantitative results

5.1. Shocks and business cycles

We first use the model to assess the effects of credit shocks on several properties of both local and international business cycles. Table 7 reports the results of the quantitative analysis. The rows labeled "Productivity only" report standard business statistics for the model with only productivity shocks. The model generates business cycles statistics quite similar (thereby sharing successes and failures) to those generated by a standard international real business cycle model. The rows labeled "Productivity & credit" in Table 7 report business cycles statistics for the version of the model with both productivity and credit shocks.

Three differences between the two versions of the model are worth noticing. First, the model with both credit and productivity shocks displays more internationally correlated GDP and GDP components than the model that only admits productivity shocks. In the segmented sectors the correlation in economic activity is simply driven by the correlation of the shocks (which for expositional purposes and simplicity we have assumed to be the same for both shocks). However, the correlation between the financially integrated sectors across countries depends on the composition of the shocks: with dominant productivity shocks, the financially integrated sectors tend to be negatively correlated, while with dominant banking shocks they tend to be positively correlated. Since the overall GDP correlation of the two economies is a combination of the correlation in the two sectors, the economies with both shocks co-move more relative to the economies with only productivity shocks. Interestingly introducing credit shocks increases the international correlation of output, employment and investment more than it does the correlation of consumption; so the models can partially explain the so-called "quantity anomaly" i.e. the fact that the model predicts that consumption patterns are more

Table 7
Business cycle statistic.

	Percentage Standard Deviations				
	GDP	Consumption	Investment	Employment	Net exports
Relative to GDP					
Productivity only	1.2	0.29	3.72	0.67	0.43
Productivity and credit	1.2	0.32	3.15	0.77	0.30
Correlations with GDP					
Productivity only	0.98	0.95	0.99	−0.44	
Productivity and credit	0.97	0.95	0.99	−0.13	
International correlations					
Productivity only	0.24	0.41	−0.33	0.15	
Productivity and credit	0.33	0.44	−0.06	0.36	

correlated than output internationally while in the data usually the opposite is observed. We conjecture that a reason for this feature is that, for our baseline parameters, credit shocks have a stronger effect on employment dynamics than on consumption dynamics.

Second, the model with both shocks generates more volatile employment relative to GDP than the model with only productivity shocks (0.77 v/s 0.67). This is due to the fact that credit shock induces movements in lending rates that cause, through the working capital channel, autonomous (i.e. not driven by productivity) movements in employment. This feature of the model is qualitatively consistent with evidence from the recent crisis showing that much of decline of U.S. GDP during the crisis is due to employment changes.

Third, the model with both banking and productivity shocks displays net exports that are less volatile and less (in absolute value) correlated with GDP. This is because credit shocks, due to their stronger international transmission, hit both countries similarly and thus reduces international flow of resources (net exports).

We would like to add a final consideration about the way we model credit shocks. The main channel through which credit shocks affect economic activity is by raising the borrowing rate of firms R^e_{it} (see Eq. (16)). But inspecting Eqs. (10), (11) and (12) it is easy to see that credit shocks also increase the resources of the economy.[29] For this reason we have also considered a version of the model in which credit shocks are modeled as a pure transfer. In particular we assume that stochastic returns on risky assets held by banks are provided by the government, which finances them by raising lump sum taxes/transfers on households; so, for example, for sector 1 in country 1 we define

$$T_{1t} = \frac{D_{1t+1}}{R_{1t}}\left(\tilde{m}\left(R^m_t - 1\right)\right)$$

and subtract T_{1t} from the budget constraint of households in that country and in that sector. In this version of the model credit shocks are the same as in the baseline version; the difference is that their realizations R^m_t, $R^{m^*}_t$ do not change the amount of resources in the economy and, as such, do not appear in the resource constraints of the economy. We found that this perturbation changes the quantitative properties of the model very little, suggesting that the main channel through which credit shocks operate is not by changing the aggregate resources of the economy, but rather by changing the inter-temporal prices faced by households and firms.

Overall the results from the calibration show that introducing a simple form of credit shocks in a standard international business cycle model generates plausible business cycles, and helps understanding some of the features that the standard model has trouble with.

[29] We thank an anonymous referee for pointing this issue to us.

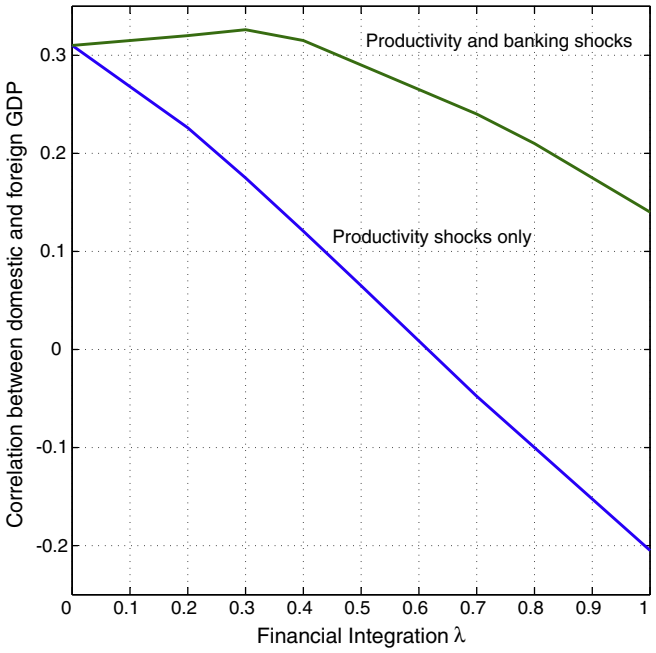

Fig. 4. Financial integration and business cycle correlation.

5.2. Banking integration and co-movement

We now connect directly the quantitative results of the model with the empirical results in the first part of the paper. We do this in two ways: first we simply conduct a simple comparative static exercise on how in the model banking integration affects co-movement, under different type of shocks. Second, to see whether the casual relation in the model is consistent with data, we will run, on artificial data generated by the model, the exact same regressions we run in the data.

5.2.1. Comparative static

We consider the two parameterizations of the model described above (productivity shocks alone and productivity and banking shocks) and for each parametrization we vary the degree of banking integration from no integration ($\lambda = 0$) to complete financial integration ($\lambda = 1$). For each value of the financial integration parameter we report the international correlation of GDP growth rates. The results of this exercise are reported in Fig. 4.

In the version of the model with only productivity shocks, the slope of the line is always negative; a higher degree of banking integration leads to less correlated output cycles. This result is consistent with our regression estimates in Tables 2 and 3, where we found that during tranquil, "non-crisis" periods, increases in cross-border banking linkages are followed by more divergent output growth rates.

In the version of the model with both productivity and banking shocks the association between financial integration and output synchronization is initially positively sloped and then declining. This suggests that, in times when output fluctuations are driven by both types of shocks, the overall effect of banking integration on output co-movement is ambiguous. Notice, however, that the difference between the lines of the model with both shocks and the model only with productivity shocks is always positive and increasing. This is in line with the results in Tables 2–5 showing that the marginal effect of banking integration on output co-movement in crisis times is positive.

5.2.2. Regressions in model and data

To make the link between the theoretical model and the empirical results tighter, we use artificial data generated by the model to run a

Table 8
Bilateral financial integration and GDP synchronization: model v/s data.

Dependent variable: GDP growth synchronization				
	Model		Data	
		(1)	(2)	(3)
Integration	−0.35	−0.248	−0.302	−0.220
		(0.06)	(0.07)	(0.06)
Integration × Crisis	0.25	0.264	0.192	0.123
		(0.03)	(0.04)	(0.05)

similar regression to the one we run in the empirical part of the paper. In particular we simulate the model for ten couples of countries, varying the banking integration parameter (λ) smoothly from 0 to 1. For each pair of countries we simulate the model for 200 periods (quarter), allowing only for productivity shocks (tranquil times) and allowing for both productivity shocks and banking shocks (crises times). We then construct the same measure of GDP synchronization we used in the data analysis (Table 3) above and then regress it on the log of financial integration (log of λ), on a dummy for crisis times and on an interaction between crisis times and log of financial integration. Column (1) in Table 8 reports the results.

When we run the regression on simulated data from the model, we find that (*i*) overall a higher degree of financial integration leads to lower level of output synchronization, as reflected in an integration coefficient of −0.35 and (*ii*) that the coefficient on the interaction term between financial integration and the crisis dummy is positive, suggesting a positive marginal effect of integration, that is in times of crisis (i.e. in periods where banking shocks are important) more integration induces more co-movement. For comparison in Table 8 we also report the coefficients on the same regression using actual data. In particular in columns 2 through 4 we report specifications (1), (2) and (3) from Table 3. The comparison between coefficients in the first column and the coefficients in the other columns suggests that the relation between financial integration and output co-movement implied by our model is statistically close to the one we estimate in the data.

6. Summary

There are two main lessons from the theory. First in the model there is a causal, structural link from banking integration to business cycle co-movement. This link manifests itself in estimated regression coefficients that relate international output correlations to cross-border financial integration, both in normal and in crises times. The regression coefficients estimated on artificial data from the model are statistically close to the ones estimated on actual data. Although this does not formally prove that financial integration is indeed a causal driver of international business cycle correlation, it shows that this hypothesis is entirely consistent with the data patterns revealed in Section 3.

The second lesson from the theory is learned by noting that the key ingredient needed in the model to weaken (as it did during the period 2007–2009) the negative link between financial integration and correlation is the presence of credit shocks to globally operating banks. This leads us quite naturally to conclude that indeed large credit shocks to financial intermediaries could have been the underlying source of the global contraction in economic activity that took place during the 2007–2009 global crisis.

7. Conclusion

We study the role of global banks in transmitting the recent crisis of 2007–2009 from the corner of the U.S. financial markets to the rest of the developed world from both an empirical and a theoretical standpoint. In the first part of our analysis we use quarterly data on country-pair banking linkages from a sample of 20 advanced countries between 1978 and 2009 to examine the effect of cross-border banking integration on business cycle synchronization. We find that while the relationship between bilateral banking integration and output synchronization has been historically negative, it has turned positive during the crisis period of 2007–2009. Moreover, we find evidence consistent with the transmission of the recent crisis from the U.S. to the rest of the industrial countries through cross-border banking linkages as we find that countries with stronger financial ties to the U.S. and its main off-shore financial center, the Cayman Islands, experienced more synchronized cycles with the U.S. during the period 2007–2009. We also find a similar association between banking linkages and output synchronization during previous large financial crisis episodes in advanced economies, such as the banking crisis in Scandinavian countries in the early 1990s.

In the second part of our paper we develop a dynamic general equilibrium model of international banking with both productivity and credit shocks. Our theoretical model includes the standard mechanism of the workhorse international real business cycle model (e.g. (Backus et al., 1992)) where financial integration magnifies total-factor-productivity shocks leading to more divergent output cycles, and the contagion mechanism of recent international macro models (e.g. (Perri and Quadrini, 2011); (Mendoza and Quadrini, 2010)) where financial shocks may spread globally among interconnected economies.

The model spells a mechanism linking bilateral financial integration with business cycle synchronization and helps interpreting the empirical evidence. The theoretical model shows that exogenous changes to financial integration can have significant effects on business cycle synchronization; crucially the sign and magnitude of these effects depend on the nature of the structural shocks hitting the economy. The theory suggests that the fact that during the recent crisis stronger financial linkages resulted in more synchronized business cycles is an indication that the drivers of the recent crisis were financial shocks.

The model finally proposes a simple mechanism through which capital losses to the financial sector have repercussions on domestic and foreign economic activities. This highlights the importance of, in terms of future research, the analysis of the effectiveness and desirability of policies geared toward reducing capital losses of the financial/banking sector, like the 2008 bailout. Our study could also shed light on the path of intra-Europe (Germany v/s countries of the European south) and U.S.–Europe divergence that has manifested after the 2007–2009 crisis. Our approach implies that the increased degree of financial integration during the last few decades has resulted in divergent output cycles within Europe and between Europe and the U.S. until the major credit shock hit the U.S. Although the U.S. and the European countries moved together during 2007–2009 as a result of this dominant credit shock as opposed to before, they have continued drifting apart since then, given the absence of further credit shocks.

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