

## B FINANCIAL MARKET CONTAGION

*Recent research has greatly improved the understanding of financial contagion. There are two main channels through which contagion may emerge among financial markets: physical exposure and asymmetric information. Contagion can be empirically identified through the propagation of extreme negative returns, the increase in interdependence compared to normal times, and the distinction from common shocks. The evidence on international financial market contagion suggests that it is a relevant phenomenon that has indeed occurred in various crises, but in severe form, it is rather rare. In most instances the breadth of contagion seems to be limited to specific countries or geographical regions. In addition, it is less frequent across different asset classes than within the same asset class. Finally, simple measures for market co-movements, such as standard correlation coefficients, do not usually perform well as indicators of contagion.*

### INTRODUCTION

Recent research has greatly improved the understanding of financial contagion, stressing the propagation of extreme negative outcomes, the increase in interdependence compared to normal times, and the distinction of contagion from common shocks. This Special Feature examines the most widely used approaches in the research literature on how to assess financial market contagion phenomena. The second section describes market contagion from a theoretical perspective and illustrates its policy relevance. The third section reviews the main approaches on how to identify financial market contagion. The fourth section provides some selected evidence about the prevalence and breadth of market contagion phenomena, covering various areas of the world. Finally, the last section offers some tentative conclusions.

## CONCEPT AND POLICY RELEVANCE OF FINANCIAL MARKET CONTAGION

When a crisis in the stock market of one country causes a crisis in the stock market of another country this can be thought of as financial market contagion. There are two main channels through which contagion may emerge in financial systems: physical exposures and asymmetric information. As an example of the exposure channel, the following scenario can be considered. Assume that a crash in one financial market reduces the wealth of traders who are also active in other markets. They may then want to rebalance their portfolios and sell assets in other markets, triggering a crash there too, even if the two markets are unrelated in terms of their fundamentals (Kyle and Xiong (2001)).<sup>1</sup>

Asymmetric information across economic agents active in financial systems may also result in contagion. King and Wadhvani (1990)<sup>2</sup> argue that traders in international financial markets face “signal extraction problems”. Traders from one country may have only imperfect information about the situation in other countries. Hence, they have to extract further information from observable stock price movements, reflecting other traders’ behaviour. However, sometimes they will confuse price movements in relation to idiosyncratic problems in a foreign country with price movements that also reveal information about their home country. In this way, asymmetric information can cause excessive price spillovers across borders, including crashes. Moreover, Kodres and Pritsker (2002)<sup>3</sup> show that the transmission of idiosyncratic shocks across markets through portfolio rebalancing tends to be reinforced through asymmetric information.

1 A. S. Kyle and W. Xiong (2001), “Contagion as a Wealth Effect”, *Journal of Finance* 56 (4), pp. 1401-40.

2 M. King and S. Wadhvani (1990), “Transmission of Volatility between Stock Markets”, *Review of Financial Studies* 3 (1), pp. 5-35.

3 L. E. Kodres and M. Pritsker (2002), “A Rational Expectations Model of Financial Contagion”, *Journal of Finance* 57 (2), pp. 769-99.

Contagion is a policy-relevant issue for two reasons. First, some contagion phenomena have the character of externalities, resulting in an inefficient allocation of risk in the economy. Agents do not take the effect of their actions on other agents into account and, hence, the level of risk is too high. Ex ante policies, such as regulating markets, could be used to re-establish efficiency. Moreover, if they are not successful, then ex post intervention could, where necessary, be attempted in order to “neutralise” the trigger of contagion or to cushion the effects on other markets. Second, if contagion is very widespread, then such propagation could in theory contribute to a general destabilisation of the financial system and adversely affect growth. In such a worst-case scenario, macroeconomic stabilisation policies could help to fight the consequences of widespread contagion for the economy as a whole.

#### HOW CAN CASES OF MARKET CONTAGION BE IDENTIFIED?

The literature has now developed a number of empirical approaches on how to identify contagion in financial markets. As different methods lead to different results, most of the debate in the literature and among policymakers is about which approach captures the notion of contagion best.

Five main criteria have been proposed so far to identify contagion: (i) a decline in an asset price leads to declines in other asset prices; (ii) the relationships between asset price declines are different from those observed in “normal” times (regular interdependence); (iii) the relationships are in excess of what can be explained by economic fundamentals; (iv) they are negative extremes, such as market crashes, so that they correspond to crisis situations; and (v) the relationships are the result of propagations over time rather than being caused by the simultaneous effects of common shocks.

Most empirical approaches proposed in the literature on how to measure market contagion capture the first criterion, but this is where agreement usually ends. Authors differ in their view as to which of the other criteria are essential for identifying cases of contagion.

#### INCREASED CORRELATION DURING CRISIS PERIODS

One influential approach advocating the second criterion has been proposed by Forbes and Rigobon (2002).<sup>4</sup> The authors argue that contagion means that correlations between different equity markets increase significantly during well-known crisis episodes. One reason may be the information channel described above, which can enhance price spillovers in times of stress. If correlations do not increase, then any propagation of volatility during these crises is nothing more than the expression of the regular interdependence between markets, rather than a sign of contagion. The authors find no significant increases in equity market correlations during some important crises, such as the US stock market crash of 1987, the Mexican crisis of 1994 or the Asian crisis of 1997.

#### CO-MOVEMENTS IN EXCESS OF ECONOMIC FUNDAMENTALS

The idea behind the third criterion in the above list (“excess co-movements”) is that if financial market prices co-move by more than what would be justified by the fundamental variables driving those prices (say, due to asymmetric information), then this would be evidence of contagion. Examples are given in various studies, such as Shiller (1989)<sup>5</sup>, Pindyck and Rotemberg (1993)<sup>6</sup>, and Bekaert, Harvey and Ng (2005).<sup>7</sup> Shiller (1989) finds

4 K. Forbes and R. Rigobon (2002), “No Contagion, Only Interdependence: Measuring Stock Market Comovements”, *Journal of Finance* 57 (5), pp. 2223-62.

5 R. J. Shiller (1989), “Comovements in Stock Prices and Comovements in Dividends”, *Journal of Finance* 44 (3), pp. 719-29.

6 R. S. Pindyck and J. J. Rotemberg (1993), “The Comovements of Stock Prices”, *Quarterly Journal of Economics* 108 (4), pp. 1073-1104.

7 G. Bekaert, C. Harvey and A. Ng (2005), “Market Integration and Contagion”, *Journal of Business* 78 (1), pp. 39-69.

that between 1917 and 1987 US and UK stock market indices co-moved by more than what would be justified by the relationship between dividends paid in the US and the UK. Pindyck and Rotemberg (1993) divide 42 US companies into six groups, so that in each group the companies included produce different goods and exhibit low earnings correlation with each other. Then, for each group they run regressions of stock returns on current and lagged macroeconomic fundamentals for quarterly data ranging from 1969 to 1987, and test whether the residuals of these regressions are correlated across (within-group) firms. It turns out that in all cases residuals are highly correlated for all groups of companies. Bekaert, Harvey and Ng (2005) estimate a two-factor asset pricing model for stock returns of 22 countries, in which risk factors can vary across specific time periods. Contagion is defined as an increase in the correlation between the model residuals that cannot be explained by shifts in the common risk factors. In other words, this methodology combines the excess co-movements approach with the increase in correlation approach. The authors find evidence of such contagion effects among Asian countries during the Asian crisis, but not during the Mexican crisis.

#### CONDITIONAL SPILLOVER PROBABILITIES

In line with the fourth (and first) criterion, a further group of papers estimates the conditional probabilities of large returns in some markets as a function of large returns in other markets. Three main techniques can be distinguished in this regard: standard limited dependent variable estimations, quantile estimations of conditional spillovers, and applications of extreme value theory.

#### Limited dependent variable estimations

Eichengreen, Rose and Wyplosz (1996)<sup>8</sup> were perhaps the first to estimate the probability that financial crises could spread across countries, using a probit model. 20 industrialised countries were covered in their study over a time span between 1959 and 1993. The authors examine whether the occurrence of a balance of

payments crisis in one country increases the probability of a balance of payments crisis in other countries, conditional on political and macroeconomic country fundamentals. The results reject the null hypothesis of no contagion. Inspired by the epidemiology literature, Bae, Karolyi and Stulz (2003)<sup>9</sup> apply the multinomial logit model to explain concurrent large negative and positive returns among 17 emerging market countries, the US and Europe between 1992 and 2000 at a daily frequency. In other words, they estimate the probability that a certain number of markets decline by more than a certain return threshold as a function of a number of other markets declining by that much. By controlling for a few fundamentals (interest rates and exchange rates), they can also incorporate some aspects of the excess co-movements approach (criterion (iii)). They find some evidence of contagion between Latin America and Asia, but none between Asia and the US during the Asian crisis. Europe seems to be quite sheltered from shocks occurring in Asia, Latin America and the US. In this literature large market returns are usually defined as the 95 percentile, so that for weekly data, a large return occurs every 20 weeks.

#### Quantile regressions and co-movement box

Cappiello, Gérard and Manganelli (2005)<sup>10</sup> estimate conditional spillover probabilities between two financial markets using quantile regressions. The estimation of conditional probabilities in this approach follows a three-step procedure. First, adopting the conditional quantile regression technique of Engle and Manganelli (2004)<sup>11</sup>, individual time varying quantiles for returns on each financial market

8 B. Eichengreen, A. Rose and C. Wyplosz (1996), "Contagious Currency Crises: First Tests", *Scandinavian Journal of Economics* 98 (4), pp. 463-84.

9 K. Bae, A. Karolyi and R. Stulz (2003), "A New Approach to Measuring Financial Contagion", *Review of Financial Studies* 16 (3), pp. 717-63.

10 L. Cappiello, B. Gérard and S. Manganelli (2005), "Measuring Comovements by Regression Quantiles", *ECB Working Paper* No 501.

11 R. F. Engle and S. Manganelli (2004), "CAViaR: Conditional Autoregressive Value at Risk by Regression Quantile", *Journal of Business and Economic Statistics* 22 (4), pp. 367-81.

are evaluated.<sup>12</sup> Second, for each return and for each quantile, indicator variables that are equal to one if the observed return is lower than the conditional quantile (and zero otherwise) are constructed. Finally, an ordinary least squares regression on these indicator functions is carried out. The regression coefficients provide a direct estimate of the conditional probabilities of co-movements. This approach can be used to estimate spillover probabilities for any quantile of the empirical return distribution, i.e. any size of return, as long as it is not too close to the sample boundaries. A graphical representation of the spillover probabilities for different return sizes (“co-movement box”) allows an assessment on whether co-movements have increased significantly or not during times of specific crises. By implementing a statistical test of significant increases in spillovers, the authors also integrate the increases in correlation approach (ii) into their analysis. They apply their technique to daily data from EMEs in Latin America between 1988 and 2004. The evidence of contagion during crisis periods turns out to be mixed.

#### Applications of the extreme value theory

The extreme value theory (EVT) literature argues that in order to identify contagion, one has to look at much more extreme market movements than the 95 or 99 percentile in order to avoid mixing crisis linkages with non-crisis linkages. For example, the great stock market crashes of October 1929 or October 1987 are much less frequent, although these are the most interesting crises from a financial stability perspective. EVT allows conditional spillover probabilities to be estimated for these crises, the most dramatic market movements in history.

Longin and Solnik (2001)<sup>13</sup> were among the first to apply bivariate EVT to estimate extreme equity market spillovers. They assume that equity returns follow a logistic distribution, similar to Bae et al. (2003). This means that the extreme dependence between equity returns is described by the logistic tail copula.<sup>14</sup> Under

this assumption and for monthly equity market returns of G5 countries between 1958 and 1996, they find that the conditional correlation of extreme negative returns (crashes) is higher than for extreme positive returns (booms). Hartmann, Straetmans and de Vries (2004)<sup>15</sup> estimate extreme conditional spillover probabilities within and between stock and government bond markets of the G5 countries for weekly returns between 1987 and 1999. Looking at crisis linkages across asset classes is important when assessing how widespread contagion can be (“systemic risk”). Moreover, they estimate the spillover probabilities semi-parametrically, so that these probabilities (and the underlying tail copulae) are not fixed to follow a specific probability law. The results suggest that extreme linkages between stock markets are higher than extreme linkages between bond markets. Contagion across different asset classes is even weaker. Actually, there is evidence of “flight to quality”, which is described by stock market crashes being accompanied by booming government bond markets.<sup>16</sup>

#### SELECTED EVIDENCE ON INTERNATIONAL FINANCIAL MARKET CONTAGION

This section presents some selected evidence on the prevalence and breadth of contagion phenomena in international financial markets. It covers the three approaches using conditional spillover probabilities described above as applied to different regions in the world. It starts with the evidence provided by

12 Different quantiles of the return distribution refer to different sizes of returns.

13 F. Longin and B. Solnik (2001), “Extreme Correlation of International Equity Markets”, *Journal of Finance* 56 (2), pp. 649-76.

14 For a given bivariate or multivariate distribution, the copula is a function that describes the dependence between the respective two or more marginal distributions.

15 P. Hartmann, S. Straetmans and C. G. de Vries (2004), “Asset Market Linkages in Crisis Periods”, *Review of Economics and Statistics* 86 (1), pp. 313-26.

16 There are also a few papers referring to our last identification criterion, the propagation of contagion over time (criterion (v)). They have been surveyed in O. De Bandt and P. Hartmann (2000), “Systemic Risk: A Survey”, *ECB Working Paper* No. 35, sub-section 4.2.1.1.2, and are not further reviewed here.

EVT on the existence of extreme linkages between the stock and bond markets of G5 countries. It then shows to what extent European stock markets are exposed to spillovers from the US, Asia and Latin America, using the multinomial logit model. Last, it reports evidence on contagion phenomena among Latin American EMEs using the quantile regression approach.

#### CROSS-ASSET CONTAGION AND FLIGHT TO QUALITY AMONG G5 COUNTRIES

Table B.1 reports the results of the EVT cross-asset analysis conducted by Hartmann et al. (2004). The upper panel (panel a.) shows three measures of domestic spillovers between stock and government bond markets in France, Germany, the UK, the US and Japan. The “correlation” column shows the estimated correlation coefficient for the respective two return series. The “contagion” column shows the estimated crisis spillover probability, which is defined as the probability that for a given country both the stock and the government bond market will crash, assuming that one of the two has already crashed.<sup>17</sup> The last column shows the estimated probability that the government bond market will boom, given the stock market crashes (“flight to quality”).

A first observation is that regular correlation is not a reliable indicator of crisis spillovers. For example, the contagion risk between the Japanese stock and bond markets (9%) is almost twice as high as between the US stock and bond markets (5%). However, the US stock and bond markets are much more highly correlated (24%) than those of Japan (5%). Second, contagion risk across both asset classes is not very high (ranging between 3% and 12%). Third, the “flight to quality” phenomenon is roughly as frequent within the five countries as contagion. The latter two results illustrate some limits to the propagation of market crises within the major industrial countries.

**Table B.1 Domestic and international extreme stock-bond market linkages among G5 countries**

Country/ country pair	Correlation	Contagion	Flight to quality
<b>a) Domestic linkages</b>			
DE	19.0	2.7	3.4
FR	24.8	11.5	5.5
UK	21.7	5.9	7.3
US	23.5	5.2	4.6
JP	5.1	9.2	5.0
<b>b) Cross-border linkages</b>			
DE-FR	18.7	9.3	5.7
FR-DE	17.2	3.9	3.9
DE-UK	7.9	7.8	5.9
UK-DE	8.3	5.3	5.2
DE-US	1.5	3.5	7.9
US-DE	12.2	6.0	5.7
DE-JP	-5.6	9.6	6.8
JP-DE	0.0	1.4	3.1
FR-UK	16.5	5.2	8.0
UK-FR	10.2	6.8	5.1
FR-US	10.1	8.0	7.7
US-FR	9.7	2.8	3.0
FR-JP	-0.7	4.1	8.3
JP-FR	2.1	3.8	3.6
UK-US	-5.5	2.5	8.3
US-UK	14.1	3.8	5.2
UK-JP	-1.5	1.6	8.0
JP-UK	4.2	4.9	3.2
US-JP	6.8	6.9	8.0
JP-US	-1.1	5.0	3.3

Source: Hartmann, Straetmans and de Vries (2004), “Asset Market Linkages in Crisis Periods”, *Review of Economics and Statistics*, 86 (1), Table 3, p. 322. ©2004 by the President and Fellows of Harvard College and the Massachusetts Institute of Technology. Reproduced with kind permission by MIT Press.  
Note: All figures in the table are percentages.

The lower panel of Table B.1 (panel b.) refers to cross-asset spillovers across borders. It also distinguishes the “directions” of spillovers. The country pairs in the left-hand column state first the country with a stock market crash and second the country with a bond market crash (or boom). For example, the probability in line FR-US and column “contagion” describes the probability of a stock market crash in France

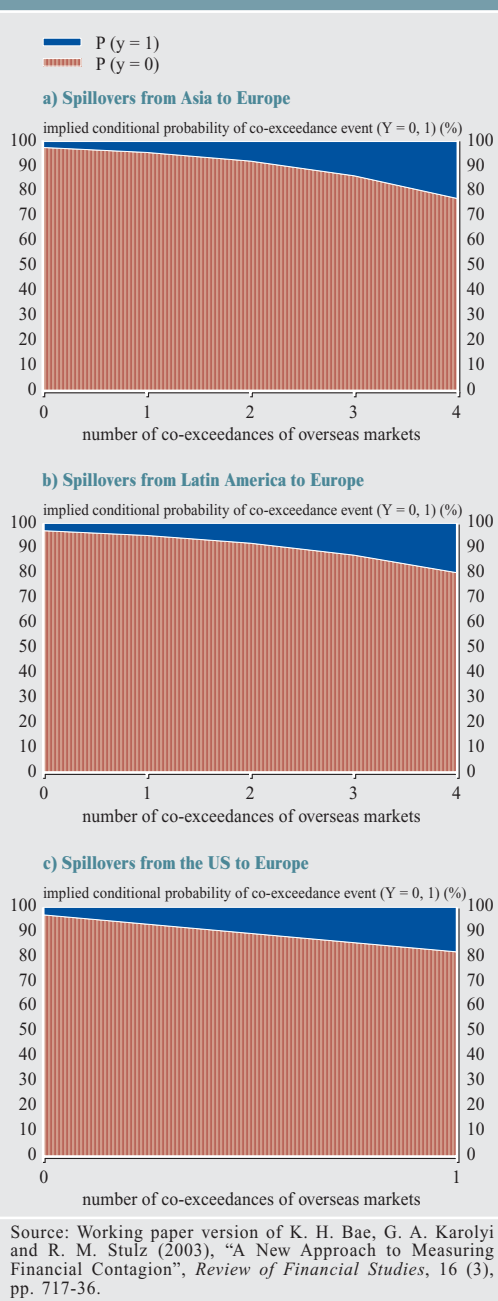
<sup>17</sup> A crash refers to a 20% weekly stock market decline and an 8% weekly bond market decline. This corresponds to the size of the 1987 stock market crash and a corresponding bond market crash, so as to make the historical frequency of both approximately equal.

given that there is a bond market crash in the United States (8%). The line underneath (US-FR) shows the reverse probability, which is substantially lower (3%). The results show that the extent of cross-border contagion risk across assets is quite similar to that of domestic risk, i.e. not particularly high. Moreover, there are not any specific geographic patterns. This may be interpreted as suggesting that with highly integrated international capital markets, distance does not shelter countries from crisis spillovers. Finally, there are some indications that the US government bond market has played the role of a safe haven. The flight to quality from other countries to the US bond market in the right-hand side column is estimated to be higher than from the US stock market to other bond markets, except for Japan.

### STOCK MARKET CONTAGION FROM OVERSEAS TO EUROPE

Charts B.1.a-B.1.c select those results from Bae et al. (2003) that provide information about the extent to which European stock markets are exposed to contagion risk from the US, Asia and Latin America.<sup>18</sup> For this application, they represent the probability that a large negative return could occur throughout Europe given large negative returns occurring in one, two, three or four Asian or Latin American countries (except for the US). The red areas show the probabilities of contagion to Europe, whereas the violet areas show the probabilities of the absence of contagion. As the number of large stock market downturns overseas increases, the red area becomes larger too, as the likelihood of adverse effects on European stock markets also rises. All in all, the relatively small area in red suggests that Europe is rather insulated against the occurrence of large equity market downturns in other regions. Nevertheless, the three charts also imply that Europe's exposure to Latin American shocks is still a little bit higher than its exposure to Asian or US shocks.

**Chart B.1 Conditional probability responses of European stock markets to large returns on overseas markets**



<sup>18</sup> Asia is covered by ten countries (China, Korea, the Philippines, Taiwan, India, Indonesia, Malaysia, Pakistan, Sri Lanka and Thailand) and Latin America by seven countries (Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela). As for Europe, the authors use the Datastream International Europe index, which includes the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK.

## STOCK MARKET CONTAGION AMONG EMERGING MARKET COUNTRIES

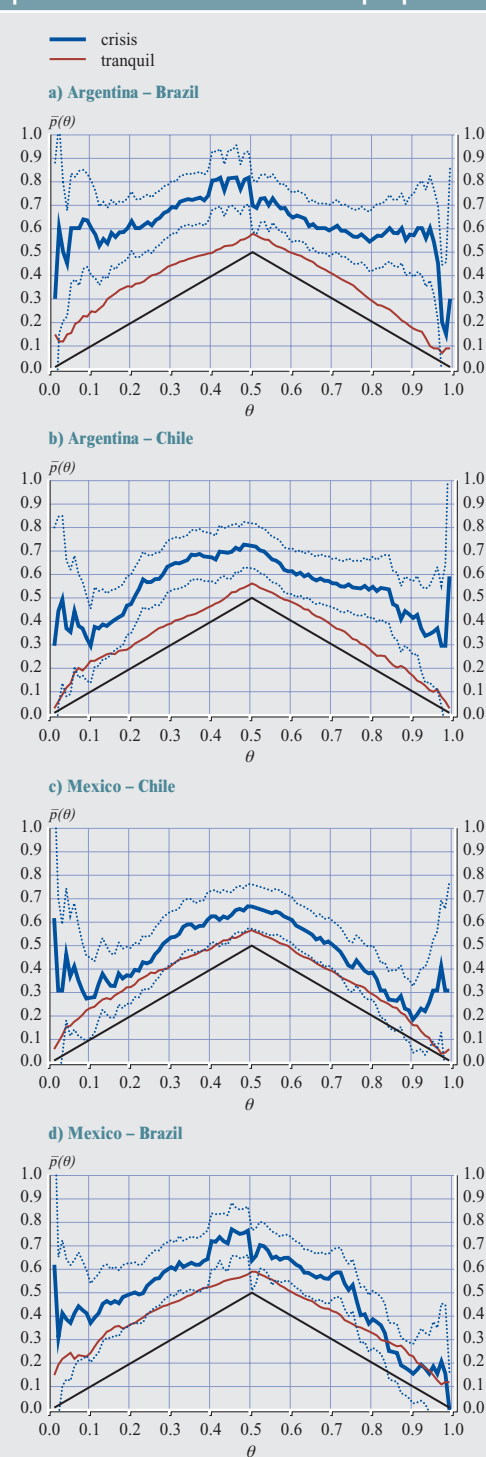
Cappiello et al. (2005) represent conditional spillover probabilities for returns estimated with quantile regressions in the so-called co-movement box. This is a square with unit side, where conditional probabilities are plotted against the thresholds. When the plot of the conditional probability lies above the 45° line, which represents the case of independence between two markets, then this is interpreted as evidence of positive co-movements. In general, the higher the conditional probability, the higher the co-dependence between two market returns. The authors use this methodology to investigate the joint impact of the “Tequila” crisis of 1994, the “Asian flu” of 1997 and the “Russian virus” of 1998 on the main Latin American equity markets (Argentina, Brazil, Chile and Mexico).

Charts B.2.a-B.2.d represent the estimated conditional probability of co-movement for a selected number of country pairs. Two solid lines are plotted together with the case of independence. The thin line indicates the conditional probability of co-movements over tranquil times. The thick line, by contrast, shows the conditional probability of co-movements during the three crisis periods. Confidence bands are plotted as dotted lines. For financial stability purposes, the emphasis is on the far left-hand side of the box, i.e. large negative returns. When the thin line there lies below the thick one and outside the confidence bands, this indicates statistically significant contagion. The results show strong evidence of contagion between Argentina and Brazil. Large negative spillovers also increase for the other three cases in the figures, but these changes are not statistically significant. Overall, it can be concluded that some EMEs are subject to stock market contagion, and others not.

## CONCLUDING REMARKS

This Special Feature illustrates that the literature has now developed a number of methods to identify and measure financial

Chart B.2 The co-movement box applied to Latin America – estimated conditional probabilities in crisis versus tranquil periods



Source: L. Cappiello, G. Gerard and S. Manganelli (2005), “Measuring Comovements by Regression Quantiles”, *ECB Working Paper*, No 501, Figure 4, pp. 25, 26.

market contagion phenomena. While all relevant features of contagion seem to be captured, there is still disagreement about which approach is the best to use. Therefore, it is probably better to employ several approaches rather than just a single one. Future research could also help to combine different approaches still further.

Keeping the above caveats in mind, the following tentative conclusions may be drawn from the evidence provided. As central banks are interested in the prevalence and breadth of contagion from a financial stability perspective, the emphasis should be on extreme market situations. While smaller correlation changes or excess co-movements may be inefficient, they will usually not be very important in terms of financial instability. Overall, international financial market contagion seems to be a relevant but relatively infrequent phenomenon. It does not occur with vehemence in each market crisis, but occasionally contagion phenomena are present. In most instances the breadth of contagion seems to be limited to specific countries or geographical regions. Moreover, the extent of contagion is easily overestimated if only stock markets are considered, which tend to be the most highly interlinked asset class. Many other asset classes, conversely, tend to be less interlinked. In addition, crisis propagation across different asset classes is much weaker than within the same asset class. The flight to quality is an economically relevant phenomenon that tends to limit the breadth of contagion. Finally, correlations are not a good indicator of contagion.

While very widespread severe financial market contagion is extremely rare, this does not mean that policymakers should disregard it altogether. Policies to maintain international financial stability are there to keep the likelihood of such extreme events – potentially related to general losses of confidence in the system – as low as possible. Policymakers must be prepared to face the consequences when such events do nevertheless occur and

risk affecting the functioning of the economy as a whole. A first step is that individual countries should “keep their own house in order” by establishing a stable macroeconomic environment and a resilient domestic financial system. In a second step – in the absence of a global central bank or supervisory authority – international financial surveillance and the setting of standards by the Financial Stability Forum and the IMF are important.