Open economies review **17**: 423–441, 2006

A Spatial Modelling Approach to Contagion Among Emerging Economies

HARRY H. KELEJIAN kelejian@eron.bsos.umd.edu
University of Maryland, College Park, U.S.A.

GEORGE S. TAVLAS gtavlas@bankofgreece.gr
Director-Advisor, Economic Research Department, Bank of Greece, Room 569, 21, E. Venizelos Avenue, Athens 102 50, Greece

GEORGE HONDROYIANNIS ghondroyiannis@bankofgreece.gr
Bank of Greece and Harokopio University, Athens, Greece

Key words: contagion, currency crises, spatial modelling

JEL Classification Numbers: F30, F32, C10

Abstract

This paper takes a spatial modelling approach in specifying and testing for contagion among emerging market economies. Our approach enables us to estimate asymmetries such as the magnitude of contagion of one country upon others, as well as how that country in turn is affected, on average, by the events of others. The approach also enables us to test for contagion in a formal, straightforward way and to take account for distance and trade linkages among countries. The results suggest that contagion is a statistically significant factor in foreign exchange markets and, furthermore, its effects are not uniform across the countries considered.

A prominent feature of crises in foreign exchange markets during the past ten years or so has been the extent to which instability in these markets was quickly transmitted from one economy to others in the same region, and in some cases, beyond. This process has come to be known as contagion and it has given rise to an expanding empirical literature that tests for its existence. In order to test for the presence of contagion, research has mainly focused on two types of channels through which a crisis in one country is transmitted to other countries. These channels involve trade and financial spilloversamong countries.[1] As one example, according to the trade-spillovers approach, when a particular country experiences a devaluation of its currency due perhaps to a change in one of its fundamentals, trading partners may experience a deterioration in their competitiveness. This change in the competitiveness

The views expressed are those of the authors and should not be interpreted as those of their respective institutions.

of the trading partners, in turn, may provoke a currency attack on them. Since this attack was initiated by a change in a fundamental, this scenario is not thought to be one of contagion since contagion is often assumed to be an influence which is above and beyond the effects of the relevant fundamental, see e.g., (Edwards, 2000).[2]

In an attempt to isolate the effects of such "pure" contagion, some empirical studies have sought to control for the role of the fundamentals. In this connection, Claessens, Dornbusch, and Park (2001) identify several empirical approaches that have been applied.[3] One approach has been to estimate changes in correlation coefficients of asset prices (e.g., Baig and Goldfaijn, 1998; Forbes and Rigobon, 2001; Hernandez and Valdes, 2001; Fratzscher, 2003; Corsetti, Pericoli, and Sbracia, 2005; Candelon, Hecq, and Verschoor, 2005); a significant increase in correlations among different countries' markets, after controlling for the fundamentals, is considered evidence of contagion.[4] A second approach is to study conditional correlations or conditional probabilities; a commonly-used methodology is to examine whether the likelihood of a crisis in a given country is higher when there is a crises a "ground zero" country, or in several countries (e.g., Glick and Rose, 1999; Kaminsky and Reinhart, 2000; Rigobon, 2002). A third approach, (Dellas and Stockman, 1993; Ahluwalia, 2000) attempts to separate similarities in economic weaknesses from shifts in investors' expectations (i.e., signals) as investors consider these signals to be sorting devices; the aim is to examine whether macroeconomic similarities can play a proximate role in causing contagion by coordinating shifts in investors' sentiments. Yet another approach estimates spillovers in volatility, i.e., cross-market movements in the second moments of asset prices, often using ARCH or GARCH techniques (e.g., Edwards, 2000; Edwards and Susmel, 2001). In general, the empirical work appears to have provided some support for the view that there is both interdependence among the asset prices of different countries due to common factors and contagion.[5]

This paper takes a different approach in specifying and then testing for contagion. First, we feel it is evident that if, for whatever reason, the fundamentals of a given country, say country A, change, the exchange markets in that country may be affected. If there are spillovers (contagion) relating to a neighboring regional country, say country B, exchange markets in that country may also be affected. Continuing in this fashion, if there are spillovers from country B to still another neighboring regional country, say country C, exchange markets in that country may also be affected. The extension of this argument to its obvious limit suggests that, if there are spillovers, exchange markets in each and every country in a region will be affected by all relevant fundamentals in all neighboring regional countries, and perhaps in countries which are not even in the region being considered. Second, and in a similar view, it follows that exchange markets in each and every country in a given region, and, perhaps, in countries beyond that region, will be affected by a random macro shock in any country in that region. All of this suggests that a model of an exchange-market variable must account for all relevant fundamentals and macro shocks in all of the neighboring regional countries, and perhaps in countries beyond that region. Notice, in the absence of spillovers (contagion), one would expect exchange markets in each and every country to only relate to the fundamentals of that country.

In modeling an exchange market variable the challenge is to account for all of these factors in a reasonably parsimonious fashion, and, if spillovers relate to such factors as geographical distance, trade, or both, to take account of those factors. Our spatial modeling approach of contagion does just that. In addition, it suggests a straightforward test for the absence of contagion. Our formulation also enables us to estimate asymmetries such as the magnitude of contagion of one country upon others, as well as how that country in turn is affected by the events in others. To the best of our knowledge the results of a spatial modeling approach applied to exchange markets have not been reported in the literature. A final point should be noted. Our modeling approach is such that contagion is the vehicle with which the effects of fundamentals in one country are transmitted to other countries. Therefore, in our framework, the effects of the fundaments and those of contagion are closely and in-separately intertwined. As we demonstrate below, the specification of "contagion" is just a convenient way of specifying complex interactions!

Our empirical results are based on a sample of 25 emerging market economies (EMEs)—(Argentina, Brazil, Chile, China, Colombia, Czech Republic, Hungary, India, Indonesia, Israel, Jordan, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Russia, Singapore, South Africa, South Korea, Sri Lanka, Thailand, Turkey, and Venezuela) during six crises—namely, the Mexican peso crisis of 1994–95, the Asian crisis of 1997–98, the Russian crisis of 1998, the Brazilian crisis of 1999, the Turkish crisis of 2001 and the Argentinean crisis of 2002. The particular sample of EMEs and the crises episodes are representative of the focus of much of the literature on contagion in foreign-exchange markets.[6]

As a preview, we first suggest two measures which describe the impacts of contagion. The first is an *emanating elasticity* which describes how a change in a fundamental in one country affects exchange markets in other countries. The second is an *own contagion* elasticity. This describes how a change in a fundamental in one country effects the exchange markets of that country above and beyond what that effect would be in the absence of contagion. We provide empirical results relating to a general empirical model, as well as with respect to both measures of contagion.

Our empirical results suggest that contagion is indeed a statistically significant factor in determining foreign-exchange-market instability. They also suggest that the magnitude of contagion, while small, was not the same during the Mexican and Asian crises, as it was for the Russian, Brazilian, Turkish, and Argentine crises. Furthermore, for certain countries contagion was affected primarily via trade linkages, while for others geographic distance was of primary importance. As an illustration of the magnitudes involved, during the Mexican and Asian crises, the elasticity of an exchange market crisis index in a country other than Malaysia with respect to a change in the real GDP in Malaysia was, on average, roughly $-.32$, with a (rather large) standard deviation of roughly 1.82. As we explain below, the negative coefficient reflects a reinforcing effect of contagion from Malaysia to the other countries of our sample. These figures indicate quite a bit of variability in contagion response! Results with respect to a change in other fundamentals in Malaysia, or in other countries, are somewhat similar.

The remainder of this paper is divided into four sections. Section 2 describes the model and variables, and our expectations concerning the effects of the variables on foreign-exchange markets. In Section 3 we give a matrix formulation of the model. This formulation is convenient for describing the ramifications of contagion as it relates to spillovers in foreign-exchange markets from one country to another. Empirical results are reported in Section 4. Conclusions and suggestions for further work are given Section 5. Certain technical details are relegated to the appendix.

1. The model and data

The model we consider is essentially an expended version of the model considered by Glick and Rose (1999).[7] Specifically, we consider the model

$$\begin{aligned} IND_{it}^{q} &= a_0 + a_1 Asia_i + a_2 Latin_i + a_3 Middle_i + \beta_1\left(RGDP_{it-}^{q}\right) \\ &\quad + \beta_2\left(RER_{it-}^{q}\right) + \beta_3\left(SDRES_{it-}^{q}\right) + \beta_4\left(CRED_{it-}^{q}\right) + \beta_5\left(EXP_{it-}^{q}\right) \\ &\quad + \beta_6\left[DUM^{q}CT1_{it}^{q}\right] + \beta_7\left[(1-DUM^{q})CT1_{it}^{q}\right] + \beta_8\left[DUM^{q}CT2_{it}^{q}\right] \\ &\quad + \beta_9\left[(1-DUM^{q})CT2_{it}^{q}\right] + \beta_{10}\left[DUM^{q}CD1_{it}^{q}\right] + \beta_{11}\left[(1-DUM^{q})CD1_{it}^{q}\right] \\ &\quad + \beta_{12}\left[DUM^{q}CD2_{it}^{q}\right] + \beta_{13}\left[(1-DUM^{q})CD2_{it}^{q}\right] + \varepsilon_{it}^{q}; \\ &\quad t = 1994, 1997, 1998, 1999, 2001, 2002; q = M, A, R, B, T, AR \end{aligned} \tag{1}$$

which, as will become shortly evident, looks a bit more complex than it really is. Each variable is explained in detail below. At this point, we give a brief overview of the model which should facilitate the interpretation of the more detailed presentation below.

1.1. *A brief overview*

The dependent variable, IND_{it}^{q}, is a foreign exchange crisis index for country i at time t during crisis q, where $q = M, A, R, B, T,$ and AR which denote, respectively, the Mexican, Asian, Russian, Brazilian, Turkish, and Argentine crises.

The first three regressors in (1) are regional dummy variables relating to Asian, Latin America, and the Middle East. Their values are 1.0 if country i is in the indicated region, and zero otherwise. Further details relating to these regions and the associated countries are given below. The next five regressors, $RGDP^q_{it-}$, RER^q_{it-}, $SDRES^q_{it-}$ $CRED^q_{it-}$, and EXP^q_{it-}, are the fundamentals of each country being considered. These variables relate to GDP, the exchange rate, short term debt, domestic credit, and exports. The minus sign relating to the time subscript on these variables is meant to indicate that they are defined at an earlier point in time than the dependent variable, IND^q_{it}. Further details on this are given below.

The next eight regressors are variables which are meant to capture contagion spillovers with respect to trade and geographic distance between countries. The reason there are eight contagion variables, and not just two, is that we allow the coefficients to be different for two sets of crises, and for two sets of countries. For example, stylized facts indicate that contagion appears to have been more prevalent during the Mexican and Asian crises than in the remaining four crises (Kaminsky, Reinhart, and Vegh, 2003, p. 61).[8] We therefore allow the model contagion coefficents to be different for the Mexican and Asian crises than for the Russian, Brazilian, Turkish, and Argentine crises. We also allow the model contagion coefficients to be different for the 20 emerging countries that are thought to be more centrally involved in contagion (henceforth, centrally involved countries), than for 5 countries which were less centrally involved (henceforth, less centrally involved countries), perhaps, due to capital controls and/or large geographic distances from the crisis epicenter.[9] Thus, e.g., there are 4 contagion variables that reflect trade consideration, namely (ignoring subscripts to be explained below) DUM*CT1, (1-DUM)*CT1, DUM*CT2, and (1-DUM)*CT2. The variable CT1 relates to centrally involved countries, and CT2 relates to the less centrally involved countries. The variable DUM is a dummy variable whose value is 1.0 for the Mexican and Asian crises, and is zero for the other four crises. To illustrate the notation, the coefficient of DUM*CT1 relates to the extent of trade contagion for the 20 centrally involved countries during the Mexican and Asian crises; the coefficient of (1-DUM)*CT2 relates to the extent of trade contagion for the 5 less centrally involved countries during the Russian, Brazilian, Turkish, and Argentine crises, etc. The notation for the next four contagion variables is similar but relates to geographical distances between the involved countries. For example, the coefficient of DUM*CD1 relates to the extent of contagion resulting from the geographic distance between the 20 centrally involved countries during the Mexican and Asian crises; the coefficient of (1-DUM)*CD2 relates to the geographic distance contagion effect of the 5 less centrally involved countries during the Russian, Brazilian, Turkish, and Argentine crises, etc.

Finally, ε^q_{it} is an error term which we assume has a mean of zero, is independently distributed over all i and t, and, in order to account for size and other differences between the countries, it is heteroskedastic over i namely, $\text{var}(\varepsilon^q_{it}) = \sigma^2_i$, $i = 1, \ldots, 25$.

1.2. Further details

The use of a crisis index to measure contagion was developed by Eichengreen, Rose and Wyplosz (1996). The particular crisis index used (and updated) in this paper was developed by Kaminsky and Reinhart (1999). The index is a weighted average of reserve losses and exchange rate depreciation (local currency against the U.S. dollar), with weights such that the two components have equal sample volatility. This weighting scheme prevents the much-greater volatility in exchange rates (owing to several very large devaluations during periods of foreign exchange crises) from dominating the crisis measure (Kaminsky and Reinhart, 2000, p. 150). Because changes in the exchange rate enter the index with a positive weight and reserves enter with a negative weight, large positive readings of this index indicate a speculative attack. The higher the value of the index, the more severe the crisis in a particular country.

In dating the beginning of each of the crises, we follow Kaminsky, Reinhart, and Vegh (2003, pp. 53–54) as follows: December 1994 for the Mexican crisis, July 1997 for the Asian crisis, August 1998 for the Russian crisis, January 1999 for the Brazilian crisis, February 2001 for the Turkish crisis and December 2001/January 2002 for the Argentinean crisis. The crisis index is constructed employing the intervals 1994M11–1995M4, 1997M5–1997M10, 1998M7–1998M10, 1998M12–1999M2, 2001M1–2001M10 and 2001M7–2002M6 for the six crisis periods respectively. That is, the length of the Mexican crisis, for example, is assumed to last six months (November 1994 through April 1995); the starting date for the crisis index is the month prior to the onset of the crisis and the ending date is the month in which the crisis index peaked.[10,11]

Again, stylized facts suggest that contagion appears to have had a strong regional element. As one example, the countries hardest hit by the Asian crisis were Indonesia, Korea, Malaysia, the Philippines and Singapore (Goldstein, 1998). To deal with the regional phenomenon, our model contains three regional dummy variables, namely $Asia_i$, $Latin_i$, and $Middle_i$ so that the constant term relates to countries in fourth region. The variable $Asia_i$ includes all Asian countries in our sample; $Latin_i$ relates to all Latin American countries in our sample; finally, the variable $Middle_i$ relates to Israel and Jordan. Given these definitions, it follows that the constant term relates to the European countries plus South Africa.

In constructing the fundamental macroeconomic variables, we follow the methodology used in the literature (e.g., Ahluwalia, 2000; Zhu and Yang, (2004). $RGDP^q_{it-}$ is, for the *i*-th country during crisis q, real GDP growth the year before the onset of the crisis. Low (or negative) real GDP growth is used as a measure of macroeconomic imbalance in the country that may have made the economy vulnerable to financial market contagion. Therefore we expect $\beta_1 < 0$. RER^q_{it-} is the change in the real effective exchange rate between December of the year preceding the year in which a crisis started and December three years earlier. A decrease in *RER* signifies an appreciation of the real exchange rate. Ceteris paribus, the more appreciated the real effective exchange rate (the less is *RER*) the greater the impending need for adjustment in the nominal exchange rate. Therefore, we expect $\beta_2 < 0$. $SDRES^q_{it-}$ is the ratio of short-term debt to reserves minus gold in the six-month period immediately prior to the crisis episode.[12] It is a measure of the amount of domestic money that can easily be converted into foreign exchange. We, therefore expect $\beta_3 > 0$. $CRED^q_{it-}$ is the corresponding percentage change in the domestic credit over the previous period ending in December of the year preceding the crisis year. A large positive value could indicate a lending boom. Accordingly, we expect $\beta_4 > 0$. EXP^q_{it-} is the percentage growth of the domestic currency value of exports over the previous year. We expect $\beta_5 < 0$.[13]

1.3. The contagion variables

We describe our 8 contagion variables in terms of two trade and two distance weighting matrices, both of which are interacted with a dummy variable. The trade weighting matrices are meant to account for the effects of trade spillovers that involve common third markets, namely the United States, Japan and the European Union countries. For example, at the time of the Asian crisis, both Thailand and Singapore exported many of the same goods to these third countries. It follows that an exchange depreciation in one of these countries could have an effect on the exchange markets of the other country. To capture such third market trade spillovers we first defined a basic trade weighting matrix, say TW, and then construct two variations on it. One of these variations relates to the twenty emerging centrally involved countries; the other relates (mostly) to the five emerging less centrally involved countries. These variations in our model allow trade spillovers effects to be different for these two sets of countries.

Following Glick and Rose (1999), we took the i, j element of our basic trade matrix TW, w^T_{ij}:

$$w^T_{ij} = \frac{X_{iA} + X_{jA}}{X_i + X_j} * \left[1 - \frac{\left| \frac{X_{iA}}{X_i} - \frac{X_{jA}}{X_j} \right|}{\frac{X_{iA}}{X_i} + \frac{X_{jA}}{X_j}} \right] \tag{2}$$

to be a weighted average of the importance of exports by countries i and j to the United States, Japan and the European Union countries, where this weighted average is adjusted for the size of countries i and j. In (2) X_{iA} and X_{jA} are the exports of countries i and j to the United States, Japan, and the European Union countries; X_i and X_j are the total exports of countries i and j. The importance of exports to the United States, Japan and European Union Countries for spillover effects between countries i and j should be greatest when these export markets are of equal importance to both i and j. Consistent with this, the definition of w^T_{ij} above is such that, *ceteris paribus*, the magnitude of w_{ij}^T is larger for countries i and j that are more equal in size than for countries that are not. Once we constructed w_{ij}^T, we took our basic trade weighting matrix as: $TW = [w_{ij}^T]_{i,j=1}^{25}$.

The i, j element our first variant say, $w_{ij,1}^T$, relates to the 20 centrally involved countries. In particular, $w_{ij,1}^T$ is exactly the same as w_{ij}^T except that $w_{ij,1}^T$ is zero if either i or j, or both correspond to the 5 less centrally involved countries, e.g., it is non-zero only if i and j relate to the 20 centrally involved countries. Thus, our first variant of the trade weighting matrix is $TW1 = [w_{ij,1}^T]_{i,j=1}^{25}$. As an illustration, if our 25 countries are ordered such that the 20 centrally involved countries were ordered first, followed by the 5 less centrally involved countries, then all of the elements of TW1 would be zero except those that are in the upper 20 $\times$ 20 block. Consistent with typical specifications of all weighting matrices, we also specify the diagonal elements of that upper 20 $\times$ 20 block to be zero.

Our second variant of the basic trade weighting matrix, say TW2, is somewhat similar with respect to the 5 less centrally involved countries, but has fewer zero elements which permits for interactions between the two sets of countries. Specifically, the i, j element, say $w_{ij,2}^T$, of our second variant is the same as w_{ij}^T except that $w_{ij,2}^T = 0$ if i and j **both** relate to the 20 centrally involved countries: $TW2 = [w_{ij,2}^T]_{i,j=1}^{25}$. Again, if the 20 centrally involved countries are ordered first followed by the 5 less centrally involved countries, the upper 20 $\times$ 20 block of TW2 would be a zero matrix; however, the (1,2), (2,1) and (2,2) blocks of this matrix would not be zero matrices. Again, consistent with all specifications of weighting matrices, all diagonal elements of TW2 are taken to be zero. Interpretations of the matrices, TW1 and TW2, are described below.

For each crisis $q = M, A, R, B, T, AR$ we define our trade contagion variables $CT1_{it}^q$ and $CT2_{it}^q$ as $CT1_{it}^q = \sum_{j=1}^{25} w_{ij,1}^T IND_{jt}^q$, $CT2_{it}^q = \sum_{j=1}^{25} w_{ij,2}^T IND_{jt}^q$ The four trade contagion variables then result by interacting these variables with the dummy variable, DUM^q. Further interpretations of these variables are given below.

The four distance contagion variables are defined in a similar way. That is, we first define a basic distance weighting matrix, say DW, and then two variants of it. The i, j element of DW is $w_{ij}^D = d_{ij}^{-1}$ where d_{ij} is the arc distance between two countries i and j.[14] Again, we take the diagonal elements of this matrix to be zero.

The elements of our first variant, DW1, are $w_{ij,1}^D$ which are equal to those of DW except that $w_{ij,1}^D = 0$ if either i or j relate to one of the 5 less centrally involved countries. Again, for the same ordering of the countries as that above, the upper 20 $\times$ 20 matrix of DW1 would be its only block which is nonzero. The elements $w_{ij,2}^D$ of our second variant DW2 are equal to those of DW except that $w_{ij,2}^D = 0$ if i and j **both** relate to one of the 20 centrally involved countries. Similar to the case for TW2, the upper 20 $\times$ 20 matrix of DW2 would be a zero matrix, but is other blocks would not be zero matrices.

Given these definitions of $w^D_{ij,1}$ and $w^D_{ij,2}$, the distance contagion variables $CD1^q_{it}$ and $CD2^q_{it}$ in (1) are, for each crisis $q = M, A, R, B, T, AR$

$$CD1^q_{it} = \sum_{j=1}^{25} w^D_{ij,1} IND^q_{jt}, \quad CD2^q_{it} = \sum_{j=1}^{25} w^T_{ij,2} IND^q_{jt}, \quad \text{for all } i = 1, \ldots, 25, \quad (4)$$

where IND^q_{jt} is the dependent variable in (1).

The specification of the contagion variables in (3) and (4) imply, via (1), a number of things. First, the crisis index for one of the centrally involved countries will react via trade competitive issues to a change in the crisis index of another centrally involved country via the contagion variable CT1; its reaction via trade issues to a change in the crisis index of one of the less centrally involved countries will be via the contagion variable CT2. Similarly, the crisis index of one of the less centrally involved countries will react via trade issues to a change in the crisis index of another less centrally involved country, or to a centrally involved country, via the variable CT2; however, these effects will not be the same because the elements of the underlying weighting matrices are different. The interaction of these variables with the dummy variable DUM implies that the coefficient will not be the same for the Mexican and Asian crises, as for the other four crises. Competitive trade issues clearly suggest that the coefficients $\beta_6, \beta_7, \beta_8$ and β_9 should be positive. The same pattern of reactions with respect to geographic proximity issues are described by the distance contagion variables, CD1 and CD2, which are interacted with the dummy variable DUM. Again, one would expect the coefficients of these variables, namely $\beta_{10}, \beta_{11}, \beta_{12}$, and β_{13} to be positive. Note that since these distance contagion variables are defined with respect to the inverse of distances, that positive effect will be less for countries that are far apart than for those that are close.

On an intuitive level, our specifications imply that a change in a fundamental in one country which effects the crisis index of that country will effect the crisis index of other countries due to both trade and distance spillovers between countries. At this point one might think that the coefficients in equation (1) describe these affects completely. They do not. The reason for this is that a change in a fundamental in one country, say country i, affects the crisis index of that country i, which in turn effects the indices of other countries, which then feed back to the crisis index of country i. A complete description of this is given in Section 3 in matrix terms. At this point we note that our parameter expectations are

$$\beta_1 < 0, \beta_2 < 0, \beta_3 > 0, \beta_4 > 0, \beta_5 < 0, \beta_j > 0, \quad j = 6, \ldots, 13$$

2. A matrix formulation of the model and corresponding implications[15]

There are 150 observations relating to (1). These observations result from the six crises and the 25 EMEs. Let IND^q be the 25×1 vector of observations on the dependent variable corresponding to the q-th crisis, where, again, $q = M$ (Mexican), A (Asian), $q = R$ (Russian), $q = B$ (Brazilian), $q = T$ (Turkish) and $q = AR$ (Argentinean). Similarly, let

$$X1^q = [e_{25}, Asian, Latin, Middle]$$
$$X2^q = [RGDP^q_-, RER^q_-, SDRES^q_-, CRED^q_-, EXP^q_-]$$

where $e_{25}, Asian, Latin$, and $Middle$ are the 25×1 vectors corresponding to the constant term, and the three regional dummy variables, and $RGDP^q_-$, RER^q_-, $SDRES^q_-$, $CRED^q_-$, and EXP^q_- are the vectors of observations on the fundamentals in (1).

Note that the corresponding vector of observations on the four contagion variables in (3) and (4) can be expressed as

$$CT1^q = [TW1 \times IND^q]; CT2^q = [TW2 \times IND^q] \tag{5}$$

$$CD1^q = [DW1 \times IND^q]; CD2^q = [DW2 \times IND^q] \tag{6}$$

Given this notation, and our definition of the dummy variable DUM^q, the model in (1) during crisis q can be expressed as

$$IND^q = X1^q A + X2^q B + \beta_6 DUM^q TW1xIND^q + \beta_7(1 - DUM^q)TW1xIND^q + \beta_8 DUM^q TW2xIND^q + \cdots + \beta_{13}(1 - DUM^q)DW2xIND^q + \varepsilon^q \tag{7}$$

where ε^q is the corresponding disturbance vector, and where

$$A' = [\alpha_0 \ldots \alpha_3] \quad \text{and} \quad B' = [\beta_0 \ldots \beta_5] \tag{8}$$

Note that in a given crisis, the dummy variable DUM^q will either be 1.0 or 0.0. Therefore, our general model in (7), which is the one we estimated, will only contain four contagion variables in a given crisis. Actually, our estimation results below suggest that the coefficients of two of these four contagion variables are not statistically significant, and so our final empirical model given below only contains two contagion variables in a given crisis. At this point we discuss the properties of the general model in (7) which facilitates the discussion below of our empirical model for the various crisis.

We first describe contagion spillover effects relating to fundamentals, as well as to the error terms, in terms of the solution of the model in (8). The solution of (7) for ***IND*** is

$$IND^q = M^{-1}[X1^q A + X2^q B] + M^{-1}\varepsilon^q \tag{9}$$

where

$$M = [I - \beta_6 DUM^q TW1 - \beta_7(1 - DUM^q)TW1 \ldots - \beta_{13}(1 - DUM^q)DW2]$$

The expression in (9), which is a reduced form equation, is informative on a number of levels. First, it should be clear that the dependent vector IND^q, depends on the disturbance vector ε^q. Since all of the contagion variables in (7) depend on the dependent vector, all of those contagion variables must be viewed as endogenous in the estimation of (7). We therefore estimated (7) by an instrumental variable technique. Secondly, the variance-covariance matrix, say VC, of the reduced form disturbance vector $M^{-1}\varepsilon^q$ in (9) is VC $= M^{-1}Diag^q(M')^{-1}$ where $Diag^q$ is a diagonal matrix due to the heteroskedasticity of the disturbance term. Simple calculations will quickly indicate that VC is not diagonal and so the error term in the reduced form Equation (9) is spatially correlated. Thus, e.g., a "disturbance shock" to any one of the countries can be expected to have spillover effects to the other countries.

Third, given the lags involved, the expected value of the dependent vector conditional on the fundamental is

$$E[IND^q] = M^{-1}[X1^q A + X2^q B] \tag{10}$$

It should be clear from (10) that the elements of IND^q, namely the crisis index for the 25 countries during the crisis $q = M, A, R, B, T, AR$ depend not only upon the "within country" values of the regressors (e.g., the corresponding elements of $X2^q$), but also upon the values of the regressors in all neighboring countries. In more detail, let g_{ij} be the i, j-th element of M^{-1}. Then, the change in the expected value of the crisis index in the j-th country during crisis q with respect to a change in a fundamental, say real GDP growth in the i-th country, namely, $RGDP^q_{it-}$ is, via (10)

$$\frac{\partial \mathrm{E}\left(IND^q_{jt}\right)}{RGDP^q_{it-}} = g_{ji}\beta_1, \quad j = 1, \ldots, 25 \tag{11}$$

Similar expressions clearly exit for cross derivatives with respect to a change in one of the other fundamentals.

In general, g_{ji} will not be zero unless $\beta_i = 0, i = 6, \ldots, 13$, i.e., there is no contagion. Alternatively, in the absence of contagion the dependent variable in each country will only respond to a change in one of its own fundamentals. Clearly, the magnitude of the cross derivative in (11) depends upon the direct within country effect of $RGDP^q_{it-}$ upon the crisis index of that country, which is β_1, and an indirect spillover effect due to contagion, which is g_{ji}. Generalizing, it should now be clear that the crisis variable in a given country will be affected by the values of all of the significant variables in (1) in all related neighboring countries because of spillovers due to issues related to trade and distance issues.

2.1. Two measures of contagion: emanating and own

At least two measures of the extent of contagion are suggested by (11). The first is a measure of how a change in a fundamental in one country, say country i, effects the crisis index in other countries, say j. We define this measure as the **emanating effect.** The second relates to how a change in a fundamental in a given country i influences the crisis index of that country after the spillover effects due to contagion are accounted for. We define this effect as the **own contagion effect.**

2.2. The emanating effect

In light of (11) the elasticity, at sample mean values, of a change in the crisis index in country j with respect to a change in *RGDP* of country i is

$$EM_{ji} = g_{ji}\beta_1(\overline{RGDP_i}/\overline{IND}_j) \tag{12}$$

where $\overline{RGDP_i}$ and $\overline{IND}_j$ are, respectively, the sample averages *RGDP* in country i and the crisis index in country j. Corresponding elasticities with respect to the other fundamentals in the model (1) should be evident.

2.3. The own contagion effect

Now consider how the existence of contagion influences the effect that a change in a fundamental in a given country has on the crisis index of that country after the effects of contagion are accounted for. In the absence of contagion, the effect of, say *RGDP*, in a given country on the crisis index of that country would be β_1. In the presence of contagion that effect would be given by (11) when $i = j$ which is not the same as β_1. Again, the reason for this is that a change in a fundamental in a given country would effect the crisis index of that country, which would in turn effect the crisis indices of other countries which would then feed back to the crisis index of original country. We take the own contagion effect as the difference between the elasticities which would result in the presence of contagion, and that which results in its absence. Thus, our own contagion elasticity at sample means is

$$OWN_i = (g_{ii} - 1)\beta_1(\overline{RGDP_i}/\overline{IND_i}) \tag{13}$$

In passing we note that the development of the measure in (13) was in terms of the variable $RGDP^{\mathrm{M}}_{it-}$. Again, corresponding own elasticities with respect to the other fundamentals in the model (1) should be evident. Clearly these results imply that the effects of the fundamentals and those of contagion are inseparable.

3. Empirical results

The empirical results relating to our basic model, Equation (1), are reported in column 1 of Table 1.[16] The following results are worth noting. First, the regional dummy variables Latin and Middle are individually significant at the two tail 5%; also the three regional dummy variables are jointly significant at the 5% level; specifically the calculated statistic (not given in Table 1) is $9.38 > \chi_3^2(.95) = 7.82$. The suggestion is that there are important regional issues in exchange markets. Now notice that all 5 of the fundamental variables have the anticipated signs, and except for exports, are all individually significant at the 5% one tail level. On the other hand, of the eight contagion variables only four are individually significant at the 5% one tail level. We also note that the other 4 contagion variables are not jointly significant in that their calculated Chi-Square statistic $= 2.2 < \chi_4^2(.95) = 9.49$.

Of the four significant contagion variables two relate to trade namely, CT2*(1-DUM) and CT2*DUM. These two variables relate to trade issues between the 5 less centrally involved contagion countries during the Mexican and Asian crises [DUM $= 1.0$] , and also during the Russian, Brazilian, Turkish, and Argentine crises [DUM $= 0$]. Trade issues do not seem to be significantly involved in the contagion experience between the 20 centrally involved countries. The other two individually significant contagion variables, namely CD1*DUM, CD1*(1-DUM), relate to the geographic distance between the 20 centrally involved contagion countries during both the Mexican and Asian crises, as well as during the Russian, Brazilian, Turkish, and Argentine crises. Interestingly, geographic distance does not seem to play a role in contagion issues between the less centrally involved contagion countries.

Our final model is the same as our basic model except that the 4 contagion variables which are not jointly significant in our basic model are dropped. Results relating to this model are also given in Table 1. Note that again the regional dummy variables Latin and Middle are significant at the two tail 5% level. Perhaps more interestingly, note from the table that all 5 of the fundamental variables have the anticipated signs, and all are significant at the two tail 5% level. Note also that the coefficients of all four of the contagion variables have the anticipated signs, and three of them are significant. The one contagion variable that is not significant relates to trade during the Mexican and Asian crises; however, the joint test of significance relating to both trade variables suggests significance: for the two trade variables in our final model, the corresponding Chi-Square statistic $= 12.01 > \chi_2^2(.95) = 5.99$.

These results suggest that contagion may be a factor in exchange markets even after the effects of relevant fundamentals are accounted for. The empirical results based on our final model suggest that trade linkages are statistically significant during all of the crises but only for the five non central contagion countries: Israel, Jordan, India, China, and South Africa. Geographic distance seems to have been the force behind contagion for the centrally involved contagion countries.

Table 1.

Model estimates

Variables	Basic model	Final model
Constant	−3.585 (−2.53)	−3.201*** (−2.30)
ASIA	3.68** (1.91)	2.887* (1.86)
LATIN	5.751*** (2.71)	4.809** (2.00)
MIDDLE	6.541** (2.41)	3.782** (2.09)
RGDP	−0.674*** (−13.61)	−0.758*** (−6.01)
RER	−0.132*** (−4.98)	−0.131*** (−7.35)
SDRES	0.023** (2.38)	0.024*** (2.83)
CRED	0.057* (1.77)	0.065*** (2.00)
EXP	−0.031 (−1.51)	−0.036* (−1.76)
CT1*DUM	−0.012 (−0.27)	
CT1*(1-DUM)	0.001 (0.06)	
CT2*DUM	0.025* (1.77)	0.029 (0.98)
CT2*(1-DUM)	0.042** (2.20)	0.060*** (2.61)
CD1*DUM	105.025*** (17.00)	96.772*** (18.54)
CD1*(1-DUM)	86.068*** (6.99)	91.453*** (4.67)
CD2*DUM	11.282 (0.76)	
CD2*(1-DUM)	−8.183 (−0.51)	
Standard error of equation	16.28	16.51

Notes: *t*-statistics are given in parenthesis. ***, ** , * indicate 1%, 5% and 10% level of significance respectively.

We also determined numerical results relating to the emanating elasticities during, respectively, the Mexican and Asian crises, and the Russian, Brazilian, Turkish, and Argentine crises with respect to a change in real GDP growth. The results are not given here due to space limitations. However, those results can be obtained by writing to the authors.

Our calculations suggest that contagion that emanates from a given country does not effect the other countries in a uniform fashion. As one example, the figures for South Africa range from to -0.28 to 0.13 with an average of -0.008 and a standard deviation which is ten times larger, namely 0.08. Actually, for all countries and for both of our crisis periods the standard deviations of the emanating elasticities are at least as large, and in most cases, considerably larger than the average of those elasticities, which is typically small. To take the case of Malaysia for the Mexican and Asian crises, the emanating elasticity with respect to real GDP ranges from -8.46 to 1.85 with an average of -0.31 and a standard deviation of 1.84. Perhaps the reason for this variation is that Malaysia is an immediate neighbor to Singapore (-8.46) so that a change in growth of real GDP in Malaysia affects the exchange rate pressure in Singapore, whereas it is far away from other countries such as Brazil ($-.06$). This insight is given in an intuitive manner; however, the reader should note that the emanating effects are the result of a complex interaction between all of the countries involved with respect to both trade and regional distance issues, see equations (7)–(9), and so such simple analyses may not always yield "intuitive insights". We also estimate the own contagion elasticities during the two sets of crises with respect to a change in real *RGDP* growth are estimated. Again, the results are similar with respect to the other fundamentals involved but are not given here due to space limitations. Those results can be obtained by writing to the authors.

Our own contagion elasticity estimates again suggest that the results are not uniform. For example, the estimated own contagion elasticities during the Mexican and Asian crises range from -6.22 for Singapore to 0.40 for Korea. Of the 25 elasticities, 14 are negative and 11 are positive. Since the coefficient of *RGDP* is negative, the negative own contagion elasticities reflect a reinforcing effect while the positive elasticities reflect a moderating contagion effect. For example, a negative own contagion elasticity indicates that the effect of a change in *RGDP* in, say country i, on the crisis index of country i will be more negative in the presence of contagion effects than in its absence—see Equations (11) and (13); a positive elasticity indicates the reverse.

4. Summary and suggestions for further work

Among other things, our modelling approach enabled us to test for contagion in a formal, straightforward way. It also enabled us to obtain measures of contagion which emanate from one country to others, as well as contagion effects which impact, or feedback, to a given country. Our contagion variables are continuous variables and so we are able to account for degrees of contagion, which clearly cannot be done in a dummy variable formulation. We have also given interpretations of our contagion specification in terms of a structural simultaneous equation, and described its solution as a reduced form equation. Our results suggest that trade linkages are statistically significant during the Mexican and Asian crises, as well as for the other crises, but only for the five less centrally involved countries Israel, Jordan, India, China, and S. Africa. On the other hand, contagion via geographic distances is statistically significant during both sets of crises, but only for the 20 centrally involved countries. Two types of contagion elasticities are suggested and estimated. The emanating elasticities relate to how a change in a fundamental in one country effects other countries; the own contagion elasticites relate to how contagion feeds back to a given country. Both sets of elasticities are generally small, on average, but have a large standard deviation which indicates that the results are not uniform over the countries.

One suggestion for further work would be to estimate a spatial model such as ours in terms of an extended data set which includes non-crisis as well as crisis periods. If such a model were properly specified, contagion could turn out to be a "continuum" that may be more intense during crisis periods, but exists never-the-less during non-crisis periods. Another suggestion would be to develop a nonlinear spatial model which is able to account for possible nonlinearities in the relationship between foreign-exchange-market activity in one country and that of its neighbors.

Appendix

As an over-view, the instruments used in estimating our basic model are the regional dummies, the five fundamental variables, and interactions of the fundamental variables with the trade and distance weighting matrices, as well as with the dummy variable DUM. However, since, the trade weighting matrix was constructed with 1998 data, we viewed that matrix as endogenous during the first three crises and hence did not interact it with the fundamental variables during those periods to construct IVs. Instead, during the first three crises we used the rate of inflation, the rates of broad money to international reserves, and changes in major stock market indexes.

The Instruments:[17] Let *RGDP* be the stacked 150×1 vector of values of the *RGDP* variable over the six crises, and let *RGDP**D1*DUM and *RGDP**D1*(1-DUM) be the *RGDP* variable pre-multiplied in each crisis by the weighting matrix D1 and, respectively, by the dummy variable DUM and (1-DUM). Let *RGDP**D2*DUM and *RGDP**D2*(1-DUM) be defined similarly with respect to the weighting matrix D2. Let this notation extend to the other variables and weighting matrices in (7), and let C denotes the 150×1 vector of unit elements which corresponds to the constant term. Let INF, M21, and ST be the corresponding vectors of values of the rate of inflation, the rates of broad money to international reserves, and changes in major stock market indexes. Finally, let DUM1 be a dummy variable whose value is 0.0 in

1998 and for periods earlier than that, and whose value is 1.0 otherwise. Then our IVs are: C, Asian, Latin, Middle, RGDP, SDRES, RER, CRED, EXP, RGDP*D1*DUM, SDRES*D1*DUM, RER*D1*DUM, CRED*D1*DUM, EXP*D1*DUM, RGDP*D1* (1-DUM), SDRES*D1*(1-DUM), RER*D1*(1-DUM), CRED*D1*(1-DUM), EXP*D1* (1-DUM), RGDP*D2*DUM, SDRES*D2*DUM, RER*D2*DUM, CRED*D2*DUM, EXP*D2*DUM, RGDP*D2*(1-DUM), SDRES* D2*(1-DUM),RER*D2*(1-DUM),CRED*D2*(1-DUM), EXP*D2*(1-DUM),RGDP* T1*DUM1, SDRES*T1*DUM1, RER*T1*DUM1, CRED*T1*DUM1, EXP*T1* DUM1, RGDP*T2*DUM1, SDRES*T2*DUM1, RER*T2*DUM1, CRED*T2* DUM1, EXP*T2*DUM1, INF*(1-DUM1), ST*(1-DUM1), M2I*(1-DUM1).

Notes

1. Surveys of the empirical literature are contained in Claessens, Dornbusch, and Park (2001), Forbes and Rigobon (2001), Kaminsky, Reinhart, and Vegh (2003) and Candelon, Hecq, and Verschoor (2005).
2. Edwards (2000, p. 880) defines contagion as "a situation where the extent and magnitude of the international transmission of shocks exceeds what was expected (based on the fundamentals) by market participants."
3. For a somewhat different classification, see Pericoli and Sbracia (2001).
4. Kaminsky and Reinhart (2002) analyze the degree of co-movement in asset prices across a large number of countries for four different asset classes. Although the study is not strictly concerned with contagion, the results indicate that there are important differences in the degree of responsiveness of different asset markets to external shocks.
5. Studies that do not find some evidence of contagion include Boyer, Gibson, and Loretan (1999), Corsetti, Pericoli, and Sbracia (2005), Forbes and Rigobon (2002) and Candelon, Hecq, and Verschoor, (2005).
6. These are the same 25 countries as those identified by Goldstein (2002) in his study of exchange-rate regimes for EMEs. The crises are the same as those identified by Kaminsky, Reinhart, and Vegh (2003). To our knowledge, the two most recent crises—i.e., those of Turkey and Russia—have not yet been incorporated into the literature dealing with contagion. Zhu and Yang (2004) incorporated the Brazilian crisis in their data sample.
7. The model used by Glick and Rose, in turn, is a generalisation of the models used by Sachs, Tornell and Velasco (1996), Tornell (1998), and Bussière and Mulder (1999). As discussed below, the specifications relating to the fundamental variables are similar to those used by previous authors. In addition, we note that some authors (e.g., Ahluwalia, 2000) considered contagion but modelled it essentially as a dummy variable which shifts the intercept.
8. Kaminsky, Reinhart, and Vegh (2003, pp. 60–61) note that spillovers effects were associated with the Russian crisis of August 1998. These authors also point out, however, that it is not clear whether the spillovers emanated from the Russian loan default or the crisis sparked by the collapse of Long Term Capital Management (LTCM) which occurred in the fall of 1998.
9. The 20 centrally involved countries are: Argentina, Brazil, Chile, Colombia, Czech Republic, Hungary, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Russia, Singapore, Sri Lanka, South Korea Thailand, Turkey, and Venezuela. The 5 less centrally involved countries are: China, India, Israel, Jordan, and South Africa.
10. The intervals for the first four crises correspond to those used by Ahluwalia (2000) and Zhu and Yang (2004), who, in turn, follow Sachs, Tornell and Velasco (1996) in determining the interval for the Mexican crisis. In constructing their crises indices, these authors begin with the month prior to the onset of the crisis. In determining the end of the crises, these authors used the month in which the crisis index peaked. For the Turkish crisis we followed a similar methodology. For the Argentinean crisis we used July 2001 as the beginning of the interval because, after the announcement of the "zero deficit" on July 11, 2001, the

country's emerging market bond index (EMBI) spread widened more than 300 basis points. As a result large amounts of bank deposits were withdrawn, resulting in large pressures on domestic interest rates and on tax revenues. See IMF (2001).

11. In constructing this index, we used the end-of-period monthly exchange rate against the U.S. dollar (IFS line ae) and total reserves minus gold (IFS, line IL. D). The sample variances of the monthly percentage changes in the exchange rate and reserves are estimated of the period 1990–2002. Because of the unavailability of data, the periods are different for the Czech Republic (1993M2-2002M12) and Russia (1994M12-2002M12).
12. Data on short-term debt were obtained from the Bank for International Settlements.
13. In addition, some other variables such as the inflation (INF), the rates of broad money to international reserves (M2I) and changes in major stock market indexes (ST) were used in a preliminary specification. These variables, however, were not significant in explaining the crisis indicator. As discussed below, these three variables are used as instruments in the estimation of Equation 1.
14. In constructing the no row standardized matrix D the following procedure is used. First, the co-ordinates for the capital of each country are collected. Next, the two co-ordinates (latitude X and longitude Y) are transformed into decimal employing the following formula: decimal = degrees + minutes times 0.01666667 + seconds times 0.00027778. The arc distance d_{ij} between two countries i and j is then calculated. Data for the two co-ordinates were obtained at the following website:www.mapsofworld.com/utilities/world-latitude-longitude.htm.
15. See kelejian and Prucha (1998, 1999) for further spatial modeling results.
16. A generalized IV method with cross section weights was used in a panel estimation. Cross section standard errors were adjusted for heteroskedacity and corrected for non-zero co-variances. A listing of the instruments used is given in the appendix.
17. See Kelejian and Prucha (1998) for suggestions as to how to construct instruments in a spatial model.

References

Ahluwalia, P. (2000) "Discriminating Contagion: An Alternative Explanation of Contagious Currency Crises in Emerging Markets." *IMF Working Paper*, 00/14.

Baig, T. and I. Goldfaijn (1998) "Financial Market Contagion and the Asian Crisis." *IMF Working Paper*, 98/115.

Boyer, B., M. Gibson, and M. Loretan (1999) "Pitfalls in Tests for Changes in Correlations." *Working Paper* 597R, Federal Reserve Board, International Finance Division.

Bussière, M. and C. Mulder (1999) "External Vulnerability in Emerging Market Economies: How High Liquidity Can Offset Weak Fundamentals and the Effects of Contagion." *IMF Working Paper*, 99/88.

Calvo, G.A. (1999) "Contagion in Emerging Markets: When the Wall Street is a Carrier." University of Maryland, mimeo.

Candelon, B., A. Hecq, and WFC Verschoor (2005) "Measuring Common Cyclical Features during Financial Turmoil: Evidence of Interdependence not Contagion." *Journal of International Money and Finance* 24:317–1334.

Claessens, S., R. Dornbusch, and Y. Park (2001) "International Financial Contagion: How it Spreads and How It can be Stopped." In S. Claessens and K.J. Forbes (eds.), *International Financial Contagion*. Boston: Kluwer Academic Publishers, pp. 3–18.

Corsetti, G., M. Pericoli, and M. Sbracia (2002) "Some Contagion, Some Interdependence: More Pitfalls in tests of Financial Contagion." *Journal of International Money and Finance* 24:1177–1199.

Dellas, H. and A. Stockman (1993) "Self-Fulfilling Expectations, Speculative Attack, and Capital Controls." *Journal of Money, Credit and Banking* 25:721–730.

Edwards, S. (2000) "Contagion." *The World Economy* 23:873–900.

Edwards, S. and R. Susmel (2001) "Volatility Dependence and Contagion in Emerging Markets." *Journal of Development Economics* 66:505–532.

Eichengreen, B., A.K. Rose, and C. Wyplosz (1996) "Contagious Currency Crises." *Scandinavian Journal of Economics* 98:463–484.

Forbes, K.J. and R. Rigobon (2001) "Measuring Contagion: Conceptual and Empirical Issues." In S. Claessens and K.J. Forbes (eds.), *International Financial Contagion*. Boston: Kluwer Academic Publishers, pp. 43–66.

Forbes, K.J. and R. Rigobon (2002) "No Contagion, Only Interdependence: Measuring Stock Market Co-Movements." *Journal of Finance* 57:2223–2261.

Fratzscher, M. (2003) "On Currency Crises and Contagion." *International Journal of Finance and Economics* 8:109–130.

Glick, R. and A.K. Rose (1999) "Contagion and Trade Why are Currency Crises Regional?" *Journal of International Money and Finance* 18:603–617.

Hernandez, L.F. and R.O. Valdes (2001) "What Drives Contagion Trade, Neighbourhood, or Financial Links?" *International Review of Financial Analysis* 10:203–218.

International Monetary Fund (2001) "The Global Economy after September 11." *World Economic Outlook.* December, Washington D.C.

Kaminsky, G.L. and C.M. Reinhart (1999) "The Twin Crises: The Causes of Banking and Balance of Payments Problems." *American Economic Review* 89:473–500.

Kaminsky, G.L. and C.M. Reinhart (2000) "On Crises, Contagion and Confusion." *Journal of International Economics* 51:145–168.

Kaminsky, G.L. and C.M. Reinhart (2002) "Financial Markets in Time of Stress." *Journal of Development Economics* 69:451–70.

Kaminsky, G.L., C.M. Reinhart, and C.A. Végh (2003) "The Unholy Trinity of Fiancial Contagion." *Journal of Economic Perspectives* 17:51–74.

Kelejian, H.H. and I.R. Prucha (1998) "A Generalized Spatial Two-Stage Least Squares Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances." *Journal of Real Estate Finance and Economics* 17:99–121.

Kelejian, H.H. and I.R. Prucha (1999) "A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model." *International Economic Review* 40:509–533.

Masson, P. (1999) "Contagion: Monsoonal Effects, Spillovers and Jumps Between Multiple Equilibria." In P.R. Agenor, M. Miller, D. Vines, and A. Weber (eds.), *The Asian Financial Crisis: Causes, Contagion and Consequences*. Cambridge University Press.

Rigobon, R. (2002) "The Curse of Non-investment Grade Countries." *Journal of Development Economics* 69:423–449.

Sachs, J., D.A. Tornell, and A. Velasco (1996) "Financial Crises in Emerging Markets: The Lessons from 1995." *Brookings Papers on Economic Activity* 1:147–215.

Tornell, A. (1998) *Common Fundamentals in the Tequila and Asian Crises. Mimeo*. Harvard University.

Zhu, L. and J. Yang (2004) *The Role of Psychic Distance in Contagion: A Gravity Model for Contagious Financial Crises*. The George Washington University.