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International Capital Mobility  
and Financial Fragility - Part  
6. Are all Forms of Financial  
Integration Equally Risky  
in Times of Financial  
Turmoil? Asset Price  
Contagion During the Global  
Financial Crisis

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**INTERNATIONAL CAPITAL MOBILITY AND FINANCIAL FRAGILITY: PART 6. ARE ALL  
FORMS OF FINANCIAL INTEGRATION EQUALLY RISKY IN TIMES OF FINANCIAL TURMOIL?  
ASSET PRICE CONTAGION DURING THE GLOBAL FINANCIAL CRISIS**

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by **Rudiger Ahrend and Antoine Goujard**

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**ABSTRACT/RÉSUMÉ**

**International capital mobility and financial fragility: Part 6.  
Are all forms of financial integration equally risky in times of financial turmoil?  
Asset price contagion during the global financial crisis**

Using the 2008-09 global financial crisis, this paper examines the role of different forms of international financial integration for asset price contagion in crisis times. Defining contagion as the transmission of financial market movements beyond the co-movements that would occur in “tranquil” times, the paper looks into the presence of contagion in the period of turmoil prior to the fall of Lehman Brothers, in the main crisis period following the Lehman collapse, and in the ensuing late stages of the crisis. The analysis uses bilateral financial and trade linkages and daily data on equity and bond prices for a sample of 46 countries between 2002 and 2011. Bilateral debt integration and common bank lenders are found to have transmitted financial turmoil through equity and bond markets at the height of the crisis. During this period, real trade linkages also increased equity price co-movements. By contrast, no robust evidence is found that equity or FDI integration increased asset price co-movements during the crisis.

*JEL classification codes:* E44; F36; F44; G15

*Keywords:* asset price co-movements; financial spillovers; trade spillovers; external debt; foreign direct investments

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**Flux de capitaux internationaux et fragilité financière : Partie 6.  
Toutes les formes d'intégration financière sont-elles risquées en cas de chocs financiers?  
La contagion des prix des actifs lors de la crise financière**

Utilisant la crise financière de 2008-09, le papier identifie le rôle de différentes formes d'intégration financière sur la contagion entre les prix d'actifs de différents pays lors des chocs financiers. La contagion est définie comme un changement du rôle des liens financiers ou commerciaux bilatéraux entre la période de crise et la période la précédant. L'analyse distingue la présence éventuelle de contagion durant la période de trouble précédant la faillite de Lehman Brothers, la principale période de crise ayant suivie la faillite de Lehman Brothers et la période ayant succédé à cet épisode. L'application empirique porte sur un échantillon de 46 pays entre 2002 et 2011. L'intégration bilatérale par la dette et la présence de banques créditrices communes apparaissent comme des vecteurs de transmission des chocs pendant la principale période de crise. Au contraire, ni les Investissements Directs Étrangers ni la détention bilatérale de capitaux n'apparaissent significativement liés à une augmentation des co-mouvements des prix d'actifs pendant la crise.

*Codes JEL :* E44; F36; F44; G15

*Mots clés :* co-mouvements des prix d'actifs; intégration financière; intégration commerciale; dette externe; investissements directs étrangers

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**INTERNATIONAL CAPITAL MOBILITY AND FINANCIAL FRAGILITY: PART 6. ARE ALL FORMS OF FINANCIAL INTEGRATION EQUALLY RISKY IN TIMES OF FINANCIAL TURMOIL? ASSET PRICE CONTAGION DURING THE GLOBAL FINANCIAL CRISIS**

**By Rudiger Ahrend and Antoine Goujard<sup>1</sup>**

### **Introduction**

1. The global financial crisis has highlighted that financial turmoil can spread rapidly, as became visible *e.g.* in synchronised, large asset price movements across countries (Bunda *et al.*, 2010, Frank and Hesse, 2009). One possible explanation for such an increase in asset price correlations could be that economic fundamentals become more correlated during financial crises. Alternatively, correlations in asset prices could increase because of contagion. The strength of contagion, in turn, may depend on financial linkages between countries, and the form through which such financial integration occurs (Didier *et al.*, 2008).

2. This paper examines whether the depth and type of cross-border financial integration may lead to asset price contagion, looking at asset price co-movements prior to and during the 2007-09 global financial crisis. A difference-in-differences identification strategy is used to assess which types of financial integration lead to cross-border contagion. Financial contagion is measured as the transmission of financial market movements beyond the co-movements that would occur in “tranquil” times (Forbes and Rigobon, 2002). For instance, contagion through bilateral debt integration is inferred if asset price co-movements increase more during the crisis (compared to normal times) for country pairs that hold larger shares of the external debt of their partner, relative to country pairs whose external debt is mainly held by third-party countries.

3. A large body of both theoretical and empirical work, reviewed *e.g.* in Kaminsky *et al.* (2003), explores how financial turmoil is transmitted. Beyond the possibility that the spreading of financial turmoil may be caused by common shocks, it has identified real trade and financial linkages as the main mechanisms of bilateral crisis transmission across countries. Both linkages can work directly or indirectly.<sup>2</sup>

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2. Financial and trade channels may not operate independently. For example, the co-movements of equity stocks may depend both on export prospects and the dependence on international trade finance of firms. Focusing on the United States, Levchenko *et al.* (2010a; 2010b) find no evidence that trade credit and other financial factors played a role in the collapse of US exports during the crisis. However, their results contradict the evidence in Amiti and Weinstein (2009) and Ahn *et al.* (2011) that suggests a causal role of finance on trade.

Direct trade effects arise, for example, when a negative shock on a country's trading partner negatively affects the country's exports, which in turn may increase the co-movement of equity markets in the two countries. Indirect trade effects can occur when crisis-driven currency devaluation that (temporarily) increases a country's competitiveness negatively affects its trade competitors (Gerlach and Smets, 1994; di Giovanni and Levchenko, 2010), thereby increasing co-movement of their equity markets. During the recent crisis, the size of trade shocks dwarfed historical levels which could partly explain particularly high financial asset co-movements during this period (Levchenko *et al.*, 2010a; 2010b).

4. Other studies have emphasized the role of financial linkages in contagion. The so-called "wake-up call" hypothesis relies on information asymmetries in financial markets to explain financial contagion: a crisis in one country can push investors to re-evaluate the riskiness of their asset holdings in countries with similar vulnerabilities, or about which they have only limited information. Information asymmetries about asset quality have been shown both theoretically (Caballero and Simsek, 2009) and empirically (de Haas and van Horen, 2011) to be especially important in crisis times.

5. The deterioration of countries' balance sheets due to capital losses on external assets may also cause contagion, with effects being amplified by financial integration. International transmission of shocks on asset prices through the balance sheets of leveraged financial intermediaries has been referred to as the "international financial multiplier" (Krugman, 2008). Domestic banks that make loans to foreign entrepreneurs will see their balance sheet negatively affected when the foreign country is hit by a shock. If these banks have to satisfy prudential regulations such as capital adequacy requirements, they may respond to increased losses on their foreign loan portfolio by reducing the supply of credit to both domestic and foreign borrowers, thereby potentially transmitting weakness in foreign equity prices to the domestic market. Didier *et al.* (2011) and Kalemli-Ozcan *et al.* (2011) find that countries with a higher level of banking integration with the United States had higher equity-price and output co-movement with the United States during the recent crisis.<sup>3</sup> Similarly, banks may react to losses in one foreign country by reducing credit to this and other foreign countries, thereby creating common-creditor contagion among their debtor countries.

6. Risks to financial stability from debt and banking integration are generally thought to differ from those of equity and – in particular – FDI integration:

- Holders of debt or loans are likely to have an inferior knowledge of their assets than equity and especially FDI investors, increasing uncertainty-aversion driven sales in times of financial turmoil (Ahrend and Schweltnus, 2012).
- Holders of debt assets or loans may be more credit-constrained in situations of financial turmoil than – often less leveraged – holders of foreign equity and especially FDI (Davis, 2011).
- Foreign banks may reduce their cross-border exposure by not rolling-over existing loans.
- As debt and equity are more liquid than FDI, distressed investors can sell these assets more easily. This may feed a fire-sale dynamics that sees deteriorations in asset prices and thereby in balance sheets resulting in the need for further sales.

7. The contribution of this paper to the literature on contagion is twofold: First, existing studies mostly explore correlations with one "main" crisis country or examine the international propagation of

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3. Boyer *et al.* (2006) provide more comprehensive, but indirect evidence in favour of this mechanism by comparing correlations of stock market returns accessible to foreigners and non-accessible to foreigners.

shocks from high-income countries to developing countries.<sup>4</sup> For example, the available empirical evidence on contagion during the latest financial crisis largely focuses on the effects of financial integration with the United States on domestic equity markets (Bekaert *et al.*; 2011; Didier *et al.*, 2011; Rose and Spiegel, 2010).<sup>5</sup> In contrast, this paper examines bilateral asset price co-movements for a large sample of developed and developing economies. Second, as emphasised by new theoretical models of international business cycles (Devereux and Yetman, 2010; Davis, 2011), different forms of financial integration could have different implications for financial co-movements. This work therefore examines the empirical importance for financial contagion risk of different financial bilateral linkages through cross-border equity and FDI ownership, or credit market integration.

8. More precisely, using daily equity and bond prices, the empirical analysis builds bilateral measures of co-movements between asset prices. It then explores whether different forms of bilateral integration have influenced the difference in co-movements of equity and bond prices during the latest financial crisis and during “normal” times. Controlling for all country-pair time-invariant characteristics that could affect both financial co-movements and bilateral asset holdings, this difference-in-differences identification strategy disentangles the increases in bilateral co-movements of financial markets that may be due to bilateral linkages from those due to common global shocks, or changes in asset-price volatility. Importantly, in addition to considering financial and trade linkages, the specification also controls for bilateral distance and similarity of industrial structure. Both of these variables have been shown to partly determine bilateral asset holdings (*e.g.* Lane and Milesi-Ferretti, 2008; Ahrend and Schwellnus, 2012) and could be associated with an increase in asset price co-movements during the crisis.

9. The main results of the empirical analysis are as follows:

- Bilateral debt integration, *i.e.* the share of the external debt of both countries held within the country-pair, is found to have strongly amplified asset price contagion during the global financial crisis in both equity and bond markets. In contrast, little robust evidence is found that equity and FDI integration increased asset-price contagion.
- Indirect banking integration among countries through common creditor banks is found to have significantly increased international asset-price contagion in both equity and bond markets. This likely reflects that leveraged financial intermediaries can propagate financial turmoil to their debtor countries through portfolio re-balancing or a contraction in cross-border lending.<sup>6</sup>
- Real international trade linkages are found to have also played a significant role in the propagation of the global financial crisis through asset price contagion in equity markets. This finding is in sharp contrast to papers that restrict their focus to the transmission of the recent crisis from the United States to other countries.
- The role of bilateral distance, that may partly proxy for information asymmetries, appears to have increased during the crisis: more distant countries displayed significantly less asset-price co-movements than in “normal” times.

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4. For example, Kaminsky and Reinhart (2001), Van Rijckeghem and Weder (2001) and Didier *et al.* (2011) focus on historical crisis episodes and define the mechanism of propagation as originating in one country (Russia, Mexico, Thailand or the United States for the recent financial crisis).

5. A related literature explores the relationship between cross-border bank lending and banks’ behaviour during the crisis (Cetorelli and Goldberg, 2011; de Haas and van Horen, 2011).

6. Ahrend and Goujard (2011) provide more general empirical evidence that contagion through bank balance sheets contributes to spread financial turmoil across countries.



- Results are robust to a number of robustness checks, including the introduction of additional control variables for regional shocks, alternative measures of financial co-movements, or the use of weekly asset returns.

10. The remainder of this paper is divided in four sections. Section 1 briefly discusses the measures of financial co-movements and describes the difference-in-differences methodology adopted for the empirical analysis. Section 2 describes the underlying data and presents some descriptive evidence on asset price contagion during the 2007-09 crisis. Section 3 presents the main econometric results for equity and bond price contagion. Section 4 presents a range robustness checks.

## 1. Methodology

### 1.1. Measuring financial co-movements

11. Measuring cross-border asset price co-movements is particularly challenging and requires high-frequency data (Merton, 1980). Bilateral co-movements are measured for equity and debt markets. Following most of the existing literature, daily returns are computed as percentage changes in US dollars (e.g. Forbes and Chinn, 2004). The preferred measure of asset price co-movements is related to the cross product of the daily returns of country  $i$  and country  $j$ .

$$Comov_{ijt} = r_{it}r_{jt} \quad , \quad (1)$$

where  $r_{it}$  and  $r_{jt}$  are daily rates of returns at time  $t$  in country  $i$  and country  $j$ .<sup>7</sup> As noted by Anton and Polk (2010), this measure of co-movements does not require defining *ex-ante* expected market returns or their realised variance.<sup>8</sup> The empirical analysis controls later for increased volatility in returns during the crisis by adding time-varying fixed effects for both countries. Another measure of co-movements developed by Giannone *et al.* (2010) and used by Kalemli-Ozcan *et al.* (2012) which takes into account the absolute difference of asset returns in both countries yields similar results (see Section 4).<sup>9</sup>

12. As the main interest is in the changes of co-movements over time, the preferred measure of co-movement is based on daily data. They are more likely to capture investors' behaviour or change in market conditions than co-movements measured at lower frequency. Furthermore, the empirical specifications control for country-pair fixed effects that capture many time-invariant characteristics that could impact the level of co-movement such as non-overlapping trading hours. For example, King and Wadhvani (1990) argue that overlapping opening hours of stock markets explain observed cross-country correlations. However, daily co-movements do not allow for any lags in contagion beyond a few hours. This restrictive definition of contagion may lead to some form of measurement error and may bias the estimates towards finding no result. Another related concern is that daily returns of less liquid assets may be based on a limited number of transactions. Therefore, as a robustness check, Section 4 uses weekly co-movements and daily co-movements corrected for trading non-synchronicity. Weekly data and corrected daily data have the shortcoming of substantially reducing the number of observations, but they lead to similar results than the ones obtained with daily measures of asset price co-movements.

### 1.2. Empirical specifications

13. Equity and bond price co-movements are then related to different forms of bilateral financial integration of the country pair to examine whether, and to what degree, different forms of financial

7. Formally,  $r_{it} = (\ln(p_{it}) - \ln(p_{it-1})) \times 100$ , where  $p_{it}$  is the price of the asset at time  $t$ .

8. Furthermore, it has lower estimation errors and serial correlation than rolling correlations.

9. This measure is defined as  $Synch_{ijt} = -|r_{it} - r_{jt}|$ .

integration contributed to asset price contagion during the global financial crisis. The analysis compares the average co-movements after the collapse of Lehman Brothers to average co-movements before the start of the crisis in a difference-in-differences framework. The bilateral specification allows controlling for all time-invariant characteristics of the country pair that can influence both financial market integration and financial market co-movements, such as similar institutional environments or comparable levels of economic development, by adding country-pair fixed effects. More precisely, the specification compares the period between January 2002 and May 2007 to subsequent time periods: the early stages of financial turmoil (June 2007 to the collapse of Lehman Brothers), the peak of the crisis (15<sup>th</sup> of September 2008 to May 2009), and the period starting June 2009.  $Turm_t$ ,  $Cri_t$  and  $Post_t$  are dummy variables for the three latter time periods.<sup>10</sup> The baseline specification relies on a bilateral fixed effects equation:

$$Comov_{ijt} = \sum_k (\beta_{T,k} Turm_t + \beta_{C,k} Cri_t + \beta_{P,k} Post_t) Integ_{ij,k} + \alpha_{ij} + \delta_t + \varepsilon_{ijt} \quad , \quad (2)$$

where  $i$  and  $j$  index the countries, and  $t$  the period of observation. The measures of bilateral financial integration,  $Integ_{ij,k}$ , are time invariant variables that measure bilateral financial linkages, trade linkages, bilateral distance, and the similarity of industrial structure, respectively. Recent empirical evidence is mixed about the relationship between cross-border holdings and asset price co-movements. While the dynamics of bilateral cross-country holdings may be partly determined by diversification gains (Coeurdacier and Guibaud, 2011; Pyun, 2011), the cross-sectional relationship between bilateral holdings and asset price co-movements suggests that investors tend to hold equity in destinations with similar stock market behaviour (Lane and Milesi-Ferretti, 2008). Though the two mechanisms are different, both would imply that bilateral asset holdings are jointly determined with asset price co-movements. In order to minimise this potential endogeneity problem, the analysis relies on the beginning-of-period values of the financial integration variables (2001). Similarly, beginning-of-period values (2001) are also used for trade integration and industry specialisation.<sup>11</sup>

14. The  $\beta$  coefficients capture the different effects of bilateral linkages in the different stages of the crisis with respect to normal times (January 2002 and May 2007). If  $\beta_C$  the effect of bilateral integration during the crisis with respect to normal times, turns out to be significantly different from zero, this would provide evidence of contagion since the role of financial integration in normal times cannot explain the extent of co-movement in asset prices during the crisis (Bekaert *et al.*, 2005; 2011).<sup>12</sup> The first parameter,  $\beta_T$ , measures if there is some evidence of asset price contagion in the early stages of financial turmoil. The last parameter,  $\beta_P$ , allows assessing if there is some hysteresis in financial market behaviour in the aftermath of the crisis, that is if bilateral linkages tend to transmit financial shocks in the same way in the post-crisis period as in normal times (January 2002 and May 2007).  $\alpha_{ij}$  captures bilateral time-invariant characteristics that could affect the level of financial co-movement and financial integration between the two countries.<sup>13</sup>

10. These crisis dates have been widely used in the literature. However, there is some margin of ambiguity about the exact timing of the crisis. Cetorelli and Goldberg (2011) focus on the period used in this paper. Didier *et al.*, (2011) consider September of 2008 until April 2009. Calomiris *et al.* (2010) use August 2007 to December 2008. Bekaert *et al.* (2011) consider alternatively 7<sup>th</sup> August 2007 or 15<sup>th</sup> September 2008 as the start of the crisis. Section 4 shows that the estimated contagion mechanisms are robust to alternative periods of comparison.

11. The vector  $Integ_{ij}$  is measured in 2001. This induces some measurement error on asset holdings. However, bilateral asset holdings are relatively stable over time. The respective correlations between debt, equity and FDI bilateral integration at the end of 2001 and 2007 are all above 0.8.

12. Part of the literature defines this type of contagion as “shift contagion” (*e.g.* Gravelle *et al.*, 2006).

13. Flavin *et al.* (2001) study the cross-sectional drivers of co-movements across financial markets that are controlled for by  $\delta_{ij}$ .

15. In theory, increased co-movements between two countries during the crisis could simply be the consequence of their exposure to common shocks, implying the need to control for the latter. Following a procedure commonly adopted in the trade literature (Okawa and van Wincoop, 2010), Equation 2 is therefore alternatively estimated with period fixed effects,  $\delta_t$ , that account for global common shocks, or with controls for regional-specific shocks. The first option is used by Kalemli-Ozcan *et al.* (2011; 2012) to study the link between business cycle coordination and banking integration. The parameters  $\delta_t$  capture unobserved macroeconomic and financial shocks that affect all countries in a similar manner, such as the large swing in prices that occurred during the global financial crisis. However, this specification may be subject to some form of omitted variable bias, if the mechanism of interest is the bilateral transmission of financial turmoil. For example, co-movements between the United States and Canada may increase because of regional shocks rather than the high financial integration between the two countries. Hence, as a robustness check, Equation 2 is also estimated including region-period fixed effects that control for time-varying regional shocks, such as time-varying expected returns or time-varying risk loading factors. Formally, this amounts to replacing  $\delta_t$  by  $\delta_{t,r1} + \delta_{t,r2}$ , where  $r1$  and  $r2$  are the regions of country  $i$  and  $j$  in Equation 2. Both specifications account for serial autocorrelation and heteroskedasticity by clustering the standard-errors at the country pair level.

16. The variables included in  $Integ_{j,k}$  are particularly important. This paper innovates by simultaneously controlling for different forms of bilateral financial integration, bilateral trade integration, geographical distance, and similarity of industrial structure when measuring the increase in financial co-movement in a period of financial crisis. Therefore, omitted variable bias in the estimated importance of these bilateral linkages should be limited. However, even these comprehensive specifications are incomplete, and numerous bilateral linkages cannot be included as bilateral data are unavailable. For example, non-bank common creditors may have played a role in the propagation of the crisis which is not possible to identify with the available data (Kaminsky *et al.*, 2003; 2004). Two findings mitigate this caveat. First, the point estimates of the financial integration variables are nearly identical without and with controls for region-specific shocks. Second, the estimated contagion effects during the crisis are of similar sign and magnitude when measured with respect to the pre-crisis or the post-crisis period. This implies that any omitted variable likely to bias the results should not only display cross-country correlation with the measures of financial linkages, but also a similar hump-shaped impact (over time) on financial co-movements, which seems highly unlikely.

## 2. Data and descriptive statistics

### 2.1. Financial market co-movements

17. The analysis focuses on co-movements between country pairs starting in 2002 as a large database on bilateral assets holdings is first available for end-2001. The sample period covers January 2002 up to November 2011. Daily returns were calculated for national equity and bond markets. Compared to other studies using a similar econometric approach, this paper relies on a large sample of countries: 43 for bond and 46 for stock markets.<sup>14</sup> Bond prices were taken from Citigroup (retrieved *via* Bloomberg) whenever available, and completed with information from Datastream. Equity prices and exchange rates were taken from Datastream.

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14. For example, Coeurdacier and Guibaud (2011) cover 27 source countries. However, a caveat regarding the interpretation of the results of this paper is that equity and bond prices as well as bilateral financial data are mostly available for advanced economies. Hence, some caution is necessary in generalising the results to bilateral linkages between developing economies. Table A2 in the Appendix presents descriptive statistics about the returns of the different financial markets.

18. Table 1 displays summary statistics for co-movements between countries for the four periods of interest: the first period corresponds to "tranquil times" (January 2002 to June 2007). The second period (June 2007 to September 2008) corresponds to the onset of the sub-prime crisis, while the third period (September 2008 to June 2009) represents the height of the crisis in the wake of Lehman Brothers' bankruptcy. Finally, the period after June 2009 corresponds to some degree to a post-crisis period that allows assessing if co-movements decrease to their pre-crisis levels. To better understand how the strength of bilateral co-movements differs between selected country groups, Table 1 reports the average financial market co-movements for the whole sample of countries, within OECD countries, and for all countries with the United States (the latter being often considered as the epicentre of the 2007-09 financial crisis).

**Table 1. Cross-border financial co-movements and the global financial crisis**

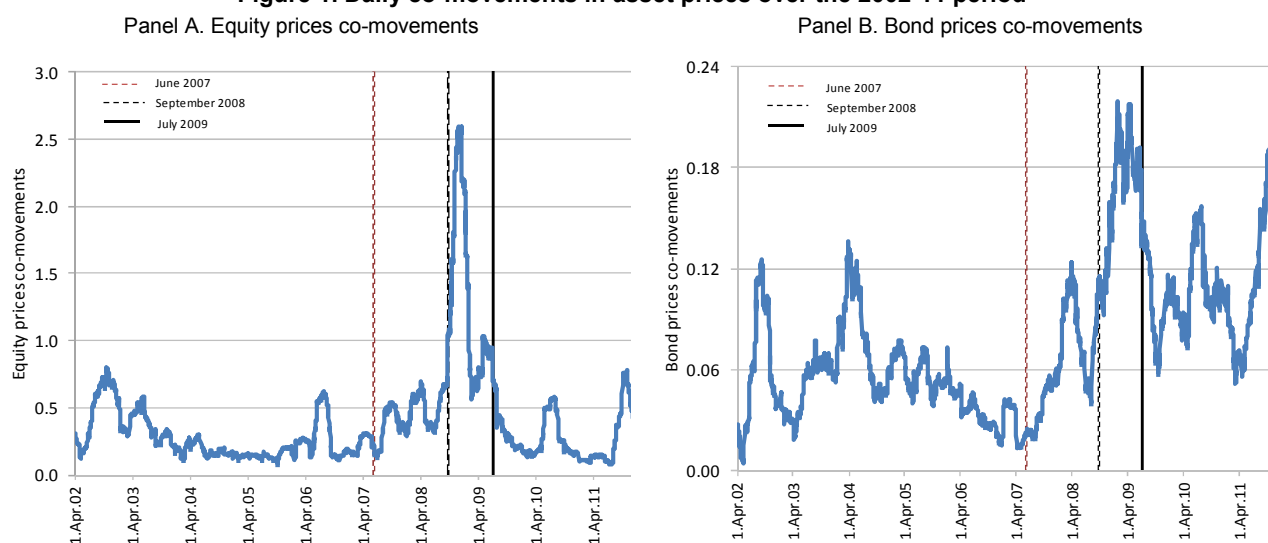
	1/1/2002 to 31/5/2007	1/6/2007 to 14/9/2008	15/9/2008 to 1/6/2009	1/6/2009 and later
<b>A. Equity prices</b>				
All countries	0.28	0.48	1.43	0.27
Among OECD countries	0.46	0.79	1.95	0.46
With the United States	0.21	0.40	1.14	0.31
<b>B. Bond prices</b>				
All countries	0.04	0.07	0.17	0.12
Among OECD countries	0.07	0.15	0.48	0.24
With the United States	0.00	0.03	0.04	0.05

Note: Period averages of cross-country daily co-movements are measured using the cross-product of daily returns.

Source: Bloomberg; DataStream; OECD calculations.

19. The equity and bond market co-movements display a similar time pattern for the three different country samples. The extent of co-movements increases somewhat in the early stages of the crisis, with a sharp increase in the wake of the Lehman Brothers bankruptcy, and – especially in equity markets – some degree of normalisation after September 2009.

20. The results are confirmed by a non-parametric inspection of the daily co-movements of equity and bond markets over time for the whole set of country pairs (Figure 1). In the early stages of the US subprime crisis (mid-2007) the co-movement in all markets started to increase. The period following the collapse of Lehman Brothers, in September 2008, marked the height of the propagation of the financial crisis. Cross-border co-movements then decreased sharply during the summer of 2009 (with bond price co-movements strongly increasing again in 2011 as the European debt crisis unfolded).

**Figure 1. Daily co-movements in asset prices over the 2002-11 period**

Note: Co-movements are measured using the product of the daily return in country *i* with the daily return in country *j*. The solid line represents the 90 day lagged moving average over all country pairs. Vertical lines in June 2007, September 2008 and July 2009 represent key crisis dates (Didier *et al.*, 2011; Cetorelli and Goldberg, 2011).

Source: Bloomberg; DataStream; OECD calculations.

## 2.2 Measures of bilateral linkages

21. This section presents the measures of bilateral financial linkages, real trade integration and additional controls such as bilateral distance and similarity of industrial structure.<sup>15</sup> Measures of bilateral integration are computed at the end of 2001. The measures are scale independent (see below) and capture the allocation of trade and financial assets across partner countries.<sup>16</sup> The analysis makes a clear distinction between financial integration through portfolio debt (bonds), portfolio equity (shares), foreign direct investment (controlling equity stakes, FDI), bank transactions (mainly loans and deposits) and exposure to common creditors.<sup>17</sup>

22. Bilateral foreign debt- and equity securities are taken from the IMF Consolidated Portfolio Investment Survey (CPIS). The CPIS reports bilateral portfolio equity and debt holdings for 74 reporting countries and 231 partner countries. While around half the countries reporting to the IMF CPIS are emerging countries, China and some major oil-exporting countries, such as Saudi Arabia, are not included as reporters in the IMF CPIS. The CPIS data include private portfolio holdings but exclude official holdings, such as foreign reserve holdings of central banks. Holdings of quasi-official entities, such as sovereign funds, are generally included. As the sample of reporting countries is limited, total external foreign assets and liabilities are taken from the updated database of external asset holdings of Lane and

15. The cross-border exposure of individual banks, firms and institutions may have played a role in the propagation of financial turmoil but these mechanisms cannot be measured with the available data (see *e.g.* Cerutti *et al.*, 2011).

16. The definition of the main variables is detailed in the Appendix in Table A1.

17. The different forms of bilateral integration may be partly blurred. For instance, the threshold for classifying equity transactions as FDI is set arbitrarily at 10% of a firm's equity, possibly resulting in some equity transactions conducted for pure portfolio motives, *i.e.* not targeting controlling equity stakes, being misclassified as FDI and *vice versa*. These caveats notwithstanding, considerable improvements in the measurement of disaggregate financial account positions over recent years allow drawing robust policy conclusions from these data.

Milesi-Ferreti (2007) that covers 178 economies from 1970 to 2007. Formally, the bilateral integration for financial assets  $A$  between countries  $i$  and  $j$  is defined as follows:

$$Integration(A)_{ij} = \frac{Assets(A)_{ij} + Liabilities(A)_{ij} + Assets(A)_{ji} + Liabilities(A)_{ji}}{Assets(A)_i + Liabilities(A)_i + Assets(A)_j + Liabilities(A)_j} \quad (3)$$

This is equivalent to:<sup>18</sup>

$$Integration(A)_{ij} = \frac{2 \times (Assets(A)_{ij} + Assets(A)_{ji})}{Assets(A)_i + Liabilities(A)_i + Assets(A)_j + Liabilities(A)_j} \quad (4)$$

where in both cases, the numerator is evaluated using the CPIS and the denominator is evaluated using the updated data from Lane and Milesi-Ferreti (2007).

23. CPIS data were completed by data on bilateral FDI integration and bilateral banking integration. FDI bilateral asset holdings, measured at the end of 2001, are taken from the OECD International Direct Investment database which covers 34 reporting and 217 partner countries. For bilateral banking integration, BIS Locational Banking Statistics are used which are available for 25 reporting countries and 205 partner countries. This database reports the liabilities towards banks of BIS reporting countries mainly through inter-bank loans and deposits on a balance of payment principle.<sup>19</sup> Bilateral FDI and banking integration are computed using Equation 4 whenever the data are available as it makes use of all the available information. Indeed, there are some discrepancies or measurement errors in the data reported by different countries for FDI assets and liabilities. If only one country of the country pair reports its assets and liabilities towards the partner country, Equation 4 is used instead.<sup>20</sup>

24. Real trade linkages are measured by the share of within-country-pair exports for the two countries in 2001. The data come from the UNCTAD COMTRADE dataset and cover 79 countries.<sup>21</sup> Finally, the specifications use (the logarithm of) distance and a measure of the dissimilarity of industrial structure as control variables to provide additional support for a causal interpretation of the estimated effects of financial and trade integration. Bilateral distance is a proxy for information frictions and unobserved bilateral linkages, while the similarity of industrial structure is a proxy for common industrial shocks that may affect countries with similar industry structures. As the similarity of industrial structure is correlated with bilateral asset holdings, global industry-specific-shocks could move equity market returns in both countries in the same direction and thereby bias the estimated effect of some forms of financial integration. More precisely, the control variables are as follows:

- **Geographical proximity** is the (logarithm of) bilateral distance taken from the CEPII distance database.
- **Industry dissimilarity** is constructed using Krugman's definition (1991). Industry dissimilarity between the two countries is computed using the cross-sectional shares of output in 2001 from

18. Bilateral financial integration can only be defined if both country  $i$  and country  $j$  are CPIS reporting countries. As CPIS countries only report their asset holdings, the two formulas are numerically identical.

19. As the countries reporting to the BIS are developed countries and financial centres, the analysis mostly ignores bilateral banking linkages between developing countries.

20. For bilateral banking integration, BIS reporting countries report their assets and liabilities towards host countries and equation 4 is used.

21. Both import and export integration are typically significant in explaining financial co-movements. The empirical specification follows Lane and Milesi-Ferretti (2008) and uses aggregate trade as explanatory variable. In the empirical analysis, similar – somewhat less precise – estimates are obtained if trade integration is measured through exports only.

the UNIDO industrial statistics database that covers the manufacturing sectors of 89 countries.<sup>22</sup> Formally, the index is given by:

$$\text{Industry Dissimilarity}_{ij} = \sum_{s \in \text{industrial sectors}} \left| \frac{o_{is}}{o_i} - \frac{o_{js}}{o_j} \right|, \quad (5)$$

where  $o_{is}$  and  $o_{js}$  represent the output of sector  $s$  in countries  $i$  and  $j$  and  $o_i$  and  $o_j$  are total industrial outputs measured in 2001. This index takes higher values if countries  $i$  and  $j$  tend to specialise in different manufacturing industries, *i.e.* they are “dissimilar”.

25. In periods of financial turmoil, international banking integration may also adversely affect financial stability through third-party countries. The exposure to **common creditor banks** is measured as proposed by Van Rijckeghem and Weder (2001):

$$\text{Common Creditors}_{ij} = \sum_{c, c \neq i, c \neq j} \left\{ \frac{b_{ic} + b_{jc}}{b_i + b_j} \right\} \times \left( 1 - \left| \frac{b_{ic} - b_{jc}}{b_{ic} + b_{jc}} \right| \right), \quad (6)$$

where  $c$  stands for the common creditor countries,  $b_{ic}$  and  $b_{jc}$  represent bank lending of country  $c$  towards countries  $i$  and  $j$ , and  $b_i$  and  $b_j$  are total bank lending amounts by BIS-reporting countries towards  $i$  and  $j$  (BIS Locational Statistics, end of 2001). The first term in curve brackets measures the share of the common lender in the external bank borrowing of countries  $i$  and  $j$ . The second term in absolute value represents, for each debtor country, the similarity in its borrowing patterns to that of its partner country. The overall indicator captures the extent to which countries  $i$  and  $j$  compete for funding from similar creditor countries.

26. Table 2 reports pair-wise correlations between measures of financial and non-financial bilateral linkages in 2001.<sup>23</sup> Pair-wise correlations between different forms of direct financial integration range from 0.6 to 0.8. Financial integration is also highly correlated with trade integration, around 0.6-0.7, which is in line with previous findings of Lane and Milesi-Ferretti (2008) for bilateral equity holdings. This is consistent with the view that countries have a tendency to trade with, and invest in, the same types of countries – which in turn are likely to be those they know well – and likely also reflects the role of trade finance in bilateral asset holdings.<sup>24</sup> These high correlations between bilateral asset holdings and bilateral trade also highlight that it may be extremely difficult in non-crisis times to disentangle the effects on asset price co-movements of different forms of financial linkages from those of trade linkages. However, the large swings in equity and bond market prices during the global financial crisis and the large sample of countries allow disentangling these effects, which is an important contribution of this paper.<sup>25</sup>

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22. Industries are defined at the 3 digit International Standard Classification System (ISIC) level.
23. Reported correlations are linear correlations. Similar patterns are observed using Spearman rank correlations (not reported). Table A3 of the Appendix displays descriptive statistics for the different potential channels of transmission. The availability of bilateral data varies widely among indices.
24. Bilateral asset holdings are also negatively correlated with bilateral distance, a proxy of information frictions.
25. In order to assess the robustness of the estimated effects to potential multicollinearity problems, different combinations of the explanatory variables are introduced in the regressions without affecting the main results.

**Table 2. Correlation between different measures of bilateral financial integration in 2001**

Financial linkages	Linear correlation between bilateral linkages <sup>1</sup>						
	Debt	Equity	FDI	Bank	Common creditors	Trade	(log) distance
Debt integration							
Equity integration	0.78						
FDI integration	0.58	0.67					
Banking integration	0.66	0.72	0.71				
Exposure to common creditor banks	0.39	0.29	0.31	0.40			
<hr/>							
Non financial linkages							
Trade integration	0.57	0.57	0.69	0.57	0.21		
(log) distance	-0.29	-0.24	-0.30	-0.26	-0.19	-0.31	
Industry dissimilarity	-0.06	-0.06	-0.06	-0.06	-0.10	-0.07	0.10

1. Pair-wise linear correlations are reported. The definition of each of the variables is reported in Table A1 of the Appendix.

2. All variables are measured at the end of 2001.

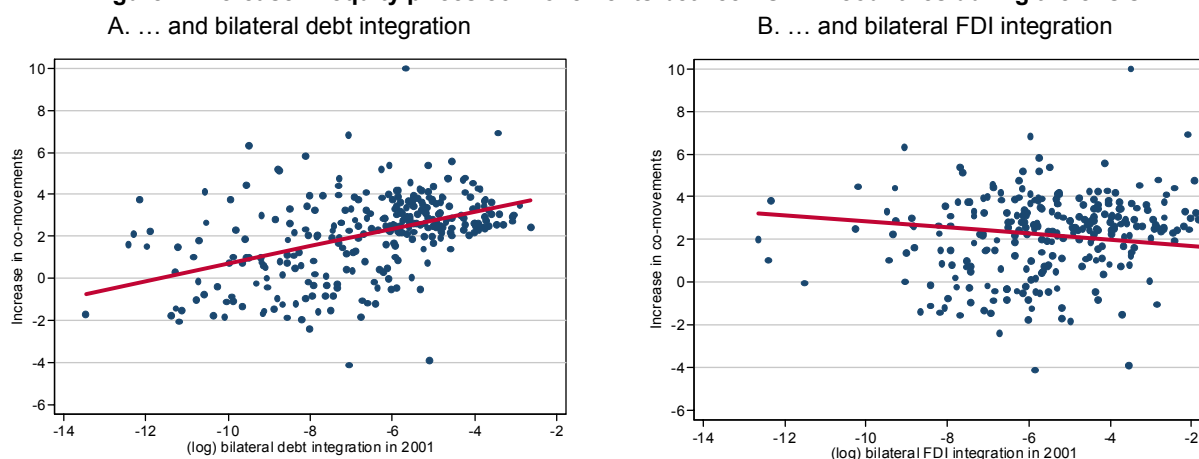
Source: IMF CPIS; BIS bilateral locational banking statistics; OECD FDI bilateral statistics; UNCTAD bilateral trade statistics; OECD calculations.

### 3. Empirical evidence

#### 3.1. Equity price co-movements during the crisis

27. Simple empirical evidence suggests that deeper bilateral financial integration *via* debt resulted in a larger increase in stock market co-movements between OECD countries during the recent financial crisis (Figure 2, Panel A). In contrast, there appears to be no systematic positive relationship between the degree of bilateral financial integration through FDI and the increase in equity price co-movements during the crisis, once bilateral debt integration is controlled for (Panel B).<sup>26</sup>

**Figure 2. Increase in equity prices co-movements between OECD countries during the crisis**



Note: Each dot represents the change in equity price co-movements between the pre-crisis period (January 2002 to May 2007) and the crisis period (15 September 2008 to May 2009) for a country pair. The solid line represents the ordinary least squares fitted line. Panel A shows the results from regressing the increase in equity price co-movement during the crisis on (the logarithm of) bilateral debt integration. Panel B shows the results from regressing the increase in equity price co-movement during the crisis on (the logarithm of) bilateral debt integration and bilateral FDI integration.

Source: IMF CPIS; Bloomberg; Datastream; OECD calculations.

28. The illustrative evidence of the graphs is confirmed by more sophisticated econometric analysis that controls for country and period fixed effects, a wide range of alternative measures of financial

26. Descriptive statistics display a similar pattern for the whole sample. However the large number of country pairs with low level of financial integration blurs the main picture.



integration, proxies for information frictions and global sectoral shocks. Table 3 reports the estimates of the additional effect of different forms of financial integration on stock market co-movements during the global financial crisis compared to normal times (January 2002 to June 2007), corresponding to the parameters  $\beta_C$  in Equation 2. Hence, a  $\beta_C$  coefficient significantly different from zero corresponds to a bilateral linkage that transmitted shocks differently during the crisis compared to normal times, thereby leading to equity-price contagion.<sup>27</sup> Each form of bilateral linkages has been standardised in order to ease the comparison between the different point estimates. Bilateral equity holdings appear to increase equity co-movements during the crisis (Column 1), but this effect is not robust to adding other forms of financial integration to the specification. In contrast, bilateral debt integration robustly increases equity co-movements during the crisis (Columns 2 and 3). Finally, there is no empirical evidence that FDI integration contributed to the propagation of financial turmoil through equity markets (Column 3). This evidence is in line with Ehrmann and Fratzscher (2009) and Didier *et al.* (2011) who, examining how the crisis was transmitted from the United States to the rest of the world, find that financial linkages contributed to spread financial turmoil through equity markets. However, while Ehrmann and Fratzscher (2009) find no substantial differences between different forms of financial integration, the empirical evidence presented here supports the conclusions of Didier *et al.* (2011) who find evidence of crisis transmission through equity and debt integration with no impact of FDI integration.

**Table 3. Equity market co-movements during the crisis**

	Dependent variable: equity prices co-movements							
	Estimator: country pair fixed effect							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.473*** (0.119)	0.040 (0.143)	-0.002 (0.162)		-0.034 (0.144)		0.069 (0.146)	
Debt integration		0.501*** (0.115)	0.415*** (0.107)		0.322*** (0.107)		0.261** (0.104)	
FDI integration			-0.007 (0.082)		-0.076 (0.092)		-0.112 (0.093)	
Bank integration				0.229*** (0.050)		0.017 (0.059)		-0.073 (0.055)
Exposure to common creditor banks				0.351*** (0.064)		0.354*** (0.063)		0.302*** (0.067)
<b>Trade integration</b>					0.099* (0.051)	0.165*** (0.042)	0.076 (0.056)	0.139*** (0.034)
<b>Other linkages</b>								
(log) distance							-0.149* (0.086)	-0.307*** (0.061)
Industry dissimilarity							0.030 (0.414)	-0.389* (0.207)
Daily observations	1 099 306	989 230	691 844	1 295 056	691 844	1 295 056	623 294	1 080 986
Country pairs	540	484	339	633	339	633	306	530

Note: All specifications control for country pair fixed effects and time fixed effects. Standard-errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_C$  in Equation 2.

Source: OECD calculations.

27. The robustness checks in Section 4 provide evidence that the contagion effects are only observed during the crisis period and that there is no evidence of asset price contagion through bilateral linkages during the onset of the sub-prime crisis (June 2007 to September 2008) or the post-crisis period (June 2009 to November 2011).

29. Given the particular role of the banks during the crisis (Kalemli-Ozcan *et al.*, 2011), bilateral banking integration and a measure of exposure to common creditor banks are introduced in the specifications. They are not introduced jointly with other forms of financial integration as this would drastically reduce the sample size. Moreover, as the BIS dataset does not distinguish between inter-bank debt activities and portfolio equity investment, the two measures of banking integration overlap bilateral debt, equity and FDI integration and would make the point estimates very difficult to interpret.<sup>28</sup> Both bilateral banking integration and exposure to common creditors are found to increase equity co-movements during the crisis (Column 4). The latter is consistent with Van Rijckeghem and Weder (2001) who argue that countries which compete for external funds from similar creditor banks co-move more in times of crisis than in tranquil times. A larger co-movement during the recent crisis may reflect a large contraction in cross-border lending from banks in mature economies (Cetorelli and Golbderg, 2011), as well as the fact that, at some international banks, parent banks in mature economies used internal capital market to raise funding from their subsidiaries (Cetorelli and Goldberg, 2008; de Haas and van Lelyveld, 2011). The estimates suggest that an increase of one 2001 standard-deviation of the extent to which two countries have common creditor banks would have led to an increase of co-movements between the two countries of 0.35 in the height of the crisis. This corresponds to around 30% of the average increase in co-movements (Column 4).

30. Finally, Columns 5 and 6 analyse jointly the effects of the financial integration variables and bilateral trade integration on the increase in equity prices co-movements during the crisis. In both specifications, the coefficient of trade integration points towards a significant role of real trade linkages on the increase in stock market co-movements during the crisis. Debt integration and common creditor banks remain highly significant, but bilateral banking integration does not appear to increase stock market co-movement during the crisis when bilateral trade is controlled for. These results are different from the empirical evidence presented by Didier *et al.* (2011) for the transmission of the crisis from the United States. Using multilateral data, they find that despite the large contraction in trade flows during the crisis period, real trade linkages did not explain the co-movement of countries' stock markets with the US stock market.

31. The results are robust to controlling for other factors such as (the logarithm of) bilateral distance and the similarity of industrial structure (Columns 7 and 8). None of these specifications alter the main results that bilateral debt integration and exposure to common creditor banks increased financial co-movements during the crisis. Taken at face value, the estimate suggests that when bilateral debt integration increases by one standard-deviation, *e.g.* from the level of the United States and Italy to the level of the United States and Germany in 2001, co-movements during the height of the crisis increase by an additional 0.26 points, corresponding to around 23% of the average increase in co-movements during this period (Column 7). The stock markets of more distant countries appear to co-move significantly less during the crisis period than during tranquil times. This result is in line with de Haas and Van Horen (2011) and Ahrend and Schweltnus (2012). The increase in uncertainty during the crisis may lead investors to particularly withdraw investments in more distant countries about which they have less information.<sup>29</sup> Thus, at a given level of financial integration, more distant stock markets could be expected to become less synchronised during the crisis.<sup>30</sup> The effect of industry specialisation on the increase of financial co-

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28. Kalemli-Ozcan *et al.* (2012) calculate that banking activities represents a declining but large share of cross-border asset holdings (around half of total foreign holdings in 2006). If the two measures of banking integration are introduced in the specification of Column 3, the sample size drops to 23 countries.

29. Distance may also measure unobserved bilateral linkages that became increasingly important during the crisis. For example, distance may partly proxy for non-bank common-creditors.

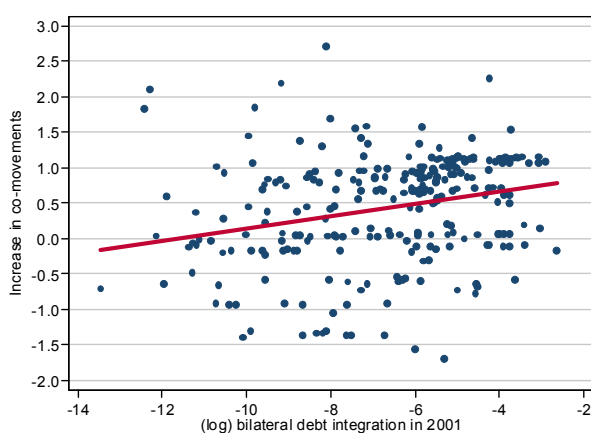
30. Besides geographical distance, the bilateral trade variable can be seen as a broad proxy for information frictions. Both trade integration and distance indicate that information frictions have played an important role during the crisis, and they are significant even when they are jointly included in the regressions.

movements during the crisis appears close to zero or with the expected negative sign (Column 6 and 7), *i.e.* a more dissimilar industrial structure decreasing equity-market co-movement. As bilateral financial linkages are partly correlated with industry structure, it is reassuring that the effects of different types of financial integration are robust to controlling for global sectoral shocks during the crisis.

### 3.1. Bond price co-movements during the crisis

32. Turning to bond markets, a clear upward sloping correlation appears for OECD countries between the increase in bond price co-movements during the 2007-09 financial crisis and bilateral financial integration *via* debt (Figure 3).

**Figure 3. Increase in bond prices co-movements between OECD countries during the crisis and bilateral debt integration**



Note: Each dot represents the change in equity price co-movements between the pre-crisis period (January 2002 to May 2007) and the crisis period (15<sup>th</sup> of September 2008 to May 2009) for a country pair. The figure shows the results from regressing the increase in bond price co-movement during the crisis on bilateral debt integration.

Source: BIS locational statistics; Bloomberg; Datastream; OECD calculations.

33. Bilateral financial integration *via* debt is indeed empirically found to be a significant and robust driver of excess bond price co-movements during the crisis (Table 4, Columns 1-3). By contrast, the estimates for bilateral equity integration appear negative or insignificant if debt integration is controlled for, while FDI integration is much smaller in magnitude and not statistically significant when the common industry shocks and (the logarithm of) bilateral distance is included in the regressions (Column 7). Furthermore, as for equity markets, there is evidence that bilateral banking integration amplified bond price co-movements during the 2007-09 crisis (Column 4). However, the main effect of banking integration appears through common creditor banks: bond price co-movement increases significantly more for countries sharing similar creditor banks (Column 4). In contrast to equity markets, there is no empirical evidence that bilateral trade linkages contributed to propagate financial turmoil through bond markets (Columns 5-8).

**Table 4. Bond market co-movements during the crisis**

Dependent variable: bond prices co-movements								
Estimator: country pair fixed effect								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.097*** (0.035)	-0.050 (0.036)	-0.103** (0.047)		-0.107** (0.046)		-0.037 (0.040)	
Debt integration		0.177*** (0.037)	0.142*** (0.037)		0.130*** (0.041)		0.108*** (0.033)	
FDI integration			0.054** (0.027)		0.045* (0.027)		0.010 (0.024)	
Bank integration				0.089*** (0.018)		0.059** (0.024)		0.032 (0.020)
Exposure to common creditor banks				0.295*** (0.066)		0.277*** (0.066)		0.189** (0.074)
<b>Trade integration</b>								
					0.013 (0.017)	0.025 (0.016)	-0.007 (0.013)	0.008 (0.014)
<b>Other linkages</b>								
(log) distance							-0.106*** (0.037)	-0.131*** (0.032)
Industry dissimilarity							0.280*** (0.086)	0.159** (0.075)
Daily observations	880 037	798 155	545 160	982 824	545 160	982 824	518 137	826 264
Country pairs	504	455	314	559	314	559	281	460

Note: All specifications control for country pair fixed effects and time fixed effects. Standard-errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_c$  in Equation 2.

Source: OECD calculations.

34. As for equity prices, the effects of bilateral debt integration and exposure to common creditor banks are robust to additional controls for bilateral distance and industry structure (Columns 7 and 8).<sup>31</sup> To give an order of magnitude, the estimate suggests that when bilateral banking integration increases by one standard-deviation, co-movements during the height of the crisis increase by 0.10 points, this corresponding to around 75% of the average increase in bond price co-movements during this period (Column 7). The effect of (the logarithm of) distance, a proxy for information frictions, also remains significantly more negatively correlated with co-movements during the crisis than in “normal” times (Columns 5 and 7).<sup>32</sup>

31. Though statistically significant, industry dissimilarity does not appear with the expected negative sign. This result would imply that countries with more dissimilar industries co-moved more during the global financial crisis than during normal times. This result could be explained if country-wide shocks were more important for bond prices than sectoral shocks during the 2007-09 crisis compared to normal times.

32. This is coherent with the “wake-up call” hypothesis for the transmission of financial turmoil. Similarly, Kaminsky and Schmukler (2002) find that neighbour-country spillovers explain a large part of changes in sovereign debt ratings and financial market outlooks in emerging economies.

#### 4. Robustness checks

35. This section assesses the robustness of the baseline specification for equity market contagion.<sup>33</sup> The analysis shows that the results for financial integration (*via* debt or common-creditor banks) or trade integration are not driven by regional shocks or by the chosen comparison period. There is also no evidence of contagion through cross-border asset holdings in the aftermath of the crisis period. Finally, the analysis is robust to the use of an alternative measure of asset price co-movements and corrections for non overlapping trading hours between international financial markets.

##### 4.1. Increase in asset price co-movements and regional shocks

36. Table 5 reports point estimates for the effects of different forms of bilateral linkages on the increase in equity price co-movements during the 2007-09 crisis compared to normal times (January 2002 to May 2007) controlling for region-specific shocks. Adding fixed effects for regions interacted with time periods allows the volatility of financial markets to be region-specific, and to control for all regional economic shocks that may affect stock market returns during the global financial crisis.<sup>34</sup> For example, controlling for the average increase in co-movements of European stock markets during the crisis, the specification identifies if the co-movements of European stock markets increase significantly more during the crisis for European countries more financially integrated *via* bilateral debt holdings.

**Table 5. Equity market co-movements during the crisis**

	Dependent variable: equity prices co-movements							
	Estimator: country pair fixed effect							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.479*** (0.122)	0.120 (0.150)	0.172 (0.168)		0.144 (0.153)		0.117 (0.147)	
Debt integration		0.371*** (0.106)	0.296*** (0.102)		0.241** (0.113)		0.159 (0.109)	
FDI integration			-0.043 (0.079)		-0.085 (0.090)		-0.037 (0.087)	
Bank integration				0.136*** (0.049)		-0.067 (0.055)		-0.075 (0.052)
Exposure to common creditor banks				0.349*** (0.060)		0.353*** (0.060)		0.308*** (0.066)
<b>Trade integration</b>								
					0.062 (0.065)	0.159*** (0.040)	0.111* (0.063)	0.175*** (0.034)
<b>Other linkages</b>								
(log) distance							0.229 (0.164)	-0.003 (0.135)
Industry dissimilarity							0.295 (0.379)	-0.264 (0.216)
Daily observations	1 099 306	989 230	691 844	1 295 056	691 844	1 295 056	623 294	1 080 986
Country pairs	540	484	339	633	339	633	306	530

Note: All specifications control for country pair fixed effects and time fixed effects interacted with regional dummy variables. Standard-errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_c$  in Equation 2.

Source: OECD calculations.

33. The same robustness checks were conducted for contagion through bond prices, confirming the results of Section 3.2.

34. Five continent dummy variables for Africa, America, Asia, Europe and Pacific are interacted with the different time-periods and included in Equation 2.

37. The results highlight the same pattern than those obtained without controlling for regional shocks, and are in fact close to those presented in Table 4. Bilateral financial integration through debt and common creditor banks appears to drive the increase of equity price co-movements during the 2007-09 crisis. Bilateral trade integration is also found to contribute to the increase in equity price co-movements during the crisis (Columns 5-8). The only noteworthy difference between the baseline specification and the one controlling for regional shocks concerns the estimated effects of the two control variables: (the logarithm of) bilateral distance and industry dissimilarity. The effects of the two control variables on the increase in equity price co-movements during the crisis become insignificant at all conventional levels (Columns 7-8), indicating that distance may be a poor proxy for information frictions within a given region, and that regional shocks and industry specific shocks may have been highly correlated during the crisis.

#### ***4.2. Definition of the comparison period***

38. The baseline specification compares the period after the Lehman Brothers bankruptcy (September 2008 to the end of May 2009) to tranquil times (January 2002 to the end of May 2007). Comparing the period before the onset of the subprime crisis to the main crisis period improves estimation efficiency by reducing the impact of measurement error on the estimated coefficients.<sup>35</sup> However, some authors have chosen alternative comparison periods. For example, Didier *et al.* (2011) compare the period from June 2007 to the Lehman bankruptcy to the immediate post-Lehman period. Table 6 reports the point estimates for this alternative comparison period using the specification controlling for regional shocks. More precisely, the reported effects correspond to the parameters  $\beta_C - \beta_T$  in Equation 2. Despite the slight increase in equity price co-movements observed in this alternative comparison period (Figure 1), the estimated effects are almost identical to those reported in Table 5. This indicates that the estimated contagion phenomenon is robust to the comparison period. Taken together, the estimates from Table 5 and 6 show that, while debt integration significantly increases co-movements between financial markets during the post-Lehman crisis period compared to the baseline period, this is not the case during the onset of the subprime crisis. Furthermore, as a tendency for financial markets to become more synchronised over time should be reflected in a steady increase in the effect of financial integration on financial co-movements, the similarity of the estimated coefficients is reassuring that the estimates are not driven by unobserved country-pair specific trends.

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35. Some observations may be misclassified as tranquil times as the exact timing of the crisis is ambiguous.

**Table 6. Equity price co-movements during the crisis, compared to the onset of the crisis**

	Dependent variable: equity prices co-movements							
	Estimator: country pair fixed effect							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.452*** (0.118)	0.100 (0.138)	0.130 (0.151)		0.099 (0.134)		0.072 (0.132)	
Debt integration		0.366*** (0.094)	0.298*** (0.092)		0.238** (0.097)		0.171* (0.098)	
FDI integration			-0.021 (0.065)		-0.067 (0.070)		-0.025 (0.072)	
Bank integration				0.143*** (0.045)		-0.048 (0.050)		-0.063 (0.046)
Exposure to common creditor banks				0.268*** (0.056)		0.271*** (0.055)		0.231*** (0.061)
<b>Trade integration</b>					0.069 (0.053)	0.150*** (0.037)	0.109** (0.052)	0.168*** (0.028)
<b>Other linkages</b>								
(log) distance							0.182 (0.151)	-0.013 (0.126)
Industry dissimilarity							0.144 (0.398)	-0.362* (0.219)
Daily observations	1 099 306	989 230	691 844	1 295 056	691 844	1 295 056	623 294	1 080 986
Country pairs	540	484	339	633	339	633	306	530

Note: All specifications control for country pair fixed effects and time fixed effects interacted with regional dummy variables. Standard errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_C$ - $\beta_P$  in Equation 2.

Source: OECD calculations.

39. Even if the estimated effects are insensitive to the chosen baseline period, the change in the transmission of financial shocks that was observed after the collapse of Lehman Brothers may be due to a correction in unsustainable mechanisms of interdependence rather than contagion. Therefore, it is important to test if the change of the financial mechanisms driving asset prices co-movements during the main crisis episode was persistent in its aftermath. Table 7 reports the point estimates of Equation 2 comparing the crisis period (September 2008 to the end of May 2009) to the aftermath of the main crisis period (June 2009 to November 2011). More precisely, the reported effects correspond to the parameters  $\beta_C$ - $\beta_P$  in Equation 2. The size of the estimated coefficients for the different forms of financial integration is again very similar to the main results of Table 5. Taken together, the results of Tables 6 and 7 show that, during the post-crisis period and the onset of the subprime crisis, the effects of bilateral financial integration and trade linkages on equity price co-movements are similar to the baseline comparison period (January 2002 to May 2007). In other words, during non-crisis periods, the propagation of asset price shocks tends to be independent of the time period considered. Therefore, the estimates of the baseline specification do not capture a secular trend in asset-price co-movements or the effect of a permanent change in the international transmission of financial shocks, but asset price contagion.

**Table 7. Equity price co-movements during the crisis, compared to the aftermath of the crisis**

	Dependent variable: equity prices co-movements							
	Estimator: country pair fixed effect							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.502*** (0.123)	0.120 (0.146)	0.146 (0.159)		0.117 (0.145)		0.095 (0.144)	
Debt integration		0.397*** (0.101)	0.313*** (0.097)		0.255*** (0.098)		0.186* (0.097)	
FDI integration			-0.000 (0.067)		-0.044 (0.072)		-0.000 (0.074)	
Bank integration				0.173*** (0.047)		-0.035 (0.050)		-0.044 (0.049)
Exposure to common creditor banks				0.325*** (0.057)		0.328*** (0.056)		0.286*** (0.062)
<b>Trade integration</b>					0.065 (0.053)	0.163*** (0.033)	0.105** (0.051)	0.176*** (0.028)
<b>Other linkages</b>								
(log) distance							0.185 (0.154)	-0.019 (0.132)
Industry dissimilarity							0.156 (0.394)	-0.355* (0.207)
Daily observations	1 099 306	989 230	691 844	1 295 056	691 844	1 295 056	623 294	1 080 986
Country pairs	540	484	339	633	339	633	306	530

Note: All specifications control for country pair fixed effects and time fixed effects interacted with regional dummy variables. Standard errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_C$ - $\beta_P$  in Equation 2.

Source: OECD calculations.

### 4.3. Alternative measures of asset price co-movements

40. Finally, the estimates reveal a similar pattern if an alternative measure of co-movements, the synchronisation index, is used as dependent variable, and if weekly returns or returns adjusted for non-common trading hours are used to measure co-movements. The synchronisation index is computed using (minus) the absolute difference of daily returns. As argued by Morgan *et al.* (2004), Giannone *et al.* (2010) and Kalemli-Ozcan *et al.* (2012), this measure does not directly reflect the volatility of equity prices during the crisis and represents an alternative measure of financial market co-movements that does not require estimating correlations. Table 8 reports the estimates of the effects of different forms of bilateral linkages on the increase in equity price co-movements during the crisis compared to normal times (January 2002 to May 2007) using the synchronisation measure. The main results for equity markets are qualitatively the same when using equity price synchronisation or equity price co-movements.<sup>36</sup> Bilateral financial integration through debt, common creditor banks and bilateral trade appear to increase equity price co-movements during the global financial crisis. The estimated effects of these three variables are always statistically significant at the 1% level with the synchronisation measure (Columns 2-8).

36. However, the point estimates differ markedly indicating the different scales of the two measures of international co-movements.



**Table 8. Equity price synchronisation during the crisis controlling for regional shocks**

Dependent variable: equity prices synchronisation								
Estimator: country pair fixed effect								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.091*** (0.026)	-0.019 (0.029)	-0.004 (0.033)		-0.013 (0.030)		-0.034 (0.031)	
Debt integration		0.123*** (0.026)	0.117*** (0.025)		0.098*** (0.025)		0.071*** (0.026)	
FDI integration			-0.004 (0.015)		-0.018 (0.016)		0.003 (0.016)	
Bank integration				0.035*** (0.010)		0.006 (0.011)		0.006 (0.013)
Exposure to common creditor banks				0.052*** (0.014)		0.053*** (0.013)		0.040*** (0.014)
<b>Trade integration</b>					0.021*** (0.008)	0.023*** (0.005)	0.046*** (0.011)	0.035*** (0.008)
<b>Other linkages</b>								
(log) distance							0.120*** (0.033)	0.036 (0.023)
Industry dissimilarity							0.070*** (0.014)	-0.111** (0.051)
Daily observations	1 099 306	989 230	691 844	1 295 056	691 844	1 295 056	623 294	1 080 986
Country pairs	540	484	339	633	339	633	306	530

Note: All specifications control for country pair fixed effects and time fixed effects interacted with regional dummy variables. Standard errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_c$  in Equation 2.

Source: OECD calculations.

41. A last concern is that international stock markets have different trading hours. Hence the use of daily returns may lead to an underestimation of the true co-movements between stock markets. Moreover, infrequent trade may also lead to bias in high-frequency co-movements. Therefore, Table 9 displays the results for the measure of co-movements specified in Equation 1 using weekly stock returns. In order to maximize the sample size, the process proposed by Lo and MacKinlay (2001) is used. The weekly return of each security is computed as the return from Wednesday to the following Wednesday. If Wednesday's price is missing, then Thursday's price (or Tuesday's if Thursday's is missing) is used. If both Tuesday's and Thursday's prices are missing, the return for that week is reported as missing.<sup>37</sup> Compared to the estimates of Table 5 the point estimates and their standard errors drop sharply in magnitude. However, estimated coefficients for bilateral debt integration and the exposure to common creditor banks remain significant at the 1% level. This suggests that weekly data aggregate the heterogeneity in a smoothing way, daily movements in opposite directions cancelling each other out. Daily data are therefore likely to provide a better picture of the microstructure effects of equity markets, which is particularly important in crisis times.

37. More precisely, the returns were computed using:  $r_{it} = (\ln(p_{it}) - \ln(p_{it-k})) \times 100/k$ , where k is equal to 7, 8 or 5. Thursday or Wednesday prices are used for 71 of the 20,037-weekly bond returns. This never occurs for the computation of weekly equity returns. Table A2 in the Appendix presents descriptive statistics about the weekly returns of equity and bond markets. Table A4 presents their evolution over time for different sample of countries.

**Table 9. Weekly equity price co-movements during the crisis**

Dependent variable: weekly equity prices co-movements								
Estimator: country pair fixed effect								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.034*** (0.010)	0.002 (0.014)	0.001 (0.017)		0.002 (0.017)		-0.005 (0.015)	
Debt integration		0.035*** (0.013)	0.029** (0.012)		0.032** (0.016)		0.017 (0.015)	
FDI integration			-0.004 (0.010)		-0.002 (0.011)		0.007 (0.010)	
Bank integration				-0.001 (0.005)		-0.014** (0.007)		-0.012* (0.007)
Exposure to common creditor banks				0.034*** (0.007)		0.034*** (0.007)		0.029*** (0.008)
<b>Trade integration</b>					-0.003 (0.010)	0.010* (0.005)	0.008 (0.010)	0.013** (0.006)
<b>Other linkages</b>								
(log) distance							0.048** (0.022)	0.018 (0.017)
Industry dissimilarity							0.072 (0.049)	0.005 (0.026)
Weekly observations	274 844	247 322	172 958	323 790	172 958	323 790	155 816	270 264
Country pairs	540	484	339	633	339	633	306	530

Note: All specifications control for country pair fixed effects and time fixed effects interacted with regional dummy variables. Standard-errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_c$  in Equation 2.

Source: OECD calculations.

42. Table 10 displays the results for the measure of co-movements specified in Equation 1, adjusting daily co-movements for different trading hours. Synchronicity adjustments are based on the assumption of zero serial correlation and zero serial cross-correlation in efficient markets (Martens and Poon, 2001). This assumption implies that adjusted co-movements can be estimated from daily returns by summing the contemporaneous, the first lead and the first lag of the cross products of the daily returns of the two countries.<sup>38</sup> This leads to drop Monday observations as well as observations where previous returns are unobserved, reducing the daily sample by roughly 25%. The results are qualitatively similar to those obtained using the non-corrected measure of daily co-movements. In line with the higher average value of the corrected measure of co-movement, the point estimates are slightly higher in absolute value and less precisely estimated than those using the full sample of daily data.

38. In other words, the adjusted co-movement is:  $Comov_{ijt}^a = r_{it}r_{jt} + r_{it-1}r_{jt} + r_{it}r_{jt-1}$ . Table A4 in the Appendix presents the evolution over time of equity and bond co-movements corrected for non-synchronicity.

**Table 10. Correction for non-synchronicity and daily equity price co-movements during the crisis**

Dependent variable: daily equity prices co-movements corrected for non-synchronicity								
Estimator: country pair fixed effect								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Financial linkages</b>								
Equity integration	0.719*** (0.149)	0.198 (0.189)	0.325 (0.222)		0.356 (0.244)		0.222 (0.221)	
Debt integration		0.563*** (0.162)	0.397*** (0.151)		0.458** (0.180)		0.238 (0.160)	
FDI integration			-0.132 (0.121)		-0.085 (0.126)		0.055 (0.111)	
Bank integration				0.132** (0.067)		-0.089 (0.078)		-0.080 (0.076)
Exposure to common creditor banks				0.561*** (0.095)		0.564*** (0.095)		0.479*** (0.105)
<b>Trade integration</b>					-0.069 (0.100)	0.173*** (0.044)	0.101 (0.095)	0.240*** (0.046)
<b>Other linkages</b>								
(log) distance							0.826*** (0.292)	0.330 (0.210)
Industry dissimilarity							1.108** (0.495)	0.343 (0.295)
Daily observations	824 427	741 880	518 863	971 233	518 863	971 233	467 455	810 689
Country pairs	540	484	339	633	339	633	306	530

Note: All specifications control for country pair fixed effects and time fixed effects interacted with regional dummy variables. Standard errors are clustered at the country pair level. \* denotes a significant estimate at the 10% level, \*\* at 5%, \*\*\* at 1%. The table reports the estimates of the parameters  $\beta_c$  in Equation 2.

Source: OECD calculations.

## 5. Conclusion

43. This paper constructs a large data-set of bilateral financial co-movements through bond and equity markets from 2002 to 2011 to assess how different forms of financial integration shape asset price co-movements in times of crisis. Bilateral asset price co-movements during the period following the Lehman Brothers' collapse appear to dwarf their historically observed levels. One possible explanation is that asset price co-movements increased because fundamental values became more correlated. Alternatively, co-movements may have increased because of contagion. Using a difference-in-differences identification strategy, the analysis distinguishes between the period of turmoil before the collapse of Lehman Brothers, the main crisis period, and its aftermath. It compares the increase in asset price co-movements during the global financial crisis for different forms of bilateral financial integration covering debt assets, equity, FDI and common bank lenders. The empirical findings reveal that equity and bond prices of countries that were more integrated through bilateral debt holdings and trade co-moved significantly more during the crisis period than during the pre-crisis period or the period following July 2009. Furthermore, equity and bond prices of countries having common bank lenders co-moved significantly more during the crisis period. This suggests that debt integration and common bank lenders propagated financial turmoil through equity and bond markets. By contrast, no robust evidence is found that equity or FDI integration led to asset price contagion during the crisis.

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## APPENDIX

Table A1. Definition of the main variables

Variable	Definition
Equity prices	Daily stock market indices between January 2002 and November 2011. Equity prices are taken from Datastream and converted in current US dollars using end-of-day exchange rates from Datastream.
Bond prices	Daily bond indices between January 2002 and November 2011. Bond prices were taken from Citigroup (retrieved via Bloomberg) whenever available, and completed with Datastream. Prices were converted in current US dollars using end-of-day exchange rates from Datastream.
Bilateral financial integration (debt, equity, FDI and banking integration)	$Int(A)_{ij} = \frac{Assets(A)_{ij} + Liabilities(A)_{ij} + Assets(A)_{ji} + Liabilities(A)_{ji}}{Assets(A)_i + Liabilities(A)_i + Assets(A)_j + Liabilities(A)_j}$ <p>Flows and mirror flows are used whenever available. Debt and equity integration are taken from the IMF CPIS database at the end of 2001. Bilateral FDI integration is computed from the OECD International Direct Investment database covering 34 reporting countries and 217 partner countries. For these three forms of financial integration, the total assets and liabilities of country <math>i</math>, <math>Assets(A)_i</math> and <math>Liabilities(A)_i</math>, are taken from the updated database of Lane and Milesi-Ferretti (2007). Banking integration are taken from the BIS Locational Banking Statistics which cover 25 reporting countries and 205 partner countries. The total assets and liabilities of country <math>i</math> towards BIS-reporting banks are computed by summing the bilateral positions.</p>
Common creditor banks	$Common\ Creditors_{ij} = \sum_{c,c \neq i, c \neq j} \left\{ \frac{b_{ic} + b_{jc}}{b_i + b_j} \right\} \times \left( 1 - \left  \frac{b_{ic} - b_{jc}}{b_{ic} + b_{jc}} \right  \right)$ <p>The liabilities of country <math>i</math> towards the banks of country <math>c</math>, <math>b_{ic}</math>, are taken from the BIS Locational Banking Statistics which cover 25 reporting countries and 205 partner countries. The total liabilities of country <math>i</math> towards BIS-reporting banks, <math>b_i</math>, are computed by summing the bilateral positions.</p>
Trade integration	$\frac{2 \times (exp_{ij} + exp_{ji})}{exp_i + exp_j + imp_i + imp_j}$ <p>Measures of bilateral exports of country <math>i</math> towards country <math>j</math>, <math>exp_{ij}</math>, come from the UNCTAD COMTRADE database that covers 79 countries. The total exports and imports of country <math>i</math>, <math>exp_i</math> and <math>imp_i</math>, are computed by summing the bilateral positions.</p>
Distance	The bilateral distance between capitals is taken from the CEPII distance database.
Industry dissimilarity	$Specialisation_{ij} = \sum_{s \in industrial\ sectors} \left  \frac{o_{is}}{o_i} - \frac{o_{js}}{o_j} \right $ <p><math>o_{is}</math> is the output of sector <math>s</math> in country <math>i</math>. The data on industry structure is from the UNIDO database which provides annual data on production, value-added, employment, and number of firms for 28 manufacturing sectors (3 digit ISIC codes are reported) for 183 countries in 2001. The data on production is in current US dollars.</p>



**Table A2. Daily and weekly returns over the 2002-11 period**

	Daily returns (in USD)		Weekly returns (in USD) <sup>1</sup>	
	Equities	Bonds	Equities	Bonds
Mean	0.04	0.01	0.02	0.02
Median	0.00	0.01	0.00	0.01
Standard-deviation	1.72	0.90	0.55	0.28
Minimum	-110.57	-32.15	-17.47	-5.58
Maximum	106.94	47.32	15.28	7.69
Observations	94 338	79 433	23 586	20 037
Countries	46	43	46	43

1. Weekly returns are average daily returns over one week.

Source: Bloomberg; DataStream; OECD calculations.

**Table A3. Real trade linkages and bilateral financial integration**

Bilateral linkages <sup>1</sup>	Country pairs	Mean	Sd	min	P25	P50	P75	max
<b>Financial linkages</b>								
Debt integration <sup>2</sup>	827	0.3	0.74	0	0	0.03	0.24	7.16
Equity integration <sup>2</sup>	818	0.68	1.85	0	0	0.05	0.4	20.75
FDI integration <sup>2</sup>	1 294	0.46	1.6	0	0	0.01	0.19	18.8
Banking integration <sup>2</sup>	2 651	0.35	1.37	0	0	0.02	0.16	28.47
Common creditor banks	21 736	0.1	0.15	0	0	0.03	0.15	1
<b>Non financial linkages</b>								
Trade integration <sup>2</sup>	12 823	0.2	0.84	0	0	0.01	0.07	29.78
(log) distance	22 578	8.81	0.78	2.35	8.47	8.99	9.38	9.9
Industry dissimilarity	3 369	0.03	0.06	0	0	0.01	0.03	0.54

1. All variables are measured at the end of 2001.

2. The different measures of bilateral integration have been multiplied by 100.

Source: IMF CPIS; BIS bilateral locational banking statistics; OECD FDI bilateral statistics; UNCTAD bilateral trade statistics and OECD calculations.

**Table A4. Alternative measures of co-movements and the global financial crisis**

	Co-movements <sup>1</sup>	1/1/2002 to 31/5/2007	1/6/2007 to 14/9/2008	15/9/2008 to 1/6/2009	1/6/2009 and later
<b>A. Equity prices</b>					
All countries	Weekly	0.04	0.06	0.16	0.04
	Corrected daily	0.36	0.53	2.22	0.42
Among OECD countries	Weekly	0.07	0.10	0.27	0.06
	Corrected daily	0.55	0.95	3.80	0.68
With the United States	Weekly	0.04	0.06	0.22	0.06
	Corrected daily	0.7	0.60	3.45	0.70
<b>B. Bond prices</b>					
All countries	Weekly	0.00	0.01	0.03	0.01
	Corrected daily	0.05	0.09	0.24	0.10
Among OECD countries	Weekly	0.00	0.02	0.07	0.02
	Corrected daily	0.09	0.16	0.64	0.19
With the United States	Weekly	0.00	0.00	0.00	0.00
	Corrected daily	0.02	0.04	0.04	0.05

1. Period averages of cross-country daily co-movements are measured using the cross-product of weekly returns and daily returns corrected for non-overlapping trading hours.

Source: Bloomberg; DataStream; OECD calculations.

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