Global Banks and Crisis Transmission[*]

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Abstract

We study the effect of financial integration on the transmission of international business cycles. In a sample of 20 developed countries between 1978 and 2009 we find that while increases in financial linkages were associated with more divergent output cycles during non-crises times, this effect becomes much smaller during financial crises. We also document that countries with stronger financial ties to the U.S. both directly and indirectly via financial centers experienced more synchronized cycles with the U.S. during the recent 2007–2009 crisis. To better understand this relationship we develop a simple general equilibrium model of international business cycles with banking. The model shows how changes in financial integration can have large effects on business cycle co-movement, and how these effects vary with the type of shocks driving the cycle. When productivity shocks are the dominant source of fluctuations (non-crisis times), more financial integration results in less synchronized business cycles; if credit shocks are the dominant source of fluctuations (crisis times), then more integration results in more synchronized business cycles.

JEL Classification: E32, F15, F36
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1 Introduction

A central question in international macroeconomics is the effect of financial integration on the international transmission of country-specific shocks. Both the theoretical and the empirical literatures try to explain the synchronization of the business cycles among countries as a function of their degree of interconnections to the global capital markets and the financial system of the shock-hit country. Yet, both literatures yield ambiguous and often conflicting results.

Theoretical models make opposing predictions on the association between financial integration and the synchronization of economic activity, depending on whether shocks to the banking sector or productivity shocks to firms dominate. In a financially integrated world, if firms in certain countries are hit by negative (positive) shocks to their collateral or to their productivity, both domestic and foreign banks decrease (increase) lending in these countries and increase (decrease) lending in the non-affected countries, thereby causing a further divergence of output growth.[1] In contrast, if the negative (positive) shock is to the banking sector, globally operating banks pull out funds from all countries, transmitting the domestic banking shock internationally, making business cycles of the two countries more alike.[2]

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 and tries to identify the effect of financial integration, and other (mostly bilateral factors) on business cycle synchronization using cross-country variation (see Rose (2009) for a review and Baxter and Kouparitsas (2005) for a thorough sensitivity analysis). This literature in general finds a positive relation between financial integration and synchronization (e.g. Imbs (2004, 2006) and Kose *et al.* (2005); Otto, Voss and Willard (2001)), independently on whether the sample focuses in tranquil times or whether the analysis also covers financial crisis episodes. Yet recent work by Kalemli-Ozcan, Papaiannou, Peydro (2012) shows that in a sample of developed countries before the pre 2007 crisis when financial crises were rare (or absent for

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[1]See, among others, Holmstrom and Tirole (1997), Morgan, Rime, and Strahan (2004), and Backus, Kehoe, and Kydland (1992) and Baxter and Cruicini (1994), among others. Obstfeld (1994) also builds a model predicting a negative association between financial integration and output synchronization that, however, operates via industrial specialization. In his model, financial integration via risk sharing enables countries to specialize in sectors where they have a comparative advantage; therefore this implies that output growth patterns among financially integrated countries are uncorrelated. International asset pricing models also predict a negative association between output synchronization and financial integration, because the benefits of diversification are larger when output cycles and thus equity returns are weakly (or even negatively) correlated (e.g. Heathcote and Perri (2004)).

[2]See, among others, Holmstrom and Tirole (1997), Morgan, Rime, and Strahan (2004), Calvo (1998), Calvo and Mendoza (2000), Allen and Gale (2000), Perri and Quadrini (2001), Mendoza and Quadrini (2010), Olivero (2010) and Enders, Kollman and Muller (2010), Devereux and Yetman (2009), Krugman (2008).

most countries), within country-pair increases in cross-border financial linkages are associated with less synchronized output cycles (see also Kalemli-Ozcan, Sørensen, and Yosha (2001) and Garcia-Herrero and Ruiz (2008)). The contagion literature, on the other hand, limits its focus on crises periods, primarily in emerging markets. Overall this body of work provides compelling evidence that crises spread contagiously from the origin mostly via financial linkages (e.g. Kaminsky and Reinhart (2000); Kaminsky, Reinhart, and Vegh (2003); Cetorelli and Goldberg (2011)).

Can we identify the effect of financial integration on business cycle synchronization using data both from tranquil periods and crisis times? This question bears utmost policy significance in the light of the recent global crisis and the ongoing problems in the euro area. To this date, the conventional wisdom is that the U.S.-originated negative credit supply shock spread to the rest of the world via international financial -banking in particular- linkages. Yet, the tentative empirical evidence on this issue is sobering. There seems to be no robust evidence that the crisis spread via financial linkages from the U.S. to the rest of the world.[3] This appears quite puzzling given the overwhelming synchronization of the economic activity (at least among developed countries) during the recent crisis that dwarfs anything in comparison since 1975.[4] The lack of systemic evidence linking financial globalization with output decline during the past years has led many to argue that the group of developed economies experienced one common (global) shock, either in financial intermediation or in the productivity of the "real" economy (e.g. Chari, Christiano and Kehoe (2008); Mulligan (2009)).

In this paper we use a rich dataset of cross-border banking linkages from the late 1970s that also covers the recent financial crisis to investigate whether an idiosyncratic U.S. based shock diffused internationally via international financial linkages or whether a common global shock explains the synchronicity of output, benchmarking our results to the tranquil period before 2007. The central challenge for identification in both the international transmission literature and in the contagion literature is the issue that output comovement may be manifestation of common shocks that hit at the same time many countries (perhaps to a differential degree), rather than an idiosyncratic

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[3]Rose and Spiegel (2010a,b) find no role for international financial linkages in transmitting the crisis both for developed countries and for emerging markets. In contrast, Cetorelli and Goldberg (2009) find that lending supply in emerging markets was affected through a contraction in cross-border lending by foreign banks; a contraction in local lending by foreign banks' affiliates; and a contraction in lending by domestic banks due to a funding shock to their balance-sheet. Employing global VARs, Helbling, Huidrom, Kose and Otrok (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 (2010), 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.

[4]Using monthly data on industrial output Imbs (2011) shows that the degree of international correlation in national business cycles since the end of 2008 is unprecedented in past three decades.

(country-specific) shock that spill-over contagiously (via trade or financial linkages). Since common shocks and contagion may be observationally similar, it is quite hard to separate out one from another in an empirical setting (see Reinhart and Rogoff (2009)). For example, 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. This finding is more in line with a common credit shock hitting financial intermediaries in all developed countries at (roughly) the same period, casting doubt on the belief that the crisis hit just a couple of U.S. banks and then got transmitted via financial linkages.

Identification of the impact of financial integration on business cycle synchronization before and after the recent crisis is challenging as it requires not only distinguishing between different types of country-specific shocks (on the productivity of firms or the efficiency of financial intermediation), but also controlling for common shocks. This is fundamental for identifying any contagion effects. To achieve this goal, we use a unique bilateral (country-pair) data-set from the Bank of International Settlements' (BIS) on the financial linkages between banks in advanced economies over the past three decades. The rich panel structure allows us to control for time-invariant country-pair fixed factors and for common to all countries shocks (as well as country-specific dynamic trends in output growth and financial integration).

Preliminary evidence before and after the recent financial crisis To get a first-pass on the data patterns on the correlation between financial integration on output synchronization, we run some 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 p.c. 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 (defined below) 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 and whether this association has changed during the current crisis.

Table 1 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. 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 within country-pairs and conditional on shocks common to all countries in the two time spans (captured by second period constant), within country-pair increases in banking integration are associated with less synchronized output cycles. Third and most importantly, 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 the total effect of financial integration is still negative so the crisis made the relation between of financial integration and synchronization *less* negative.

Results Preview In the empirical part of our paper we analyze in detail the evolution of the correlation between financial integration and output synchronization over the period $1978 - 2009$, distinguishing between tranquil and crisis periods, as theoretically the association between the two variables is not the same. Our main empirical findings can be summarized as follows. First, we show that before the 2007/2009 crisis within country-pair increases in cross-border financial/banking linkages are associated with more divergent, less synchronized output cycles. This result is in line with the recent evidence of Kalemli-Ozcan, Papaioannou, and Peydro (2012) who also show a significant negative within country-pair correlation between financial integration and output synchronization. Second, we present novel evidence that during the recent crisis the association between financial integration on output synchronicity is less negative. Interestingly, we obtain similar results when we examine previous financial crisis episodes in other developed countries such as Finland and Sweden in the early 1990s and Japan in the mid/late 1990s. Third, we find that during the recent crisis there has been a positive correlation between output synchronization and exposure to the U.S. financial system and that correlation emerges only when, on top of direct links to the U.S., we also consider indirect links via the Cayman Islands (and other financial centers).

After establishing the main patterns in the data, we develop a dynamic stochastic general

Table 1: Bilateral Financial Linkages and Output Correlations

Dependent Variable: Pairwise GDP Growth Correlations			
	(1)	(2)	(3)
Sample	All	All	No LUX, CHE
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). Results are very similar if 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' external assets and liabilities in the entire world in the beginning of each period. Column (3) omits LUX and CHE. 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.

equilibrium model of international banking. The model serves two purposes. The first is to suggest a causal link between financial integration and business cycle synchronization. Our empirical findings document a relationship between the two, but do not speak about causation. We derive quantitative results from the the model that show how these findings are indeed fully consistent with the hypothesis that exogenous changes to financial integration have significant effects on business cycle synchronization, and how 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. For example our findings that during the recent crisis financial linkages with the US resulted in more synchronized business cycles suggest that the cause of the recent crises were financial shocks.

We consider a two-country, two sectors, one-good set-up. In each sector consumers supply labor and save; firms hire labor and make investment decisions; and banks intermediate funds between

firms and consumers. Sector 1 is financially separated from the rest of the economy and banks intermediate only between consumers and firms within the sector. Sector 2 is financially integrated in the sense that consumers in sector 2 in both countries have financial transactions, through banks, with firms in both countries. This two-sector structure allows easily to consider couple of countries with different degree of banking integration (simply by varying the size of sector 2). The model predicts that when the shocks are primarily in the productivity side then a higher degree of banking integration results in a lower degree of business cycle synchronization. As in Heathcote Perri (1992) a higher degree of financial integration enables capital to flow more from the less to the more productive country; this in turn magnifies output divergence between countries when they are hit by different real shocks (because employment and investment follow different patterns in the two countries).

We then introduce shocks to bank capital (via shocks to returns on risky assets held by banks). When banks experience a shortfall in their revenues they are forced to make up for the lost revenues charging a higher interest rates to firms; the higher cost of borrowing, through a working capital (liquidity) channel, has a negative impact on economic activity. We explain in detail how, with financial shocks interacting with the liquidity needs of firms a higher degree of banking integration may result in a higher degree of output synchronization; under financial integration disturbances in the banking sector of one country affect the interest rates charged by global banks in all interconnected countries. We then calibrate the model and use data simulated from our model to run a similar regression as the one we run in the data, relating output co-movement to banking integration in periods dominated by productivity shocks (tranquil times) and in periods with prominent banking shocks (crisis times). Interestingly we find that the relation estimated on artificial data in times with dominant productivity shocks is negative and roughly of the same magnitude as the one estimated on the data in the period $1978 - 2006$; we also find that the coefficient on integration interacted with periods with large credit shocks is less negative and again of similar magnitude as the one estimated on the periods of financial crisis in the data. This result shows that the empirical findings are consistent with a causal relationship going from integration to business cycle co-movement.

Overall the theoretical and empirical results suggest that the at least part of the 2007-2009 the world recession was the outcome of a credit shock in the U.S. capital markets, that spread contagiously to other industrial countries that had strong linkages with the U.S. and its main off-shore center, the Cayman Islands.

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 and presents the quantitative results. Section 5 concludes.

2   Methodology and Data

2.1   Specification

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

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

$Synch_{i,j,t}$ 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.[5] 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.).[6] 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

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[5]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.

[6]Kalemli-Ozcan, Papaioannou, and Peydro (2012) show that accounting for country-pair fixed-factors is fundamental. Working in a similar to ours 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.* (2011), banking in particular (Buch (2003); Papaioannou (2008)) and the literature on the determinants of output comovement (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 both financial integration and output synchronization.

and hard-to-observe country-specific output dynamics. We control for other factors, such as the level of income, population bilateral trade, etc.[7] 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 centers 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—they overstate exposure to and from small financial centers (and understate exposure to the U.S. and the U.K.).[8] 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.

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.

$$Synch_{i,,j,t} \equiv -|(\ln Y_{i,t} - \ln Y_{i,t-1}) - (\ln Y_{j,t} - \ln Y_{j,t-1})|. \tag{2}$$

This index, which follows Giannone, Lenza, and Reichlin (2010), is simple and easy-to-grasp. In addition, it is not sensitive to 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 (see also the preliminary findings in the introduction), this synchronization index does

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[7]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, Duflo, and Mullainathan (2004)).

[8]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 Sa (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).

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 (2006)).[9]

2.3   International Banking Linkages

To construct the bilateral financial linkages measures we utilize proprietary data from 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 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.[10] Thus we have a rich bilateral panel dataset on banks' positions spanning from $1978 : q1$ till $2009 : q4$.

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

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[9]For robustness and for comparability with the work of Morgan, Rime, and Strahan (2004) on the impact of banking integration on the evolution of business cycles across states in the US, we also experimented with an alternative (though similar) synchronization measure finding similar results. To construct the Morgan, Strahan and Rime (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.

[10]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.

and government bonds.[11]

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 others off-shore financial centers), 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. 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 has 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 dataset 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 $0.75 - 0.99$.

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[11]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.

Other country-pair datasets on foreign capital holdings also suggest a strong correlation of the various types of international investment. For example, Kubelec and Sa (2009) 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 ($Linkages_{i,j,t-s}$) with two measures. 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.

$$\left[Linkages_1 = \frac{Assets_{i,j,t} + Liabilities_{i,j,t} + Assets_{j,i,t} + Liabilities_{j,t,t}}{(GDP_{i,t} + GDP_{j,t})} \right]$$

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

$$\left[Linkages_2 = \frac{Assets_{i,j,t} + Liabilities_{i,j,t} + Assets_{j,i,t} + Liabilities_{j,t,t}}{Tot\_Assets_{i,t} + Tot\_Liabilities_{i,t} + Tot\_Assets_{j,t} + Tot\_Liabilities_{j,t}} \right]$$

Likewise we 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. standardized with the sum of the two countries' GDP in each quarter and standardized with the sum of total external assets and liabilities of the two countries in each quarter. 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.[12] Table 2 gives descriptive statistics for the variables employed in the empirical analysis.

Table 2: Descriptive Statistics

	N	mean	sd	min	max	p1	p5	p25	p50	p75	p95	p99
Pairwise corr. of GDP	25061	.1757	.2963	-.8462	.9698	-.5085	-.3066	-.0278	.1708	.3815	.6664	.8578
Synch. of GDP	27911	-4.303	4.587	-45.66	-.0007	-22.37	-12.90	-5.638	-2.93	-1.320	-.2571	-.0511
Banking Links/GDP	18192	.0187	.0418	0	.6444	.0000	.000	.0011	.0046	.0170	.0809	.2316
US Banking Links/GDP	15322	.1324	.1615	.0061	1.486	.0095	.0171	.0419	.0850	.145	.4591	.8783
Banking links/total	18183	.0260	.0348	0	.2478	.0002	.000	.0042	.0118	.035	.0980	.1702
US Broad Links/GDP	13156	.1846	.2054	.0099	1.853	.0195	.0309	.0707	.1203	.2078	.6110	1.099

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[12]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.

3 Empirical Results

In this section we first report the results of our empirical analysis that examines the correlation between banking integration and business cycle synchronization in the period $1978-2009$. We then examine whether financial linkages to the U.S. before the crisis has affected the synchronicity of output during the 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 hit advanced economies.

3.1 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 the introduction (Table 1), 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 the causality runs from synchronization to integration.[13] To control for this issue Kalemli-Ozcan, Papaioannou, and Peydro (2012), for the period 1978–2006, use instrumental variables and found that reverse causation is not quantitatively important. Unfortunately those instruments are not available for the recent crisis period and so we'll return to the issue of causation in the model section. There we'll run these exact regressions on artificial data where we know the causation runs from integration to synchronization. The fact that we find similar coefficients in those data suggest that the estimates are indeed consistent with the view that integration determines correlation.

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 period implies that during the $2007-2009$ years an increased degree of banking integration was followed by more synchronized cycles. This result offers support to the idea that the major source of fluctuations during this period was the negative shock to the U.S. (and more generally to the international) banking/financial system.

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[13]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).

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 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.[14] 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.[15]

The total effect of financial integration $(\beta + \gamma)$ is negative, with the exception of specification (1) and (5) where we do not include 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 column (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 given the omission of the time fixed effect. 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

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[14]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.

[15]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 (2004); Aviat and Coeurdacier (2007)) 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.

during the crisis.[16]

In columns (4)-(6) 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 tranquil times a higher degree of banking linkages is associated with less synchronized, more divergent, output cycles. Yet the negative association between banking integration and output synchronization during the recent financial crisis is attenuated during the 2007-2009 crisis period.

3.2   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, several 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 past two years 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 US banking linkages during the recent financial crisis is in line with the recent work of Rose and Spiegel (2010a,b), who also fail to find a systematic correlation between international linkages to the US 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

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[16]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 and available upon request.

Table 3: Bilateral Financial Linkages and GDP Synchronization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Dependent Variable: GDP Growth Synchronization				
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 fixed	yes	yes	yes	yes	yes	yes	yes	yes
Time fixed	no	yes	yes	yes	no	yes	yes	yes
Country trends	yes	no	yes	yes	yes	no	yes	yes
Difference (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	14328	14328	14328	13567	14328	14328	14328	13567

Notes: The table reports panel (country-pair) fixed-effect coefficients estimated over the period 1978:q1–2009:q4, using 18×17 country-pairs omitting LUX and CHE. 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 the coefficients.

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.[17] Accounting for

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[17] 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

Table 4: Bilateral Financial Linkages, U.S. Financial Linkages, and GDP Synchronization

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: GDP Growth Synchronization					
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
US Linkages/GDP	0.2298	0.1177	0.0204			
	(0.1556)	(0.1563)	(0.1425)			
	1.48	0.83	0.13			
US 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		
US Broad Linkages/GDP				-0.7337***	-0.0191	-0.4836***
				(0.1518)	(0.1560)	(0.1705)
				-4.83	-0.12	-2.84
US 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 fixed	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	12452	12452	12452	10847	10847	10847

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 (US 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 (US 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 the coefficients.

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other financial centers are available only after 2000.

indirect links to the U.S. financial system appears fundamental. The coefficients on the U.S. linkages 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 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.

3.3   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 is (to some at least degree) comparable with some previous banking crises episodes in other advanced economies, namely Spain ($1977 - 1985$), Finland ($1991 - 1994$), Sweden ($1991 - 1994$), and Japan ($1997 - 2001$).[18]

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%

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

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 can not 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 country-pairs that are strongly tied to the U.S., conditional on time fixed effects and trends. This is an extremely strict specification that can separate contagion from the common shock and to the best of our knowledge the first evidence that shows transmission as a result of financial integration for the pairs that are integrated more with the U.S.

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 these 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 two, shows that the relation changes during crisis times, but does not speak about causation. Here we will use the model to derive quantitative results that show how the empirical findings are indeed fully 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. For example our model 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

Table 5: Financial Linkages and Output Synchronization in Tranquil and Turbulent Times

	(1)	(2)	(3)	(4)
Dependent Variable: GDP Growth Synchronization				
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
US Broad Linkages/GDP	0.0600	-0.4074**	0.0965	-0.3467**
	(0.1444)	(0.1663)	(0.1447)	(0.1704)
	0.42	-2.45	0.67	-2.04
US 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	10847	10847	10847	10847

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 (US 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 and Rogoff (2007) 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 the coefficients.

were financial shocks.

The model is similar in spirit to recent models of international banks (see, for example, Kolmann et. al, 2011) but one innovation is that it allows to study different degree of financial integration in a very simple fashion and thus it is well suited to analyze the effects of integration of business

cycle synchronization.

4.1 The economy

We consider a two-countries, two-sectors, one-good world. Figure 1 contains a stylized representation of the economy. In each country (foreign country variables will be 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. There are firms (F_i and F_i^*) which hire labor, make investment decisions, pay dividends and wages to households in their sector and which 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 are financially separated from the rest of the economy and banks in that sector ((B_1, B_1^*) in figure 1) intermediate only between consumers and firms within the sector. Sectors 2 are financially integrated in the sense that all consumers and firms in sector 2 in both countries have financial transactions through the same set of (global) 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 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 there is the case of $\lambda = 1$ (maximum financial integration) in which all banks are global and intermediation markets are fully integrated. Besides financial integration the two sectors in each country are identical in every respect and they are hit by the same country specific shocks to productivity z, 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. Notice that our model of banks is highly stylized: our objective is not to provide a realistic description of how the world banking system works, but to provide a simple set-up in which shocks to banking activities can have real repercussions in multiple countries under a different degree of banking integration. Also our modeling of banking/financial integration is highly simplified as the degree of internationalization of the banking system is simply captured by the exogenously given parameter, λ.
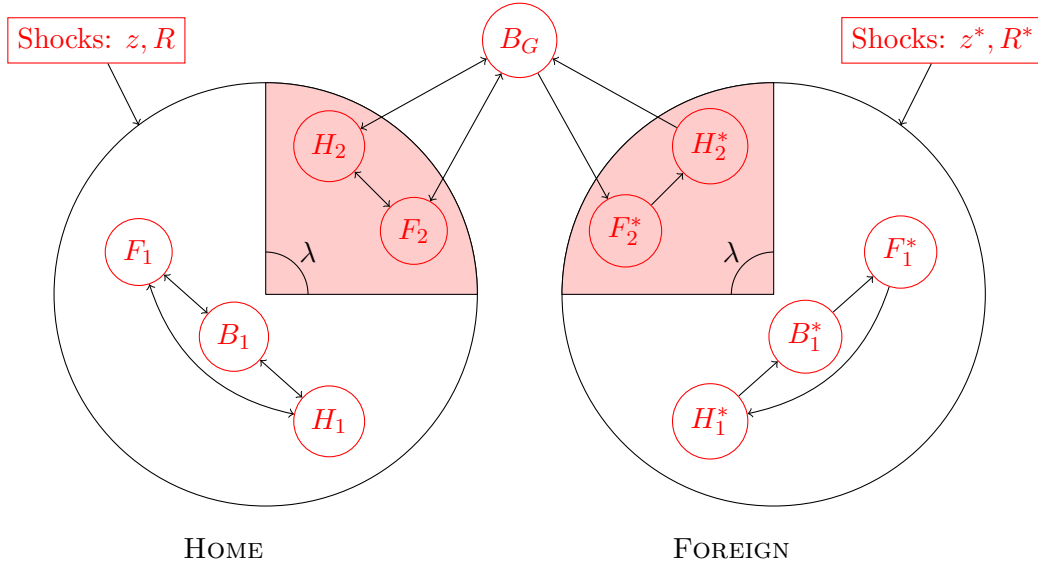
Figure 1: The Economy

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

$$E \sum_{t=0}^{\infty} \beta^t U(c_{it}, l_{it}), \qquad i = 1, 2 \tag{3}$$

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 time 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.[19] In each period they 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

$$c_{it} + \frac{D_{it+1}}{R_{it}} = w_{it} l_{it} + d_{it} + D_{it}, \qquad i = 1, 2 \tag{4}$$

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

Consumers' problem is to choose sequences for consumption, labor, and bank deposits to maximize (3) subject to (4) 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 deposit rate for sector 2 consumers is equalized across countries i.e.

$$R_{2t} = R_{2t}^*, \qquad \text{for all } t$$

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 stock (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 the banks with firms 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). The real world correspondence will be the liquidity requirement of the firm. Firms in sector i pay a gross lending rate R_{it}^e on loans from banks. As it will become clear later, due to the intermediation process, the lending rate R_{it}^e 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

$$d_{it} = e^{z_t} F(k_{it}, l_{it}) - R_{it}^e w_{it} l_{ibvt} - x_{it} \tag{5}$$

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

$$k_{it+1} = (1 - \delta)k_{it} + x_{it} - \phi k_{it} \left[\frac{x_{it}}{k_{it}} - \delta \right]^2, \qquad i = 1, 2 \tag{6}$$

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

autoregressive process

$$\begin{bmatrix} z_t \\ z_t^* \end{bmatrix} = A_z \begin{bmatrix} z_t \\ z_t^* \end{bmatrix} + \begin{bmatrix} \varepsilon_t^z \\ \varepsilon_t^{z*} \end{bmatrix} \tag{7}$$

where A_z is a $2x2$ matrix and $[\varepsilon_t^z, \varepsilon_t^{z*}]$ is a vector of *i.i.d.* innovations with mean 0, standard deviation $\sigma_{\bar{\varepsilon}}^z$ and correlation $\rho_{\bar{\varepsilon}}^z$. The problem of firms in country 1 and sector i is then

$$\max_{l_{1t}, k_{1t}, x_{1t}} E \sum_{t=0}^{\infty} d_{it} Q_{it}$$

$$s.t.$$

$$(5), (6), (7) \quad k_{i0} \text{ given}$$

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. Notice finally that in the financially integrated sectors firms can shop for banks in the two countries so we will have for the lending rates that

$$R_{2t}^e = R_{2t}^{e*}$$

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 both financially integrated sectors, i.e. their 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 the deposit 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 modelled 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.[20] We denote with R_t^m and R_t^{m*} the stochastic gross returns on risky

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[20]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.

technologies in the two countries, which we assume to have equal mean in each country. Banks first, without knowing the realizations of returns R_t^m, R_t^{m*}, 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. $0 < \bar{m} < 1$. After returns R_t^m, R_t^{m*} are observed (but not cashed in), banks compete among each other offering loans to firms in their sector. Since firms borrow to finance the wage bill, equilibrium loans of banks L_{it} are given by

$$
\begin{aligned}
L_{1t} &= w_{1t}l_{1t}, L_{1t}^* = w_{1t}^*l_{1t}^* \\
L_{2t} &= w_{2t}l_{2t} + w_{2t}^*l_{2t}^*
\end{aligned}
$$

At the end of the period banks receive the proceeds from lending to firms, from risky investments, pay back deposits plus interests to consumers and pay the 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 autoregressive process given by

$$
\begin{bmatrix} R_t^m \\ R_t^{m*} \end{bmatrix} = \begin{bmatrix} \bar{R}^m \\ \bar{R}^m \end{bmatrix} + A_R \begin{bmatrix} R_{t-1}^m \\ R_{t-1}^{m*} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^R \\ \varepsilon_t^{R*} \end{bmatrix}
$$

where A_R is a $2x2$ matrix and $[\varepsilon_t^R \ \varepsilon_t^{R*}]$ is a vector of $i.i.d.$ innovations with mean μ, standard deviation σ_ε^R and correlation ρ_ε^R. We conclude this section by acknowledging that we 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 any given bank can, and do, change the composition of their portfolio. If 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. Also the crucial ingredient here is that banks are always exposed to some additional risk that interferes with their lending to firms; the assumption that the size of this risk is constant is made for analytical simplicity.

4.2 Equilibrium

An equilibrium, for a given size of the two sectors λ, is a collection of price sequences,R_{it}^e, R_{it}, w_{it}, Q_{it}, R_{it}^{e*}, R_{it}^*, w_{it}^*, Q_{it}^*, exogenous shock processes z_t, R_t^m, z_t^*, R_t^{m*} and quantities c_{it}, l_{it}, k_{it}, x_{it}, d_{it}, D_{it}, c_{it}^*, l_{it}^*, k_{it}^*, x_{it}^*, d_{it}^*, D_{it}^* such that

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

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

$$\bar{m}R_t^{m^*} + (1 - \bar{m})R_{1t}^{e^*} = R_{1t}^* + \iota \qquad \text{for all } t \qquad (9)$$

$$\bar{m}\left(\frac{1}{2}R_t^m + \frac{1}{2}R_t^{m^*}\right) + (1 - \bar{m})R_{2t}^e = R_{2t} + \iota \qquad \text{for all } t \qquad (10)$$

Note that the right hand sides of (8, 9) represent banks' costs (per unit of deposit) in the segmented sectors in the two countries and the right hand side in (10) represents the typical global bank cost; similarly the left hand sides of (8, 9) represent revenues (per unit of deposit) from risky capital and revenues from lending to firms in the segmented sectors and the left hand side of (10) represents the global banks revenues.

2. Goods markets clear i.e.

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

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

$$c_{2t} + c_{2t}^* + x_{2t} + x_{2t}^* + (D_{2t+1} - D_{2t}) + (D_{2t+1}^* - D_{2t}^*) \qquad (13)$$
$$= e^{z_t}F(k_{2t}, l_{2t}) + e^{z_t^*}F(k_{2t}^*, l_{2t}^*) + \frac{(D_{2t}^* + D_{2t})}{R_{2t}}\left(\frac{\bar{m}}{2}\left(R_t^m + R_t^{m^*} - 2\right) - \iota\right) \qquad \text{for all } t$$

Note that 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}^*, the terms $(D_{it+1} - D_{it}), (D_{it+1}^* - D_{it}^*)$ representing the investment in banking deposits, 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 inter-mediation costs $\frac{D_{it}}{R_{it}}(\bar{m}(R_i^m - 1) - \iota)$ and $\frac{D_{it}^*}{R_{it}^*}(\bar{m}(R_i^{m^*} - 1) - \iota)$.

3. Financial intermediation markets clear, that is 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 i.e.

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

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

$$L_{2t} + L_{2t}^* = (1 - \bar{m})\frac{(D_{2t} + D_{2t}^*)}{R_{2t}} \qquad \text{for all } t \tag{16}$$

4.3 Parameterization

Unfortunately the equilibrium described above does not admit analytical solution so in order to characterize its properties we need to assign functional forms to utility and production, numerical values to various parameters and then proceed to 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 and 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).

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	$A_R = \begin{pmatrix} 0.95 & 0.0 \\ 0.0 & 0.95 \end{pmatrix}, \rho_\varepsilon^R = 0.3, \sigma_\varepsilon^R = 0.03, \bar{R}^m = 6\%$
Intermediation costs	$\iota = 4\%$

The parameters which characterize the banking sector are less standard and 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 US and other developed countries.[21].

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[21]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 $\bar{m}$ affects 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 equation 17). 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

Next regarding the stochastic process for credit shocks we assume that 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 $\rho_\varepsilon^R = \rho_\varepsilon^z$).[22] When we consider a version of the model with two types of 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 US GDP increased from about 0.5% in the 1984-2006 period to about 0.8% in the 2007-2010 period and so, attributing the entire increase in US 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 investment undertaken by the banking sector and the volatility of returns of these risky investment. The simple calibration approach though suggests that in order for these shocks to explain a significant fraction of GDP volatility, the volatility of returns of these risky investment in the banking/financial sector has to be large: much larger than the volatility of productivity shocks and comparable to the volatility of returns in stock prices.

We finally set the average return on risky assets, $\bar{R}^m$, to match an average real return on 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.[23]

4.4   The effects of shocks

Productivity shocks in this model operate similarly as in a standard two country RBC model. In the segmented sector a negative domestic productivity shock lowers labor demand and investment and hence output in the home sector, 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

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and that makes the correlation between net exports and output less negative than in the model with low $\bar{m}$

[22]We recognize that these are rather arbitrary assumptions. Our key results though, that concern the impact of integration under two different type of dominant shocks are robust to significant perturbations in these assumptions.

[23]We experiment with several values of these last two parameters, in particular with the returns on risk assets ranging from 2% to 10% and the intermediation costs ranging from 0% to 8% and the business cycle statistics produced by the model vary very little.
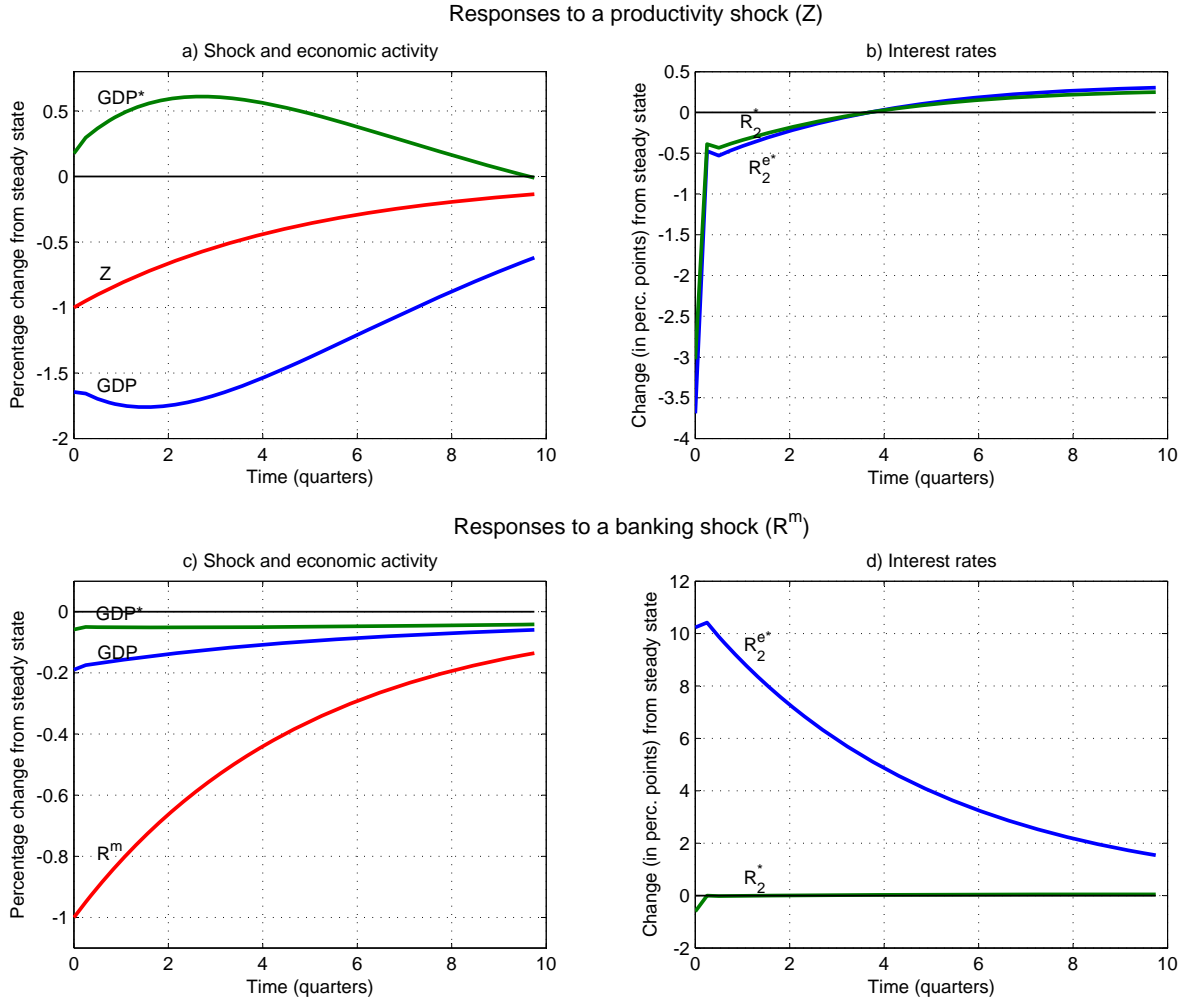
Figure 2: Impulse responses to productivity and banking shocks

increase in investment abroad. The larger the financially integrated sector (i.e. the larger λ) the more integrated are the two economies and the more a negative productivity shock at home has an expansionary effect abroad and hence the less the economies are correlated; financial integration, enabling resource flows from the less productive to the more productive country, reduces correlation between the economies. The top two panels of figure 2 show the responses of a negative domestic productivity shock. The home country contracts and foreign country expands (panel a) and the reason why foreign country expands is the fall in the sector 2 (the financially integrated) interest rates (panel b).

The shocks which are novel are the ones to returns to 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 country 1. Remember that the two key interest rates are, R_{1t}, the rate depositors receive, which represents the cost of raising funds for banks; and R_{1t}^e, the lending rate banks charge firms. 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 (8) to get

$$R_{1t}^e = \frac{1}{1-\bar{m}}\left(R_{1t} + \iota\right) - \frac{\bar{m}}{1-\bar{m}}R_t^m. \tag{17}$$

Equation (17) shows that

i) 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.

ii) Negative shocks to the return to the risky asset (rate) increase the spread between depositor rate and lending rate

iii) 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.

To further understand the effect of a financial shock figure 3 below represents equilibrium in the financially segmented sector, for a given level of k_1, z and R^m. The positively sloped line ZP represent a combination of deposit rates and lending rates that yield zero profit for banks (equation 17); they are 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 (equation 14). It is in general 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. This represents lower 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
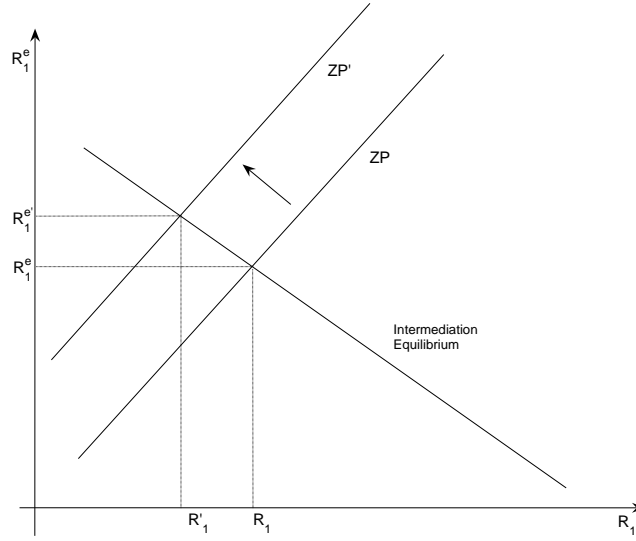
Figure 3: Equilibrium interest rates and the effect of credit shocks

from R_1^e to $R_1^{e\prime}$. Higher lending rates, through the working capital channel, reduce firms labor demand and hence equilibrium employment and economic activity falls, as a result of the shock to the revenues of the banking sector.

The effects of a negative shock to R^m in the financially integrated sector is similar with the difference that the shock gets transmitted in the financially integrated sector abroad through interest rates. 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 figure 2 above show how in response to an adverse credit shock economic activity in both countries contract (panel c). In country 1 activity contracts in both sectors because lending rates in both sectors raises, in country 2 it contracts because the lending rate in the financially integrated sector, R_2^{e*}, raises (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, 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.

4.5 Credit shocks and business cycles

In this section we use the model to assess the effects of credit shocks on several properties of business cycles.

The rows in table 7 labelled "productivity only" reports standard business statistics for the model only with productivity shocks. Note that the model generates business cycles statistics very similar (thereby sharing successes and failures) to those generated by a standard IRBC model (see for example Baxter and Crucini (1995)).

The lines labelled "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 models are worth noticing. The first is that the model with credit shocks display more internationally correlated GDP and GDP components than the model with only productivity shocks. To understand why this the case recall that in the segmented sectors the correlation in economic activity is simply driven by the correlation of the shocks (which we assumed to be the same for both shocks). The correlation between financially integrated sectors instead depends on the composition of the shocks: with dominant productivity shocks financially integrated sector tend to be negatively correlated while with dominant banking shocks they tend to be positively correlated. Since the overall correlation of the economy 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 it partially help explain the so-called "quantity anomaly" i.e. the fact that the model predicts that consumption patterns are more correlated than output internationally while in the the data usually the opposite is observed.

The second feature is that the model with both shocks generates a more volatile employment relative to GDP than the model with only productivity (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 US evidence from the recent crisis showing that much of decline of US GDP during the crisis is due to employment changes. The final feature to notice is that the model with banking shocks display 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 reduce international flow of resources (net exports).

Table 7: Business cycle statistics

	GDP	Consumption	Investment	Employment	Net Exports
		Percentage Standard Deviations Relative to GDP			
Productivity only	1.2	0.29	3.72	0.67	0.43
Productivity & 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 & credit		0.97	0.95	0.99	-0.13
		International Correlations			
Productivity only	0.24	0.41	-0.33	0.15	
Productivity & credit	0.33	0.44	-0.06	0.36	

Note: all statistics are average over 20 simulations each 200 periods long. All statistics except net exports refer to first difference in the log of the variables. Net exports statistics refer to first differences in the ratio (Exports-imports)/GDP.

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_{it}^e (see equation 17). But inspecting equations 11, 12 and 13 it is easy to see that credit shocks also increase the resources of the economy.[24] For this reason we have also considered a version of the model in which credit shocks are modelled 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

$$T_{1t} = \frac{D_{1t+1}}{R_{1t}} \left(\bar{m}(R_t^m - 1) \right)$$

and subtract T_{1t} from the budget constraint of households in that country and in that sector. By doing so we can have the same process for credit shocks as in the baseline version but now credit shocks R_t^m, $R_t^{m^*}$ 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 variant did not change the quantities properties of the model significantly so results are not available on the paper but are available in an appendix on the authors web pages.

Overall this section shows that introducing a simple form of credit shocks in a standard international business cycle model generates plausible business cycles, and helps understanding some of

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

the features that the standard model has trouble with.

4.6   Banking integration and Business Cycle Synchronization

In this last section we 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 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 integration ($\lambda = 1$). For each value of the integration we report the international correlation of GDP growth rates. The results of this exercise are reported in figure 4. Note how in the model with only productivity shocks the slope of the line is always negative, i.e more integration leads to lower correlation. This is consistent with the finding in tables 1 and 3 for the "non-crisis" periods.
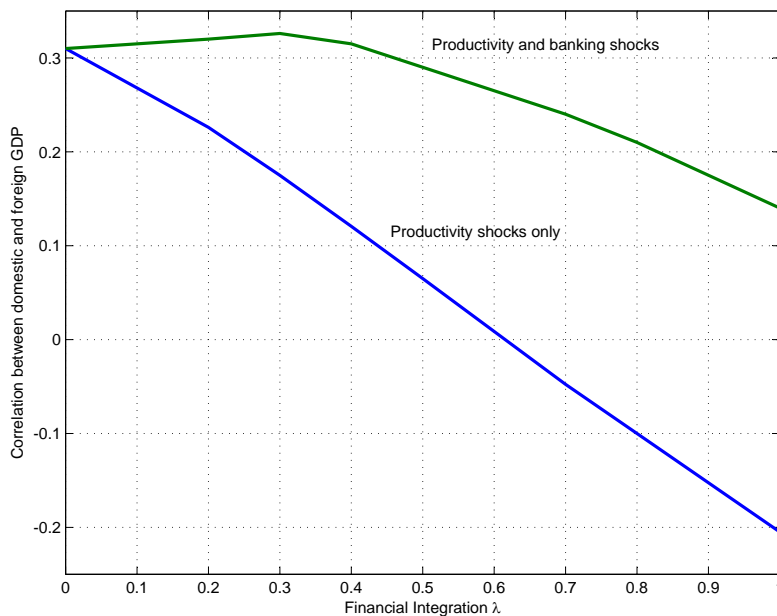

Figure 4: Integration and correlation

The curve for the model with both shocks is initially positively sloped and then declining suggesting that, in times with both shocks, the overall effect of integration on co-movement is ambiguous. Notice though that the difference between the lines is always positive and increasing, showing that the marginal effect of integration on co-movement in crisis times is positive, consistently with

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findings in tables 1 and 3.

To make the link between model and data quantitatively more precise we use artificial data generated by the model to run the same regression we run in table 3 above. In particular we simulate the model for ten couples of countries with integration parameter (λ) varying smoothly from 0 to 1. For each couple of countries we simulate the model for 200 periods with only productivity shocks (tranquil times) and with productivity shocks and banking shocks (crisis times). We then construct the same measure of GDP synchronization we used in the data analysis in table 3 above and then regress it on the log of integration (log of λ), on a dummy for crisis times and on an interaction between crisis times and integration. Results are reported in table 8 below.

On the data simulated from the model we find that integration leads to lower synchronization and that the coefficient on the interaction between integration and crisis times (i.e. period with credit shocks) is positive, suggesting again a positive marginal effect of integration. For comparisons in the table we report also the coefficients on the same regression in the data. (in particular we report specifications (1),(2) and (3) from table 3) and note that the model implies a relation between integration and co-movement which is very close to the one we measured in the data.

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	-0.249	-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)

We conclude this section summarizing the two main lessons we learn from the model.

The first is that in the model there is a clear causal, structural link from integration to business cycle co-movement. This link manifests itself in regression coefficients that relate correlation to integration, in normal and in crises times. The regression coefficients estimated on artificial data from the model are remarkably close to the ones estimated on actual data. Although this does not formally prove that integration is indeed a driver of business cycle correlation, at least it shows that such an hypothesis is entirely consistent with the data.

The second lesson is that the key ingredient that was needed in the model to weaken the negative link between integration and correlation, as in recent data, is the presence of significant credit shocks. This leads us quite naturally to conclude that indeed large credit shocks are important to understand the recent crisis.

5   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. In the first part of our analysis we use quarterly data on country-pair banking linkages from a sample of 20 developed countries between 1978 and 2009. We find that while the relationship between banking linkages and output synchronization has been negative for almost all of the times before the recent crisis, the partial correlation turned positive during the recent crisis. We also find evidence in favor of the transmission of the crisis through banking linkages. We document that countries with stronger financial ties to the U.S. and the Cayman Islands experienced more synchronized cycles with the U.S. during the 2006-2009 period. We also show that there is nothing different about this crisis since when we examine previous financial crises periods among the developed countries in our sample, we find a similar positive association between the financial linkages and output synchronization.

In the second part of our paper we develop a simple dynamic general equilibrium model of international banking that allows for both productivity and credit (bank capital) shocks. Our model nests the standard mechanism of the workhorse international real business cycle model (e.g. Backus, Kehoe, and Kydland (1992)) that financial integration magnifies total-factor-productivity shocks leading to more divergent output cycles with the contagion mechanism of recent international macro models (e.g. Perri and Quadrini (2011); Mendoza and Quadrini (2009)) where financial shocks may spread quickly globally among interconnected economies.

Our model precisely spells a causal link between financial integration and business cycle synchronization, it helps to interpret the empirical evidence and shows that exogenous changes to financial integration can have significant effects on business cycle synchronization, and that the magnitude of these effects depends on the structural shocks hitting the economy. The model with our empirical findings can help us identify sources of output fluctuations. For example our model 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 activity and thus points, in terms of future research directions to the analysis of the effectiveness, as a stabilization tool, and desirability of policies geared toward reducing capital losses of the financial/banking sector, like the 2008 bailout of the financial sector.

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