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# **Contagion: How it spreads and How it can be stopped?\***

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## *Abstract*

Recent events have drawn attention to the issue of contagion. Dependencies among countries, including through trade links, will cause shocks to an individual country (or group of countries) to affect other countries, often on a regional basis. Such linkages are not contagion, but an increase in cross-market linkages after a shock to one country could be contagion. Weak countries' economic fundamentals, macro-similarities and exposures to certain type of financial agents and associated transmission channels are found to increase the risk of spillovers. And the rules in place for the international financial system can also play a role in contagion. Much is still unknown, however, about what makes countries vulnerable to contagion and through which precise mechanisms it is transmitted. Although much of contagion need not represent irrational behavior on the part of investors, it is clear that volatility will remain. Specific measures at the national level and the international financial architecture are necessary to reduce these risks, manage their impact, and recover as efficiently as possible.

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## *1. Introduction*

The financial turbulence that hit many East Asian countries in 1997 and then spread to other parts of the world, continued unabated in the fall of 1998. Russia was led to default on its debt as global financial market confidence evaporated. The turmoil next hit developed countries' capital markets, dramatically altering the (relative) pricing of many financial instruments, which in turn accelerated the collapse of Long-Term Credit Management (LTCM), a large U.S. hedge fund. The turmoil subsequently affected Brazil, where it created large uncertainties about its ability to roll-over its public sector debt, and spilled-over into other Latin American emerging markets and elsewhere (see further World Bank 1999 and IMF 1999)

International capital markets in general appear volatile, both on the down-side and the up-side, with emerging market economies suffering most. In the mid-1990s, aggregate private capital flows into five crisis-affected East Asian countries (Indonesia, Korea, Malaysia, the Philippines and Thailand) averaged more than \$40 billion per annum, reaching a peak of about \$70 billion in 1996. In the second half of 1997, more than \$100 billion in short-debt bank loans were recalled from these same five East Asian countries, currencies sharply depreciated and stock markets collapsed. In early 1999, capital flows to East Asian countries reversed themselves again and stock markets rebounded sharply across the region as portfolio and other foreign investors channeled resources back. As inflows in the early 1990s and increases in asset markets prices had added to the credit booms in many East Asian countries, the outflows in the 1997 severely aggravated the East Asia financial crisis. The inflows in 1999 may again have slowed down reform processes in some countries. The fall 1998 markets' turmoil was followed by a slowdown in capital flows to many developing countries. The slowdown in inflows in late 1998/early 1999, and even outflows in some cases, triggered recessions in many developing countries, most notably Latin America (see Perry and Lederman 1998), and in 1999 two-fifths of the world economy experienced a recession, with most GDP-declines concentrated in the developing world.

The exact causes of this volatility are not yet known nor how to design the best system guiding the movements of international capital, i.e., the "international financial architecture." Yet, reducing volatility and contagion has been an important stated objective of recent reforms. Fischer (1998), for example, points out two important reasons why the world economy needs a revamped international financial architecture.

One reason is the high degree of volatility of international capital flows to emerging markets and their limited ability to deal with this volatility, which subjects recipient countries to shocks and crises that are both excessively large and frequent, and very disruptive. Another is the high, at least apparent, susceptibility of international capital markets to contagion. To be effective, however, in reducing the extent of volatility and contagion, reform proposals for a revamped international financial architecture must be based on a good understanding of the causes and consequences of contagion.

While there had been episodes of high international capital markets volatility before to the Asian crisis, such as the Tequila effect—mainly affecting Latin America countries following the Mexican devaluation in December 1994, the issue of financial contagion had not yet caught the full attention of policymakers in either developed or emerging market economies (see, however, Kindleberger 1989 for many historical cases). After the East Asian crisis and the spread to Russia and Latin America in 1998, the notion of excessive volatility in international capital markets has become more widely accepted in policy circles. In the mean time, since the Mexican crisis and Tequila contagion in 1994, research in identifying and analyzing the causes of financial contagion had been conducted, with the East Asian financial crisis further stimulating this.

Although research has progressed, there is not yet a uniform definition of what constitutes contagion. One could argue that one needs to study the degree of comovements in crisis period relative to that in tranquil times give the many normal interdependence of economies. Contagion is then best defined as a significant increase in cross-market linkages after a shock to an individual country (or group of countries). An increase in comovement still not need reflect irrational behavior on the part of investors. Liquidity constraints can force investors to rationally withdraw from other countries once one is hit by a shock. As many financial transactions are conducted by agents, rather than principals, incentive issues also play a role in triggering volatility. It can also reflect coordination problems among investors and insufficient mechanisms at the international level to deal with a country's liquidity problems. Distinguishing between these various forms of investor behavior is very difficult in practice, however.

While it is hard to determine whether comovements have been irrational or excessive, empirical work has been able to document patterns in the vulnerability of countries to volatility and identify possible channels of transmission of contagion. Trade

links, regional patterns, and macro-similarities have been found to make countries vulnerable to volatility. Common creditor and other links through international financial centers are found to be mechanisms through which volatility is transmitted from a particular country to other countries at a particular point. These regularities have helped to identify those countries which are at risk of contagion. Less is known on the importance of micro-economic conditions and institutional factors in propagating shocks, including specific financial agents' actions through which contagion appears to happen.

As the exact causes of contagion are not known, neither are the precise policy interventions which can most effectively reduce it. Minimizing the risks of financial contagion and better management of its impact will require actions by governments and the private sector in both emerging markets and leading industrialized countries, as well as from international financial institutions. But the balance is unclear: should the major burden be on the countries to improve the quality of their financial sectors and enhance the transparency of data, or is there more need to reform the rules under which international investors operate? Does contagion always represent fundamental factors or should countries simply have more access to liquidity support to withstand pressures of contagion? The approach to reforming the international financial architecture to date includes aspects of each and it is unclear whether reforms address the causes of contagion specifically.

This paper reviews current knowledge on contagion, highlighting the areas of limited insight. It starts with a definition of contagion, followed by a review of the various causes for contagion. It then reviews the statistical evidence of asset and other price correlations, the probability of a currency crisis in one country spilling over onto another country, and other empirical work. It concludes with analysis of areas of policy reform.

## *II. Definition of contagion and causes of contagion*

Contagion in general is used to refer to the spread of market disturbances—mostly on the downside—from one (emerging market) country to the other, a process observed through co-movements in exchange rates, stock prices, sovereign spreads and capital flows. Contagion can occur for different reasons and can conceptually be divided into two categories (Masson 1998, Wolf 1999, Forbes and Rigobon, 1999 and Pritsker, 1999).

The first category emphasizes spillovers resulting from the normal interdependence among market economies. The interdependence will mean that shocks, whether of a global or local nature, will be transmitted across countries because of their real and financial linkages. Calvo and Reinhart (1996) term this type of crisis propagation “fundamentals-based contagion.” These forms of comovements could be considered not to constitute contagion as they reflect normal interdependence but during a period of crisis in a country. Most empirical studies seek to explain the degree of comovements and mechanisms of transmitting them. Studies try to determine, for example, how and under what conditions a speculative attack on a single currency is propagated to other currencies on the bases of some fundamental relationships, although many and varied.

The other category involves a financial crisis which cannot be linked to observed changes in macroeconomic or other fundamentals and is solely the result of the behavior of investors or other financial agents. Under this definition, contagion arises when there is comovement that cannot be explained on the basis of fundamentals, i.e., there are no global shocks, interdependence is not present or controlled for, and fundamentals are controlled for. A crisis in one country may, for example, lead investors to withdraw their investments from many markets without distinguishing differences in economic fundamentals. This type of contagion is often said to be caused by “irrational” phenomena, such as financial panic, herd behavior, loss of confidence, and increases in risk aversion. But, these phenomena can be individually rational, and still lead to a crisis. We next discuss each category in more detail.

### ***Fundamental Causes***

#### *Common Shocks*

A common, global cause—such as major economic shifts in industrial countries and changing commodity prices—can trigger crises in or large capital inflows to emerging markets. Changes in US interest rates have been identified with movements in capital flows to Latin America (Calvo and Reinhart, 1993, Claessens et al. 1996). The strengthening of the U.S. dollar against the yen in 1995–96 has been identified as an important factor contributing to weakening exports of East Asian countries and their financial difficulties thereafter (Corsetti et al. 1998, Radelet and Sachs 1998a and

1998b). In general, a common shock can lead to comovement in asset prices or capital flows.

### *Trade Links and Competitive Devaluations*

Local shocks, such as a crisis in one economy, can also affect economic fundamentals in other economies. One channel involves trade links. Any major trade partner of a country where a financial crisis has caused a large currency depreciation could experience declines in asset prices, large capital outflows or become the target of a speculative attack, because investors naturally foresee a decline in its exports to the crisis country and hence a deterioration in its trade account.

A second channel can be competitive devaluations. A devaluation of a country stricken by a crisis which reduces the export competitiveness of other countries which compete in third markets, can put pressure on other countries' currencies, especially when those other countries have currencies which are not freely floating. According to Corsetti et al. (1998), a game of competitive devaluation can cause greater currency depreciation than that required by any initial deterioration in fundamentals. In addition, the non-cooperative nature of the game can result in still greater depreciation relative to what could have been attained in a cooperative equilibrium. If market participants expect that a "game" of competitive devaluations will follow as a result of a currency crisis in one country, they will naturally sell their holdings of securities of other countries, curtail their lending, or refuse to rollover short-term loans to borrowers in those countries. The fact that during the East Asian crisis in 1997 even countries such as Taiwan and Singapore, which did not necessarily appear vulnerable to a speculative attack on the basis of their fundamentals, saw their exchange rates depreciate substantially lends some credence to this theory.<sup>1</sup>

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<sup>1</sup> An interesting question is whether these two countries let their currencies depreciate to maintain export competitiveness or to conserve foreign reserves because investors "irrationally" withdrew money from these countries. Corsetti et al. (1998) argue that these two countries were able to defend the original parities with their massive holdings of reserves and thus to withstand irrational withdrawal, but were concerned about a loss of competitiveness. It can also be argued, however, that their decision to float their currencies was motivated by their efforts to fend off possible speculative attacks driven both by arbitrary shifts in expectations and the reaction of panicky and irrational investors. While in either case the response of the governments may have been rational and optimal, in that the perceived welfare costs of maintaining a stable exchange rate might have been too high, the contagion aspects and policy implications are quite

### *Financial Links*

A channel similar to trade links can be financial links. The process of economic integration of an individual country into the world market will typically involve both trade and financial links. In a world or region that is heavily economically integrated—covering trade, investment, and financing links—a financial crisis in one country can then lead to direct financial effects, including reductions in trade credit, FDI and other capital flows to other countries. For example, as firms in East Asia are linked to say Thailand by trade, investment and financial transactions, their prospects would be adversely affected when the crisis in Thailand limits the ability of Thai firms to engage in FDI, extend credit etc. This implies that the Thai financial crisis would rationally be reflected in other countries, leading, for example, in asset price and capital flow correlations.

### *Investors' behavior*

With regard to the spread of a crisis, the degree of financial market integration is obviously important. If a country is tightly integrated in the global financial markets, or the financial markets of countries in a region are tightly integrated, then financial markets are the mechanisms which makes asset prices in those markets and other economic variables move together. The higher the degree of financial market integration, the more extensive could be the contagious effects of a common shock or a real shock to an other country. Vice-versa, countries which are not financially integrated—due to capital controls or lack of access to international financing—are by definition immune to contagion. In this sense, financial markets facilitate the transmission of real or common shocks, but do not cause them. These actions of investors, which are both ex-ante individually rational as well as collectively rational, although they do lead to volatility and may require policy changes, should be grouped under fundamental causes.

It can, however, also be that investors' behavior themselves, whether rational or irrational, leads to shocks spilling from one country to the next. The literature differs, however, on the scope of rational versus irrational investor behavior, both individually

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different.

and collectively. It is useful to start with a classification of the type of investor behavior (see also Pritsker, 1999). First, there are actions which are ex-ante individually rational, but which do lead to what could be called excessive comovements, in the sense of not being explained by real fundamentals.<sup>2</sup> This can broadly be called the investors' practice channel: contagion is transmitted through the actions of investors outside the country, e.g., in New York, each of which acts individually rational. Conceptually, one can further distinguish this investor behavior into liquidity and incentive problems; and informational asymmetries and market coordination problems. Second, there can be cases of multiple equilibrium, similar to those in models of commercial bank runs, which can imply contagious behavior. Third, there can be changes in the international financial system, or rules of the game, which make investors behave differently following an initial crisis.

#### *Liquidity and incentive problems*

One form of individual rational behavior relates to liquidity and other constraints on lenders or investors. During the East Asian crisis, for example, the large depreciation of the currency and decline in equity prices in Thailand and other early affected East Asian countries caused some international institutional investors to incur large capital losses. These losses may have induced investors to sell off securities in other emerging markets in order to raise cash in anticipation of a higher frequency of redemptions. Liquidity problems may also be faced by commercial banks that have their lending concentrated in particular regions. Suppose there is a single common creditor country with a heavy regional exposure, such as Japan in East Asia or the U.S. in Latin America. If banks from the common creditor country experience a marked deterioration of the quality of loans to one country, banks may attempt to reduce the overall risk of its loan portfolio by reducing exposures in other higher risk investments elsewhere, possibly including in other emerging markets which are most correlated.

This tendency to sell off several markets at the same time can also be due to the incentive structure for individual financial agents. It is possible, for example, that an initial crisis induces investors to sell off their holdings in other emerging countries

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<sup>2</sup> There can obviously also be cases of investors following strategies which are ex-ante irrational given investors' own preferences and the behavior of other investors. While one can not rule out that this category is large, its lack of conceptual definition makes it difficult to analyze.



because of their tendency to maintain certain proportions of a country or region's stock in their portfolios. As a result, equity markets and other asset markets in other emerging markets would also experience large declines in prices and their currencies would depreciate significantly. Schinasi and Smith, 1999, for example, demonstrate that the Value-at-Risk models used by many commercial banks can explain why banks and other investors may find it optimal to sell many higher-risk assets when a shock to one asset occurs. While individually rational, this type of behavior can lead to overall adverse outcomes.<sup>3</sup> Garber, 1998, analyzes the possible unpleasant dynamics associated with the use of financial derivatives which relate to increased ability to avoid regulation and supervision in weak institutional settings through the use of derivatives.

One of the implications of the liquidity and incentive problems might be that countries whose financial assets are widely traded in global markets and whose domestic financial markets are more liquid, are more vulnerable to financial contagion (Calvo and Mendoza 1998, and Kodres and Pritsker 1998). Another implication is that, since global diversification of financial portfolios involves the cross-market hedging of macroeconomic risks, countries where asset returns exhibit a high degree of comovement with a crisis-affected country in tranquil periods, will be more vulnerable to contagion (Kaminsky and Reinhart 1998).

These liquidity constraints and incentives structures could be important for all type of investors dealing with emerging markets. However, is it possible that particular investors are more susceptible to this type of behavior. In particular, international institutional investors such as open-end emerging market mutual funds, hedge funds and proprietary traders as well as proprietary trading operators are thought to be so. Leveraged investors, such as hedge funds and banks facing margin calls, are more likely to experience liquidity difficulties in the wake of a crisis in a country and have to sell

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3 Goldfajn and Valdes (1995) make a related argument why financial institutions can propagate shocks to other countries. When foreign investors withdraw their deposits and loans, asset prices decline and asset markets become illiquid, banks and other financial institutions may run into the risk of failure because they cannot readily liquidate their assets. The liquidation problem may cause a run on these intermediaries themselves, provoking a banking or confidence crisis. The run on intermediaries can lead to a speculative attack on the currency, as foreign investors withdraw and convert their investments into foreign exchange. These crises can spread to other countries when international investors are forced to sell off their positions in other national markets to make up for the liquidity shortage caused by the crisis in one country.

their asset holdings in other markets. Open-end fund managers may also need to raise liquidity in anticipation of future redemptions by investors. Faced with these liquidity problems, both leveraged investors and open-end fund managers are likely to keep those assets whose prices have already collapsed and where secondary markets have become less liquid, and sell other assets in the portfolio. By doing so, investors cause other asset prices to fall and the original disturbance can spread across different financial instruments and across different markets. The large financial turmoil in the fall of 1998, when spreads on U.S. corporations rose to almost 200 basis points, from a normal level of 100 basis points, suggests that these type of spillovers need not be limited to emerging markets alone, but can affect a broad spectrum of markets and borrowers.

#### *Information Asymmetries and Coordination problems*

Another cause of contagion relates to imperfect information and (differences in) investor expectations. In the absence of better information to the contrary, a financial crisis in one country may lead investors to believe that other countries might be facing the same problems. A crisis in one country may then lead to an attack on currencies of other countries, which have conditions similar to those of the country where the crisis began. This type of behavior can reflect rational as well as irrational behavior. If a crisis reflects and reveals weak fundamentals, investors may rationally conclude that similar countries would also face similar problems, thus leading to contagion. This channel presumes, of course, that investors are imperfectly informed about each country's true characteristics and need to make their decisions on the basis of some known indicators, including those revealed in other countries, which may or may not reflect the true state of the country's vulnerabilities. The information set investors use may include the actions of other investors, which brings us to the effects of informational asymmetries on intra-investor behavior.

Investors often do not have a full picture of the condition of each and every country as it affects their returns. In part, this can reflect the cost of gathering and processing information. Calvo and Mendoza (1998) show that in the presence of information asymmetries, fixed costs involved in gathering and processing country-specific information could lead to herd behavior, even when investors are rational. In their model, financial investors can be divided into informed and uninformed or less informed groups. Given the fixed cost of gathering and processing information, most of the small investors simply cannot afford to collect and process country-specific

information individually (see also Agenor and Aizenman 1998). Uninformed investors may instead find it less costly and therefore advantageous to follow the investment patterns of informed investors. Before making their own asset choices, uninformed investors will then take into account portfolio decisions made by other, informed investors since such decisions provide useful market information.

Investors, both informed and uninformed, will tend to seek new information from those investors who acted earlier in adjusting their portfolios. If informed investors move to a bad equilibrium, then the information cascade leads less informed investors to disregard their own information and follow the informed investors, thereby causing a bad equilibrium (Wermers 1995, Calvo and Mendoza 1998 and Scharfstein and Stein 1990). One argument for an increase in herding is that the fixed cost of gathering and processing country-specific information increases as the number of countries where investments can be placed grows and the range of investors widens. Some papers argue therefore that (an increase over time in) herd behavior may not be irrational (Bikhchandani et al. 1992, Banerjee 1992, and Shiller 1995) and is instead “an outcome of optimal portfolio diversification that becomes more prevalent as securities markets grow” (Calvo and Mendoza 1998).

Another argument for increased herding over time is that with more diverse investors, as has been the trend in the last decade, establishing reputation becomes relative more costly. Faced with relative high reputational costs, investors may find it less costly to follow the herd. Since some investors, in particular fund managers, may be more sensitive to maintaining a reputation that depends on the performance of their portfolios relative to that of a given market portfolio rather than on their absolute performance, this risks of cascading behavior may be particularly high among institutional investors (see Kim and Wei 1999 for foreign exchange trading). If these reputational costs are high, an individual institutional investor may refrain from acting first, even if market developments favor a new portfolio, for fear that she may suffer a loss in her reputation if his decision should prove to be wrong. To be on the safe side, individual investors may follow the herd. All these outcomes involve investor behavior which is, albeit constrained, individually rational, but nevertheless can cause financial volatility.

### *Multiple equilibriums*

A more general explanation of contagion based on investors' behavior involves changes in expectations that are self-fulfilling in financial markets subject to multiple equilibria. In this framework, contagion occurs when a crisis in one emerging market causes another emerging market economy to move or jump to a bad equilibrium, characterized by a devaluation, drop in asset prices, capital outflows, or debt default. In the bank-run model of Diamond and Dybvig (1983), it is rational for individual depositors to either hold funds in the bank or withdraw funds depending on the actions of all other depositors. A bad outcome, i.e., a bank run, or a good outcome, where depositors keep their money in the bank, can both be the equilibrium result. Analogous, investors could suddenly withdraw from a country as they fear that if they do not, they will be too late to have a claim on a limited pool of foreign exchange reserves.

Many have argued that sudden shifts in market expectations and confidence are the key causes of investors reevaluating countries and contagion. Formal analytical multiple equilibrium models have been developed to explain recent experiences in emerging markets (Masson, 1998, Jeanne 1997, Gerlach and Smets 1995, Chang and Majnoni, 1999). These type of models, of course, do not lend themselves easily to empirical tests as the move or jump can be triggered by many factors, some of which may appear to be fundamental causes. Drazen 1999, for example, presents evidence that political factors may have played a role in causing contagion during the 1992-3 ERM crisis. And, of course, such changes in equilibrium are not limited to emerging markets, but can equally play a role in volatility and contagion in domestic financial markets.

#### *Changes in the rules of the game*

Finally, contagion may also occur if investors change their assessment of the rules under which international finance takes place. The Russian default in the fall of 1998, for example, increased investors' concern that other countries might follow similar, unilateral policies regarding the treatment of foreign private creditors or may not be bailed out by international financial institutions in the way it was expected before. The discussion on the international financial architecture itself following the East Asia financial crisis may have caused changes in the views on the rule of the game and the odds of official bailouts. This concern is often claimed by market participants to have caused the turbulence in Brazil in the fall of 1998 (see Calvo 1998, Dornbusch 1998, 1999 and Park 1998). Other reasons could include concerns on the supply of funds

from international lenders of last resort: in the Fall of 1998, for example, the IMF had one of the highest usage of its resources, leading to some concern whether it would be able to deal with many more liquidity crises. This could lead liquidity crisis in one country to triggering a run on other countries out of fear of any country being the last eligible for support.

### *III. Empirical Evidence of Contagion*

Empirical examination on the evidence for contagion have largely focussed on comovements in asset prices and much less on “excessive” comovements in capital flows or disturbances in real markets. We discuss tests under the following categories: correlation of asset prices; conditional probabilities of currency crisis; changes in volatility; comovements of capital flows and rates of return; and other tests.

#### *Correlation of asset prices*

The asset price tests consists of estimates of correlation coefficients of changes in interest rates, stock prices, and sovereign spreads of different economies (Forbes and Rigobon, 1999, survey the recent literature). Under this approach, a marked increase in correlations among different countries’ markets is considered as evidence of contagion. Most studies estimating correlations among markets find evidence of large comovements in a variety of asset returns, although there is less of a consensus on whether such comovements increases in the wake of a crisis. A number of studies suggest that the Mexican crisis in 1994 was contagious. Calvo and Reinhart (1996) find evidence that the comovement of weekly returns on equities and Brady bonds for Asian and Latin American emerging markets was higher after the Mexican crisis than before. Frankel and Schmukler (1996) present evidence that the prices of country funds in Latin America and East Asia displayed higher comovement with those of Mexican country funds. According to Valdes (1997), the movements of secondary market debt prices and credit ratings confirm that the Mexican crisis was contagious in Latin America. Agenor, Aizenman and Hoffmaister (1999) show that the Mexican crisis had a sizable effect on movements in domestic interest rates spreads (and output) in Argentina. Baig and Goldfajn (1998) show that the cross-country correlations among currencies and sovereign spreads of Indonesia, Korea, Malaysia, the Philippines and Thailand significantly increased during the East Asian crisis period (from July 1997 to May 1998) compared to other periods.

A marked increase in correlations among different countries' markets may, however, not be sufficient proof of contagion. If markets are historically cross-correlated, then a sharp change in one market will naturally lead to changes in the other markets and markets could exhibit an appreciable increase in correlations during crisis periods. Forbes and Rigobon 1998a and b, show that in the presence of heteroskedasticity of asset price movements, which is likely as volatility increases following a crisis, an increase in correlation could simply be a continuation of strong transmission mechanisms which exist in more stable periods. They also show that an increase in correlations of asset prices may result when changes in economic fundamentals, risk perception, and preferences are correlated without any additional contagion being present. Because of this endogeneity, estimation of correlations must control for comovement in these variables during normal times and for the effects of fundamentals in order to be able identify pure contagion.

In practice, it is impossible to adjust for the effects of heteroskedasticity and endogeneity (as well as omitted variables) without making some, more restrictive assumptions. Some papers have done so. Forbes and Rigobon (1999) investigate, using daily data for stock indices of up to 28 developed countries and emerging markets the evidence of contagion during the 1987 US stock market crash, the 1994 Mexican peso crisis, and the 1997 East Asian crisis. They show that correlation coefficients across multi-country returns are not significantly higher during crisis periods, if the problems of endogenous variables, omitted variables and changes in the variance of residuals are properly corrected for. Rigobon (1999) conducts further tests and finds, correcting for these effects, that in less than 10 percent of countries was there an increase in correlations after financial crises. Arias, Hausman and Rigobon (1998) also do so and find limited evidence of contagion.

In a test for the ERM-crisis, Favero and Giavazzi, 1999, find, however, that, controlling for normal interdependence by estimating a structural model of the behavior of among European interest rates, there was still evidence of contagion in interest rates residuals. Using an autoregressive model, and thus controlling to some degree for structural relationships, Park and Song 1999 show that the Southeast Asian crisis did not directly trigger the crisis in Korea, but that its fall out to Taiwan played an important role in causing the Korean crisis (see also Connolly and Wang 1998, and Tan 1998 for comovements of stock prices in Asia, and Doukas 1989 for sovereign spreads).

### *Conditional probabilities*

Another way to control for the role of fundamentals is to study conditional correlation or probabilities rather than raw correlations and thus use a narrower definition of contagion. The most commonly used methodology, introduced by Eichengreen, Rose, and Wyplosz (1996), Sachs, Tornell and Velasco (1996), is to examine whether the likelihood of crisis is higher in a given country when there are crises in one (“ground-zero”) country or several countries. This literature builds on the extensive, single-country crisis prediction literature (see Dornbusch, Goldfjan and Valdes 1995, and Sachs and Velasco 1996 for early models of predicting a single currency crisis; Berg and Patillo 1999 review this literature, and Goldstein, Kaminsky and Reinhart 2000 provide a more general exposition of early warning systems).

The approach taken is generally estimating the probability of a crisis conditional on information of the occurrence of crisis elsewhere, taken into account fundamentals or similarities. One advantage of this definition is that it readily allows statistical tests of the existence of contagion. These tests can also try to investigate the channels through which contagion may occur, distinguishing, among others, trade and financial links. Eichengreen et al. (1996), using a probit model and a panel of quarterly macroeconomic and political data covering 20 industrial economies from 1959 through 1993, show that the probability of a domestic currency crisis increases with a speculative attack elsewhere and that contagion is more likely to spread through trade linkages than through macroeconomic similarities. Using a similar methodology, De Gregorio and Valdes 1999 conduct an extensive test of spillovers of the 1982 debt crisis, the 1994 Mexican crisis and the Asian crisis using indexes of exchange rates pressures over 3 and 12-month horizons, real exchange rate movements, and changes in credit ratings.<sup>4</sup> They find that the Mexican crisis was the least “contagious” while the Asian crisis was as “contagious” as the 1980s crisis (note that their methodology does not allow them to answer whether spillovers represent normal comovements or contagion). Importantly, they find that both debt composition and exchange rate flexibility limit the

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4 Caramazza, Ricci and Salgado, 1999, investigate the Mexican, Asian, and Russian crises using a similar approach to Eichengreen, Rose and Wyplosz, 1997. They also find that these crises do not differ much. Fundamentals, including trade spillovers, common creditor and financial fragility, are highly significant in explaining crises, while exchange rate regimes and capital controls do not seem to matter.

extent of contagion, whereas capital controls do not appear to curb it.

Taken an even longer perspective, Bordo and Murshid, 1999, examine the record of financial crises over the past 120 years and the evidence of contagion in several macroeconomic variables. They find some evidence that correlations among markets were higher during crisis periods based on regional and trade patterns. The core countries of the prewar and interwar gold standards appear important players in disseminating shocks to the rest of the world, however, such patterns appear to be actually weaker during periods of crises. In contrast, during the post-1973 period, they find that countries that are otherwise not correlated show considerable comovement in asset prices at times of a crisis. They also find, however, that the volatility in correlation coefficients can quite high; they are therefore reluctant to interpret the increase in correlations during recent period as evidence of contagion, also given the Forbes and Rigobon criticism. On the whole, these tests find no solid evidence that contagion has been increasing over time.

Glick and Rose (1998) apply a similar approach to five episodes of currency crises and 161 countries and find that trade linkages are important in propagating a crisis. They argue that contagion tends to be regional than global because trade tends to be more intra-regional than inter-regional (see also Diwan and Hoekman 1998). Kaminsky and Reinhart (1998) find that, in terms of conditional probabilities, information of a large share of crisis countries in the sample increases the predictability of the knowledge of a crisis elsewhere, particularly at a regional level. Their study further supports the evidence that contagion has been a primarily regional phenomenon (see also Calvo and Reinhart 1996, Frankel and Schmukler 1996, Kaminsky and Schmukler 1999).

The evidence on the trade channel as an explanation of the regional nature of contagion appears more relevant for Latin America than East Asia. Kaminsky and Reinhart (1998) find that the possibility of a crisis spreading through third party linkages among Latin American countries (Brazil, Colombia, Mexico, and Venezuela) is high, while the similar linkages are not significant in East Asia. Brazil, Colombia, Mexico, and Venezuela have the largest share of bilateral trade with the U.S. among Latin American countries. Baig and Goldfajn (1998) analyze the trade matrix of East Asian countries and find that trade linkages among those countries are weak. They argue that trade linkages were not important in spreading the crisis through East Asia in



1997. Alba et al. (1998) investigate the effects of competitive devaluations and argue that these alone could not have explained the large depreciation of other regional currencies after the Thai devaluation.<sup>5</sup> For transition economies, Gelos and Sahay 1999 find that correlations in exchange market pressures can be explained by direct trade linkages, but not by measures of other fundamentals. They also find that the patterns of market reactions following the Russian crisis looks very similar to that observed in other regions during turbulent times. Tests thus find strong evidence that contagion is related to trade links and has been of a regional character.

Kaminsky and Reinhart (1998) test the significance of the common creditor channel. They show that the probability of crisis in Indonesia, Malaysia, and Thailand, countries heavily dependent on Japanese commercial bank lending, increases on the knowledge that one or two of these countries has a crisis. Similar results are found in the case of Latin America, where the conditional probability of a crisis in one Latin American country when several other Latin American countries already face crisis is estimated as high as 78 percent. Latin American countries obtain a large portion of credit from American commercial banks, a common creditor to Latin America. Similar effects appear present for other types of investors. Using closed-end country fund data, Frankel and Schmukler (1996) test whether adverse shocks from the Mexican crisis were transmitted directly to other Latin American and East Asian countries or through New York. They find that the Mexican crisis was spread through Wall Street to East Asian countries, but was directly transmitted to other Latin American countries.

#### *Volatility spillover*

Another way is to test estimates of spillover in volatility, i.e., cross-market movements in the second moments of asset prices. Using an augmented GARCH model, Edwards (1998) examines whether the effects of the rise in Mexican interest rates in 1994 spilled over into Argentina and Chile. He finds that there was strong evidence of contagion from Mexico to Argentina, but not from Mexico to Chile. Park and Song (1998) apply a GARCH model to East Asian data to test whether a volatility spillover among foreign exchange markets in East Asian countries occurred during the crisis period. They find that the effects of the crisis in Indonesia and Thailand were

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5 In contrast Baig and Goldfajn, they do find, however, large trade links among East Asian countries which could explain some spillover based on reduced demand for intra-regional exports (see also Huh and Kasa 1997).

transmitted to the Korean foreign exchange market, while the Korean crisis was not contagious to the two Southeast Asian countries. So far, these approaches do not control for fundamentals and do thus not distinguish between pure and fundamental based contagion.

### *Capital flows tests*

There have been few tests of the comovements of capital flows, which can provide the best insights into the channels of transmission of contagion. Van Rijckeghem and Weder, 1999, test the role of bank lending and the presence of a common lender effect using a panel of capital flows to 30 emerging markets. For the Mexican and Russia crisis, they find that the degree to which countries compete for funds from common bank lenders is a fairly robust predictor of both disaggregated bank flows and the incidence of a currency crisis. Froot, O'Connell and Seasholes, 1999, study the behavior of portfolio flows by US and other investors in and out of 44 countries from 1994 through 1998. They find strong evidence of investor positive feedback trading (trend following). They also find regional factors in the correlations of flows which appear to be increasing in importance over time. This suggests that the actions of institutional investors could be a channel for transmission of shocks.<sup>6</sup>

This is confirmed by the evidence of Kaminsky, Lyons and Schmukler, 1999, who analyze mutual fund at the portfolio level over several crisis periods. They find that emerging-market funds exhibit positive momentum, i.e., they systematically buy winners and sell losers in both crisis and non-crisis periods, with contemporaneous momentum (buying current winners and selling current losers) stronger during crises, whereas lagged momentum (buying past winners and selling past losers) stronger during non-crisis periods. Momentum was also the strongest during the 1994 crisis in Mexico. Importantly, they find that funds use contagion strategies, i.e., they sell assets from one country when crisis hits another. This provides strong evidence of the presence of contagion through the actions of portfolio investors.

### *Other tests.*

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<sup>6</sup> Other studies, such as Choe, Kho and Stulz, 1999 find, however, that foreign portfolio investors did not add to volatility in the specific case of Korea. For a general review of the evidence on the impact of portfolio flows in case of single countries, see Stulz, 1997.

Most empirical papers find that macroeconomic weaknesses are an important cause of contagion as they make a country vulnerable to a crisis. Similarities in macroeconomic weaknesses can, however, also lead to a shift in investors' expectations as investors consider these signals as sorting devices and thereby be a cause for a crisis. Ahluwalia 1999 attempts to separate the two effects and finds empirical evidence to support the view that, after controlling for the direct effect of weaknesses, macroeconomic similarities can play a proximate role in contagious currency crises by coordinating investor shifts. In a study of the behavior of the local lending activities of domestic- and foreign-owned banks in Argentina and Mexico, Goldberg, Dages and Kinney 1999 find that foreign-owned banks may have had a stabilizing influence on overall banking sector credit growth, thereby potentially reducing a country's vulnerability to crisis. There have been few tests which use structural models to explain the degree of spillovers in real and financial markets. One is the application of a full trade model for crisis-affected East Asian countries is Abeysinghe (1999). He finds that, although transmission through trade played an important role, the immediate economic contractions are largely a result of direct shocks that are attributable to pure contagion.

#### *IV. Implications and Reform options*

The general empirical finding is that fundamentals help predict spillovers and that trade-links and neighborhood are important factors as well. The degree of spillovers does not appear to have increased over time and there are many similarities in the empirical regularities across periods and countries. Common creditor and other links through financial centers are found to be some of the mechanisms through which volatility is transmitted from a particular country to other countries at a particular point. This work thus helps to identify those countries which are at risk of volatility spillovers. Less is known, however, on the importance of micro-economic conditions and institutional factors in propagating shocks, including specific financial agents' actions and transmission channels through which spillovers appears to happen. As result, it has been difficult to attribute the spillovers to contagion.

These findings suggest that much of comovements is unavoidable as they reflect trade and other links. It also suggests that fundamental factors are important. To reduce the risks of financial contagion, reforms at the country level may thus be useful. Many of these are of a general nature, however, covering reducing fiscal and current account deficits, better exchange rate management, improvements in the quality of their

financial sectors, enhancement of the transparency of data, etc. Many have proposed, and some have analyzed, specific policy reform options to deal with contagion. Stiglitz and Bhattacharya (1999) argue, for example, that disclosure requirements may not need ed, since markets can and do provide optimal incentives for disclosure. They also argue that under certain circumstances, information disclosure could exacerbate fluctuations i n financial markets and precipitate a financial crisis.<sup>7</sup> Furman and Stiglitz (1998) point to the fact that even countries with good regulation and supervision and which did not s uffer from the non-transparency problem nearly as much as the East Asian countries, such as Sweden, have had financial crises.

Many also agree that, although improved standards for data disclosure could have prevented the buildup of vulnerabilities and reduced the risk of currency crises, this is but a first step. Improved implementation and surveillance are necessary as well for standards to be effective. Hawkins and Turner, 1999, for example, analyze the role of prudential and other standards for financial institutions and the required supervision. They stress the implementation issues as well and expect that many countries will continue to have difficulty complying with what are essentially developed countries standards. For these reasons, a number of observers have argued for the use of prudential controls, particularly for financial institutions, to limit the risk of sudden capital outflows. Many countries already limit the maturity mismatches on foreign exchange liabilities and assets and in general monitor tightly the internal risk management systems of financial institutions and issue sanctions for poor systems. Tightening could mean limits on the net open positions financial institutions can take in foreign currency market and limits on the amount of gross foreign currency liabilities (as a fraction of total liabilities or as a ratio to equity). Guidelines on internal risk management systems can be issued and financial institutions can be more intensely monitored in this area. A further precautionary measure can be to require banks to hold more liquid foreign exchange assets relative to total foreign exchange liabilities than they are required to hold on domestic currency liabilities. And, finally, capital controls on (some type of) inflows might be useful to prevent the buildup of vulnerabilities.

It is less clear what reforms to the rules under which international investors

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<sup>7</sup> Bushee and Noe, 1999, looking at U.S. equity markets, find that improved disclosure by firms increases the volatility of their stock price, as it attracts more transient investors due to the seemingly reduced information asymmetry and increased liquidity of the market.

operate are most useful, and whether access to liquidity support to withstand pressures of contagion needs to be enhanced, including through an international lender of last resort and standstills on payments following a crisis. It has been clear that, whatever reforms occur, liquidity crises will still arise and a good part of the debate on the international financial architecture has focussed on improving the way crises are dealt with. In their analysis of the supply of international liquidity, Chang and Majnoni 1999 stress that liquidity provisions when conditioned on certain policies and applied at penalty rates face a tradeoff as they can worsen the possibility of a full crisis. At the same, moral hazard concerns call for conditions and higher rates. Some new facilities—the Supplemental Reserves Facility, the Contingent Credit Lines of the IMF, the guarantee facility of the World Bank, and private sector facilities—are set up ex-ante which may reduce these concerns. They may also induce foreign investors to avoid generating a level of debt that may place the economy in a fragile situation.

## V. *Conclusions*

Recent global events—including the East Asian financial crisis, global financial turmoil in the fall of 1998 and follow-on effects on many emerging markets—have drawn attention to the issue of contagion, that is the spill-over of financial turbulence in some countries to other countries or globally. Much of the current debate on reforming the international financial architecture is aimed at reducing the risks of contagion.

Contagion is best defined as a significant increase in cross-market linkages after a shock to an individual country (or group of countries). This definition highlights that there are many links through which shocks are transmitted in normal times from one country to another, including trade and financial links. The way in which shocks are transmitted do seem to differ, however, during times of crisis. Empirical work has helped identify the type of links and other macro-economic conditions which can make a country vulnerable to contagion during such crisis periods, although less is known on the importance of micro-economic conditions and institutional factors in propagating shocks. It thus has helped to identify those countries which are at risk of contagion and the general policy interventions which can reduce risks.

Much is still unknown, however, through which mechanisms it is transmitted from a particular country to other countries at a particular point in time. Although there

is empirical evidence that commercial banks and mutual funds can play a roles, it is difficult to separate, in theory and practice, rational from irrational investor behavior and whether irrational investor behavior is the sole source of contagion. Individually rational, but collective irrational, and (perceived) changes in the international financial system may also have play a role. Further research—whether theoretical, empirical and case-studies, or covering the role of international financial agents and the international financial system—may shed light on these aspects, thereby help identify characteristics which make countries vulnerable to contagion, and develop policy prescriptions to reduce the risks and manage the impact of contagion, and recover as efficiently as possible from the impact. In the meantime, it will be difficult to identity whether any measures—beyond strengthening the international financial architecture more generally—can reduce the risks of contagion specifically.

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