Financial markets in times of stress

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Abstract

In this paper, we examine which markets are most synchronized internationally and exhibit the greater extent of co-movement. We focus on daily data for four asset markets: bonds, equities, foreign exchange, and domestic money market. Our sample covers 35 developed and emerging market countries during 1997–1999. The extent of co-movement and responsiveness to external shocks is examined in different ways. To measure the response of these markets to adverse external shocks, we date the peaks in domestic interest rates and bond spreads and the largest daily declines in equity prices and assess the extent of clustering around the same period. We also analyze which markets show evidence of greatest co-movement, in general, irrespective of whether there are adverse shocks or not.
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1. Introduction

Much has been written about globalization and the greater degree of capital market integration in the past decade. One strand in this vast literature has developed a variety of approaches to test for the extent of capital mobility.[3] Another rapidly growing branch has attempted to document the incidence of contagion, spillovers, or international propagation of shocks. Often, these studies focused on the cross-country correlations of asset returns.

However, most of this literature has paid little attention to the probable case that not all asset markets are likely to be affected by external shocks in the same manner or equally integrated internationally.[4,5] Such differentiation in the sensitivity to external shocks or the extent of global integration may arise for several reasons. For instance, Reinhart and Reinhart (1999) provide a simple model, where investors have perfect access to the international bond market, but bank customers do not. They show that if depositors have access to international capital markets interest rates on deposits will co-move with the international interest rates on bonds; however, if borrowers cannot borrow from abroad, lending rates of interest need not covary with the international interest rates on bonds.[6] Similarly, if a government allows its bonds to be freely traded internationall,y but has restrictions on the foreign ownership of equities, one would expect that bond yields would be more responsive to external shocks than equity returns. However, market segmentation of these types will not be the only reason why some asset markets may be more sensitive to external shocks than others. While a variety of narratives describing episodes of contagion suggest that speculative attacks on currencies are bunched together across countries, the heterogeneity in exchange rate arrangements and monetary policy across countries would suggest that exchange rates and the "policy" domestic interest rate are likely to show less covariation across countries than an internationally traded sovereign bond or equity.[7] Foreign investors may play a more prominent role in some markets (i.e., the market for sovereign bonds) which may increase the degree of co-movement across countries, since the same decision makers are involved. Along the same lines, equity price indices may have a markedly different industry composition across countries, which may act to dampen co-movement with equity markets across international borders. In other words, the domestic idiosyncratic component in some asset markets is greater than in others.

In this paper, we examine which markets are most synchronized internationally and exhibit the greater extent of co-movement. We focus on daily data for four asset markets: bonds, equities, foreign exchange, and domestic money market. Our sample covers 35 developed and emerging market countries during 1997–1999. The extent of co-movement and responsiveness to external shocks is examined in different ways. First, to measure the response of these markets to adverse external shocks, we date the peaks in domestic interest rates and bond spreads and the largest daily declines in equity prices and assess the extent of clustering around the same period. Second, we conduct principal component analysis over the entire sample to analyze which markets show evidence of greatest co-movement, in general, irrespective of whether there are adverse shocks or not.[8]

In the next section, we describe and date the various episodes of regional or global financial turmoil that we study and provide some background on the international setting

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[4]   External shocks may take the form of a rise in international interest rates, an oil shock, or a financial crisis in another country.

[5]   An exception is Hausman and Rigobon (2000).

[6]   Obviously, the opposite is true if borrowers are the ones with access to international capital markets, while depositors do not.

[7]   One example is Eichengreen et al. (1996), which analyzes of Europe's Exchange Rate Mechanism crisis.

[8]   In the working paper version of this paper, we look for volatility spillovers, working with the simplest of the generalized autoregressive conditional heteroskedasticity (GARCH) models to examine whether there was a marked change in volatility much along the lines of Edwards (1998) and Edwards and Susmel (2000) and (2001).

during our sample period. In Section 3, we compare the extent of co-movement across countries and the profile of daily volatility in four asset markets—bond, equity, foreign exchange, and domestic money market. Concluding remarks, sprinkled with some policy implications, are presented in Section 4.

2. Episodes and background

In what follows, we turn our attention to some of the events or "shocks" that have shaped financial markets in recent years; all these episodes are likely to be familiar to the reader, as these have received considerable attention in the financial press.

2.1. Asset markets

Shocks may be confined to a single market, such as equities, or may have more far-reaching consequences, simultaneously affecting foreign exchange, domestic money, and the international bond markets. Most often, when a country is mired in a deep financial crisis, all markets are affected; the currency weakens, domestic interest rates rise as expectations are unsettled (this may be compounded if the monetary authorities tighten policy to restore credibility), the terms of borrowing in international capital markets (assuming access is not lost altogether) deteriorates, and other asset prices (i.e., equity and real estate) slide. Volatility increases across the board. Milder periods of turbulence, owing to external developments, may not have such widespread effects. For instance, the period of financial market turbulence around October 27–28, 1997, was nearly global in scope, but was largely confined to equity markets. In the analysis that follows, we will pay particular attention to how the spread of disturbances across countries differs among the four asset markets we study.

2.2. Events

Table 1 presents a brief chronology of significant events during the January 1, 1997–August 31, 1999 period. The list is not meant to be exhaustive, rather it highlights some of the key episodes we analyze.[9] In the remainder of this paper, our focus is primarily on four events. In chronological order, they are: the devaluation of the Thai baht on July 2, 1997; the Russian devaluation and default on August 17, 1998; the September 1–2, 1998 stint, during which Malaysia introduced fairly drastic capital control measures (on September 1st) and LTCM issued a letter to its shareholders revealing its precarious condition (on September 2nd); and the recapitalization of LTCM that began on September 23, 1998.

While these events are a focal point of our study, there are other episodes that are encompassed in our analysis. These include: the crash of the U.S. equity market and the

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[9] For a more comprehensive chronology of the events surrounding the Asian crisis the reader is referred to Nouriel Roubini's home page; for a more detailed listing of significant events in the fall of 1998, see Bank for International Settlements (1999); and for a more extensive chronology of capital controls, see Edison and Reinhart (2001).

Table 1
Selected significant events during 1997 and 1998

Date	Event
July 2, 1997	Devaluation of the Thai baht
August 14, 1997	Indonesia abandons the rupiah trading band
October 28, 1997	US and Hong Kong markets crash
November 17, 1997	Korea abandons its defense of the won
July 6, 1998	Salomon Brothers bond arbitrage desk disbanded
July 20, 1998	First Wall Street Journal headline on LTCM losses
August 17, 1998	Russian effective default and ruble devaluation
September 1, 1998	Malaysia introduces capital controls
September 2, 1998	LTCM shareholder letter issued
September 23, 1998	LTCM recapitalization
October 15, 1998	Intermeeting Federal reserve rate cut
January 10,	Market disrupted after Chinese government refused to help foreign creditors of GITIC
January 13	Fears of debt crisis in China sweep through Hong Kong. Brazil devalues

Sources: The authors and Bank for International Settlements, A Review of Financial Market Events in Autumn 1998, October 1999.

speculative attack on Hong Kong on October 28, 1997; the evolution of the Korean crisis following the devaluation of the won on November 17, 1997; the closure of Solomon Brothers' bond arbitrage desk on July 6, 1998; the first Wall Street Journal article on the profit pressures on LTCM on July 20, 1998; the inter-FOMC meeting reduction in U.S. interest rates on October 15, 1998; and the Brazilian devaluation on January 13, 1999, which also coincided with rumors about a possible debt crisis in China.

2.3. Data and sample

Our data is daily and spans the period beginning on January 1, 1997 through August 31, 1999. Because of the daily frequency of the data, the variables we analyze are confined to financial markets. Specifically, these variables are: the domestic overnight interbank interest rates (whenever possible); the daily return on equities in the local currency taken from local bourse indices;[10] the percent change in the daily exchange rate vs. the dollar or vs. the deutschemark (DM);[11] and the interest rate spreads on bonds that capture the "pricing of risk." For the industrial countries, the interest rate spread is between corporate and sovereign bonds, while for emerging markets the spread is between a sovereign bond and a comparable United States Treasury security. As regards sovereign bonds, we have tried to use the most liquid of these, since bonds that are infrequently traded are not likely to reflect short-term shifts in market sentiment. The particulars for all the data used for the 35 countries in our sample are provided, along with their respective sources, in Appendix A.

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[10] More precisely, returns are defined as the percent change in equity prices, as dividend data is not available on a daily frequency.

[11] For all the countries, the exchange rate is bilateral against the U.S. dollar. The exceptions are Estonia and the European countries, for which bilateral exchange rates vs. the DM are used. The exchange rate is expressed as number of local currency units per dollar or DM; hence, an increase denotes a depreciation. After January 1, 1999, DM quotes are based on a strict translation from Euros.

The countries in our sample cover more of the mature-to-emerging market range of experiences. Countries with less developed capital markets and a significant extent of financial repression are not a part of this study, as the focus rests on high-frequency capital market developments. We can classify the sample into five, somewhat arbitrary, seven-country groupings: the G-7 countries, which are comprised of Canada, France, Germany, Italy, Japan, United Kingdom, and the United States; and the Transition economies, which include Bulgaria, Czech Republic, Estonia, Hungary, Poland, Russia, and the Ukraine. The remaining three groups are primarily by region. There is the Asian cluster, which includes Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, South Korea, and Thailand. The other European group, which excludes those countries that are part of the G7 and includes, Finland, Greece, Holland, Norway, Spain, Sweden, and the non-European Turkey. Finally, the Latin American sample consists of the larger economies in the region, Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.

2.4. The international setting

Tables 2 and 3 present a broad brush view of the key variables during three subperiods in our sample: the period in between the devaluation of the Thai baht and that of the Russian ruble; the couple of weeks in between the Russian devaluation and the introduction of capital controls in Malaysia, which occurs a day before LTCM issued a letter to its shareholders; and the stretch between that day and the relatively rare interim easing of monetary policy in the United States. Table 2 presents the cumulative change in the variables of interest, which simply compares the end point to the first observation of the sample. Hence, for example, interest rates were roughly the same on August 17, 1998 as they were on July 1, 1997 for the G7 and the Latin American economies although rates were higher for the Asian and transition economies (7.09% and 13.14%, respectively.) Since the first subsample covers a much longer period, Table 3 presents the same data for daily changes at a monthly rate.[12] Thus, for instance, during the first subsample, interest rates rose (on average) by 0.69% per month for the transition economies; however, the increase was close to zero for the G7 countries.

The three subsamples are quite distinct from one another. Prior to the Russian crisis, Asian exchange rates had depreciated markedly against the U.S. dollar—largely owing to the collapse of the Indonesian rupiah. Asian equity prices fell 56%, while the terms at which they could borrow in international capital markets deteriorated, as reflected in the widening of bond spreads of 354 basis points. Over this period, other emerging markets also experienced declining asset prices, despite relatively stable exchange rates and interest rates. For the Latin American group, equity prices fell 32%, as equity markets in the region fell across the board.[13] More surprisingly, bond yield spreads widened 522 basis points—even more than for the Asian crisis countries.[14] The widening in bond spreads is even more pronounced for the transition economies. However, this is largely owing to Russia. Equity

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[12] Specifically, the change reported in Table 3 divided by the number of days in the subsample raised to 30 to present it as a monthly rate.

[13] The decline in equity prices was largest for Venezuela (56%) and smallest for Colombia (11%).

[14] Again, the largest deterioration was for Venezuelan bonds, as the spread widened by 1793 basis points.

Table 2
Changes over selected periods in domestic interest rates, exchange rates, stock prices, and bond spreads (in percent)

Regional averages	July 1, 1997 to August 17, 1998	August 17, 1998 to September 1, 1998	September 1, 1998 to October 14, 1998
Cumulative changes in interest rates			
Asia	7.09	− 0.13	− 1.47
Europe	1.18	0	− 0.13
G-7	0.11	0.15	− 0.3
Latin America	0.95	4.13	− 0.14
Transition economies	13.14	5.66	− 5.44
Cumulative changes in exchange rates			
Asia	100.87	− 3.66	− 5.06
Europe	13.35	1.03	3.11
G-7	6.29	− 1.55	− 3.04
Latin America	13.36	2.69	1.14
Transition economies	7.71	12.06	8.66
Cumulative changes in stock prices			
Asia	− 56.11	− 9.9	20.05
Europe	37.46	− 14.02	− 11.72
G-7	23.04	− 9.29	− 5.56
Latin America	− 32.16	− 20.03	5.18
Transition economies	− 18.98	− 14.11	− 7.24
Cumulative changes in bond spreads (in basis points)			
Asia	353.58	161.25	45.17
Europe	10.64	125.47	1.48
G-7	15.39	16.41	18.24
Latin America	521.51	668.98	− 289.14
Transition economies	1000.34	868.43	137.25

Data sources are described in Appendix A.

markets were falling nearly everywhere for the transition group, with the exception of Hungary. By contrast, most European and G-7 equity markets had substantial rallies during this period, with notable exceptions being Japan (down 25%) and Norway (down 11%).

Following the Russian devaluation and before the LTCM story entered the public domain, the picture changes markedly.[15] Equity markets take a tumble everywhere, with the exceptions of South Korea and Russia, which begins to recover from its massive slide. Latin American markets are particularly hard hit. Bond spreads widen dramatically, especially for Latin American sovereign borrowers. For Russia, the spread widens to more than 6300 basis points. Bid-ask spreads on debt instruments also widen dramatically, reflecting the loss of market liquidity. As the next section will illustrate in the context a simple model, this reflected several withdrawals from risk-taking. Domestic interest rates in Latin America rise during this period, with Mexico and Peru posting the largest increases. The higher interest rates during this period owe both to the loss of credibility

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[15] It is important to note that stories of LTCM's financial difficulties were circulating as early as July 20.

Table 3
Average daily changes over selected periods in interest rates, exchange rates, stock prices, and bond spreads (in percent, monthly rates)

Regional averages	July 1, 1997 to August 17, 1998	August 17, 1998 to September 1, 1998	September 1, 1998 to October 14, 1998
Interest rates			
Asia	0.43	− 0.23	− 1
Europe	0.08	0.01	− 0.09
G-7	0.01	0.3	− 0.2
Latin America	0.06	8.99	− 0.23
Transition economies	0.69	15.73	− 4.39
Exchange rates			
Asia	4.12	− 6.84	− 3.45
Europe	0.76	2.08	2.05
G-7	0.42	− 3.02	− 2.07
Latin America	0.9	5.52	0.74
Transition economies	0.53	32.58	5.24
Stock prices			
Asia	− 5.91	− 18.29	12.73
Europe	2.19	− 25.89	− 8
G-7	1.32	− 17.58	− 3.77
Latin America	− 2.91	− 35.9	3.26
Transition economies	− 1.59	− 23.89	− 5.33
Bond spreads (in basis points)			
Asia	25.09	326.93	28.26
Europe	0.75	258.38	0.98
G-7	1.12	32.87	12.15
Latin America	36.73	1412.36	− 197.67
Transition economies	65.95	1936.26	88.82

Data sources are described in Appendix A.

many emerging markets suffered following the Russian default—in part, on the reassessment of the likelihood of bailouts by the International Monetary Fund−and to the use of tight-money policies by many emerging market central banks to defend exchange rates.

What is striking about the last subsample, which are the six weeks preceding the Fed's interest rate cut, is that emerging markets appeared to be recovering already from the Russian shock. Interest rates had started to decline, particularly, in Asia, while equity markets were recovering, especially in Malaysia and Thailand. Bond spreads for Latin America had began to narrow (by about 289 basis points) although yield spreads remained well above precrisis levels. For industrial countries, the picture is very different from the emerging markets, as equity markets continued to tumble and bond spreads widened further.

This strikingly divergent performance between emerging and mature capital markets in this last period may owe to the fact that, during these weeks, there was much speculation in financial circles as to whether there would be more LTCMs. Hence, there was concern about the health of the financial centers, rather than the periphery. By then, the periphery

had already been hard hit and portfolio inflows of capital (bond and equity) had dramatically dried up. This stands in contrast to the equity market booms most of the industrial countries were enjoying prior to the Russian/LTCM shock.

3. International co-movement in asset markets: some evidence

To begin our enquiry as to which asset markets show the greatest extent of co-movement across countries, we examine some basic descriptive statistics. In particular, we compare the dates of maximum and minimum values during the full sample to those of the episodes we are interested in analyzing. Many of the countries in our sample do not allow their currencies to float freely—even when they say they do.[16] As a consequence, we focus in the overnight domestic interest rate, as the highest rates may be associated with speculative attacks on the foreign exchange market. Table 4, which provides the dates of the maximum values, reveals that, for most of the Asian countries in our sample, interest rate peaks occur in the second half of 1997 and into early 1998, a period of much turbulence in the region.[17] August and September 1998 also shows numerous entries, coinciding with the Russia/LTCM crises.[18] However, with only a couple of exceptions, peaks in domestic interest rates are not highly synchronized across countries. This lower degree of co-movement could owe to the heterogeneity across countries as regards what money market interest rates reflect or simply because monetary policy responses vary across countries. The global coordination of disturbances is far more evident in Tables 5 and 6, which provide the dates of the largest daily equity market declines and the largest increase in the bond yield spread. These equity market crashes are overwhelmingly clustered on October 27–28, 1997 and in the interval between the Russian devaluation and the Federal Reserve's intermeeting interest rate cut. The bunching of disturbances across countries is even more evident in the bond spread data presented in Table 6. With a few exceptions, the largest daily increases occur in the late summer and fall of 1998.

On the basis of these simple observations, it would appear that the October 1997 disturbance, while far-reaching in its global scope was, confined to equity markets, while the August–October 1998 disturbances extended to bond markets as well.

3.1. Principal component analysis

To assess more formally how the degree of co-movement across countries in several financial variables evolves over time and across regions, we applied principal component analysis to the financial time series data over the full sample as well as several subsamples.

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[16]   See Reinhart (2000) and Calvo and Reinhart (2002) on the pervasiveness of the "fear of floating" across both industrial and emerging market countries.

[17]   This issue will be discussed in more detail in the next section.

[18]   When confronted with a common shock that affects the financial center (such as Russia and LTCM), "fear of floating" (if not an explicit peg) may also bring about a synchronized rise in domestic interest rates, as central banks tighten in an effort to cap the slide in the currency (see Calvo and Reinhart, 2002).

Table 4
Daily overnight interest rate peaks: January 1997–August 1999

Month and year	Country/date	Maximum value
January 1997	Germany/1	4.66
	Hungary/15	28.10
March 1997	United States/31	7.07
April 1997	Japan/1	0.61
	Finland/14	7.49
May 1997	Czech Republic/29	168.76
July 1997	Thailand/2	27.0
	Malaysia/11	35.0
August 1997	Indonesia/20	91.45
October 1997	Philippines/7	102.63
	Greece/31	80.50
November 1997	Argentina/4	13.50
	Brazil/14	70.37
	Poland/26	27.09
December 1997	Chile/04	
	Korea/26	35
January 1998	Singapore/8	17.50
February 1998	Spain/23	10.95
March 1998	Estonia/2	17.22
	Holland/24	4.50
April 1998	Turkey/8	76.88
May 1998	Sweden/29	4.56
June 1998	Venezuela/19	140.40
	Italy/30	8.00
August 1998	Russia/18	160.00
	Norway/25	10.00
	Hong Kong/31	17.50
	Canada/31	5.85
September 1998	Ukraine/9	145.00
	Mexico/11	40.0
	Peru/24	55.0
October 1998	UK/06	8.88

Data sources are described in Appendix A.

We focus on four daily time series, the domestic policy interest rate, the return on equity, the change in the exchange rate (in percent), and the bond spreads, for 34 of the 35 countries in our sample.[19] From these series, we constructed a smaller set of series, the principal components, that explain as much of the variance of the original series as possible. The higher the degree of co-movement in the original series, the fewer the number of principal components needed to explain a large portion of the variance of the original series. In case where the original series are identical (perfectly collinear), the first principal component would explain 100% of the variation in the original series. Alternatively, if the series are orthogonal to one another, it would take as many principal components as there are series to explain all the variance in the original series. In that case, no advantage would be gained by looking at common factors, as none exist.

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[19] Owing to limited data availability, Bulgaria is excluded from the sample.

Table 5
Largest daily stock market declines: January 1997–August 1999

Month and year	Country	Date	Percent change
August 1997	Philippines	8/28	− 9.3
October 1997	Argentina	10/27	− 13.7
	Canada	10/27	− 6.2
	Mexico	10/27	− 13.3
	Peru	10/27	− 7.3
	US	10/27	− 6.9
	Germany	10/28	− 8.0
	Hong Kong	10/28	− 11.6
	Hungary	10/28	− 16.4
	Italy	10/28	− 6.2
	Poland	10/28	− 9.8
	Singapore	10/28	− 9.2
November 1997	Estonia	11/10	− 19.4
	Korea	11/24	− 11.0
	Japan	11/25	− 5.1
January 1998	Indonesia	1/08	− 12.0
February 1998	Thailand	2/04	− 9.5
August 1998	Greece	8/27	− 7.7
	Turkey	8/27	− 13.1
	Czech Republic	8/27	− 6.8
September 1998	Ukraine	9/02	− 15.4
	Malaysia	9/08	− 21.5
	Brazil	9/10	− 15.8
	Chile	9/10	− 7.4
	Russia	9/15	− 24.0
	Norway	9/17	− 7.0
	France	9/17	− 5.0
	Holland	9/21	− 5.7
October 1998	Finland	10/08	− 6.9
	Sweden	10/08	− 6.7
December 1998	UK	12/01	− 3.6
	Venezuela	12/11	− 10.2
January 1999	Spain	1/13	− 6.5
	Colombia	1/28	− 5.5

Data sources are described in Appendix A.

The procedure begins by standardizing the variables so that each series has a zero mean and a unit standard deviation. This standardization ensures that all series receive equal treatment and the construction of the principal component indices is not influenced disproportionately by the series exhibiting the largest variation. The correlation matrix of the standardized series is decomposed into its Eigen vectors and the diagonal matrix of Eigen values.

The Eigen vectors are the loading factors, or weights, attached to each of the original series. For a particular time series, the higher the degree of co-movement with other series the higher (in absolute value) its loading factor. If a particular time series is uncorrelated with the remaining series included in the analysis, then its loading factor in the first principal component should be close to zero. A priori, this is what we should expect to see

Table 6
Daily peaks in bond spreads: January 1997–August 1999 (in basis points)

Month and year	Country/date	Maximum value
March 1997	Holland/25	116.58
January 1998	Hong Kong/12	591.17
August 1998	Argentina/27	1525.32
	Venezuela/27	4097.92
September 1998	Turkey/1	1030.67
	Korea/4	964.30
	Brazil/10	2120.99
	Peru/10	1090.24
	Mexico/11	1598.93
	Colombia/15	1090.24
	Philippines/21	1231.03
October 1998	Canada/5	101.50
	Hungary/5	192.79
	Indonesia/5	1843.30
	Poland/5	581.76
	Singapore/5	3.36
	Sweden/6	106.77
	Greece/6	56.20
	Russia/8	6819.17
	Finland/15	75.43
	Germany/15	62.00
	United States/15	183.94
	Thailand/28	92.85
December 1998	Spain/1	136.36
January 1999	France/8	37.00
	United Kingdom/27	110.00
August 1999	Italy/20	141.15
	Japan/20	71.00

Data sources are described in Appendix A.

for the time series of, say, a small country with a "perfectly idiosyncratic" shock, or for a country which has binding capital controls.[20]

The results are presented in Tables 7 and 8 for the four regional groupings and for the G-7 countries. The share of the variance of the original series (in this case, equity returns) explained by the first principal component ranges from a low of 0.36 for the transition economies to a high of 0.57% for the European group—with the other groups falling in between. These results are hardly surprising, in light of the lack of homogeneity in the Transition economies group relative to the higher degree of integration in Europe.

Examining the factor loadings by region or group, the outcomes are equally intuitive.

Among the Asian countries in our sample (Japan excluded), South Korea has the lowest factor loading (0.24); this result is not surprising, given that its own financial crisis began months after the onset of turmoil in Thailand, Indonesia, Malaysia, and the Philippines.[21]

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[20] The controls insulate the country from external disturbances (see Edison and Reinhart, 2001).

[21] See Kaminsky and Reinhart (2001) for an analysis of the interdependence of the Asian economies before and after the 1997 crisis.

Table 7
Principal component analysis: daily data, January 1, 1997–August, 1999, factor loadings by region

	Overnight interest rates	Factor loading in first principal component		
		Stock returns	Exchange rate changes	Bond spreads
Proportion of the variance explained by the first principal component: **Asia**	0.17	0.46	0.38	0.71
Hong Kong	0.31	0.43	0.06	n.a.
Indonesia	0.14	0.38	0.43	0.5
Malaysia	− 0.19	0.32	0.18	n.a.
Philippines	− 0.41	0.38	0.5	0.57
Singapore	0.68	0.47	0.36	n.a.
South Korea	0.42	0.24	0.47	0.48
Thailand	0.2	0.38	0.43	0.43
Proportion of the variance explained by the first principal component: **Europe**	0.16	0.57	0.32	0.63
Finland	0.34	0.44	0.44	0.55
Greece	− 0.16	0.22	0.26	n.a.
Holland	0.28	0.44	0.36	n.a.
Norway	0	0.4	0.47	n.a.
Spain	0.42	0.41	0.32	0.36
Sweden	0	0.44	0.43	0.51
Turkey	0.59	0.2	0.31	0.55
Proportion of the variance explained by the first principal component: **G-7**	0.23	0.56	0.31	0.47
Canada	0.18	0.36	− 0.01	0.49
France	0.56	0.45	− 0.31	0.36
Germany	0.56	0.42	0.6	0.3
Italy	0.47	0.41	− 0.39	0.16
Japan	0.1	0.21	0.4	0.26
United Kingdom	− 0.08	0.43	0.47	0.45
United States	0.32	0.31	–	0.49

Data sources are described in Appendix A.

Malaysia shows the next-to-least degree of co-movement (the loading factor is 0.32)—
then again, Malaysia had capital controls throughout the latter part of the sample. Among
the European grouping, the extent of co-movement is the least for Turkey, which has
unresolved chronic inflation problems, and Greece. Among the G-7 countries, the patterns
of co-movement are also largely defined along regions. The four European countries move
in unison; the United States and Canada move in another block.[22] Japan shows the least
co-movement with the other G-7 countries.

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[22] This is evident in the factor loadings of the second principal component, shown in the next column.

Table 8
Principal component analysis: daily data, January 1, 1997–August 1999, factor loadings by region

	Factor loading in first principal component for:			
	Changes in overnight interest rates	Stock returns	Exchange rate changes	Bond spreads
Proportion of the variance explained by the first principal component: **Latin America**	0.27	0.49	0.2	0.93
Argentina	− 0.42	0.46	0.13	0.41
Brazil	0.46	0.45	0.36	0.41
Chile	n.a.	0.4	0.44	n.a.
Colombia	0.59	0.11	0.39	0.4
Mexico	0.09	0.44	0.59	0.41
Peru	− 0.53	0.38	0.39	0.41
Venezuela	n.a.	0.28	0.04	0.4
Proportion of the variance explained by the first principal component: **Transition**	0.22	0.38	0.28	0.75
Czech Republic	0.58	0.5	0.6	n.a.
Estonia	0.11	0.26	0.10.	n.a.
Hungary	0.39	0.54	0.58	0.59
Poland	− 0.44	0.51	0.52	0.6
Russia	− 0.54	0.34	0.01	0.44
Ukraine	0.14	0.14	− 0.14	n.a.

Data sources are described in Appendix A.

Turning to Latin America, co-movement is strongest among the larger three-Argentina, Brazil and Mexico, and least for Colombia and Venezuela. These patterns of covariation are not unique to the 1997–1999 sample. In the immediate aftermath of the Mexican crisis, when most Latin American equity markets posted substantial declines, Colombia's equity market posted moderate gains. Lastly, co-movement is strongest among the earlier reformers—Poland, the Czech Republic, and Hungary—and weakest the Republics of the former Soviet Union.

Tables 7 and 8 also report, for comparison purposes, the results for interest rate changes and exchange rates. As is evident for all the country groups, the extent of covariation is noticeably lower reaching 0.4 for any group's exchange rates and interest rates.

3.2. Conditional variances

In this section, we work with the simplest of the generalized autoregressive conditional heteroskedasticity (GARCH) models to examine whether there was a marked change in volatility during and around the various episodes analyzed in the preceding section).[23] To

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[23] In all cases, a GARCH (1, 1) model was estimated.

economize on space, we only summarize our findings, which are reported in greater detail in the working paper version of this paper. We consider the following models:

$$r_t = \sum_{t=t-i}^{k} \beta_i r_{t-i} + \varepsilon_t$$

$$\sigma_{r_t}^2 = \omega + \alpha_{\varepsilon_{t-1}^2} + \delta_{\sigma_{t-1}^2} \tag{1}$$

where stock returns are denoted by r_t, in Eq. (1), and the random shock is denoted by ε.[24] In the variance equation, ω is the mean of the variance; the lag of the mean squared residual from the mean equation (i.e., ε_{t-1}^2) is the ARCH term; and last period's forecast variance (i.e., σ_{t-1}^2) is the GARCH term. The number of autoregressive lags, k, was selected on a country-by-country basis using both the Akaike and Shwartz criteria; if these yielded different results as regards the optimal lag length, both models were estimated. We also estimated a comparable model for the domestic interest rate and the change (in percent) of the exchange rate. Periods of turbulence that are part of our sample of daily observations render the assumption of identically and independently distributed conditionally normal disturbances in the most basic GARCH model inadequate.[25] Given the presence of heteroskedastic disturbances in our sample (i.e., the εs), we use the methods described in Bollersev and Woolridge (1992) to compute the Quasi-Maximum Likelihood covariances and standard errors.

Before turning to a discussion of specific countries, however, there are some general patterns that emerge from the analysis of the conditional variance of equity returns for these 33 countries that merit mention.[26] Even without knowing what events transpired during the three years covered in our sample, the equity returns data reveal four periods of general market stress, as reflected in large-to-moderate spikes in the variance of equity returns. Two periods stand out most clearly from a review of the figures: a marked period of turbulence at end October–early November of 1997 in most of the equity markets in our sample—this episode was, for the most part, relatively short-lived; and a more severe and far more protracted bout of volatility that, for most countries, begins in August of 1998 and lasts through October of that year.[27] Indeed, in more than half of the countries in the sample, the largest spikes in volatility were recorded in the late summer and fall of 1998 and that in 19 of the 33 countries, this period was associated with the most persistent bout of volatility in the sample.

In addition to the two more obvious episodes of market volatility on a global scale, there are two periods of market stress which merit discussion. The first of these occurs in early

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[24] More precisely, the variable in question is capital gains or losses, as there is no dividend data at a daily frequency.

[25] For a discussion of some of the implications of changes in the variance of economic fundamentals during crises periods in the analysis of the international transmission of shocks, see Forbes and Rigobon (in press).

[26] The conditional variance of daily equity returns is plotted for each country in Appendix Figs. 1–18, and Tables 17–21 in the working paper version of this paper.

[27] The first of these episodes lines up with the equity market crash in New York and, particularly, Hong Kong on October 28, 1997, while the second spans the Russian crisis—LTCM debacle.

1998, at the height of the Asian crisis, and it engulfs all the Asian countries in our sample including Japan.[28] Indeed, for seven of the countries in our sample (all in Asia), this episode shows the most marked and persistent rise in equity market volatility. The high volatility during this period, however, is largely confined to Asia, as both mature and emerging markets elsewhere are relatively tranquil. The other market turbulence episode revealed by this data occurs in January 1999, and it is most evident in Latin America. The equity markets of four countries in our sample (all in Latin America) record their largest spike in volatility in that month; the shock, however, seems to be relatively short-lived. Several European and Transition economies' equity markets also show more moderate increases in volatility. This spike corresponds to both the Brazilian devaluation of the real and several market disruptions after the Chinese government refused to help foreign creditors of GITIC. Fears of debt crisis in China also swept through Hong Kong at this time.

As regards individual countries, it is worth noting that, in some cases, overlap with ''global events'' may be more of a coincidence that the conditional variances reveal. For example, as discussed earlier in the context of the principal component analysis, Colombia is a country whose equity market shows little co-movement with the rest of Latin America or other equity markets. Its deep financial crisis, which occurs shortly after the devaluation of the ruble, had little to do with Russia or LTCM—as it had been brewing for fundamental reasons for some time. Similarly, the spike in interest rates in Greece following the equity market turbulence in end October 1997 was owing to an attack on the drachma motivated by predominantly domestic considerations. Another feature of the conditional variances, which applies to several ''crisis'' countries, is that the conditional volatility of equity returns remains consistently higher in the postcrisis period. This is most evident of Indonesia and South Korea, but it also applies to Colombia, the Philippines, and Thailand. In sum, the analysis of the variance of equity prices provides additional support that disturbances have an important global dimension in the period under scrutiny. Far more so than what is observed in foreign exchange and money markets.

4. Concluding comments

This paper has presented evidence to suggest that there are important differences in the responsiveness to external shocks and, more broadly, in the extent of international synchronization across asset categories. Hence, the implications that one can draw about the extent of globalization and the degree of capital market integration depends importantly on which is the market examined. With the exception of the G-7, which includes heterogenous cycles among the United States and Canada, Europe, and Japan, bond yield spreads exhibit—by far—the highest degree of co-movement both across countries for the entire sample and various subsamples.[29] One can speculate that, given that these spreads are dominated by sovereign risk, they represent a more homogeneous asset class than the

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[28] Korea's devaluation of the won occurs on November 17, and their negotiations with the International Monetary Fund last into late December 1997–early January 1998. Furthermore, during this period, there are recurring rumors that China will devalue and set the stage for a new round of financial instability in the region.

[29] Not all of these are reported here, but the results are available from the authors upon request.

equity, currency, and money market counterparts—sovereign bonds may also have a more common and homogenous foreign investor base. A distant second in the extent of co-movement in returns (again, the exception being the G-7 group) are equity markets; for the G-7 countries, however, equity markets are the most correlated of the four asset markets we examine. Furthermore, in terms synchronicity, as measured by the overlap of dates in which the largest declines were observed, equity markets also show substantial respon-siveness to external shocks.

For nearly all the regions or country groupings, the exchange rate market followed bonds and equities (in that order) as the most correlated across countries. The policy interest rate not surprisingly—given the heterogeneity across countries in monetary policy and the extent of credibility—comes as a distant fourth in terms of international co-movement. Idiosyncratic domestic shocks appear to be the dominant factor in explaining their behavior.

In sum, studying the extent of capital mobility and the impacts of external shocks has been most often too limited to focusing on a particular asset market. Our results, taken together, suggest that even countries with little capital account restrictions may be subject to other forms of capital market segmentation. Hence, the differences in the degree of capital mobility is something that not only needs to be understood across countries, but across markets in a particular country as well.

Acknowledgements

Appendix A. Data Appendix

A.1. Stock market indices

Country	Index	Source
Argentina	Merval Index (local currency)	BLOOMBERG
Brazil	lBOV Index (local currency)	BLOOMBERG
Canada	TS300 Index (local currency)	BLOOMBERG
Chile	IPSA index (local currency)	BLOOMBERG
Colombia	COSMlBB Index (local currency)	BLOOMBERG
Czech Republic	PX50L Index (local currency)	BLOOMBERG
Estonia	TALSE Index (local currency)	DOW JONES ONLINE
Finland	HEX Index (local currency)	BLOOMBERG
France	SBF250 Index (local currency)	BLOOMBERG
Germany	DAXI Index (local currency)	BLOOMBERG
Greece	ASE Index (local currency)	BLOOMBERG
Holland	AEX Index (local currency)	BLOOMBERG
Hong Kong	HKAOl Index (local currency)	BLOOMBERG

Appendix A.1 (*continued*)

Country	Index	Source
Hungary	BUX Index (local currency)	BLOOMBERG
Indonesia	JCI Index (local currency)	BLOOMBERG
Italy	MlB30 Index (local currency)	BLOOMBERG
Japan	TPX Index (local currency)	BLOOMBERG
Korea	KOSPI Index (balanced) (local currency)	BLOOMBERG
Malaysia	KLCl Index (local currency)	BLOOMBERG
Mexico	MEXBOL Index (local currency)	BLOOMBERG
Norway	OBX Index (local currency)	BLOOMBERG
Peru	ISBVL Index (local currency)	BLOOMBERG
Philippines	PCOMP Index (local currency)	BLOOMBERG
Poland	PWSMWIG Index (local currency)	BLOOMBERG
Russia	ASPGEN Index (local currency)	BLOOMBERG
Singapore	STI Index (local currency)	BLOOMBERG
Spain	MADX Index (local currency)	BLOOMBERG
Sweden	GENX Index (local currency)	BLOOMBERG
Thailand	SET Index (local currency)	BLOOMBERG
Turkey	TKSMSCOMP Index (local currency)	BLOOMBERG
UK	IBVC Index (local)	BLOOMBERG
Ukraine	PFTSOTC Index (local currency)	BLOOMBERG
USA	SPX Index (local currency)	BLOOMBERG
Venezuela	IBVC Index (local currency)	BLOOMBERG

A.2. Overnight interest rates

Country	Interest rate description	Source
Argentina	ARLBPl Index: Buenos Aires Interbank Offer Rate	Bloomberg
Brazil	BROVERN Code: Brazil Financing Overnight—Middle Rate	Datastream
Canada	CCLR Index: Canadian Call Loan rate	Bloomberg
Chile	CLREPl D Code: Chile Repo 1 Day—Middle Rate	Datastream
Colombia	CBIBKON Code: Colombian Interbank Overnight—Middle Rate	Datastream
Czech Republic	PRIBOVN Index: Czech Interbank Rates, Overnight	Bloomberg
Estonia	ETONOIN: Estonian Interbank O/N rate	Bloomberg
Finland	FNIWAON Code: Finland Interbank W/A Overnight—Middle Rate	Datastream
France	TMP Index: Taux Moyen Pondere	Bloomberg
Germany	FD00ON Index: Fibor DEM Zka 11 A.m Fixing	Bloomberg
Greece	GIBOON Index: Greech Drachma Interbank Deposit	Bloomberg
Holland	DGCMR Index: Netherlands Overnight Call Rate: EURO	Bloomberg
Hong Kong	HIBRON Index: Hong Kong Dollar Interbank, Overnight	Bloomberg
Hungary	HFDRO/N Index: Hungarian Forint Depo Rates, Overnight	Bloomberg
Indonesia	JINON Index: JAKARTA Interbank Offering Rate	Bloomberg
Italy	RIBORMON Index: Rome Interbank Offer Rate	Bloomberg
Japan	JYMU1T Currency: JPY MUTAN CALL: 1DY	Bloomberg
Korea	KWCRlT Currency: KRW CALL RATE: Overnight	Bloomberg
Malaysia	KLIMON Index: Klibor Interbank Offer Rate, Overnight	Bloomberg
Mexico	MXRPRP1 Index: Mexican Government Paper Rate (Overnight)	Bloomberg
Norway	NOBRON Index: Norway Overnight Lending Rate	Bloomberg
Peru	PSDRlT Currency: PEN DEPOSIT 1DY Peru New Sol	Bloomberg
Philippines	PPCALL Index: Philippine Peso Interbank	Bloomberg

Appendix A.2 (*continued*)

Country	Interest rate description	Source
Poland	WIBOTN: Warsaw Interbank Offer/Bid Rate	Bloomberg
Russia	RSBIBK Code: Russian Interbank I Day—Middle Rate	Datastream
Singapore	SISDON Index: Singapore Dollar Interbank, Overnight	Bloomberg
Spain	ESMIBON Code: SPAIN Interbank Overnight—Middle Rate	Datastream
Sweden	S1BORTN Code: Sweden Interbank Tomorrow/Next	Datastream
Thailand	BITBON Index: Bangkok Interbank Offer Rate	Bloomberg
Turkey	TUIBON Index: Turkish Interbank Rates, Overnight	Bloomberg
UK	BPODR Index: British Pound Overnight Deposit	Bloomberg
Ukraine	UIBRON Index: UKRAINE Average Interbank, Overnight	Bloomberg
USA	FEDLO1 Index: Federal Funds Effective Rate	Bloomberg
Venezuela	VENOVER Code: Venezuela Overnight—Middle Rate	Datastream

A.3. Exchange rates

Country	Description	Source
Argentina	Local currency/US$	Bloomberg
Brazil	Local Currency/US$	Bloomberg
Canada	Local Currency/US$	Bloomberg
Chile	Local Currency/US$	Bloomberg
Colombia	Local Currency/US$	Bloomberg
Czech Republic	Local Currency/US$	Bloomberg
Estonia	Local currency/DM	Bloomberg
Finland	Local currency/DM	Bloomberg
France	Local currency/DM	Bloomberg
Germany	Local Currency/US$	Bloomberg
Greece	Local currency/DM	Bloomberg
Holland	Local currency/DM	Bloomberg
Hong Kong	Local Currency/US$	Bloomberg
Hungary	Local Currency/US$	Bloomberg
Indonesia	Local Currency/US$	Bloomberg
Italy	Local currency/DM	Bloomberg
Japan	Local Currency/US$	Bloomberg
Korea	Local Currency/US$	Bloomberg
Malaysia	Local Currency/US$	Bloomberg
Mexico	Local Currency/US$	Bloomberg
Norway	Local currency/DM	Bloomberg
Peru	Local Currency/US$	Bloomberg
Philippines	Local Currency/US$	Bloomberg
Poland	Local Currency/US$	Bloomberg
Russia	Local Currency/US$	Bloomberg
Singapore	Local Currency/US$	Bloomberg
Spain	Local currency/DM	Bloomberg
Sweden	Local currency/DM	Bloomberg
Thailand	Local Currency/US$	Bloomberg
Turkey	Local currency/DM	Bloomberg
UK	Local Currency/US$	Bloomberg
Ukraine	Local Currency/US$	Bloomberg
Venezuela	Local Currency/US$	Bloomberg

A.4. Spreads

Description of government bonds

Government bond	Coupon rate currency	Maturity date	Security type	Source
Argentina	US$6.8125	0313112005	EMERGING MARKETS	Bloomberg
Brazil	US$7.00	O4llSI2OO9	EMERGING MARKETS	Bloomberg
Bulgaria	US$6.5	0712812011	EMERGING MARKETS	Bloomberg
Canada				FED
Chile	US$6.875	04128/09	GLOBAL	Bloomberg
Colombia	US$7.25	02123104	YANKEE	Bloomberg
Finland	US$5.875	02127/06	GLOBAL	Bloomberg
France				FED
Germany				FED
Greece	DM6.75	11/1312006	EURO MTN	Bloomberg
Holland	€ 6.5	04/15/2003	N-US, INTL DOM	Bloomberg
Hungary	US$6.5	04/08/2003	EURO–DOLLAR	Bloomberg
Indonesia	US$7.75	08/01/2006	YANKEE	Bloomberg
Italy	€ 11.5	03/01/2003	N-US, INTL DOM	Bloomberg
Japan				FED
Korea	US$8.875	04/15/2008	GLOBAL	Bloomberg
Malaysia	US$8.75	06101/09	GLOBAL	Bloomberg
Mexico	US$6.0675	12131/2019	EMERGING MARKETS	Bloomberg
Norway	8.375 CAD	01/27/03	EURO NON-DOLLAR	Bloomberg
Peru	US$3.75	03/07/2017	EMERGING MARKETS	Bloomberg
Philippine	US$6.00	06/01/2008	EMERGING MARKETS	Bloomberg
Poland	US$4.00	10/27/2024	EMERGING MARKETS	Bloomberg
Russia	US$9.25	11127/2001	EURO–DOLLAR	Bloomberg
Spain	€ 10.5	10/30/2003	N-US, INTL DOM	Bloomberg
Sweden	US$5.75	03/26/2001	EURO MTN	Bloomberg
Thailand	US$7.75	04/15/07	YANKEE	Bloomberg
Turkey	US$10.00	05/23/2002	EURO–DOLLAR	Bloomberg
UK				FED
USA	US$5.875	11115/2005	U.S. GOVERNMENT	Bloomberg
Venezuela	US$6.875	03131/2007	EMERGING MARKETS	Bloomberg

Description of corporate bonds

Source	Bonds name	Currency	Bonds description
CANADA	FED Data	CAD	AA corporate—10-year maturity
France	FED Data	FF	AA Corporate—10-year maturity
Germany	FED Data	DM	Mortgage backed—10-year maturity
ITALY	Bloomberg ELFV2A10 Index	ITL	Euro Lira Fair Value AA 10 years
UK	FED data	UKP	AA Corporate—10-year maturity
USA	Bloomberg C6A0 12/72 U.S. Corporates, 5–10 years	US	Index C6AO ORIGINAL SERIES
MLyr			
SPAIN	Bloomberg EPFV2A10 Index	ESP	Euro Peseta Fair Value AA 10 years

A.5. Construction of spreads

Given availability of data, spreads were either constructed with respect to a corporate bond or with respect to government bonds (US or German). Here is a breakdown of spreads used.

Countries	Spread construction
Greece	Spread between Greek government bond and German government bond (DM)
Canada, France, Germany, Italy, UK, US, Spain	Spread between local government bonds and respective corporate bonds (local currency)
All other countries	Spread between local government bonds and U.S. government bond (US$)

References

Bank for International Settlements, 1999. A Review of Financial Market Events in Autumn 1998 Bank for International Settlements, Basle, Switzerland. October.

Bollersev, T., Woolridge, J.M., 1992. Quasi-maximum likelihood estimation and inference in dynamic models with time varying covariances. Econometric Reviews 11, 143–172.

Calvo, G.A., Reinhart, C.M., 2002. Fear of floating. Quarterly Journal of Economics CXVII (2, May), 379–408.

Edison, H., Reinhart, C.M., 2001. Stopping hot money. Journal of Development Economics 66 (2 December), 533–554.

Edwards, S., 1998. Interest rate volatility, contagion, and convergence: an empirical invesatigation of the cases of Argentina, Chile, and Mexico. Journal of Applied Economics 1 (1), 55–86.

Edwards, S., Susmel, R. 2000. Interest Rate Volatility and Contagion in Emerging Markets: Evidence from the 1990s, mimeo, UCLA.

Edwards, S., Susmel, R., 2001. Volatility dependence and contagion in emerging markets. Journal of Development Economics 66 (2 December), 505–532.

Eichengreen, B., Rose, A., Wyplosz, C. 1996. Contagious Currency Crises. National Bureau of Economic Research Working Paper No. 5681.

Forbes, K., Rigobon, R., 2002. No contagion, only interdependence: measuring Stock Market Co-Movement. Journal of Finance (in press).

Frankel, J., 1992. Measuring international capital mobility: a review. American Economic Review: Papers and Proceedings 82 (May), 197–202.

Hausman, R., Rigobon, R., 2000. Financial contagion in emerging markets. In: Fernandez-Arias, E., Hausman, R. (Eds.), Wanted: World Financial Stability. Inter-American Development Bank, Washington, DC.

Kaminsky, G.L., Reinhart, C.M., 2001. Bank lending and contagion: evidence from the asian crisis. In: Ito, T., Krueger, A. (Eds.), Regional and Global Capital Flows: Macroeconomic Causes and Consequences. University of Chicago Press for the NBER, Chicago, pp. 73–99.

Obstfeld, M., 1995. Capital mobility in the 1990s. In: Kenen, P. (Ed.), Understanding Interdependence: The Macroeconomics of the Open Economy. Princeton Univ. Press, Princeton, pp. 201–261.

Reinhart, C., 2000. The mirage of floating exchange rates. American Economic Review 90 (2 May), 65–70.

Reinhart, C.M., Reinhart, V.R., 1999. On the use of reserve requirements to deal with the capital flow problem. International Journal of Finance and Economics 4 (January), 27–54.