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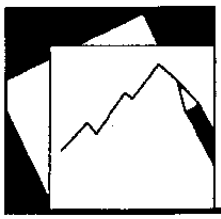

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Discriminating Contagion: An Alternative Explanation of Contagious Currency Crises in Emerging Markets

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Discriminating Contagion: An Alternative Explanation of Contagious Currency Crises in Emerging Markets

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Abstract

This paper shows that a country's vulnerability to contagious crises depends on the *visible similarities* between that country and other countries that are experiencing crises. A country is vulnerable to shifts in investor sentiment if it exhibits weaknesses in the same economic variables as other countries affected by a contagious crisis (particularly the country that started the contagious wave), or if it is located in the same region. The paper uses a sample of 19 emerging markets, and data from the Mexican, Asian, and Russian crises to provide evidence of this *discriminating contagion*, after controlling for alternative channels of contagion such as trade spillovers and financial linkages.

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I. INTRODUCTION

Following the Tequilazo of 1994-95, the Asian flu of 1997, and the Russian virus of 1998, contagion-or the temporal clustering of currency crises-has received much attention. The empirical literature on the subject can be divided into two categories. One strand has focused on trade or financial *linkages* between countries. Another has attempted to explain contagious crises in terms of *common weaknesses* in macroeconomic fundamentals.[2] This paper adopts an altogether different approach, emphasizing the importance of *visible similarities* between countries in determining vulnerability to contagious crises. The focus is on investor expectations and specifically on examining whether the visible characteristics of a country could cause investors to "group" it alongside other countries exhibiting similar characteristics.[3]

We assume that currency markets are characterized by multiple equilibria and that a change in investor expectations can cause a shift from one equilibrium to another, even if there has been no change in economic fundamentals.[4] This paper suggests that a crisis in a country exhibiting certain visible characteristics-weaknesses in key economic variables and location in a particular region-could result in crises of confidence in other countries exhibiting those characteristics, *regardless* of whether they were responsible for the original crisis. In other words, a country is more likely to be affected by a contagious currency crisis if weaknesses in the same economic variables and location in the same region as other countries experiencing crises suggest to investors that it is *similar* to them. Investors sort "weak" countries from "strong" ones on the basis of these characteristics, giving rise to what we call *discriminating contagion*. Such sorting on the part of investors is consistent with rational behavior. Calvo and Mendoza (1999) demonstrate that in globalized financial markets, utility maximizing investors with internationally diversified portfolios will follow market conventions, even if these are arbitrary, since undertaking comprehensive country-

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[2] This view implies that such crises are not really "contagious" in the epidemiological sense. While they owe to weaknesses in the same fundamentals, and while some have argued that these weaknesses might owe to a common cause, a crisis in one country does not, in this scheme of things, "cause" a crisis in another.

[3] We do not enter into a theoretical discussion of this idea of contagion. It has, however, been formalized (although not in the context of modelling contagion) elsewhere. Shiller (1995) discusses the idea of signals from one financial market influencing events in another. Chari and Jagannathan (1988) present a theoretical model of bank runs where expectational shifts are coordinated by an observable variable-the "length" of the line outside the bank. The idea, here, is that there are other observable variables that could coordinate expectations in currency markets

[4] While this "second-generation" characterization of currency crises is widely accepted there has been recent theoretical work that calls into question the idea of multiple equilibria in currency markets, demonstrating that under imperfect information the equilibrium can be unique. See Morris and Shin (1998).

specific analyses is costly. This paper identifies one such convention in currency markets. This characterization of contagious currency crises is similar to the "wake-up call" hypothesis of Goldstein (1998) according to which creditors are "awoken" by a crisis in one country and proceed to reassess the creditworthiness of others. It can be considered a more specific version of the Goldstein (1998) hypothesis in that we address the issue of *how* this reassessment takes place.[5]

We consider significant deviations of economic variables from their historical trends (in directions that would make the economy vulnerable) to be indications of economic weakness. What is important, then, in determining whether expectations will shift in the case of a particular country, is not whether its key economic variables take similar values, or exhibit similar levels, as those of other countries that are experiencing crises, but whether the same variables exhibit significant (negative) changes in these countries. Likewise, the location of countries can signal vulnerability. If investors believe that the collapse of one exchange rate regime in a region can call into question the viability of others, they will sort countries on the basis of location during episodes of contagion. This could happen either because they know these countries have significant trade linkages, so that a devaluation or depreciation in one could have adverse implications for the competitiveness of others, or due to financial linkages between them, or because they feel such countries are structurally similar. It could even follow from the belief that other investors are likely to group countries in the same region together, regardless of the similarities or differences between them.

In addition to demonstrating that such characteristics can serve as sorting devices, we examine why certain characteristics suit this purpose better during certain crises. In particular, we show that similarities to the "ground-zero" country, or the country responsible for triggering a wave of contagious crises, make countries especially vulnerable to expectational shifts. In other words, the first crisis serves as a "wake-up call" to investors who then focus their attention on that country's macroeconomic weaknesses (and location) and look for similar weaknesses (and locations) in other countries in order to decide which ones are vulnerable.

We thus identify a channel of contagion that has hitherto been unexplored in the literature. This channel is most likely to operate in emerging markets, where investor confidence is relatively thin and their behavior considerably more volatile, which implies a potentially important role for coordination devices. The rest of this paper is divided into five sections. Section (ii) provides a brief literature review. Section (iii) outlines the basic econometric model used to demonstrate that variables measuring discriminating contagion have significant marginal explanatory power. We use a sample of nineteen emerging markets and data from three episodes of contagious crises in the nineties-the 1994, 1997, and 1998 episodes. Three *contagion indicator variables* were constructed. One variable measures the number of countries experiencing a crisis during a particular contagious

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[5] We also consider similarities between the country for which the observation is being taken and all other countries experiencing crises, in addition to testing for wake-up calls.

episode that have at least one "signal" of economic weakness from a variable that is also "signaling" a crisis in the country for which the observation is being taken. These weaknesses are computed using a methodology similar to Kaminsky, Lizondo, and Reinhart (1997) (henceforth KLR), who consider a significant deviation from trend in an economic variable to be a leading indicator of vulnerability. A second contagion indicator variable considers only signals in crisis countries in the same region. Hence, we test for the effect of signals from economic variables alone, and from economic variables and location together. A third variable was constructed, which measures the number of signals a country has in common with the country which triggered the wave of contagious crises-Mexico in 1994, Thailand in 1997 and Russia in 1998. All three variables turn out to be powerfully significant after the direct effect of macroeconomic fundamentals has been accounted for. A number of robustness checks were conducted, which included controlling for non-linear effects of economic variables and for alternative channels of contagion such as trade spillovers and financial linkages. The results suggest that discriminating contagion has considerable marginal explanatory power in explaining the spread of contagious currency crises.

In order to conclusively prove this point, however, two other studies of contagious currency crises are considered- the well known Sachs, Tornell and Velasco (1996) and Tornell (1998) models, henceforth referred to as STV/T, considered in section (iv), and the recent Bussière and Mulder (1999) model, henceforth referred to as BM, considered in section (v). Using these two models, *their* data, and the polytomous contagion indicator variables developed here, we demonstrate that these variables significantly increase the explanatory power of their regressions. Section (vi) presents some concluding remarks.

II. Literature Review

There are three principal prevailing theories of contagious currency crises, emphasizing trade linkages, financial linkages, and common macroeconomic and financial weaknesses respectively. Gerlach and Smets (1994), using a sample of Scandinavian countries, pioneered the study of "spillovers," or the increased vulnerability of countries to expectational shifts following devaluations by their trading partners or competitors.[6] This happens because the country itself has incentive to devalue, in order to maintain competitiveness. Investors therefore know that the central bank is less likely to resist depreciation, which leaves the country more vulnerable to speculative attacks. Glick and Rose (1998) present a comprehensive empirical study using emerging markets and developed countries, and show that contagious crises over the past few decades are fairly well explained by trade linkages.

Theories of financial contagion explain the spread of currency crises across countries in terms of financial connections between them. There are two varieties of such theories. Kaminsky and Reinhart (1999) and Caramazza et al. (1999) argue that if a group

[6] Corsetti et. al. (in press) present a theoretical framework in which to view the welfare effects of competitive devaluations.

of countries borrows from the *same creditors*, and one country experiences a currency crisis, their creditors might need to call loans in other countries in an effort to recapitalize, provision, and readjust the risk level of their portfolios. Goldfajn and Valdes (1995), Calvo (1998), Kodres and Pritsker (1999), as well as Kaminsky and Reinhart (1999), examine the role of *financial markets* in the spread of currency crises. Kodres and Pritsker (1999) reason that countries whose assets exhibit a high degree of comovement with the assets of countries that are experiencing crises could be vulnerable to contagion via cross market hedges. Goldfajn and Valdes (1995) and Calvo (1998) attribute contagion to illiquidity in financial markets. When a crisis occurs in one country, financial intermediaries are forced to provide exiting investors with domestic currency. Intermediaries facing liquidity problems in one market could be forced to unwind positions in other markets, which would create currency troubles in those countries.

There have been many attempts to explain vulnerability to contagious currency crises in terms of common macroeconomic weaknesses, most notably Sachs, Tornell, and Velasco (1996).[7] Eichengreen, Rose, and Wyplosz (1996), in their seminal paper which provided the first empirical evidence of contagion, also used a number of macroeconomic variables along with a variable that tested for contagion to estimate the strength of contagion effects. Eichengreen and Rose (1999) compare macroeconomic fundamentals and trade linkages as channels of contagion and present evidence which indicates that trade is the more important one.

The approach adopted in this paper is complementary to previous work, rather than opposed to it. In order to account for the role of macroeconomic fundamentals, we include macroeconomic variables in our regression equations, along with variables that measure the potential for the type of contagion discussed here, and find that the latter have high marginal explanatory power. We also control for trade and financial linkages. The emphasis is not on refuting or disproving these other theories, but on establishing the marginal explanatory power of the explanation of contagion proposed in this paper, after accounting for other explanations.

It is pertinent to make a point, here, regarding the scope of this paper. In writing on a subject as exhaustively researched as currency crises, it is important to state clearly what a study is *not*. Accordingly, if the reader is looking to find a general theory of contagious currency crises in this paper, he or she is likely to be disappointed. It is generally agreed that this is no more possible than it is to formulate a general theory of illness, a project that was abandoned by the medical profession towards the end of the Middle Ages. This paper is an attempt to analyze a certain type of contagion to which emerging markets are

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[7] Closely related to this approach is the concept of "monsoonal effects," discussed at length in Masson (1998). This line of reasoning holds that contagious currency crises are a set of individual crises, caused by macroeconomic troubles in the countries concerned, which owe their origin to a common cause. This approach has not been explicitly pursued in empirical work on currency crises, although a number of papers have attempted to explain vulnerability to contagious crises in terms of macroeconomic fundamentals.

especially vulnerable, and which, as we show, seems to have characterized the major contagious crises of the nineties.

III. The Model

A. Sample Selection

Our nineteen-country sample contains seven East Asian economies, seven Latin American economies, and five others. It includes Indonesia, Korea, Malaysia, the Philippines, Taiwan, Thailand, Singapore, Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela, India, Pakistan, Sri Lanka, Jordan, and South Africa. The selection of these countries is, following STV, based on their inclusion in the IFC *Emerging Stock Markets Factbook*. This indicates that these are countries in which investors may invest with relative freedom. Zimbabwe and Ecuador, which were included in STV, are not considered here, because of problems obtaining data for certain variables.[8]

Three episodes of contagion among the countries in our sample were identified within a ten year time period running from 1990 to 1999- the 1994-95, 1997, and 1998 crisis episodes. The reason for confining attention to the nineties is that private capital flows to these regions were considerably smaller in earlier years.[9] Also, some countries experienced macroeconomic turmoil, including hyperinflation, during the eighties, making it difficult to identify signals of vulnerability from certain variables. The criterion used for the selection of these three episodes was that at least one third of the countries in the sample should have experienced a crisis within at least three months of each other, with no crisis being separated from any other by more than 12 months. A crisis is defined as a month in which an index of exchange rate pressure, calculated at monthly intervals over the ten year period, is more than 1.5 standard deviations above the value of its sample mean over the period. This index and the criterion for defining a crisis have become more or less standard in the empirical literature on currency crises, and a detailed discussion of the index is given in the Appendix. Table 1 presents the countries that experienced crises during each episode.

This index is also used as the main dependent variable in our model. However, it is computed over different intervals (1994M11-1995M4, 1997M5-1997M10, 1998M7-1998M10), in that formulation, to reflect the extent to which countries suffered over a particular crisis period. This allows us to distinguish between the *incidence* and *severity* of crises. So, while the East Asian countries did experience currency crises in the summer of 1998 (based on the monthly calculations of the index, used for sample selection and defining "crises"), their currencies rebounded quickly and therefore they do not exhibit high

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[8] Following STV, transition economies such as Hungary, Poland and China have been excluded, as have members of the EU such as Greece and Portugal.

[9] See World Bank (1996) for a detailed history and analysis of private capital flows to emerging markets.

values of the crisis index (i.e. the dependent variable) in this episode. This is particularly important when speaking of contagion-a short plunge would be sufficient, in terms of our theory, for investors to consider a country as being in crisis and focus attention on its characteristics. In other words, this is sufficient to render it "contagious." However, it is the judgment (regarding the currency) they make in the medium term which determines the value of the index that is used as the dependent variable in our regression.

With 19 observations for each episode, and three episodes, we have 57 observations in all, across crisis episodes. The basic model was estimated using these observations. However, when using the variable which tests the *combined* explanatory power of location and fundamentals, the regression was restricted to the countries in East Asia and Latin America, since the other countries are in regions with fewer emerging markets. India, Pakistan and Sri Lanka each have only two other countries in their region, whereas Jordan and South Africa have none. This variable measures the number of countries within a particular region that could account for discriminating contagion. If there are fewer countries in one region than there are in another, the two are not comparable. Hence, a truncated sample was defined, comprising only of the East Asian and Latin American countries. In this truncated sample of 14 countries, we have 42 observations. For the other contagion indicator variables, the larger sample was used.

B. Discussion of Variables

The regression equation is a pooled, cross-sectional, Ordinary Least Squares (OLS) estimation, in which an index of exchange rate pressure is regressed on various economic variables and a contagion indicator variable, which measures the effect of discriminating contagion *based on the same economic variables*. The model has seven such variables, all of which have been widely used in the literature on the analysis and prediction of currency crises.[10] However, acceptance of the conclusions reached in this paper should not hinge critically on whether these variables are the single best way of explaining the variation of the crisis index. The idea, here, is to show that given a parsimonious set of variables that have been widely used in explaining currency crises, *the effect (on vulnerability) of discriminating contagion based on these variables is strongly significant after accounting for their direct effect.* It is this *marginal* explanatory power which is of key interest. In order to conclusively dispel any doubts regarding our choice of variables, sample selection, data, omitted variable problems etc. we demonstrate that adding variables to two other models, while using their data, raises their explanatory power considerably, with our variable being highly significant.

The variables are (i) the *real effective exchange rate appreciation* (in percentage terms) over the previous three calendar years (RER); (ii) the percentage growth in *exports* over the previous calendar year (EXP); (iii) the ratio of *M2* to international reserves in

[10] The first four variables are the top four in KLR's ranking of variables on the basis of their accuracy in signaling currency crises in advance. The next three are used by STV/T and BM, among other studies.

December of the year prior to the crisis (M2); (iv) the change in *stock prices* over the previous calendar year (ST); (v) the percentage change in the ratio of *domestic credit* to GDP over the previous two calendar years (CRED); (vi) the ratio of short term debt to reserves at the semi annual interval immediately prior to the crisis episode (SD); and (vii) the current account deficit as a percentage of GDP during the previous calendar year (CAD).[11] A detailed discussion of the construction of the variables mentioned above is given in the Appendix.

While the vector of coefficients on the economic variables measures the direct effect of these variables on the crisis index, the coefficient on the contagion indicator variable measures the effect of discriminating contagion. Three polytomous contagion indicator variables were constructed. One version (CT) records the number of countries in crisis with at least one signal in common with the country for which the observation was being taken. These signals are calculated based on KLR's methodology, which considers a macroeconomic variable to be signaling a crisis if it crosses a certain threshold value in its percentile distribution over time in a given country. The threshold value is the same across countries for a given variable and set between the eightieth and ninetieth percentile, or the tenth and twentieth, depending on whether high or low values of the variable are supposed to signal a crisis. In this study, we use the 20% threshold for all variables.[12] CT can be written as:

$$CT_{j,t} = \sum_{q=1}^{18}\left[CRI_{q,t} \times \left[I\left[\sum_{i=1}^{7} \left\{ I\left(X_{i,j,t} > \overline{X}_{i,j}\right) \times I\left(X_{i,q,t} > \overline{X}_{i,q}\right)\right\} > 0 \right]\right]\right] \qquad (1)$$

Here, q denotes (in turn) the 18 countries other than country j for which the observation is being taken. I is a function which takes the value 1 if the condition that is its argument holds, and zero otherwise. $CRI_{q,t}$ is a dummy which takes the value 1 if country q experienced a crisis during contagious episode t, and zero otherwise. $t \in (1994, 1997, 1998)$ denotes the contagious episode. The X_i denote the 7 macroeconomic variables discussed earlier, measured at annual intervals, except for SD which is measured at semi-annual intervals.[13] So, $X_{i,j,t}$ denotes the value taken by variable i for country j during crisis period t, which is the value of this variable at the measurement interval immediately before the start of the crisis period in year t. We use data over the period 1990-99 for the Latin American

[11] In the case of Mexico, for the 1994 Tequila crisis, we use November 1994, rather than December 1994 as the "end of the year." Also, for ST in the 1998 episode we use the annualized change since the end of the previous crisis period, for those countries that experienced crises in 1997.

[12] Other thresholds have been tested and the results are robust to the choice of threshold.

[13] For the sake of mathematical precision, for exports and stock prices, the X_i denote the *negative* of those series, since *low* values of the variables signal crises.

countries and 1985-99 for the other countries.[14] The $\overline{X}_i$ are threshold levels set such that 20% of the values of a given variable for a given country over the relevant interval would be considered signals. The second contagion indicator variable (CR) is constructed similarly except that it counts only signals from countries *in the same region* as the country in question. CR can be written as:

$$CR_{j,t} = \sum_{q=1}^{18}\left[\left(CRI_{q,t} \times DR\right)\times\left[I\left[\sum_{i=1}^{7}\left\{I\left(X_{i,j,t} > \overline{X}_{i,j}\right)\times I\left(X_{i,q,t} > \overline{X}_{i,q}\right)\right\} > 0\right]\right]\right] \qquad (2)$$

Where DR=1 if both j and q are East Asian or Latin American countries. While CT considers signals from fundamentals alone, CR considers signals from location and fundamentals.

The third contagion indicator variable (WC1) tests for "wake-up-calls." The reasoning is that investors are "awakened" to weaknesses in a country by a currency crisis in that country, and look for similarities between that country and other countries, to decide which ones could be vulnerable. Investors would have looked for countries that had signals in common with Mexico in 1994, Thailand in 1997, and Russia in 1998.[15] WC1 tests the extent to which similarities to these "ground-zero" countries can help explain the variation in the crisis index. The variable WC1 can be written as:

$$WC1_{j,t} = \sum_{i}^{7}\left[I\left(X_{i,j,t} > \overline{X}_{i,j}\right)\times I\left(X_{i,q,t} > \overline{X}_{i,q}\right)\right] \qquad (3)$$

Here, the subscript q denotes Mexico for t=1994, Thailand for t=1997, and Russia for t=1998. Hence, WC1 measures the number of signals each country has in common with the ground zero country.

Let us take an example to illustrate the construction of these variables. Consider Singapore during the 1998 episode of contagious currency crises. All 7 East Asian countries were in crisis. Here, Singapore displayed signs of vulnerability in the stock market and in the growth of domestic credit. Among the other six Asian countries, Indonesia and Thailand displayed signs of vulnerability on at least one of these. So CR, for Singapore, would take the value 2. The variable CT, for Singapore, measures the number of countries (in the total sample) in crisis which have at least one fundamental weakness in common with Singapore for a given episode. In the rest of the sample (excluding East Asia) for 1998 Brazil, Colombia, India, Pakistan and South Africa were in crisis. Brazil had stocks and the current

[14] This is because the eighties were a decade characterized by macroeconomic turmoil in many Latin American economies. The nineties are generally seen as a decade significantly distinct and delinked from the 1980's when speaking of economic circumstances in Latin America.

[15] Although Russia is not part of our sample, we calculate signals for it, for 1998, which are presented along with the signals for other countries in Table 4.

account signaling weakness, while Colombia had signals from stocks and M2/I. India and Pakistan had signals from export growth and the real exchange rate, whereas South Africa had signals from stock prices. So CT=5. Russia, the country which triggered the wave of crises in 1998, had signals from RER and SD. So WC1 would equal 0 for Singapore, since it has no signals in common with the ground zero country. The contagion indicator variables are presented in Table 3.

C. Results

The basic regression equation used to demonstrate the marginal explanatory power of discriminating contagion was as follows:

$$IND= \beta_1 + \beta_2 (M2) + \beta_3(CRED) + \beta_4(RER) + \beta_5(EXP)+ \beta_6(ST)+ \beta_7(SD)+ \beta_8(CAD)+\beta_9(CT)+ \varepsilon \quad (4)$$

The results for this estimation are presented in Table 5. Note that we drop the observations for Mexico in 1994 and Thailand in 1997.[16] As the table shows, CT is highly significant with a t-statistic of 2.59. Equation (4) was reestimated after dropping CT. The adjusted R^2 dropped from 0.20 to 0.11. An F-test for the differential in R^2 yielded an F-statistic of 11.59, as the table shows, indicating that the variable significantly increased the explanatory power of the model. The equation was estimated for the truncated sample, first in its original form, then after dropping CT, and finally after replacing CT with CR. The results indicate that CR does a slightly better job than CT (with an adjusted R^2 of 0.51 rather than 0.48).[17]

Equation (4) was next estimated using WC1 instead of CT or CR. As Table 6 shows this variable is significant, and outperforms CT, although it does not outperform CR when it is interacted with LOCD, a dummy that equals 1 if the country is in the same region as the ground zero country, in order to include locational effects.[18] This is understandable, since CR takes into account all the signals that crisis countries have in common whereas WC1 takes into account only signals in common with the ground zero country. While wake-up calls do not explain the whole story, they certainly seem to be an important aspect of contagious currency crises in emerging markets.

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[16] Leaving these observations in raises the R^2 substantially. However, since these were the crises that triggered the contagious episodes, whereas the crises that came later happened more or less simultaneously, the crisis index for these data points cannot be explained by the number of other countries in crisis.

[17] Taken alone, this would suggest that the marginal explanatory power of location is modest. Other results, discussed below, indicate otherwise.

[18] Since WC1, CT, and CR are collinear, we cannot any of them as regressors together.

In order to truly appreciate the significance of this finding, however, we have to compare the performance of WC1 with variables that test for similarities with alternative ground zero countries. In other words, we have to show that it is only similarities with the country that started the contagious wave that count. Accordingly, WC2 was constructed, which was defined the same way as WC1, except that q (see Equation (3)) was defined as the country with the highest value of IND in a particular crisis period, excluding the ground zero country. In other words, we test for the importance of similarities to the "second most important country." q was Argentina for t=1994, Indonesia for t=1997, and Brazil for t=1998. The results of the regression using WC2 are also presented in Table 10. As the table shows, the variable is insignificant. WC3 and WC4 were constructed analogously, and tested, and the results remained insignificant.

D. Robustness Checks

Various robustness checks were tried. The model is robust to the formulation of the index. Results using DEP (an index of exchange rate pressure which simply equals exchange rate depreciation) as the dependent variable are shown in Table 7. Results using the BMG index (an index developed by BM whose construction is similar to IND except that gold holdings are included in reserves) are shown in Table 8. The additional explanatory power of CR is somewhat higher in these models, but it is clear that discrimination based on economic fundamentals rather than location is the driving force behind the explanatory power of the contagion indicator variables. When dummies which took the value 1 if a country had experienced a crisis in a particular period and 0 if it had not, were used as the dependent variables in probit and linear probability versions of the OLS model proposed here, the results remained consistent with the theory. The sample proved robust to the exclusion of countries one at a time, with the results remaining basically similar. White tests indicated that none of the regressions exhibited heteroscedasticity.

Our model, as presented in Equation (4), essentially presupposes macroeconomic linearities, in that the direct effect of macroeconomic fundamentals on vulnerability is captured through including these variables in the regression, while significant deviations from trend in the same variables measure the effect of discriminating contagion. It is possible, however, that such deviations on the part of these variables make a country more vulnerable to crises, *directly*. We therefore tested an extended version of the model where we included the $I(X_{i,j,t} > X_{i,j})$, for all i macroeconomic variables, as additional independent variables.[19] These variables equal 1 if a particular indicator was signaling a crisis prior to the relevant crisis episode. Hence, the direct effect of having a variable significantly deviant from its trend is accounted for by these variables. The discriminating contagion effect is accounted for by the contagion indicator variable. The results for this estimation are presented in Table 9. As the table shows, the contagion indicator variable is highly significant, raising the adjusted R^2 from 0.14 to 0.40. In other words, the effect of discriminating contagion is significant even after accounting for non-linear direct effects.

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[19] These variables are labeled DM2, DRER, and so on.

We rely on signals from economic variables to determine which countries are potentially contagious. The more signals a country has from economic variables, the greater the likelihood that it will have a signal in common with another country, and thus be considered contagious. However, if the extent to which a country is suffering were to depend simply on the number of signals, the contagion indicator variables would pick up this effect. We therefore check the extent to which this is the case. The variable SIG was constructed as follows:

$$SIG_{j,t} = \sum_{i=1}^{7} I\left(X_{i,j,t} > \overline{X}_{i,j}\right) \qquad (5)$$

In other words, SIG equals the number of macroeconomic variables signaling a crisis for a given country in a given period. When SIG was included in the regression specified in equation (4) it turned out to be insignificant. However, this could be due to collinearity with CT, CR or WC1. We therefore replaced the contagion indicator variable with SIG. The results are shown in Table 11 and indicate that SIG does much worse than any of these variables in explaining variation in IND. We can therefore be confident that the explanatory power of the contagion indicator variables does not owe simply to the effect of more signals on the crisis index. Rather, it is the number of signals *in common with other countries experiencing crises* that counts.

The marginal explanatory power of the discriminating contagion hypothesis over other theories of contagion was tested empirically by adding variables measuring trade and financial sector linkages to the regression equation.[20] TR, taken from Caramazza et al. (1999)'s study of trade and financial contagion, is a variable that measures the potential for "trade contagion" or spillovers across countries. The variable weighs the price and income effects of exchange rate changes in other countries during the crisis period, using a relative weight of one for two. The price effect is proxied by adjusting IMF data on REER by replacing the actual exchange rate change and inflation in the specified country over the crisis period by projections based on their trends over the previous three years. The "own-country" change in the real effective exchange rate is thus neutralized, and the change in the real exchange rates of a country's trading partners is considered while holding that country's real exchange rate constant. The income effect is proxied by implied post-crisis export market growth, or the expected contraction in the output of partner countries due to the crisis. It is a trade weighted average of the slowdown in output growth in these countries relative to a three year trend.

FI measures the potential for contagion via the financial linkage of a common creditor. The common creditor is defined as the largest lender to the country which started the contagious wave. FI is the product of the share of BIS debt borrowed from the common

[20] By including the economic variables in the regression equation, we have already controlled for common economic weaknesses.

creditor and the share of BIS credits lent to the common creditor. A third variable, FM, was used to control for linkages via financial markets. Based on Kaminsky and Reinhart (1999), two clusters of countries whose assets show significant comovement were identified- Argentina, Brazil, Mexico and Peru in Latin America and Indonesia, Malaysia, Philippines and Thailand in East Asia. FM is a polytomous variable equal to the number of other countries in a cluster that are experiencing a crisis, if the country for which the observation is in the cluster, and zero if it is not. Equation (4) was estimated after adding these three variables. The results are shown in Table 10, and demonstrate that the contagion indicator variable has significant marginal explanatory power. Hence there is empirical evidence of the type of contagion discussed in this paper, *even after accounting for trade spillovers and financial linkages.*

We further tested a number of alternative specifications of the contagion indicator variables. These replaced CT in equation (4), since most of them are somewhat collinear with our contagion indicator variables. For instance, a variable called LOC was constructed, which took a value equal to the number of other countries in the region that were experiencing a crisis. As Table 11 shows, it turned out to be insignificant in a regression.[21] However, when the dummy variable (LOCD) which took the value 1 if the country was located in the same region as the ground zero country was used, it turned out to be highly significant, outperforming CT but not CR. These results are also shown in Table 11. While it seems clear, therefore, that the combined explanatory power of economic variables and location surpasses the individual explanatory power of either, their relative success depends on how one represents location. Proximity to the "ground zero" country seems to do a better job of explaining vulnerability than the number of other countries in the region that are experiencing crises.

We also tested for the possibility that there is, in fact, no discrimination on the part of investors, and that the likelihood of a country being in crisis depends simply on the number of other countries in crisis, without regard to any common characteristics. To test whether this objection was valid, a "naive" polytomous variable (NA) was constructed which was simply equal to the number of other countries in crisis, without accounting for any sort of discriminating factor. When the index was regressed on this variable (results in Table 10), it turned out to be insignificant. Countries do not, it turns out, experience more pressure just because more countries are experiencing crises. In 1998, for instance, just as many countries were hit as in 1997-however, none of them suffered heavily, since there was no reason for investors to believe that the crises reflected new evidence of similar problems in these countries.

Another variable tested the effects of country reputations on vulnerability to contagious crises. Is a country that has experienced pressure on its exchange rate regime in one round of contagious crises more likely to experience pressure in future rounds? In other

[21] A similar variable, which was a dummy which took the value 1 if a majority of the countries in crisis were in the same region as the country for which the observation was being taken, also turned out to be insignificant.

words, do investors have some sort of "memory" that classifies certain countries as being "prone to contagion" and others as not? A dummy variable (MEM) was constructed, which equaled 1 for countries that had experienced attacks in the previous crisis period and 0 for those that had not. For the 1994-95 crisis period, the dummy was constructed based on a period of contagious crises in 1989-90. As Table 11 shows, the coefficient on the dummy turned out to be insignificant. It turns out therefore, that investors do not automatically label countries as being crisis prone, just because they have previously experienced crises. Perhaps the best examples of this are Mexico, which, despite being the worst sufferer in the previous round, came out of the Asian crisis relatively unscathed, and the East Asian countries, which suffered little in 1998.

The econometric work undertaken seems to indicate that there is clear discrimination regarding *what* countries to lose faith in during a contagious crisis, in the minds of investors. The empirical evidence further suggests that our characterization of the discrimination performs rather well when benchmarked against alternative hypotheses. However, in order to conclusively prove our point we use the STV/T and BM models, and their data, and demonstrate that adding the contagion indicator variables constructed in this paper raises the explanatory power of their models.

IV. The Sachs, Tornell and Velasco (1996) and Tornell (1998) Models

STV/T used the standard crisis index developed by Eichengreen, Rose, and Wyplosz (1996), which is what we use here, as their dependent variable. They used two independent variables. One was a lending boom variable LB, which is defined as the four year growth (prior to the crisis) in domestic credit to the non (central) government sector. The other was a measure of real (effective) exchange rate appreciation, called RER, which they construct as a trade weighted average of bilateral real exchange rates with the EU, Japan and the U.S. and measure over a four year period. These variables are interacted with certain dummies, whose construction is explained below, and the cross products are included as additional independent variables. Their sample, unlike ours, does not include the 1998 crises. We rely on BM's presentation of the STV/T data set, and use the basic equation from Tornell (1998).

There is a dummy for high reserves D^{HR}, which equals one if the country has a ratio of M2 to international reserves that is below 1.8 and a dummy for strong fundamentals, D^{SF}, which equals one if the lending boom is negative and real exchange rate appreciation under 5%. Cross products of D^{LR} and D^{SF} with the two independent variables discussed above are included as additional independent variables. The resulting equation is:

$$IND = \beta_1 + \beta_2(LB) + \beta_3(RER) + \beta_4 (D^{HR} \times RER) + \beta_5 (D^{HR} \times LB) + \beta_6(D^{SF} \times RER) + \beta_7(D^{SF} \times LB) + \beta_8 (CT) + \varepsilon \quad (6)$$

This equation was estimated for our sample. The results are presented in Table 12, and indicate that CT, and CR (when Equation (6) was estimated after replacing CT with CR) are significant in the regressions using the full and truncated samples respectively. WC1,

however, is not significant. F test statistics of 9.48 and 10.96 for CT and CR, respectively, indicate that their contribution to the explanatory power of the model is substantial.

V. The Bussière and Mulder (1999) Model

BM, as discussed earlier, construct an index of exchange rate pressure (BMG) which counts gold holdings as reserves. This index is regressed on the current account deficit, short term debt, real exchange rate appreciation, and a dummy which equals 1 if the country had an IMF program. Their current account deficit variable is the ratio of the sum of quarterly deficits for four quarters ending in the quarter preceding the crisis episode, divided by GDP. Their real exchange rate data was obtained from the IMF's INS database, and the variable is the four year appreciation ending in the month prior to the start of the crisis episode. We add our contagion variable which gives us the following equation:

$$BMG = \beta_1 + \beta_2(CAD) + \beta_3(STD) + \beta_4(RER) + \beta_5(FUNDP) + \beta_6(CT) + \varepsilon \qquad (7)$$

The results are presented in Table 13. As can be seen, the contagion indicator variable is significant, after taking the effect of the macroeconomic fundamentals used by BM into account. The F-tests for the difference in explanatory power yield statistics of 15.63, 32.74, and 28.31, for CT, CR, and WC1 respectively. Hence, discriminating contagion seems to have rather powerful marginal explanatory power.

VI. Conclusions

We have demonstrated the following: (i) The contagion indicator variables designed to capture the effect of discriminating contagion based on economic variables and location have significant marginal explanatory power. (ii) There is evidence of "wake up calls" or similarities between the country that triggers a wave of contagious crises and the countries affected by the wave. (iii) Taking two other studies that seek to explain contagion in terms of economic variables, we have shown, using their methodology and their data, that adding our contagion variable significantly improves the results. Hence, we conclude that there is empirical support for the theory of contagion proposed in this paper, which emphasizes the role of economic variables and location as sorting devices used by investors during crisis periods.

Most of the research on contagious currency crises, thus far, has sought to explain expectational switches as *exogenous* events. A key contribution of this paper is to demonstrate that such switches can, in fact, be *endogenous* to a model that explains crises in terms of economic fundamentals. Fundamentals can not only make a country vulnerable to expectational shifts, they can cause the shift itself by acting as sorting devices. Moreover, the specific sorting device used can change from crisis to crisis. As the evidence in favor of "wake up calls" suggests, it seems to depend on the macroeconomic woes of the country that triggered the wave of contagious crises.

This poses a difficult problem for those in the business of crisis prevention and containment. Since countries are rarely invulnerable on every economic criterion, the type of currency crisis discussed in this paper could occur in just about any emerging market. While this does not mean that weak fundamentals will not make a crisis significantly more likely, it does imply that it is virtually impossible for countries to be wholly immune to contagion. It also suggests that contagion is not the irrational pandemonium it is often thought to be. There is clearly a method to the madness of currency traders. Capital controls on short-term flows could therefore be a partial solution. In raising the cost of portfolio adjustment, through taxes or other controls, governments could increase the incentive for the incentive for investors to undertake detailed country-specific analyses of economic fundamentals rather than follow arbitrary market conventions.

But the long-term solutions will have to be of a different nature. Such coordinated expectational shifts would be less likely in developed countries, since the circumstances of each individual country are better known and understood by investors. So, if Britain were to experience a currency crisis, Germany would not necessarily follow, since British and German economic circumstances are well understood, and investors do not need to look to Britain to understand what other investors think about the viability of currency regimes in Germany. However, when Thailand experiences a currency crisis, investors know others are likely to gauge implications for the rest of East Asia based on the situation there, and are thus more likely to lose confidence in other countries. The true solution to the problem of currency crises, then, lies in targeting the basic reason investors are prone to frequent "coordinated" losses of confidence in these economies-the fact that there is less understanding of their structure and functioning, which makes investors more likely to look across currency markets for indications of the viability of the currency regime. Greater emphasis on informational openness, standardization of economic and financial data, as well as prudent and standardized disclosure and accounting norms would go a long way towards mitigating this tendency.

Table 1: Occurrence of Crises

Crisis Episode	East Asia	Latin America	Other	Total
1994-95	Malaysia	Mexico	*None*	8
	Singapore	Argentina		
	Philippines	Brazil		
	Taiwan	Peru		
1997	Indonesia	Colombia	India	10
	Malaysia		Pakistan	
	Philippines			
	Taiwan			
	Thailand			
	Singapore			
	Korea			
1998	Indonesia	Brazil	India	12
	Malaysia	Colombia	Pakistan	
	Philippines		South Africa	
	Taiwan			
	Thailand			
	Singapore			
	Korea			

Table 2: Indices of Exchange Rate Pressure

	1994			1997			1998		
Countries	IND	DEP	BM	IND	DEP	BM	IND	DEP	BM
Argentina	20.2	0.13	20.3	-2.14	0	-8.1	-0.8	0	-0.9
Brazil	19.65	15.14	19.5	7.38	5.47	11.4	31.5	72.3	32.4
Chile	-5.63	-2.33	-7.4	-2.06	8.02	4.1	-0.7	1.74	-0.7
Colombia	4.31	19.13	4	15.82	24.88	15.9	14.1	13.17	13.8
India	-1.2	8.35	-1	0.76	8.07	9.3	-0.8	2.10	-2.1
Indonesia	1.32	5.24	1.2	48.22	25.8	94.7	-18.5	-28.26	-16.7
Jordan	-1.5	-1.27	-1.5	-0.21	0.00	-0.4	0	0.00	0.2
Korea	-3.7	-2.46	-3.7	3.35	83.11	66.1	-3.4	-6.25	-3.4
Malaysia	-2.6	-0.78	-2.5	30.92	52.77	45.2	-9.9	-0.41	-9.8
Mexico	79.3	121.5	78.4	-2.21	8.53	1.6	13.3	14.58	13.2
Pakistan	0.7	2.77	0.7	5.16	8.65	8.8	0	7.47	0.1
Peru	-2.69	6.43	-2.7	-4.26	5.24	-1.2	1.8	7.34	4.3
Philippines	7.19	9.77	7.2	30.57	53.04	33.7	2.4	4.96	2.4
Singapore	-9.19	-3.38	-9.19	10.91	12.58	10.91	-3.96	-2.99	-3.96
South Africa	0.53	2.73	0.5	5.19	9.92	6.2	-6.9	9.68	-6.7
Sri Lanka	0.7	5.70	0.7	1.59	4.72	2.7	1.5	3.46	1.5
Taiwan	4.26	4.54	4.26	5.64	17.55	5.64	-11.77	-1.2	-11.77
Thailand	-1.82	0.55	-2.4	43.41	66.35	48.1	-7.2	-8.56	-7.1
Venezuela	5.16	6.81	3.2	-13.36	5.93	-4.9	-0.5	70.6	-0.9

Table 3: Contagion Indicator Variables

	1994-95			1997			1998		
Countries	CR	CT	WC1	CR	CT	WC1	CR	CT	WC1
Argentina	3	5	3	0	0	0	1	2	0
Brazil	3	5	1	1	5	1	1	8	0
Chile	0	0	0	1	10	3	2	8	1
Colombia	3	3	1	0	9	4	1	7	1
India		0	0		4	2		3	1
Indonesia	1	3	2	5	6	2	1	3	0
Jordan		1	1		4	1		5	1
Korea	0	0	0	6	7	3	2	3	0
Malaysia	1	2	0	6	8	2	4	7	1
Mexico	3	5		1	6	1	2	8	1
Pakistan		6	1		6	2		3	1
Peru	3	5	1	1	7	1	2	6	0
Philippines	2	4	2	5	8	2	0	0	0
Singapore	0	0	0	5	6	1	3	5	0
South Africa		0	0		0	0		5	0
Sri Lanka		4	1		6	1		2	1
Taiwan	1	3	2	3	4	2	1	2	0
Thailand	0	3	1	6	9		3	5	0
Venezuela	1	7	2	2	8	2	2	6	1

Table 4: Signals of Vulnerability

Countries	1994-95	1997	1998
Argentina	CRED, CAD, ST	*None*	*None*
Brazil	CRED, RER	CAD	CAD, CRED, ST
Chile	*None*	ST, EXP, M2/I, CRED, CAD	RER, ST
Colombia	CRED	ST, EXP, M2/I, RER, CAD	ST, M2/I, SD
Jordan	ST	EXP	M2, RER
India	*None*	ST	ST, RER
Indonesia	M2/I, ST	RER, CAD	EXP
Korea	*None*	ST, EXP, CAD, CRED	ST
Malaysia	RER	CRED, RER, SD	EXP, M2/I, CRED, ST, CAD
Mexico	ST, M2/I, CAD, SD, CRED	RER	RER, ST
Pakistan	CAD	M2/I, ST, SD	EXP, RER
Peru	ST, RER	CRED, RER	ST
Philippines	ST, CAD, RER	RER, CRED, CAD	*None*
Russia	n.a.	n.a.	RER, SD
Singapore	*None*	RER, CRED	CRED, ST
South Africa	*None*	*None*	ST
Sri Lanka	M2	RER	SD
Taiwan	CAD, SD	EXP, M2/I, SD	M2/I, SD
Thailand	CRED	EXP, CAD, RER, ST, SD	CRED, ST
Venezuela	M2/I, EXP, SD	ST, RER	RER, ST, CRED

Table 5: IND regressed on Macroeconomic Variables and Contagion Indicator Variables

Variable	Full Sample		Truncated Sample		
M2	0.34	0.54	2.82	6.15	3.56
	0.93	*1.52*	*2.13*	*4.70*	*2.77*
RER	-0.19	-0.14	-0.26	-0.25	-0.28
	-2.68	*-1.94*	*-3.01*	*-2.69*	*-3.15*
CAD	0.62	0.59	0.62	0.62	0.98
	1.94	*1.92*	*1.44*	*1.36*	*2.23*
SD	0.03	0.03	0.04	0.07	0.04
	1.16	*1.08*	*1.25*	*2.02*	*1.22*
CRED	-0.03	-0.02	-0.02	-0.006	-0.07
	-0.47	*-0.34*	*-0.28*	*-0.08*	*-1.04*
EXP	-0.08	0.06	-0.08	0.30	0.10
	-0.47	*0.35*	*-0.33*	*1.03*	*0.41*
ST	0.001	0.02	0.001	0.001	0.0007
	1.24	*1.42*	*0.98*	*0.83*	*0.41*
CT		1.54		2.75	
		2.59		*3.04*	
CR					4.35
					3.35
Constant	-1.57	-10.58	-12.16	-42.72	-24.19
	-0.43	*-2.11*	*-1.8*	*-4.45*	*-3.75*
F-test Statistic		11.59			18.63
R^2	0.23	0.32	0.33	0.58	0.61
Adjusted R^2	0.11	0.20	0.19	0.48	0.51

t-statistics given in italics

Table 6: IND on Macroeconomic Variables and Other Contagion Indicator Variables

Variable	WC1		WC1*LOCD		WC2
	Full Sample	Truncated	Full Sample	Truncated	
M2	0.30	1.30	0.30	0.89	0.33
	1.11	*1.22*	*1.22*	*0.87*	*1.14*
RER	-0.08	-0.12	-0.12	-0.16	-0.13
	-1.46	*-1.67*	*-2.48*	*-2.40*	*-2.23*
CAD	0.36	0.39	0.32	0.48	0.39
	1.52	*1.17*	*1.43*	*1.57*	*1.55*
SD	0.006	0.02	-0.005	0.008	0.005
	0.34	*0.66*	*-0.30*	*0.33*	*0.23*
CRED	-0.003	-0.001	-0.03	-0.02	-0.03
	-0.07	*-0.02*	*-0.63*	*-0.34*	*-0.65*
EXP	0.041	0.02	0.05	-0.04	-0.01
	0.31	*0.10*	*0.36*	*0.36*	*-0.07*
ST	0.002	0.002	0.001	0.002	0.002
	2.23	*1.78*	*1.59*	*1.4*	*1.79*
Contagion Indicator	3.89	3.64	5.99	5.70	1.70
Variables	*2.89*	*2.03*	*3.74*	*2.91*	*0.88*
Constant	-5.89	-10.38	-12.16	-6.06	-2.58
	-1.89	*-1.83*	*-1.8*	*-1.20*	*-0.77*
R^2	0.36	0.40	0.33	0.48	0.25
Adjusted R^2	0.24	0.23	0.19	0.33	0.11

t-statistics given in italics

Table 7: DEP regressed on Macroeconomic Variables and Contagion Indicator Variables

Variable	Full Sample		Truncated Sample		
M2	0.80	1.12	4.30	9.0	5.24
	1.44	*2.06*	*2.20*	*4.72*	*2.85*
RER	-0.51	-0.43	-0.65	-0.64	-0.67
	-4.74	*-4.01*	*-5.05*	*-4.62*	*-5.25*
CAD	0.48	0.43	0.41	0.40	0.92
	0.99	*0.92*	*0.64*	*0.60*	*1.46*
SD	0.05	0.05	0.08	0.11	0.07
	1.40	*1.34*	*1.54*	*2.26*	*1.47*
CRED	0.04	0.05	0.06	0.07	-0.028
	0.44	*0.63*	*0.59*	*0.71*	*-0.26*
EXP	-0.50	-0.28	-0.62	-0.06	-0.32
	-1.87	*-1.03*	*-1.69*	*-0.16*	*-0.86*
ST	-0.003	-0.006	-0.0007	-0.0009	-0.002
	-0.13	*-0.003*	*-0.30*	*-0.35*	*-0.81*
CT		2.37		3.86	
		2.54		*2.92*	
CR					6.49
					3.50
Constant	3.42	-10.47	-10.64	-53.6	-27.9
	0.62	*-1.38*	*-1.06*	*-3.84*	*-3.03*
F-test Statistic		13.22			10.61
R^2	0.38	0.46	0.49	0.61	0.67
Adjusted R^2	0.29	0.36	0.38	0.50	0.60

t-statistics in italics

Table 8: BMG regressed on Macroeconomic Variables and Contagion Indicator Variables

Variable	Full Sample			Truncated Sample	
M2	0.51	0.86	5.02	7.97	3.81
	0.88	*1.55*	*2.52*	*5.24*	*2.73*
RER	-0.23	-0.14	-0.36	-0.28	-0.32
	-2.06	*-1.27*	*-2.80*	*-2.57*	*-3.30*
CAD	1.001	0.94	1.01	0.80	1.36
	1.98	*1.98*	*1.58*	*1.49*	*2.84*
SD	0.09	0.08	0.12	0.14	0.09
	2.24	*2.24*	*2.42*	*3.35*	*2.36*
CRED	-0.05	-0.04	-0.03	-0.01	-0.13
	-0.58	*-0.45*	*-0.31*	*-0.18*	*-1.63*
EXP	-0.34	0.09	-0.39	0.21	-0.05
	-1.24	*0.34*	*-1.06*	*0.64*	*-0.20*
ST	0.001	0.001	0.008	0.001	-0.0002
	0.51	*0.67*	*0.35*	*0.50*	*-0.10*
CT		2.64		4.26	
		2.76		*4.03*	
CR					7.21
					5.12
Constant	-1.10	-16.58	-21.0	-58.72	-30.39
	-0.19	*-2.14*	*-2.07*	*-5.26*	*-4.34*
F-test Statistic		15.04			47.04
R^2	0.22	0.33	0.38	0.67	0.73
Adjusted R^2	0.21	0.22	0.25	0.59	0.66

t-statistics in italics

Table 9: IND on Macroeconomic Variables, Signals and CT

M2	RER	CAD	SD	CRED	EXP	ST	DM2	DRER	DCAD	DSD	DCRED	DEXP	DST	CT	Constant	R^2	Adj. R^2
0.61	-0.14	0.90	0.06	0.04	-0.44	0.002	-4.09	4.30	6.73	12.33	-3.70	-7.97	3.16		-3.34	0.36	0.14
1.22	*-1.25*	*1.99*	*1.78*	*0.39*	*-1.70*	*0.95*	*-0.61*	*0.91*	*1.18*	*1.80*	*-0.59*	*-1.12*	*0.72*		*-0.52*		
0.90	-0.12	0.65	0.05	0.06	-0.11	0.002	-4.75	-3.30	4.50	8.12	-5.64	-10.88	-5.56	3.45	-14.89	0.55	0.39
2.14	*-1.29*	*1.70*	*1.46*	*0.76*	*-0.47*	*1.30*	*-0.84*	*-0.75*	*0.93*	*1.39*	*-1.05*	*-1.80*	*-1.32*	*4.24*	*-2.46*		

t-statistic given in italics

F-test Statistic=36.64

Table 10: IND on Macroeconomic Variables, TR, FI, FM and CT

M2	RER	CAD	SD	CRED	EXP	ST	TR	FI	FM	CT	Constant	R^2	Adj. R^2
0.99	-0.18	0.64	-0.03	-0.04	0.19	-.002	5.67	0.04	2.42	1.44	-14.77	0.70	0.61
2.48	*-2.31*	*1.46*	*-0.80*	*-0.72*	*0.95*	*-0.46*	*0.35*	*5.14*	*1.36*	*2.13*	*-2.70*		

Table 11: IND Regressed on Macroeconomic Variables and Alternative Contagion Indicators

Variable	NA	LOC	MEM	SIG	LOCD	
					Full Sample	Truncated
M2	0.32	0.49	0.36	0.37	0.43	2.32
	0.86	*1.30*	*0.96*	1.02	*1.30*	*1.41*
RER	-0.19	-0.22	-0.20	-0.15	-0.16	-0.23
	-2.63	*-3.01*	*-2.69*	-2.08	*-2.43*	*-2.84*
CAD	0.60	0.60	0.63	0.60	0.50	0.63
	1.85	*1.87*	*1.95*	1.84	*1.71*	*1.61*
SD	0.03	0.02	0.03	0.03	0.017	0.04
	1.19	*0.60*	*1.14*	1.07	*0.74*	*1.21*
CRED	-0.03	-0.06	-0.03	-0.03	-0.037	-0.02
	-0.49	*-0.95*	*-0.52*	-0.60	*-0.67*	*-0.40*
EXP	-0.14	-0.001	-0.67	0.07	-0.06	-0.11
	-0.74	*-0.007*	*-0.36*	0.35	*-0.37*	*-0.49*
ST	0.001	0.001	0.001	0.002	0.006	0.0006
	0.96	*1.11*	*1.11*	1.33	*0.44*	*0.39*
Contagion Indicator	-0.88	1.22	1.67	2.23	11.78	11.32
Variable	*-0.86*	*1.42*	*0.51*	1.66	*3.31*	*2.79*
Constant	7.72	-5.36	-2.65	-7.01	-3.26	-12.38
	0.68	*-1.20*	*-0.62*	-0.14	*-0.97*	*-2.01*
R^2	0.24	0.13	0.23	0.27	0.38	0.47
Adjusted R^2	0.11	0.11	0.10	0.14	0.27	0.33

t-statistics given in italics

Table 12: Sachs, Tornell & Velasco (1996)/Tornell (1998) Model w/ Contagion Indicator Variables

Variable	Full Sample			Truncated Sample	
LB	0.29	0.26	0.20	0.29	0.22
	4.37	*4.15*	*2.73*	*3.32*	*2.73*
RER	-0.12	-0.02	-0.08	-0.18	-0.21
	-0.73	*-0.12*	*-0.54*	*-0.59*	*-0.81*
$D^{HR}\times$ RER	-0.18	-0.07	0.11	-0.16	-0.25
	-0.21	*-0.09*	*0.15*	*-0.15*	*-0.26*
$D^{HR}\times$ LB	-0.30	-0.29	-0.21	-0.30	-0.25
	-3.53	*-3.57*	*-2.46*	*-2.81*	*2.53*
$D^{SF}\times$ RER	0.34	0.13	0.19	0.41	0.53
	0.66	*0.27*	*0.43*	*0.55*	*0.80*
$D^{SF}\times$ LB	0.25	0.48	0.38	0.23	0.29
	0.61	*1.19*	*1.10*	*0.43*	*0.62*
CR					4.05
					2.37
CT		1.74			
		1.92			
WC1			1.89		
			0.79		
Constant	-4.31	-10.01	-2.65	-4.97	-11.25
	-1.05	*-2.02*	*-0.63*	*-0.60*	*-1.25*
F Test Statistic		9.48			10.96
R^2	0.53	0.59	0.46	0.52	0.65
Adjusted R^2	0.43	0.48	0.31	0.35	0.50

t-statistics given in italics

Table 13: Bussière and Mulder (1999) Model with Contagion Indicator Variables

Variable	Full Sample			Truncated Sample	
RER	-.17	-.88	-0.05	-.18	-.15
	-1.58	*-.78*	*-0.55*	*-1.36*	*-1.47*
CAD	0.95	0.85	0.85	1.44	1.68
	1.97	*1.86*	*1.96*	*2.09*	*3.31*
STD	0.008	0.08	0.08	0.09	0.07
	2.00	*2.23*	*2.35*	*1.85*	*1.78*
FUNDP	-5.67	-4.94	-4.61	-10.22	-10.65
	-1.13	*-1.05*	*-1.03*	*-1.90*	*-1.98*
CT		2.42			
		2.78			
CR					7.90
					5.56
WC1			8.71		
			3.74		
Constant	-.14	-10.63	-8.80	-2.46	-15.33
	-.02	*-1.85*	*-1.86*	*-0.35*	*-2.74*
F-test Statistic		15.63	28.31		32.74
R^2	0.18	0.30	0.36	0.20	0.58
Adjusted R^2	0.12	0.22	0.30	0.11	0.52

t-statistics given in italics

APPENDIX

The Dependent Variables

Three dependent variables-indices of exchange rate pressure- are used, in turn, in this model. The principal dependent variable, called IND, is essentially a weighted average of the percentage change in the exchange rate, and the negative of the percentage change in international reserves.[22] The higher the value of the index, the more severe the crisis in the country.

The index is a weighted average, since its two components, the percentage change in the exchange rate and the negative of the percentage change in reserves, have different volatilities. Therefore, their conditional variance must be equalized. This is accomplished by weighting each component by the inverse of its variance, and dividing by the sum of the inverses of the variances of the two components. We get:

$$IND = [((1/\sigma^2_{EX}) / ((1/\sigma^2_{EX}) + (1/\sigma^2_{RES}))) * EX] + [((1/\sigma^2_{RES}) / ((1/\sigma^2_{EX}) + (1/\sigma^2_{RES})))*(-1)*RES] \quad (8)$$

Here, EX is the percentage change in the exchange rate, and RES is the percentage change in reserves over the relevant interval. σ^2_{EX} and σ^2_{RES} are the variances of the percentage changes in the exchange rate and international reserves respectively. Table 2 presents the values of IND for each country in each crisis episode. The variances used were calculated using the annual change in the exchange rate and reserves over the previous 10 years. When IND was used to define crisis periods, the sample variances of the monthly percentage changes in the exchange rate and reserves for the entire period (1990-99) were used as weights.

Used by ERW, KLR, Kaminsky and Reinhart (1996), and STV, among others, this index has become a standard feature of empirical work on currency crises. ERW also include the level of the domestic interest rate in their index. However, because data on these are missing for certain countries in the sample, this component was dropped, following KLR, Kaminsky and Reinhart (1996) and STV. The data for the exchange rate and international reserves were obtained from the *International Financial Statistics*. The exchange rate used is the end-of-period monthly exchange rate vs. the U.S. dollar (IFS line ae). The figure used for international reserves is the entry under Total Reserves Minus Gold (IFS line 1L.D).

Since crises often last for over a month (the frequency of our data), we require an interval over which to measure the change in the exchange rate and reserves, which fully reflects the extent to which a country suffers as a result of a currency crisis. Hence the index

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[22] It should be noted that this index takes into account the fact that currency crises do not have to be manifested in falling exchange rates. Rather, the central bank could be defending a peg under pressure by running down reserves.

was constructed using the period 1994M11-1995M4, 1997M5-1997M10, and 1998M7-1998M10. This essentially follows the methodology of STV/T and BM, and allows us, as mentioned earlier, to distinguish between the incidence and severity of currency crises.

Two other crisis indices were tried. The first is called DEP and simply measures the depreciation of a country's currency. The intervals used were 1994M11-1995M9, 1997M5-1998M2,1998M5-1998M10, for the 1995, 1997 and 1998 crises respectively.[23] One attraction of this approach is that since individual crises end at different points in time, while the period over which the index is computed is fixed for a particular episode, reserves could very well rise, in the aftermath of a crisis, either because of "profit taking" or buybacks or both. So, including reserves in the index might not give a wholly accurate picture of the intensity of a crisis. The second index was devised by BM, and is identical to IND, except that gold holdings are included in reserves. One justification for the use of this methodology is that the liquidity of gold has increased substantially in recent years. The intervals used are the same as for IND except that the interval used for 1997 is 1997M7-1997M10, following BM. The variable is called BMG. Both these indices are also presented in Table 2.

Independent Variables

Real Effective Exchange Rate Depreciation (RER)

The more appreciated the real effective exchange rate relative to its equilibrium value, the greater the adjustment that will be required in the nominal exchange rate, to ensure external balance.[24] Hence, an overly appreciated real effective exchange rate is an indicator of the impending need for adjustment in the nominal exchange rate. Such an adjustment can come in one of two ways, by a fall in the price level, without a rise in the nominal exchange rate, or by a fall in the nominal exchange rate. Given the difficulty of engineering the former, at least in the short run, markets correctly presume that the government will be compelled to correct real exchange rate overvaluation by abandoning the exchange rate regime and devaluing the currency. The variable used here is the change in the real effective exchange rate over a three-year period preceding the crisis year. That is, the change in the real effective exchange rate between December of the year preceding the year in which the crisis started, and December three years earlier. The data was obtained from the IMF's INS database

The ratio of M2 to international reserves (M2/I)

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[23] A number of different measurement intervals were tried, including the STV/T and BM intervals. The results are robust to the intervals used, and we show the best fit obtained.

[24] The reason for this is straightforward. While the policy instrument the government controls is the nominal exchange rate, the variable the current account responds to is the real exchange rate.

Also termed "reserve adequacy," this ratio is an important indicator of the extent to which a country's financial system is vulnerable to a run by investors. Its use in gauging vulnerability to currency crises was first suggested by Guillermo Calvo, in an influential 1995 paper.[25] Prior to this, the convention was to use the ratio of reserves to the value of one month of imports. Calvo argued, persuasively, that what was relevant was not the government's ability to finance the current account in the short term, but rather the ability of players in financial markets to purchase domestic currency that could, with relative ease, be converted to foreign currency at the prevailing price.[26]

The arguments for using reserve adequacy to estimate vulnerability to currency crises are grounded in the view that such crises bear a basic similarity to bank runs. Suppose depositors, or investors, in the case of currency crises, feel that a bank or country will not be able to honor its obligations tomorrow. In the case of the bank, this would mean not being able to give them their money if they asked for it, in the case of a country it would mean not being able to give them their money at the pegged exchange rate. In that case, the depositors or investors will withdraw their money *today*.[27] When higher-order beliefs are factored in, banks or countries are shown to be even more vulnerable, as a collapse could occur if investors think other investors think (and so on) that the bank or country would not be able to honor its obligations.

The variable is constructed by dividing the sum of Money (IFS line 34) and Quasi Money (IFS line 35) by the product of Total Reserves Minus Gold (IFS line 1L. D), henceforth denoted by 'I,' and the exchange rate (IFS line ae). For a given country in a given crisis period, the value of M2/I in December of the year preceding the crisis year is used.

Domestic Credit (CRED)

This variable is the percentage change in the ratio of domestic credit to GDP over a three-year period. If this ratio rises very fast in a short period of time, however, it is likely that the country is experiencing a lending boom. The increased vulnerability of countries to

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[25] Calvo(1996) has since amended his earlier proposal, suggesting that in comparing countries with significant structural differences, the ratio of M2 to international reserves be adjusted by its first log difference standard deviation. He made this observation in the context of comparing Mexico to Austria. Here, since the countries being compared are rather similar (with the possible exception of Singapore), structurally, in that they are all emerging markets, this adjustment is perhaps less necessary.

[26] The assumption here is that capital controls are not an option.

[27] This is the essence of the classic model of bank runs proposed by Diamond and Dybvig (1983). Chang and Velasco (1998) propose a theoretical model of currency crises based on this idea.

currency crises as a result is two-fold. As Gavin and Hausman (1995) and Rojas-Suarez and Weisbrod (1995) have argued, in the presence of a lending boom, banks' portfolios are likely to be more vulnerable to fluctuations in the business cycle.[28] Hence, a government faced with an unsustainable current account deficit or a fall in capital flows or both, will be less willing to engineer a recession to achieve external balance and will instead choose to go the devaluation route.[29] In addition, as Chang and Velasco (1998) have stressed, a high rate of growth of this ratio increases the danger that banks themselves will be subject to self-fulfilling runs. In this scenario, the central bank will be in the unenviable position of having to choose between bailing out domestic banks (by extending credit and printing more money) and defending the exchange rate peg (which will then come under more pressure as the central bank's domestic liabilities increase).

Claims on the Private Sector at Current Prices (IFS line 32D) are divided by nominal GDP to obtain the ratio of domestic credit to GDP on an annual basis. The variable used in the model is the percentage change in this ratio over a two-year period ending in December of the year preceding the crisis year.

Exports (EXP)

This variable gives us an idea of the incentive the government has to devalue in order to boost exports, since export led growth is a goal that has been popular among policymakers in developing countries. If exports are sluggish, a government may devalue, in order to boost them.

There are, of course, caveats to be kept in mind here. For one, if a country's exports have a high import content, then, unless the countries from which it imports these intermediate contents are also expected to devalue, a devaluation would increase the cost of production of the export sector, and have an adverse effect on competitiveness. The reasons

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[28] Bank loans to the private sector are made on the basis of expectations that economic growth will occur at a certain rate. During lending booms, these expectations tend to be unusually optimistic-because banks have excess funds to lend, they are willing to lend to riskier projects. Hence the increased vulnerability of their portfolios to economic contractions.

[29] The former would hurt the banking sector by raising interest rates and reducing growth, at a time when its loan portfolios have an unduly high proportion of loans that are risky, in that they will be repaid only if economic growth is high. This has, of course, to be considered in the context of the currency composition of the liabilities of the banking sector. If a high proportion of liabilities, relative to assets, is denominated in foreign currency, then a devaluation will also hurt banks, by increasing their liabilities by more than their assets. If, however, a large proportion of liabilities is denominated in domestic currency, the devaluation will be a blessing.

for the decline in exports are also important. If exports are declining because of supply side reasons, a devaluation might not be the best solution. This variable is the percentage growth in the domestic currency value of exports (IFS line 70) over the previous year.

Stock Prices (ST)

This variable is the percentage change in the major stock price index of the country over the year prior to the crisis. It gives us an idea of the difficulty the government faces in reversing capital flows and the extent to which the outflows are a permanent exit from an unattractive economy rather than a temporary retreat from a troubled one. Put differently, it is a proxy for the overall unattractiveness of an economy to portfolio investors, among the most volatile movers in international financial markets and a major force in equity markets, which could translate into their finding the currency unattractive as well.

In the context of the coordination of expectational shifts that was discussed earlier, this provides some indication to portfolio investors as to how pessimistic their comrades are about a country. Kumar et. al. (1998) point out that rising stock prices could, however, be taken to be indicative of a speculative bubble, and hence contribute to investor pessimism. However, even they admit that the data indicates that crises have largely been preceded by declining stock prices. The data was obtained from the *Global Financial Database* and the *IFC Emerging Stock Markets Factbook*. The variable is the change in the index given in the publication over the previous year.

Short Term Debt/Reserves (SD)

Like M2/I this variable measures the amount of domestic money that can be converted to foreign exchange easily. In fact, it has to be converted to foreign exchange in under 12 months. This variable does not, however, give us the whole picture. The currency composition of debt needs to be ascertained before one can estimate the effects it has on vulnerability. In particular, if a large share of the debt is denominated in foreign currency, a devaluation might actually make matters worse. However, the data needed to make these adjustments is difficult to assemble, and particularly so for our sample of emerging market economies. We therefore rely on this cruder formulation. The data on short term debt was obtained from the BIS webpage, while the data on reserves is simply IFS line 1L.D. We use the semi-annual interval immediately prior to the crisis episode in question.

Current Account Deficit (CAD)

The size of the current account deficit is an indication of how large the adjustment in the real exchange rate will have to be in order to restore external balance, in the event of a fall in capital flows. A large current account deficit implies the necessity of a large capital inflow, to cover the deficit, and consequently of high confidence in the economy on the part of foreign investors. It is not unusual for emerging market countries to show large current account deficits, since these countries are net importers of capital. If, however, the deficit is too large, assuming each marginal investor is less committed to investing in the country, such

a situation could leave countries highly vulnerable to switches in expectations. The data (in U.S. dollars) was obtained from the IFS (line 78). The variable is IFS line 78 divided by IFS (line 99b) for the previous year.

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