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External Vulnerability in Emerging Market Economies: How High Liquidity Can Offset Weak Fundamentals and the Effects of Contagion

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Abstract

This paper investigates the factors behind the 1994 and 1997 crises and whether these can explain the 1998 crisis. The study reveals that: (i) variables used in an Early Warning System model developed by IMF staff scored well in predicting the 1998 crisis out-of-sample; (ii) all three crisis episodes can be well explained by a parsimonious set of core fundamentals and liquidity related variables; and (iii) the presence of an IMF-supported program significantly reduced the depth of crises. The results suggest that as a rule of thumb countries should hold reserves to the tune of short-term debt to avoid contagion-related crises, provided their current deficits are modest and their real effective exchange rates are not significantly misaligned.

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I. Introduction and Summary

The economic crisis that hit Russia and dried up the financing to most developing countries for the remainder of 1998, is one in a series of major economic shocks that have affected emerging economies over the last five years, including the "tequila" crisis of late 1994, and the Asia crisis that began in 1997. Many observers have attributed the rapid spread of these crises to contagion. In line with this conclusion the IMF instituted, in April 1999, a new mechanism, the contingent credit line or CCL, to provide countries with additional liquidity to overcome the impact of contagion.

Opponents of the extension of such international liquidity tend to argue that this leads to moral hazard: excessive risk taking by (potential) recipients of such insurance. It is thus of particular interest to find out to what extent the depth and incidence of crises reflect solvency related fundamentals, and whether and to which extent they reflect a lack of liquidity. The former should in principle be dealt with through underlying policy measures that reestablish solvency, the latter, if present, either through the extension of liquidity by an international body or lender of last resort (Fischer 1999) or the buildup of additional reserves (Feldstein 1999).

Sachs, Tornell and Velasco (1996), hereafter STV, provides a useful methodology to examine vulnerability during general crisis periods, and in which risks of contagion are highest. The STV methodology focuses on external vulnerability during a window of about five months following the outbreak of a major crisis (the Mexican crisis in their application), i.e. the period during which countries are most prone to contagion, and most vulnerable to the lack of international liquidity that frequently follows eruption of major crises. This approach is consistent with stylized facts regarding the data on emerging market bond spreads, which tend to peak following a major crisis in a leading emerging market economy, and frequently coincide with a dearth of international financing.

To establish credibly which key variables are relevant, we first examine which sets of variables are able to predict the 1998 crisis out-of-sample. This is especially important given the relatively small number of observations implied by the STV methodology, and the poor results of various methods in out-of-sample tests for the 1997 crisis (Berg and Pattillo, 1998).[2] The key sets of variables we use are those used by Tornell (1998) (referred to as STV/T) in his extension of STV to the 1997 crises (lending boom, real exchange rate appreciation, reserve adequacy, and "strong fundamentals"), and the variables that feature in an Early Warning System model developed by Fund staff (EWS hereafter) (current account

[2] Berg and Pattillo concluded that key models, including work by Sachs, Tornell and Velasco (1996), Frankel and Rose (1996), and Kaminsky, Lizondo and Reinhart (1998) did not predict well out-of-sample. Tornell (1998), who extends the STV model to include the 1997 crisis, suggests that with minor adjustments the 1997 crisis can be well explained by the STV model.

deficit, short term debt over reserves, export growth, real exchange rate appreciation, and the change in reserves) as presented to the IMF Board.[3]

The out-of-sample projections for 1998 yield very clear results. Making only relatively minor a priori data improvements (regarding the definition of data such as reserves and real exchange rates) the results indicate that the combined STV/T set of variables, as estimated for 1994 and 1997 crises, functions as a *contraindicator* for the 1998 crisis. When the key variable, the lending boom, is adjusted for an obvious flaw (namely that it exaggerates vulnerability of those countries that already underwent a banking crisis and cleaned up their banking systems), it still does not perform well. This contrasts with the results obtained when using the EWS variables. Predictions of the rankings of the vulnerable countries based on the EWS variables match more closely the actual ranking, although the extent of vulnerability of a number of countries is overestimated.

Estimations of the crisis periods, combined and separate, confirm that the three crisis periods can be largely explained by a parsimonious equation of three of the five EWS variables. Two of the three variables are fundamental variables that feature very prominently in evaluations of countries' solvency prospects (the overvaluation of the exchange rate and current account deficit). Of these two, the first is generally found to be significant, whereas the second usually is not (Kaminsky, Reinhart and Lizondo, 1998 or KLR). The third (short-term debt over reserves) is the liquidity-related variable that has been emphasized as the most prominent indicator of liquidity conditions (Greenspan 1999, Sachs and Radelet 1998, and recent internal guidance for IMF staff).

Having obtained such a parsimonious and fairly stable model allows us to conduct a number of additional tests. In particular, we investigate the role of domestic credit related variables. We show that, while the 1994 and, to some extent, 1997 crises were driven by credit to the banking sector, credit to the government sector was a key explanatory variable in the 1998 crisis. In addition we conduct a number of tests on liquidity-oriented variables to examine whether alternative specifications, such as various ratios of reserves over money, and the traditional reserve coverage of imports perform better—which they clearly do not. We furthermore test for alternative specifications for the current account which indicate that financing deficits through FDI might limit vulnerability, but the effect is very weak. Finally we test for the relevance of having a Fund program. None of the studies in the literature as

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[3] Berg and Pattillo's model formed the basis for an Early Warning System model (EWS), developed during 1998 (Borensztein, Berg, Milesi-Ferretti and Pattillo, 1999 forthcoming) because of superior out-of-sample performance of their model. However, the test of their model was not quite as rigorous as that of others in the sense that the model selection was not performed completely without hindsight. This paper verifies the out-of-sample performance of the EWS by conducting such a rigorous out-of-sample, "out-of-sight" test as the design and variable selection for the EWS (the version referenced in this paper) was finalized before the Russia crisis broke, and we test its power in explaining the Russia crisis. We do so in the STV framework rather than that adopted for the EWS, which is based on a signals approach (there is a crisis threshold) and is estimated over a continuous period regardless of the incidence of crises.

reviewed by KLR report testing of such an effect, even though having Fund program might be expected to have a mitigating impact on crises. We find a very significant impact of having a Fund program on reducing the depth of a crisis. Having a program reduces the crisis indicator by 10 percentage points. This compares to an average level of the crisis indicator of 5.2 in the tequila crisis, 18.8 in the Asia crisis and 8.9 in the 1998 crisis.[4] This result is obtained despite the fact that two countries deeply affected by the 1998 crisis (Russia and Zimbabwe) had Fund programs. Moreover, the results pass various robustness tests.

This suggests that Fund programs reduce vulnerability even beyond the positive effect they may have on the fundamentals included in the specification. This result could indicate that fundamentals not included in the estimations are sounder in countries with Fund programs (e.g. confidence in countries taking appropriate adjustment measures, solid structural policies). It could also indicate that having a Fund program creates the expectation of additional cushion of liquidity or has a reputational or catalyst effect.

The estimation results suggest that higher liquidity (as presented by the level of reserves over short-term debt) can offset weak fundamentals (as represented by the current account deficit and the appreciation of the exchange rate) and limit the vulnerability of countries in periods of contagion.[5] The existence of such an ability to offset weak fundamentals by high liquidity contrasts sharply with a fundamentals only view of the world, in which solvent countries are always able to exploit their solvency by borrowing their way out of a potential crisis, and thus have no real need for a cushion of liquidity. Apparently, "solvency is very much like honesty: it can never be fully certified, and proofs are slow to materialize," to quote Calvo (1996), and liquidity is required while investors learn whether the crisis effected countries are solvent or not.

The relation between reserves and fundamentals we find, can be used to establish some rules of thumb or guidance for judging reserve adequacy. Making use of the fact that the crisis index in STV is continuous, and that our empirical results are quite parsimonious, we calculate the reserve coverage of short-term debt that is compatible with reducing external vulnerability. The results imply a differentiated reserve coverage depending on easily observable variables (the real exchange rate appreciation over the last 48 months and the current account deficit), and having a Fund program, which is presented in a straightforward set of tables (Tables 13a-c). The results indicate as a rule of thumb, that for countries with real exchange rates that are not significantly misaligned, and modest current account deficits, a reserve coverage of total short-term debt of one (as suggested by Greenspan 1999), is broadly consistent with avoiding sizable contagion, especially for countries with Fund programs.

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[4] The crisis index is a weighted average of exchange rate and reserve losses during the crisis period (see section IIA for a detailed definition and Table 15 for data).

[5] These fundamentals are indicative of the sustainability of the balance of payments: An appreciating real effective exchange rate is likely to undermine future export growth and stimulate imports, while the current account deficit is an indicator of the expected build up in external liabilities.

It is in this regard worthwhile to emphasize a simple but important logical implication: adequate reserve coverage of short-term debt can be accomplished either by increasing reserve levels or by reducing exposure to short-term debt. Clearly, countries need not deter short-term debt. Rather than attempting to control short-term capital inflows, countries can pursue increased reserves.

Targeting reserve cover of short-term debt has a number of other implications as well. First it provides an incentive for central banks to avoid explicit or implicit biases in favor of short-term inflows (as in Korea and Thailand prior to their crises), as such inflows would require higher reserve levels. Second, if reserve management focuses on coverage of short-term debt by remaining maturity as a key benchmark, this builds in incentives to guide public debt management in such a way as to lengthen the maturity and to avoid bunched repayments. Thus focussing on such a criteria may reduce the need for debt management guidelines (Greenspan 1999). Moreover, focus on debt guidelines this should not distract from improving data—comprehensive data on derivative positions of central banks and short-term debt, while part of newly agreed data dissemination standards, are still not yet widely available, and the reliance of this paper on creditor data on debt testifies to that.[6]

The paper is organized as follows. Section II presents the out-of-sample prediction of the STV model for 1998 based on the parameters obtained in 1994 and 1997. Section III tests the EWS variables. Section IV reports on detailed tests on alternative liquidity ratios and additional and alternative variables. Section V discusses implications for reserve management, given the level of short-term debt and other macroeconomic variables, while Section VI characterizes the three crisis periods based on the estimation results. The paper concludes with health warnings.

II. Replicating and Testing STV/Tornell

A. Specification and Data Replication

A key feature of STV/T's approach is the use of a continuous crisis index as independent variable rather than a threshold variable. This allows an examination of the depth of a crisis and the attributes and policies that help countries to avoid crises or actually gain strength during periods of contagion. The index weighs the exchange rate loss heavy if the exchange rate fluctuations were relatively limited and similarly for the reserve loss.[7]

STV/T's set of variables to explain the crisis index consists of a lending boom variable (proxying weaknesses in the banking system by the increase in credit to the private sector over the

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[6] International standards on the collection and provision of data on the maturity structure of debt remain under discussion.

[7] The crisis index, Crisisind, is defined as the weighted average of the loss in reserves and the change in the real exchange rate over the crisis /contagion period—the weights are equal to the precision (i.e. one over the variance) of the real exchange rate and of reserves over a 10 year period.

preceding 48 months, LB), the real effective exchange rate depreciation over the preceding 48 months (RER), a dummy for high reserves (Dhr=1 if the ratio of M2 to reserves is less than 1.8), and one for strong fundamentals (Dsf, when the lending boom is below 0% and the real effective exchange rate appreciation is less than 5%):

$$Crisisind_{i\,t} = \alpha_0 + \alpha_1 LB_{i\,t} + \alpha_2 RER_{i\,t} + \alpha_3 Dhr*LB_{i\,t} + \alpha_4 Dhr*RER_{i\,t} + \alpha_5 Dsf*LB_{i\,t} + \alpha_6 Dsf*RER_{i\,t} + e_{i\,t}$$

where $\alpha_1>0$ and $\alpha_2<0$. In case $\alpha_1 = -\alpha_3 = -\alpha_5$ and $\alpha_2 = -\alpha_4 = -\alpha_6$ high reserves or strong fundamentals completely counter the negative implications of having either a lending boom or an overappreciated exchange rate—countries with high reserves and strong fundamentals do not overlap in the sample.[8]

STV focused on a sample of 20 emerging countries, including many prominent market borrowers (Table 5, attached). This sample was extended by STV/T with 3 more countries, Hong Kong SAR, Hungary and Poland, to provide a balanced representation of the main market borrowers in the various continents. The present study extends the sample to Russia for 1997 and 1998, as this was a major crisis country in 1998—there are not sufficient data available to include Russia for 1994. However, we eliminated Taiwan POC from the sample, as no standardized data are published in the IFS, and Hong Kong SAR which is less comparable due to its special status: Hong Kong SAR is not a country but a separately administered part of China. This might for example result in liquidity support from the Public Bank of China.

The data used by STV/T (and reported in their data appendix) could mostly be replicated, even though some definitions used actually differ in details from the description in STV and STV/T—Table 14 in the data appendix presents in detail the data reported by STV and STV/T and our relative success in reproducing the data. More importantly, the data as defined by STV/T have some drawbacks. This motivated the decision to estimate the model also with the following a priori adjustments to the data set:

- Including gold in reserves. Not only does our sample include a few large gold holders, notably Russia and South Africa, but gold has become more liquid through gold loans, price developments can be hedged, and sometimes significant changes in gold holdings take place (e.g. Turkey);

- Using the real effective exchange rate as calculated in the IMF's Information Notice System (or INS) for its country surveillance work, RERINS. This definition takes account of third party effects, the immateriality of the origin or destination country of commodity trade, and is more comprehensively calculated than the variable used by STV and STV/T, which is based on the direct trade relations with the major currency blocks;

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[8] Note that the variables defining the cut off point for strong fundamentals, RER and LB, are included in the specification. The specification thus implies that countries with strong fundamentals should not see an appreciation of their exchange rate or increase in their reserves. In other words it is more an asymmetry variable than a test of strong fundamentals.

- Using July 1997 as the starting point for the 1997 crisis, rather than May. July is regarded by most observers as the starting point of the crisis (e.g. Fischer 1999). It puts the start of the crisis period when the slide of the Thai Baht commenced and its end in December 1997, ensuring that the crisis period includes the point at which the Korean Won was floated and allowed to depreciate sharply;

- Defining the lending boom and high reserve ratios using monthly data ending in the month preceding the crisis, rather than annual data as in STV and STV/T. The latter method implies in the case of the 1994 crisis some overlap with the crisis and in case of the other crises significant lags.

B. Regression Results for 1994-97 with Replicated and Improved Data

Table 6 (attached) presents various regression results obtained using: (i) the STV/T data set; (ii) the data we have replicated using the STV/T methodology; and (iii) similar data that were computed on the same basis, but which reflect, as discussed above, improvements on a priori methodological grounds. The data are discussed in detail in the data appendix. Crisind1, refers to the index that has been replicated using STV/T's methodology. CrisindGld, and RERINS refer to variables computed in a similar way as STV/T, however with the noted a priori improvements.

The estimation results of STV/T could be exactly replicated using the data reported by STV/T. When we use replicated data the results barely alter. Noteworthy results are:

- The lending boom variable is very significant across the various specifications, whether with replicated or improved data. The real exchange rate on the other hand appears to be insignificant. Both STV/T's original and the INS based real effective exchange rate (RERINS) are insignificant.

- Using the improved crisisindex, CrisindGld, whose measurement period begins in July instead of May 1997, results in a relatively sharp drop in the R-squared. Taking the starting point of the 1997 crisis (in May instead of July) too early has the effect of underestimating the crisis index of Asian countries (particularly Korea) and overestimating the explanatory power of the variables.

C. Extending STV to 1998

To test the predictive power of the different specifications and formulations of data, we first calculated the data for the 1998 crisis, taking the period July-October as the core of the 1998 crisis. The starting point is relatively early: while some casual observers seem to assume that the Russia crisis erupted in mid-August at the time the default was announced, emerging

market bond prices started their rapid descent near the end of July. The end-point of the crisis includes what thus far is the bottom of JPMorgan's emerging market bond index.

The most eye catching result for 1998 is not which country had a crisis, but how few countries did experience a crisis based on our indicator, especially in view of the massive increase in Brady bond spreads that swept undiscriminatingly through the markets and reached the peaks of the Tequila crisis of 1994. Of the countries in our sample only Brazil, Russia and Zimbabwe experienced a major crisis, whereas Colombia, Mexico and Turkey underwent some difficulties. Zimbabwe's crisis was about as bad as Russia's, based on STV/T's crisis index, and was aggravated by its involvement in the war in neighboring countries.

Out-of-sample Prediction of the 1998 Crisis based on the STV/T specification
The out-of-sample prediction yields very strong results as presented in Table 7. The prediction based on the STV/T specification (using replicated data without the a priori improvements in the definitions of variables), suggest that this set of variables is a contraindicator of the 1998 crisis. More in particular, the STV/T core equation overshot for all Asian countries, due to their high lending boom values in 1998. Thus, the model predicts a much higher crisis index for Indonesia, Korea, Malaysia, the Philippines, and Thailand (29.9 on average) than the actual index (on average –7.3). But mispredictions are not limited to Asian countries: the model clearly underestimates the crisis index for Brazil, it predicts no crisis for Russia (-5.9 instead of 89.3), and a small one for Zimbabwe (3.4 instead of 87.4). The correlation of the predicted ranking with the actual ranking is negative (see Spearman's rank correlation coefficient at the bottom of Table 7), indicating that the STV/T variables combined function as a *contraindicator*.

III. EWS Variables

A. The EWS Set of Variables

Staff of the IMF have developed an Early Warning System model (EWS). Its design is meant to allow for a long-range alert of the external vulnerability of countries, thus providing adequate time to implement adjustment measures. The EWS features 5 variables: the current account deficit as percent of GDP, export growth, the deviation of the real exchange rate from trend, short-term debt over reserves, and the percent change in reserves.[9] Data on these variables are presented in the data appendix. In general these variables correspond to well-known arguments. The current deficit, export growth, and real appreciation are indicators of solvency, with the latter a predictor of the future path of the current deficit, and high export

[9] While STV and Tornell identified a number of alternative variables, they did not find significant results. STV tested and rejected 6 alternative variables: investment, saving, government consumption, current account capital inflows, and short-term capital inflows (all scaled by GDP). Tornell tested three variables - government consumption, current account deficit and capital inflows - and concluded that these variables did not significantly impact the crisis index.

growth ensuring that future debt service as a percent of external revenue is smaller for any given current account deficit. The change in reserves is an indicator of the residual influences on the balance of payments, while short-term debt (on a remaining maturity basis) over reserves is a key indicator of external liquidity: the ability of a country to service its debt if the country is cut off from external financing.[10]

For the specifications of the variables we have used, to the extent possible, STV/T's approach with our a priori improvements. Thus we use the real effective exchange rate appreciation over the past 48 months (RERINS) rather than the deviation from trend used in EWS. For reserves we use reserves including gold. In line with the EWS we use the BIS data on short-term debt by remaining maturity, in the absence of a reliable more comprehensive alternative.[11]

B. Regression Results and Out-of-sample Prediction for 1998

Regression results for EWS variables

Estimation results using the EWS variables for 1994-97, are presented in Table 6. It shows the significance of a core set of fundamental and liquidity-related variables:

- The real effective exchange rate appreciation, the current account deficit and the ratio short-term debt over reserves are all significant;

- The change in the rate of export growth (XDELTA) and the percent change in reserves (RESG) have the correct sign but are quite insignificant.

Out-of-sample forecast for the 1998 crisis

Would an observer knowing the results of EWS for 1994-1997 have been able to effectively predict in June of 1998 which countries would be effected if a major international crisis were to occur in late July? Based on the estimation of the EWS variables for 1994-97 we have applied the same out-of-sample forecasting test as for the STV/T specification. As it readily appears in the attached Table 7, EWS performs much better than STV in 1998. The

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[10] There are drawbacks to this latter measure, especially for the more industrialized countries that have nonofficial external assets to offset debt. In our sample this clearly is the case for South Africa, whose non reserve assets cover about 60 percent of its liabilities. As South Africa has a particularly high level of short-term debt and low levels of reserves, ignoring its assets biases the results significantly. We have therefore adjusted the level of debt for South Africa to match the average of the sample (to neutralize the effect), and present robustness tests to examine the impact of this ad hoc adjustment. A few other countries have high non reserve assets ratio's in our sample (notably Jordan and Venezuela) but their asset data are less reliable (notably Venezuela's) and their short-term debt over reserve ratio's are below average.

[11] The BIS data only include debt due to banks, not to official creditors, or debt held by non-bank private creditors.

Spearman rank correlation coefficient has the correct sign and is significant at the 1 percent level. It correctly predicts three of the five most vulnerable countries and three of the five least vulnerable countries, although it overstates the actual magnitude of the crisis index (notably Argentina, Peru, South-Africa and Venezuela). A fourth country, Pakistan, is widely regarded as being very vulnerable and has initiated rescheduling negotiations with private and official creditors.

Table 1. The Five Most and Least Vulnerable Countries in 1998
(Comparison EWS Forecasts and Actual Values)

	Country	Fitted Crisis Index With EWS	Actual Crisis Index in 1998	Actual Rank
1	Zimbabwe	68.9	82.2	2
2	Russia	53.7	87.2	1
3	Pakistan	35.4	0.1	11
4	Argentina	29.7	-0.9	16
5	Brazil	26.4	32.4	3
18	Korea	3.1	-3.4	18
19	Malaysia	1.5	-9.8	21
20	Sri Lanka	-0.6	1.5	9
21	Jordan	-4.7	0.2	10
22	India	-6.5	-2.1	17

Source: Estimation based on Equation (2), Table 6.

Based on these out-of-sample predictions, the fact that these EWS variables correspond to standard arguments, and function well in estimating and predicting in two different estimation methodologies, provides a fair degree of confidence. Of the five EWS variables, three core variables are responsible for the results within the STV estimation methodology. This point can also be inferred by extending the estimations of the EWS variables to 1998, as in Table 8: The coefficients are virtually identical for the three significant variables (REER, the external current account balance, and the ratio of short-term debt over reserves), with and without the two insignificant variables (export growth and the change in reserves). Moreover estimations of a specification with just these three variables show stable coefficients. The coefficients of these three variables are fairly stable for the sub periods (the coefficients are generally within one standard deviation of the three period average) (the Chow test for the subperiods indicates a probability of 73 percent that there is no structural break).

The reasons for the limited results for the STV/T specification can be inferred from the estimations for the full three periods (Table 8). The coefficients are quite different from the estimation for the combined 1994 and 1997 crisis periods reported in Table 5. Moreover, in estimations for the subperiods, the signs of coefficients change for all but one variable (Dsf*REER), and that variable has the incorrect sign. This may reflect the extensive use of dummies in small samples. In addition, the results reflect omitted variables misspecification. The absence of short-term debt over reserves, emphasized by Sachs in later work (Sachs and

Radelet 1998) and by other observers, and the current account deficit affects the parameter estimates.

The key variable in the STV and STV/T specification, the lending boom index, which was so significant in the 1994 crisis, proves to be a contra-indicator in 1998 and explains the negative correlation between the actual and predicted rankings of crisis countries. As can be readily seen in Table 8, its sign becomes negative in the last period (with a t-statistic significant at the 5% level). This spectacular change in sign may be explained as follows: It can be readily observed that the crises in Indonesia, Korea, Malaysia, the Philippines and Thailand, as measured by the crisis index, did not deepen in 1998 but rather abated. However, the lending boom variable, as defined by STV/T, for these countries was still high in 1998 as the stock of credits was still up compared to 4 years earlier. The lending boom does not take account of the fact that the actual occurrence of a banking crisis induces a thorough review of the banking sector and a clean up of the banking system. To check whether this explanation holds, we constructed an alternative lending boom, LBC, which measures the increase in private credit since the previous crisis ended.

In Table 7, we also report out-of-sample predictions using improved specifications of variables based on a priori grounds (RERINS instead of RER etc.) and the correction on the lending boom to account for the special situation of Asian countries. As the results in Table 7 show (see predicted crisis index with STV2), this does significantly improve the rank correlation of the projections. Instead of negative, the Spearman coefficient is positive, albeit still not significant. Although the modification improves the forecasts for the Asian countries, important errors remain (notably the crisis in Russia and Zimbabwe are not predicted), and our basic conclusion is thus not altered.

IV. Fund Programs, Other Variables and Robustness

Having found a parsimonious result that satisfactorily predicts the 1998 crisis out-of-sample (and out-of-sight in the sense that it is based on variables that were selected before the onset of the Russia crisis), and which shows stable coefficients for the three sub periods, we can use this result to test alternative explanations, without being overly exposed to the dangers of finding spuriously correlated results. It is in particular of interest to test the following: the role of Fund programs in mitigating or exacerbating crises; alternative specifications for the liquidity ratios—this has potentially important implications for reserve targets; the role of credit expansion to the public sector—to capture the role of fiscal expansion; alternative specifications for the current account deficit which focus on exports as a denominator rather than GDP and the vulnerability mitigating role of FDI in financing such deficits. Moreover, we test the robustness of the results by excluding vulnerable countries, and test for fixed and regional effects.

A. Fund Programs

Have IMF programs helped in crisis prevention or reduction or has it made matters worse? To conduct a simple test we use a dummy variable that takes value 1 if a country had a program with the Fund at the time the crisis erupted. Thus we do not distinguish between countries in which the program was in good standing and those in which it was not, thus making the test more difficult by including those countries that performed less well. Table 15 (data appendix) details which countries had a program—7 countries of our sample had a Fund program in 1994, 6 in 1997 and 10 in 1998. The latter includes the ill-fated programs with Russia and Zimbabwe. While alternative specifications could be used (years with a Fund program, undrawn or drawn balances, performance or standing under the program), this is the only dummy we tested to limit the risks of obtaining spurious relations.

As can be seen in Table 9, having a Fund program has a significant effect on vulnerability (at the 5 percent level). Moreover, FUNDP increases the adjusted R-squared to 0.54 (from 0.50, significant at the 5 percent level on the basis of an F test), indicating that the parsimonious three variable specification plus the Fund dummy explains about three-quarters of the variation in the crisis index.

The size of the coefficient for FUNDP (estimated at about 10), should be considered against the average value of the crisis index of about 20 for those countries where it took a positive value, and peak crisis indices in each crisis period in the range of 80-95. The countries with Fund programs in our sample had roughly balanced effective exchange rates (as measured by RERINS), while non-program countries had significantly appreciated effective exchange rates. The countries with Fund programs had on average slightly higher current deficits and significantly lower reserves to short-term debt ratios. Thus, countries with a Fund program experienced fewer and less severe crises on two counts, better fundamentals, and the effect represented by the Fund program dummy. The effect of the sound fundamentals is, however, offset by their more limited reserve coverage. On balance countries with Fund programs experienced significantly less deep crises on account of policies and effects that underlie the significance of the Fund program dummy.

The effect of the Fund program dummy points to sound policies that help the countries reduce external vulnerability (for example sound structural policies) that are not included in the estimation or a positive reputational effect associated with having a Fund program. The estimations based on our sample do not support the notion that countries with Fund programs pursue riskier policies. They do have less liquidity, which is partly supplemented through an arrangement with the Fund.

Table 2. Sample Averages for Explanatory Variables

	CrisindGld	RERINS	CA/GDP	STD/R
With Fund program	7.93	-2.94	3.41	96.78
Sample	11.04	-9.01	3.07	82.01
No Fund program	13.11	-13.07	2.84	72.16

B. Alternative Liquidity Ratios

From a policy perspective it is important to examine which liquidity based variable needs to be closely examined and possibly targeted. Our estimations find a very significant effect for short-term debt in relation to reserves. However, alternative specifications for liquidity have been emphasized. In the post war period, the ratio of imports over reserves, has often been targeted by countries as part of reserve management policies (and is also sometimes used as a crisis indicator (Kumar, Perraudin and Zinni 1998). In currency boards base money is the key indicator for assessing reserve adequacy. More recently it has been argued by Calvo (1996) that broad money is the appropriate standard for assessing reserves for pegged exchange rate regimes. To empirically assess the relevance of these measures, we have tested four ratios in conjunction with our core variables: successively imports over reserves, and the foreign currency equivalent of M0, M1 and M2 over reserves. The test results, presented in Table 9, leave little doubt as to the superiority of the short-term debt over reserves as an indicator of liquidity related problems in the present context. In our sample of market borrowers imports over reserves is not significant in the specification which feature short-term debt over reserves, while none of the money based liquidity ratios are significant or have the expected sign.[12]

It could be argued that these liquidity ratios are too crude, as they do not differentiate between countries with stable and unstable money demand. To test this view, we estimated the significance the ratio of M2 over reserves premultiplied by the square and other, higher roots, of the variance of M2 over reserves and CPI. Some of these adjusted liquidity ratio's had the correct sign but were still insignificant at the 10 percent level. This contrasts with the highly significant short-term debt to reserves ratio.

In Table 12 (eq. 7) we also report on short-term debt over GDP as an additional indicator, to test whether the level of short-term debt given liquidity, significantly adds to vulnerability. However, this variable is clearly insignificant, suggesting that the trade-off between liquidity and vulnerability is altered by the level of short-term debt.

C. Credit Variables

While Sections II and III established that private sector credit growth did not perform well in predicting the 1998 crisis (even when the variable is respecified to encompass possible effects of banking sector reforms), this does not completely rule out the relevance of credit in contributing to external vulnerability. In addition we have not explained the significance of the lending boom variable in the first crisis period and the switch in the signs between crisis periods from which even the corrected lending boom variable suffers. To tackle these issues we first tried to correct the scaling. Second, we examined the impact of credit to the public

[12] The three ratios have a positive sign when STD/reserves is excluded from the equation; however, they are still insignificant at the 10% level.

sector, especially since the 1998 crisis was centered in countries with large domestically financed fiscal deficits.

LBC scaled by reserves

In the STV/T approach, the lending boom is measured as the percent change of the credit to the private sector (in real terms) over a four year period, regardless of the relative importance of private sector credit to the economy. As an alternative, we used the increase in credits to the private sector in real terms, scaled by the level of reserves, for which data are available monthly, and which are indicative of the resources available to the monetary authorities to prevent a banking sector crisis to spillover into an external crisis:

$$LBRPC = \frac{\frac{L_i}{CPI_i} - \frac{L_{i-48}}{CPI_{i-48}}}{e_i . \mathrm{Res}_i}$$

where i is a given month (October 1994, June 1997, and June 1998 in our estimation); L represents credit to the private sector, CPI is the normalized consumer price index, e the exchange rate, and Res the level of international reserves. In line with the adjustment of LB to LBC we use, instead of the increase in credit over 48 months, only the increase in credit since the previous crisis for those countries that underwent a banking sector reform. Table 10 presents results obtained with this variable combined with the three core variables. LBRPC clearly performs better than LBC, when combined with the EWS variables, but still is not significant over the three periods combined. Noteworthy is that it is significant with the expected positive sign for the first two periods, but just as LBC its sign in the Russia crisis period is negative.

Credit to the government

To test the role of credit to the government we constructed another variable, along the lines of LBRPC for the banking sector credit to the government: [13]

$$LBGOVP = \frac{\frac{LGOV_i}{CPI_i} - \frac{LGOV_{i-48}}{CPI_{i-48}}}{e_i . \mathrm{Res}_i}$$

where CPI, e and Res are the same as in the previous equation, and LGOV represents credits to the government sector. It is noteworthy that when tested for the 1998 crisis alone, this variable is very significant, has the correct sign and leads to a jump in the R-squared that indicates that about 90 percent of the variation in the crisis index is explained. In 1998, crisis

[13] We also tested a number of other specifications, such as domestic debt to capture a wider gamma of the public sector financing (but data do not appear to be sufficiently reliable), and the tax base as the denominator. These results were generally less significant and confirm in terms of sign the results obtained for LBGOVP. Eliminating countries with declining credit to the government yielded somewhat better results but not dramatically.

countries had a very high LBGOVP variable, as summarized in Table 3, which ranks the countries with the highest LBGOVP variable.

Table 3. Five Highest Increases in Credit to the Government (in percent)

	LBGOVP
Russia	182
Zimbabwe	149
Brazil	52
Pakistan	49
Indonesia	37

However, in the two earlier periods, credit extension to the government is not only insignificant but also has the wrong sign. I.e. the variable performs opposite to LBRPC. In 1994 and 1997 most crisis countries had a negative LBGOVP variable (like Brazil and Mexico in 1994, Indonesia, Korea, Malaysia and Thailand in 1997). In 1994, credit to the government, decreased rapidly in Mexico and Brazil, with the government switching to non-bank financing thus freeing bank credit for private lending (see also Dornbusch 1997). Such phenomena thus seem to have contributed to the high and significant LBRP for 1994, while reverse pressures were at play in 1998, with governments to some extent at least crowding out private lending.

This would suggest that total credit would be a better indicator but this is not so.[14] Thus the data suggest that rapid credit expansion to either the private or government sector can significantly add to vulnerability, while a contraction of credit in the other sector does not provide relieve.

D. Alternative Specifications of the Current Account Variable

Scaling with exports

In cross country analysis and as a shorthand indicator for external vulnerability, the current account balance is usually scaled by GDP to reflect its relation to the overall size of the economy. This practice does not take into account the degree of openness, which is essential to evaluate the capacity of a country to repay its debt. Therefore we also tested the current account as a percentage of exports of goods and services. However, when tested, the current account deficit scaled by GDP was more significant by a wide margin (Table 9).

[14] The increase of total credit to the economy has the correct sign but is insignificant at the 10% level.

The role of FDI in current deficits

FDI has become an increasingly important source of funding for current deficits in emerging economies. For example, Brazil's current deficit is on balance largely financed by FDI, and the same applies for a number of other Latin American countries (see Table 4). It has been frequently argued that such FDI mitigates vulnerability, as the stock can not leave the country quickly, profits remittances could be countercyclical, FDI contributes to higher (export) growth, and a drop in non-portfolio FDI often leads to a significant decline in imports of investment goods. Therefore we also tested for the significance of FDI over GDP. This variable was not significant at the 10 percent level, although it had the correct sign, suggesting only a limited reduction in vulnerability as a result of FDI financing of the deficit. It should of course be noted that countries with significant FDI tend to have less short-term debt, and thus some of the positive effects of FDI are indirectly captured in that variable.

Table 4 : Current Account Deficit over GDP Before and After FDI for Selected Countries with Substantial FDI

	CA/GDP	(CA-FDI)/GDP
Colombia 1998	7.24	-0.38
Peru 1998	5.22	0.58
Chile 1998	5.26	-1.76
Brazil 1998	4.21	1.76
Argentina 1998	2.91	0.86
Venezuela 1998	-5.30	-11.05

E. Non-Linear Functional Forms

The core equation for the crisis index is linear in the dependent variables. However, the fact that two of the variables are ratios implies that the relation vis à vis the nominator in the ratios is non-linear (see Figure 1). To further examine any non-linearity we tested various alternative specifications, including logarithmic, exponential and multiplicative. Only the multiplicative specification in short-term debt over reserves performs well, notably the following (Table 11, eq. 6):

$$\text{Crisisind} = (-0.45*\text{RERINS} + 1.52*\text{CA/GDP} + 0.13*\text{STD/ R} - 13.2\ \text{FUNDP})*(\text{STD/R})/100 - 2.5$$

This specification explains well over 80 percent of the variation, compared to 70 percent for the standard specification that is linear in the dependent variables (Table 9, Eq. 1). The significance of most terms increase. The interpretation of this result is discussed in Section V. The main difference with the linear specification is that a high ratio of debt over reserves (limited liquidity) increases the vulnerability for a deterioration in the fundamentals. I.e.,

weaknesses reinforce each other at the margin.[15] When this specification is estimated for 1994 and 1997, it predicts the 1998 crisis out-of-sample better than the specification that is linear in the dependent variables, as measured by Spearman's rank correlation coefficient, which becomes 0.76.

F. Robustness Tests

Country Outliers

How robust are our results for changes in the country composition of the sample? Each crisis period is marked by a few countries with very high crisis indicators, and it could be argued that a few of these "outliers" drive the results. To test for robustness, we successively remove the biggest outliers from the sample (Table 12) to verify that our results are not affected by one single outlier. We also remove the observation for South Africa for all three periods, to check that this country (a big outlier for the short-term debt over reserves variable, for which we corrected in a relatively ad hoc manner), does not bias the results. The regression passes the tests very successfully: the coefficients are very stable, the t-statistics of the four variables never drop significantly, and neither does the R-squared. The biggest impact comes from removing Russia 1998 from the sample, but even that is minor.

Removing the three countries where the crises commenced, Mexico, Thailand and Russia, also do not drastically alter the results. Variables remain significant and coefficients remain within two standard errors of the benchmark result. The results suggest that the crisis in the countries which triggered periods of contagion are governed by broadly the same relation as those which were effected by the contagion.

Fixed Effects, Regional Effects

In Table 11 we present the results of introducing fixed effects into the equation, which is another way of testing the stability of the results over the various subperiods. The dummy variables FIX97 and FIX98 take value 1 in 1997 and in 1998 respectively, zero otherwise. The regression does not support the presence of significant fixed effects in either period. The dummy variable for fixed effect in 1997 has a somewhat higher t-statistic and a higher coefficient than the one for 1998, but it does not cross the 10% level.

Moreover, we test for regional effects. Casual observation might suggest that the crisis extended mainly to Latin American countries in 1994 and to East Asian countries in1997, either because of localized contagion, trade effects or other local spillover effects (regional concentration of creditor banks etc.). We created two dummy variables, D-LATAM94 and D-ASIA97 that equal 1 for Latin American countries in 1994 and for Asian countries in 1997 respectively, zero otherwise.[16] Only one of the two dummies, the Asian one, is significant

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[15] The derivative of the crisisindex to a change in short-term debt over reserves remains broadly unchanged at 2*0.13*STD/R (the average of STD/R is 82 percent).

[16] Thus, D-LATAM94 equals 1 for Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela in 1994, zero for all other country-years, and D-ASIA97 equals 1 for Indonesia, Korea, Malaysia, the Philippines and Thailand in 1997, zero for all other country-years.

(above the 1 percent threshold); it has a high coefficient and contributes very significantly to the increase in the R-squared (Table 11). Yet, it has to be underlined that the other variables we have identified as key variables (the exchange rate appreciation, the current account deficit, the ratio short-term debt over reserves and the dummy for Fund programs) retain their significance after the regional dummies are introduced into the equation, and their coefficients do not move outside the band width of one standard error.

V. Policy Implications for Crisis Prevention

Greenspan (1999) suggests that it is necessary to pay closer attention to the ratio of short-term debt to reserves and suggest that a ratio of one may be an appropriate target. In the same vein, the IMF's new CCL facility specifies that close attention needs to be paid to short-term debt by remaining maturity. Our parsimonious and rather robust result underscores the importance of this variable and lends itself well for evaluating the desirable level, as the equation can be solved for the ratio of reserves over short-term debt. The result implies that the higher the reserve coverage, the less vulnerable a country is. It also suggests that there is a trade-off: that high levels of reserves reduce vulnerability and can, to some extent, help overcome the vulnerability caused by high current account deficits and overvalued exchange rates. I.e. it suggest there is a choice between vulnerability and liquidity.

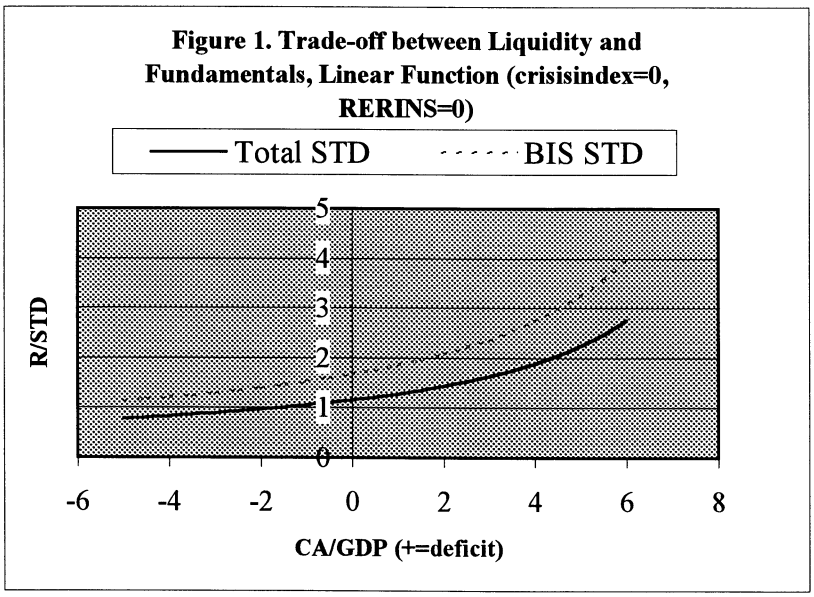


Figure 1. Trade-off between Liquidity and Fundamentals, Linear Function (crisisindex=0, RERINS=0)

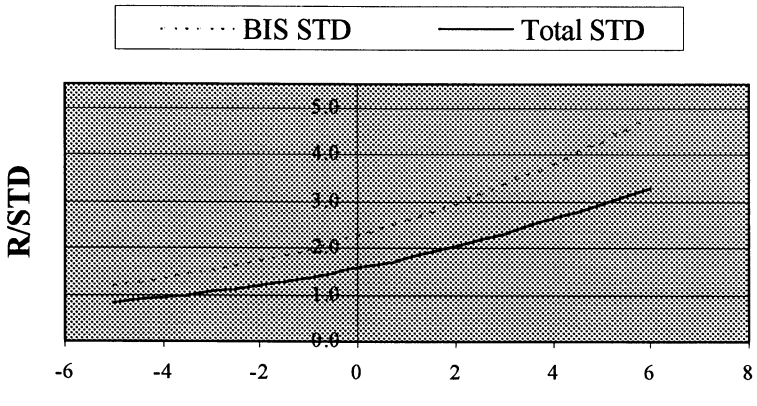
Tables 13a-b quantify the trade-off embodied in the core linear equation with the Fund program dummy (Table 9, equation 1) for ranges of current account deficits and real effective exchange rates. The results are illustrated in the Figure below. The Figure illustrates the extent liquidity can offset poor fundamentals based on the definition of debt used in the estimations (BIS data on claims of banks) and an inferred relation based on total short-term

debt by remaining maturity—the size of debt reported by the BIS amounts in our sample to about seventy percent of the total short-term debt on a remaining maturity basis.[17]

The results show that if the real exchange rate is not overvalued and the current account has a modest surplus, a ratio of reserves to total short-term debt of 1 would result in a zero crisis index for countries without a Fund program. Countries with a Fund program or countries willing to tolerate a modest crisis index (a weighted reserve/exchange rate loss of 10 percent), the data imply that a modest current deficit (2-3 percent) and a slightly appreciated exchange rate (6-9 percent) could be maintained. The results also indicate that, especially for very unbalanced real exchange rates, and significant current deficits, little remedy in reserves is available, as the liquidity ratios implied are very sizable and presumably unsustainable from a fiscal perspective.

The non-linear specification has broadly similar implications. Avoiding a crisis altogether requires a somewhat higher ratio of reserves to short-term debt for countries without Fund program (Figure 2). For slightly higher levels of the crisisindex, the ratio is still about 1, as Table 13c illustrates—Table 13c quantifies the impact on the crisisindex of different ratios of reserves over debt with varying degrees of exchange rate appreciation, assuming a current account deficit of 3 percent.

Figure 2. Trade-off Fundamentals and Liquidity, Multiplicative Function (Crisind=0, REER=0)



Both results confirm that a ratio of reserves to short-term external debt of about one is a useful benchmarks. In translating these empirical results into predictions good note should be taken of the fact that both reserves and short-term debt used here are gross concept. As our adjustments for South Africa indicate, the neglect of non-reserve assets is likely to exaggerate vulnerability for countries with significant non reserve assets in relation to their debt. The use of BIS data by remaining maturity implies that we include items in short-term

[17] This percentage is based on data reported to the Fund for surveillance purposes.

debt such as foreign currency deposits by residents with the branches of banks whose headquarters report their positions to the BIS. This may for example contribute for example to the overestimation of the vulnerability of Argentina (Table 1). Moreover some of the debt maybe owed by foreign invested enterprises reducing vulnerability. Finally reserves may be undermined by liabilities (both contingent and contingent ones) and derivative positions. Publicly available data do not at present allow for a more refined estimation of the effect of such positions.

VI. A Characterization of the Three Crises

The estimation results for the three periods allow for a broad characterization of the three crisis periods:

- All three crises were characterized by a strong liquidity-related element—and not just for the Asia crisis where the effect of this variable was emphasized. The ratio of short-term debt to reserves is the key liquidity indicator, and empirically outperforms the ratio of M2 to reserves and other money-based indicators and the traditional import based indicators with a wide margin.

- The real effective exchange rate played a key role in the 1998 crisis. Countries which experienced a crisis in 1998 (Russia and Brazil, Colombia to a lesser extent) had experienced a sharp appreciation of their real exchange rate index (respectively 35.7%, 37.5% and 24.5%). The Asia countries, which experienced a recovery during this period, underwent a depreciation of their real exchange rate, and this is associated with a negative crisis index for 1998.

- For the three crisis periods combined credit did not have a significant effect. However, for subperiods credit played a significant role. Credit to the government sectors aggravated the 1998 crisis. Estimates for this period, when including variables capturing such credit extension explain about 90 percent of the variation in the crisis index.

- Credit to the private sector contributed to the 1994 crisis. Not only as an indicator of a banking sector weakness, but also as an indicator of failed policies to maintain low banking sector interest rates by substituting government credit for non-bank financing (e.g. Dornbusch 1997) resulting in even higher private credit expansion.

- Credit to the private sector also played a role in the 1997 crisis. However, the extension of such credit as measured in this study (over the preceding 48 months) was closely correlated with the real exchange rate appreciation over the same period and the size of the current deficits, which contributed consistently to all crises. Moreover regional spillover effects were unusually strong, as indicated by the regional dummy for Asia.

VII. Concluding Remarks

As with investing in stock market funds, crisis models require a clear warning: "Past performance is no guarantee for future performance." While the results we obtain are relatively robust and yield very interesting insights, especially about the desired level of reserves, we feel that two specific provisos need to be emphasized.

First, regarding liquidity. The results reflect the present state of play: this is subject to change. An expansion in the liquidity available to international arbitrageurs such as banks trading for their own portfolio and hedge funds, is likely to result in increasingly sharp reactions to deviations in fundamentals from sustainable levels. In contrast, the higher the liquidity of the IMF, and the more its lending is based on providing liquidity support to countries with sound fundamentals, the less likely are crises based in a lack of liquidity in countries (potentially) willing to embrace or seek Fund support.[18] However, without fundamental changes in the system, a level of reserves equal to or higher than short-term debt by remaining maturity appears an advisable target for countries with broadly balanced exchange rates and modest current account deficits. Countries with higher deficits, even when financed through FDI, and appreciated exchange rates need significant higher reserve cover to limit the impact of contagion on their economies.

Second, solvency is a very complex function of economic and political variables. The types of models we are estimating capture only a few of the relevant variables. Thus in the 1994 and 1997 crises government credit did not rear its head, but in 1998 it was important. Sound predictions and evaluations require in-depth solvency and liquidity evaluations. Simplified models, as this contribution, are no substitute for discriminating and detailed analysis of the vulnerability of countries. These models are aids in the identification of the more relevant variables and critical magnitudes, but other latent variables maybe essential to future crises.

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[18] Moreover, additional use of instruments such as currency derivatives by countries may have a very sizable effect on the extent to which higher liquidity (reserves in relation to short-term debt) can offset less than stellar solvency: The use of derivatives by central banks can reduce the impact on reserves of attempts to flee currency exposure, but dramatically undermines the solvency of a country and future liquidity if the exchange rate does not hold and losses are made.

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Data Appendix

The main data source is the IMF's International Financial Statistics. All data are from this source, unless otherwise indicated. Due to data unavailability for a few of the countries during specific periods, data have been completed and interpolated using alternative sources (mostly Bloomberg and country data published in the website hyperlinked to the Data Dissemination Bulletin Board (DSBB) of the SDDS (@IMF.org). Definitions and alternative sources are spelled out in this appendix. First, however, we discuss the success in replicating the published STV and STV/T data sets. Then we discuss the computation of the main variables and specific data sources used.

Replicating the STV and STV/T Data Set

Both STV and STV/T describe fairly precisely how the variables are derived from raw data, mostly from IFS. They report their data, which are summarized in Table 14. As is evident from the table, we could replicate Tornell's data quite well with only a few differences, notably for the ratio of M2 over reserves. The difference is especially large for South Africa. Both STV and Tornell profess to use reserves minus gold in the computation of the crisis index. Yet, as noted by Berg and Pattillo (1998), the ratio of M2 over reserves in STV seems to include gold for South Africa - as is usually done for this country with high gold production and sizable gold holdings, but contrary to what is explained in STV's data appendix.

With regards to the real effective exchange rate, another peculiarity should be noted: STV and Tornell calculate this variable based on the direct trade relations with the major currency blocks only. Moreover, replication reveals that STV/T seem to have used all industrialized countries except the United States and Japan to compute the trade shares to weight the DM rate, and not just the EU countries as they report.

The lending boom variable could be well replicated. There are two noticeable exceptions: for the lending boom Brazil (1994 and 1997) and Malaysia (1997); for the exchange rate: Brazil (1994 and 1997). The large difference for Brazil could stem from using another than the standard inflation rate for Brazil.

Computation of the Variables and Data Notes

Except for the data we duplicate based on STV/T's methodology, the methodology we have used for the computation of all variables consists in choosing the last available observation before the starting point of the crisis. For monthly data this implies a monthly lag, for quarterly data a lag of up to a quarter. Due to data unavailability however, we sometimes had to use a longer lag, particularly for current account data.

1. Crisis Index

All crisis indexes used are computed following STV's methodology. The crisis index is a weighted average of the nominal exchange rate depreciation and the loss of reserves during the crisis periods. The nominal exchange rate was computed using the official exchange rate vis-à-vis the US dollar, period average (line rf of IFS). The weights are equal to the precision (i.e. one

over the variance) of the exchange rate and of reserves over a 10 year period (respectively 1984M10-1994M10, 1987M6-1997M6, 1988M6-1998M6).
Crisisind1 are replicated data using total reserves minus gold (IFS line 1L.d). The crisis period used is 1994M11-1995M4, 1997M5-1997M10, and 1998M7-1998M10.
CrisisindGld is equal to Crisisind1 but computed with gold at market prices and the crisis period for 1997 is defined as 1997M7-1997M12.

Due to data availability problems, the following adjustments had to be made:
Argentina: for the missing values for reserves (1991 M8, M10 and M11) the previous observation (1991 M7 etc.) was substituted.
Chile: computation of the precision begins 1987M12 (the IFS series are not available before that date).
Hungary: The calculation of the precision begins 1990M1. Data on reserves are available till 1998M9; for 1998M10, data have been completed using the country website hyperlinked to the DSBB (SDDS).
Poland: precision begins in 1990M1 when the currency and the price level stabilized after the transition to a free market economy.
Russia: Data are unavailable before 1995M6 for the exchange rate (line rf) and 1994M1 for reserves (used as starting point for the computation of precision); therefore line ae is used for the computation of precision of the exchange rate (starting 1992M7).

2. Lending Boom

Following STV/T the lending boom is defined as the increase in banking sector credit to the non-government sector over a four year period preceding the crisis. Tornell measured the lending boom through the period 1990M12-1994M12, 1992M12-1996M12 using monthly data. We used the periods 1990M10-1994M10, 1993M6-1997M6 and 1994M6-1998M6, which corresponds to the latest observations before the crisis period commences, and therefore does not overlap with the measurement period of the crisis index. The data used are IFS, line 32 for domestic credit and line 32an for claims on central government (net).

For Indonesia, Korea, Malaysia, Philippines and Thailand, the computation of LBC in 1998 starts at the end of the previous crisis (1998M1).
Hungary: data have been completed using the country website hyperlinked to the DSBB (SDDS).
Russia: Due to lack of available data, and to match the availability of real effective exchange rate data, the measurement of the lending boom index for 1997 starts 1993M12 instead of 1993M6.

3. Real Exchange Rate Depreciation, Dummy Variable for Strong Fundamentals

STV/T computed the real exchange rate depreciation as the percent change in the weighted average of the bilateral real exchange (using CPIs) vis-a-vis the yen, the dollar and the DM. The weights sum to one and are proportional to the bilateral trade shares with Japan, the US and the European Union. STV/T used the real exchange rate change between 1990 and 1994 for the first crisis and between 1992 and 1996 for the second crisis, using annual data (line rf in IFS).

RERINS (IFS line EREER, see Desruelle and Zanello 1997 for a detailed discussion of the methodology) was measured over the periods 1990M11-1994M11, 1993M6-1997M6 and 1994M6-1998M6. Due to data unavailability, the measurement of the RERINS depreciation

begins in 1993M11 for Russia. The same starting point is taken for the other transition economies (Hungary and Poland) to avoid the impact of the transition period. In the equation replicating STV/T and in the projection for 1998, due to data unavailability, we use the RERINS value for the real exchange rate appreciation for Russia in 1997 and 1998, instead of following the STV/T methodology, which requires data on a longer range than is currently available.

The dummy for strong fundamentals (Dsf) was defined by Tornell as follows: the dummy equals 1 if the lending boom is negative and if the real exchange rate appreciation is below 5%. In Tornell's 1998 paper, countries with strong fundamentals were Taiwan POC and Turkey in 1994, and Hungary, Mexico and Venezuela in 1997. Based on the duplicated exchange rate and the duplicated lending boom, countries with strong fundamentals were Turkey in 1994, Hungary, Mexico and Venezuela in 1997 and Mexico in 1998. Using the improved lending boom (LBC) and RERINS, countries with strong fundamentals were Hungary, Poland and Turkey in 1994, Hungary and Mexico in 1997, and Hungary, Korea, Malaysia, Mexico, Philippines and Thailand in 1998.

4. Ratio M2/Reserves, M1/Reserves, M0/Reserves, Dhr, change in reserves.
Tornell measured the ratio M2 over reserves with monthly data from IFS, using line 1L.d for official reserves (total reserves *minus* gold) and the sum of lines 34 and 35 (money and quasi-money) for M2. We computed total reserves *with* gold at market prices using gold in million fine troy ounces (line 1ad). For the price of gold we use gold London average second fixing (line 11276KR). Reserves have been converted in national currency using official exchange rates, end-of-period (line ae). Tornell measured M2/reserves in November 1994 and June 1997, thus overlapping with the crisis index. To avoid this overlap and to be consistent with the measurement of other monthly data, we used 1994M10, 1997M6 and 1998M6.

The change in reserves equals the percent change in the stock of reserves with gold at market prices over the 12 months period preceding the outburst of the crisis (i.e. respectively 1993M10 and 1994M10, 1996M6 and 1997M6 and 1997M6 and 1998M6).

In line with STV/T the dummy for reserve adequacy Dhr equals 1 if the ratio M2/reserves is below 1.8. In Tornell's original paper, countries with sufficient reserve adequacy were Chile, Peru, and Venezuela in 1994, and Chile, Hong Kong, Peru and Venezuela in 1997. Thus, there is an overlap between the Dsf and the Dhr sets of variables in 1997 (Venezuela); this overlap induces a change in the interpretation of the role of the dummies (the impact of the lending boom and of the real exchange rate may be canceled by either Dsf or Dhr). The Dhr variable that we have calculated with the duplicated M2/reserves ratio equals 1 for Chile, Colombia, Peru and Venezuela in 1994, Chile, Peru and Venezuela in 1997 and Peru and Venezuela in 1998. The Dhr variable that we have calculated with the improved M2/reserves (reserves including gold at market price, and measurement period does not overlap with crisis index) is the same as the Dhr variable calculated with duplicated data, with the exception of Sri Lanka in 1994, which was also a high reserve country.

Hungary: Data for M2 have been completed using the country website hyperlinked to the DSBB (SDDS).

5. Data Pertaining to the Current Account

CA/GDP is the ratio current account deficit over gross domestic product over the 12 months preceding the starting point of the crisis (1993Q4-1994Q3, 1996Q2-1997Q1 and 1997Q1-1997Q4 for the 1994, 1997 and 1998 crises respectively). The choice of 1997Q4 as end point for the 1998 crisis stems from the lack of data availability for all countries after this date.
We use quarterly current account data from IFS (line 78ald).
For Colombia, and Venezuela, data have been interpolated from the annual IFS series; for Poland and Malaysia, data have been completed using the countries websites hyperlinked to the DSBB (SDDS).
Quarterly data on GDP are interpolated based on IFS annual data (line 99b).

(CA-FDI)/GDP is measured over the same periods as CA/GDP. For FDI we use quarterly data on foreign direct investment in the reporting economy from IFS (line 78bed).
For Colombia, Malaysia and Venezuela, data have been interpolated from annual IFS data; for Poland after 1991Q1, data have been completed using the country website hyperlinked to the DSBB (SDDS); for Zimbabwe we use data provided by the country desk.

For **IMPORTS/RES** we use quarterly data on imports from IFS (line 78abd) in 1994Q3, 1997Q1 and 1997Q4 and reserves including gold in 1994M9, 1997M3 and 1997M12.
For Colombia, Malaysia and Venezuela, data have been interpolated from annual IFS data; for Poland after 1995Q3, data have been interpolated from annual data presented on the printed version of IFS; for Zimbabwe after 1995Q1, we use data provided by the country desk.

In line with EWS we define **XDELTA** as the difference between the annual percent change in exports (in 1994M10, 1997M6 and 1998M6 for the 1994, 1997 and 1998 crises respectively) and the same figure 12 months before. We use exports in millions of US$, in the international transaction section of IFS (line 70).
For Colombia between 1993M9 and 1994M5 data have been interpolated from annual data; for Hungary, the missing observation in 1998M6 has been replaced by the last available observation (1998M4); for Zimbabwe after 1997M7, data have been replaced by quarterly data from the country desk.

Exports of goods and services in **CA/X** consist of the sum of exports of goods (f.o.b., IFS line 78aad) and services credits (line 78add). We use 1994Q3, 1997Q1, and 1997Q4 for these variables.

6. Short Term Debt/Reserves

We used the consolidated short-term debt data published semi-annually by the Bank of International Settlements on its website. These data refer to the international positions of all reporting banks on countries outside the reporting area and are defined on a remaining maturity basis. Short-term debt data for 1994M6, 1997M6 and 1998M6 were used (i.e., last semi-annual observation before the crisis periods commenced); reserves data for 1994M10, 1997M6 and 1998M6 were used (last monthly observation available before the beginning of the crisis measurement period).

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Figure 3. Actual and Fitted Crisis Index.
(Eq. (1), Table 9)

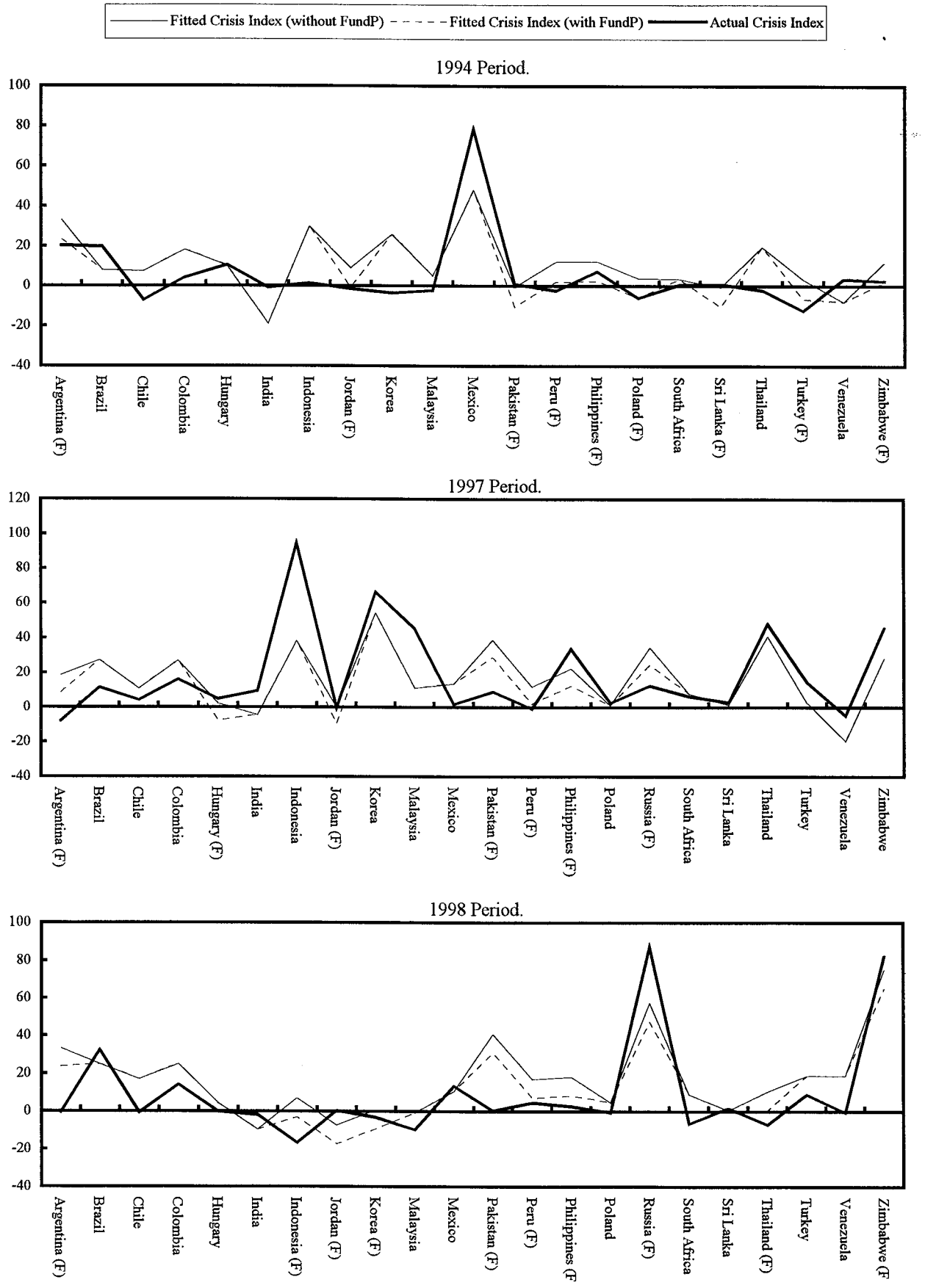

Table 5: Sovereign Credit Ranking of Estimation Sample, November 1998.

	Moody's	S&P
Chile	Baa1	A-
Hungary	Baa2	BBB-
Colombia	Baa3	BBB-
Malaysia	Baa3	BBB-
Poland	Baa3	BBB-
South Africa	Baa3	BB+
Korea	Ba1	BB+
Philippines	Ba1	BB+
Thailand	Ba1	BBB-
India	Ba2	BB
Mexico	Ba2	BB
Argentina	Ba3	BB
Jordan	Ba3	BB-
Peru	Ba3	BB
Turkey	B1	B
Brazil	B2	BB-
Venezuela	B2	B+
Indonesia	B3	CCC+
Russia	B3	CCC-
Pakistan	Caa1	CCC-
Sri Lanka	n.a.	n.a.
Zimbabwe	n.a.	n.a.

	Moody's	S&P
Investment grade	Aaa, Aa, A, Baa	AAA, AA+, AA, AA-, A+, A, A-, BBB+, BBB, BBB-
Noninvestment grade	Ba, B	BB+, BB, BB-, B+, B, B-
Default grade	Caa, Ca, C, D	CCC+, CCC, CCC-, CC, C

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Table 6: Regression Results for STV/T and EWS Specifications for the 1994-1997 Crises.

	STV/T Specification				EWS Specification		
Ind. variable	Crisind 1/	Crisind1	CrisindGld			CrisindGld	
	(1)	(2)	(3)	(4)		(5)	(6)
LB	0.24	0.24	0.25	0.29	RERINS	-0.32	-0.33
	4.76	*5.20*	*3.28*	*3.50*		*-1.90*	*-1.98*
RER	-0.12	-0.09	-0.12		CA/GDP	1.65	1.55
	-1.00	*-0.79*	*-0.59*			*2.03*	*2.05*
RERINS				-0.05	STD/Res	0.27	0.28
				-0.22		*4.23*	*4.75*
Dhr*LB	-0.25	-0.24	-0.25	-0.30	XDELTA	-0.10	
	-3.62	*-3.51*	*-2.22*	*-2.75*		*-0.70*	
Dhr*RER	0.15	0.21	0.49		Reserve Change	0.00	
	0.25	*0.28*	*0.40*			*0.05*	
Dhr*RERINS				0.07			
				0.15			
Dsf*LB	-0.04	-0.09	-0.11	-0.45			
	-0.12	*-0.34*	*-0.28*	*-1.07*			
Dsf*RER	0.17	0.20	-0.05				
	0.52	*0.59*	*-0.09*				
Dsf*RERINS				-0.41			
				-0.51			
C	-1.27	-1.80	2.83	0.93	C	-15.38	-17.22
	-0.41	*-0.58*	*0.56*	*0.18*		*-2.06*	*-2.80*
R2	0.45	0.50	0.31	0.36	R2	0.43	0.43
Adj. R2	0.37	0.41	0.19	0.25	Adj. R2	0.36	0.38

t- statistics in italics; OLS estimates using Eviews econometric package.

Eq. (1): STV/T's original regression (data provided by Tornell in the data appendix to his article).
Eq. (2): Independent variable is Crisind1, replicated using the same methodology as STV/T.
Eq. (3): Data reflect a priori improvements for CrisindGld (computed with July 1997 as a starting point for the second crisis; reserves include gold at market prices).
Eq. (4): Data reflect a priori improvements in the measurement period of LB and use of RERINS.

1/ For Equation 1, the sample includes Hong Kong and Taiwan and excludes Russia 1997.
When Newey-West correction is used in Eq. (1), as in Tornell's paper, t-statistic for RER is -2.15.

Table 7: Ranking of Most Vulnerable Countries for the 3 Models (Values for 1998 are Predicted Out-of-Sample Using Parameters Estimated over 1994-97).

Actual Crisis Index for 1998					Fitted Crisis Index with STV1 1/				Fitted Crisis Index with STV2 2/				Fitted Crisis Index with EWS 3/			
(1)	Crisind1		(2)	CrisindGld	(3)		Actual Rank (1)		(4)		Actual Rank (2)		(5)		Actual Rank (2)	
1	89.3	Russia	1	87.2 Russia	1	32.7 Philippines	8		1	33.3 Turkey	6		1	68.9 Zimbabwe	2	
2	87.4	Zimbabwe	2	82.2 Zimbabwe	2	29.4 Indonesia	22		2	22.7 Colombia	4		2	53.7 Russia	1	
3	31.5	Brazil	3	32.4 Brazil	3	24.7 Malaysia	21		3	21.0 Poland	14		3	35.4 Pakistan	11	
4	14.1	Colombia	4	13.8 Colombia	4	22.5 Turkey	6		4	19.9 Chile	13		4	29.7 Argentina	16	
5	13.3	Mexico	5	13.2 Mexico	5	18.3 Colombia	4		5	13.1 South Africa	19		5	26.4 Brazil	3	
6	7.4	Turkey	6	8.6 Turkey	6	15.3 Poland	7		6	11.1 Brazil	3		6	23.1 Colombia	4	
7	3.4	Poland	7	4.3 Peru	7	14.9 Chile	15		7	10.3 Argentina	16		7	23.1 Peru	7	
8	2.4	Philippines	8	2.4 Philippines	8	12.3 Thailand	20		8	8.5 India	17		8	23.0 Venezuela	15	
9	1.8	Peru	9	1.5 Sri Lanka	9	10.9 Korea	18		9	7.4 Pakistan	11		9	19.8 Philippines	8	
10	1.5	Sri Lanka	10	0.2 Jordan	10	7.9 South Africa	19		10	6.6 Jordan	10		10	19.6 Turkey	6	
11	0.0	Pakistan	11	0.1 Pakistan	11	6.8 Brazil	3		11	6.4 Sri Lanka	9		11	19.1 Chile	13	
12	0.0	Jordan	12	-0.3 Hungary	12	5.9 Argentina	16		12	6.4 Zimbabwe	2		12	16.4 South Africa	19	
13	-0.5	Hungary	13	-0.7 Chile	13	5.6 India	17		13	3.5 Mexico	5		13	11.6 Mexico	5	
14	-0.5	Venezuela	14	-0.9 Poland	14	3.4 Zimbabwe	2		14	2.6 Hungary	12		14	11.6 Thailand	20	
15	-0.7	Chile	15	-0.9 Venezuela	15	3.3 Pakistan	11		15	0.6 Indonesia	22		15	7.4 Indonesia	22	
16	-0.8	Argentina	16	-0.9 Argentina	16	2.9 Sri Lanka	10		16	-0.3 Philippines	8		16	7.1 Poland	14	
17	-0.8	India	17	-2.1 India	17	2.4 Jordan	12		17	-0.7 Venezuela	15		17	5.2 Hungary	12	
18	-3.4	Korea	18	-3.4 Korea	18	-2.4 Hungary	13		18	-0.9 Peru	7		18	3.1 Korea	18	
19	-6.9	South Africa	19	-6.7 South Africa	19	-3.3 Peru	9		19	-5.9 Thailand	20		19	1.5 Malaysia	21	
20	-7.2	Thailand	20	-7.1 Thailand	20	-4.6 Venezuela	14		20	-6.1 Russia	1		20	-0.6 Sri Lanka	9	
21	-9.9	Malaysia	21	-9.8 Malaysia	21	-4.9 Mexico	5		21	-6.4 Malaysia	21		21	-4.7 Jordan	10	
22	-18.5	Indonesia	22	-16.7 Indonesia	22	-5.9 Russia	1		22	-10.2 Korea	18		22	-6.5 India	17	
Spearman's rank correlation coefficient (df=20)							-0.31				0.22				0.56	
t-statistic (** indicates significance at the 1% level)							-1.47				0.99				**2.99	

1/ Fitted values for 1998 calculated using STV/T, Eq. (2), Table 6 (data calculated based on original STV/T methodolgy); compare with Crisind1.
2/ Fitted values for 1998 calculated using STV/T, Eq. (4), Table 6 (with a priori data improvements and corrected lending boom); compare with CrisindGld.
3/ Fitted values for 1998 calculated using EWS, Eq. (6), Table 6; compare with CrisindGld.
4/ Spearman's rank correlation coefficient: correlation coefficient between (3) and (1) for STV1, (4) and (2) for STV2, and (5) and (2) for EWS.

Table 8: Extending STV/T and EWS Specifications to the 1998 Crisis.

	STV/T Specification						EWS Specification					
Ind. variable	Crisind1	CrisindGld		CrisindGld								
	(1)	(2)	(3)	1994 only	1997 only	1998 only		(4)	(5)	1994 only	1997 only	1998 only
LB	0.06	0.07					RERINS	-0.39	-0.38	-0.35	-0.22	-0.43
	1.07	*1.02*						*-3.87*	*-3.95*	*-1.76*	*-0.76*	*-3.54*
LBC			0.14	0.36	0.25	-0.45	CA/GDP	1.68	1.67	1.45	1.51	1.92
			1.76	*4.28*	*1.70*	*-2.32*		*2.50*	*2.67*	*1.49*	*1.23*	*1.53*
RER	-0.40	-0.39					STD/Res	0.28	0.28	0.21	0.29	0.30
	-2.42	*-2.02*						*6.10*	*6.66*	*2.65*	*3.18*	*4.65*
RERINS			-0.33	0.07	0.18	-0.66	XDELTA	0.00				
			-1.85	*0.24*	*0.46*	*-2.68*		*0.03*				
Dhr*LB	-0.08	-0.08					Res Change	0.01				
	-0.96	*-0.86*						*0.09*				
Dhr*LBC			-0.16	-0.38	-0.28	0.37						
			-1.73	*-3.64*	*-1.43*	*1.69*						
Dhr*RER	0.73	0.85										
	1.07	*1.06*										
Dhr*RERINS			0.42	-0.50	0.37	0.90						
			1.60	*-1.02*	*0.45*	*2.56*						
Dsf*LB	0.07	0.00										
	0.20	*0.00*										
Dsf*LBC			-0.24	-0.77	0.25	0.53						
			-0.60	*-2.47*	*0.15*	*0.63*						
Dsf*RER	0.43	0.17										
	0.82	*0.28*										
Dsf*RERINS			-0.33	-0.38	0.17	-0.80						
			-0.48	*-0.67*	*0.04*	*-0.72*						
C	4.71	7.48	5.75	-10.25	13.38	20.34	C	-20.78	-20.48	-16.83	-12.66	-27.16
	1.15	*1.54*	*1.29*	*-2.18*	*1.29*	*2.54*		*-3.75*	*-4.46*	*-2.14*	*-1.22*	*-3.80*
R2	0.14	0.12	0.20	0.69	0.29	0.42	R2	0.50	0.50	0.40	0.43	0.66
Adj. R2	0.05	0.03	0.12	0.56	0.00	0.19	Adj. R2	0.46	0.48	0.29	0.33	0.60

t- statistics in italics.

Equations (1)-(5) are estimated over the three periods combined.

Table 9: Fund Programs and Alternative Liquidity Variables.

	Fund Programs		Reserve Adequacy Variables				
	3 periods	1994-97	M0/Res	M1/Res	M2/Res	IMP/Res	STD/GDP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RERINS	-0.35	-0.30	-0.35	-0.34	-0.33	-0.36	-0.35
	-3.62	*-1.92*	*-3.56*	*-3.44*	*-3.37*	*-3.64*	*-3.42*
CA/GDP	1.71	1.66	1.74	1.66	1.65	1.66	1.70
	2.82	*2.29*	*2.83*	*2.70*	*2.68*	*2.69*	*2.73*
STD/Res	0.30	0.27	0.30	0.31	0.31	0.28	0.29
	7.16	*4.87*	*7.11*	*7.07*	*7.05*	*5.24*	*6.37*
FUNDP	-9.93	-12.56	-9.41	-10.14	-10.40	-10.10	-9.89
	-2.20	*-2.26*	*-2.03*	*-2.22*	*-2.28*	*-2.22*	*-2.17*
Additional Variable			-0.02	-0.01	0.00	0.04	0.04
			-0.85	*-0.97*	*-0.82*	*0.52*	*0.11*
C	-17.71	-12.17	-15.99	-16.47	-16.01	-18.62	-17.99
	-3.82	*-1.95*	*-3.16*	*-3.40*	*-3.15*	*-3.74*	*-3.39*
R2	0.54	0.49	0.54	0.55	0.54	0.54	0.54
Adj. R2	0.51	0.44	0.50	0.51	0.51	0.50	0.50

Independent variable is CrisindGld.

t-statistics in italics.

Equations are estimated over the three periods unless otherwise indicated.

Equations with M0 and M1 exclude Hungary in 1998 (due to missing observations).

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Table 10: Credit Variables.

	Credit Variables							
	LBC		LBRPC			LBGOVPC		
	1994-97-98	1994-97	1994-97-98	1994-97	1998	1994-97-98	1994-97	1998
RERINS	-0.37	-0.25	-0.37	-0.27	-0.43	-0.38	-0.32	-0.25
	-3.62	*-1.34*	*-3.81*	*-1.71*	*-3.61*	*-3.88*	*-1.94*	*-2.99*
CA/GDP	1.55	1.28	1.57	1.33	2.08	1.82	1.35	2.95
	2.27	*1.58*	*2.51*	*1.81*	*1.68*	*2.77*	*1.65*	*3.62*
STD/Res	0.28	0.27	0.26	0.20	0.30	0.27	0.28	0.02
	6.63	*4.57*	*5.87*	*3.13*	*4.78*	*5.94*	*4.75*	*0.28*
Credit Variable	0.02	0.05	0.03	0.05	-0.05	0.03	-0.03	0.33
	0.46	*0.94*	*1.39*	*2.08*	*-1.25*	*0.75*	*-0.66*	*5.30*
C	-20.79	-17.46	-21.05	-16.67	-24.91	-20.86	-15.79	-13.93
	-4.45	*-2.84*	*-4.60*	*-2.82*	*-3.43*	*-4.50*	*-2.41*	*-2.70*
R2	0.50	0.44	0.52	0.48	0.69	0.51	0.43	0.87
Adj. R2	0.47	0.38	0.49	0.43	0.62	0.47	0.37	0.84

Independent variable is CrisindGld.
t-statistics in italics.

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Table 11: Fixed and Regional Effects, Alternative Current Account Variables, Alternative Functional Forms.

	Fixed Effects	Regional Effects	Alternative Current Account Variables		Alternative Functions of STD/Res	
					Inverse	Multiplicative
	(1)	(2)	(3)	(4)	(5)	(6)
RERINS	-0.34	-0.30	-0.36	-0.35	-0.32	
	-3.52	*-3.53*	*-3.63*	*-3.70*	*-2.72*	
RERINS*(STD/Res)						-0.004
						-5.266
CA/GDP	1.70	1.30	1.10	1.75	1.79	
	2.83	*2.40*	*0.94*	*2.91*	*2.37*	
(CA/GDP)*(STD/Res)						0.015
						2.933
(CA-FDI)/GDP			0.73			
			0.60			
-CA/X*XGR 1/				-0.04		
				-1.65		
STD/Res	0.29	0.25	0.29	0.31		
	7.02	*6.57*	*6.58*	*7.44*		
(STD/Res)^2						0.001
						5.343
Res/STD					-0.07	
					-3.63	
FUNDP	-9.01	-6.52	-10.13	-9.36	-7.00	
	-2.01	*-1.61*	*0.60*	*-2.10*	*-1.27*	
FUNDP*(STD/Res)						-0.132
						-3.494
FIX97	6.96					
	1.32					
FIX98	-1.94					
	-0.37					
DLATAM94		6.07				
		0.98				
DASIA97		33.21				
		4.42				
C	-19.38	-16.75	-15.72	-18.95	19.67	-2.474
	-3.68	*-4.07*	*-2.75*	*-4.09*	*3.17*	*-1.083*
R2	0.56	0.66	0.54	0.56	0.30	0.69
Adj. R2	0.52	0.62	0.50	0.52	0.25	0.67

Independent variable is CrisindGld.
t-statistics in italics.
Equations estimated over the three periods.
1/ XGR is the percent change in exports over 4 preceding quarters.

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Table 12: Robustness Tests: Removing Outliers.

	Benchmark	All countries except							
	All countries 3 periods	Mexico 1994	South Africa 1994-97-98	Indonesia 1997	Korea 1997	Thailand 1997	Russia 1998	Zimbabwe 1998	First 3 Countries 1/
RERINS	-0.35	-0.33	-0.33	-0.35	-0.35	-0.35	-0.29	-0.34	-0.27
	-3.62	*-3.51*	*-3.35*	*-4.04*	*-3.61*	*-3.58*	*-3.11*	*-3.52*	*-2.9*
CA/GDP	1.71	1.57	1.65	1.72	1.69	1.67	1.99	1.51	1.78
	2.82	*2.62*	*2.64*	*3.13*	*2.76*	*2.70*	*3.39*	*2.38*	*3.07*
STD/Res	0.30	0.28	0.30	0.27	0.29	0.29	0.26	0.28	0.23
	7.16	*6.76*	*7.06*	*6.92*	*6.53*	*6.96*	*6.13*	*6.34*	*5.46*
FUNDP	-9.93	-8.76	-10.66	-7.59	-9.31	-9.66	-11.58	-10.33	-9.92
	-2.20	*-1.96*	*-2.27*	*-1.84*	*-2.02*	*-2.11*	*-2.68*	*-2.29*	*-2.32*
C	-17.71	-16.76	-16.87	-17.08	-17.24	-17.57	-14.90	-15.75	-13.42
	-3.82	*-3.68*	*-3.46*	*-4.08*	*-3.68*	*-3.76*	*-3.30*	*-3.19*	*-3.02*
R2	0.54	0.51	0.54	0.54	0.50	0.52	0.52	0.48	0.45
Adj. R2	0.51	0.47	0.51	0.51	0.47	0.49	0.48	0.44	0.41

Independent variable is CrisindGld.

Equations estimated over the three periods.

1/ Countries first hit by each crisis: Mexico 1994, Thailand 1997, Russia 1998.

Table 13a. Ratio of Reserves over Short-term Debt Required to Avoid Crises (linear function) 1/

Real Eff. Exchange Rate (- is appreciation	Current Account (- is deficit) 2/												
	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6
18	0.87	0.91	0.96	1.02	1.08	1.16	1.24	1.33	1.44	1.58	1.73	1.93	2.17
15	0.89	0.94	**1.00**	1.06	1.13	1.20	1.29	1.40	1.52	1.67	1.85	2.07	2.35
12	0.92	0.97	1.03	1.10	1.17	1.26	1.36	1.47	1.61	1.77	1.97	2.23	2.56
9	0.95	**1.01**	1.07	1.14	1.22	1.32	1.42	1.55	1.70	1.89	2.12	2.42	2.81
6	0.99	1.05	1.11	1.19	1.28	1.38	1.50	1.64	1.81	2.02	2.29	2.64	3.12
3	1.02	1.09	1.16	1.24	1.34	1.45	1.58	1.74	1.94	2.18	2.49	2.91	3.50
0	1.06	1.13	1.21	1.30	1.40	1.53	1.68	1.85	2.08	2.36	2.73	3.24	3.99
-3	1.10	1.18	1.26	1.36	1.48	1.61	1.78	1.98	2.24	2.57	3.02	3.66	4.64
-6	1.15	1.23	1.32	1.43	1.56	1.71	1.90	2.13	2.43	2.83	3.38	4.20	5.55
-9	1.19	1.28	1.38	1.50	1.65	1.82	2.03	2.30	2.66	3.14	3.84	4.93	6.89
-12	1.25	1.34	1.45	1.59	1.75	1.94	2.19	2.51	2.93	3.53	4.43	5.96	9.09
-15	1.30	1.41	1.53	1.68	1.86	2.09	2.37	2.75	3.27	4.03	5.25	7.54	13.35
-18	1.36	1.48	1.62	1.79	1.99	2.25	2.59	3.04	3.69	4.69	6.44	10.25	25.15

1/ Without Fund program. Short-term debt (STD) by remaining maturity based on BIS data. Total STD includes debt due to other creditors than banks and is about 45 percent higher, implying lower ratios for total short-term debt.
2/ Current account balance as percent of GDP in the preceding 12 months.
3/ REER percent change over the preceding 48 months.

Table 13b. Ratio of Reserves over Short-term Debt Required to Avoid **Limited Crises (10%),** Linear Function 1/ 2/

Real Eff. Exchange Rate (- is appreciatio	Current Account (- is deficit)												
	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6
18	0.67	0.70	0.73	0.76	0.79	0.83	0.87	0.92	0.97	1.03	1.09	1.17	1.25
15	0.69	0.72	**0.75**	0.78	0.82	0.86	0.90	0.95	1.01	1.07	1.14	1.22	1.31
12	0.70	0.73	0.77	0.80	0.84	0.88	0.93	0.98	1.04	1.11	1.19	1.27	1.37
9	0.72	**0.75**	0.79	0.82	0.87	0.91	0.96	1.02	1.08	1.15	1.24	1.33	1.44
6	0.74	0.77	0.81	0.85	0.89	0.94	1.00	1.06	1.13	1.20	1.29	1.40	1.52
3	0.76	0.79	0.83	0.88	0.92	0.97	1.03	1.10	1.17	1.26	1.35	1.47	1.61
0	0.78	0.82	0.86	0.90	0.95	1.01	1.07	1.14	1.22	1.31	1.42	1.55	1.70
-3	0.80	0.84	0.88	0.93	0.99	1.05	1.11	1.19	1.28	1.38	1.50	1.64	1.81
-6	0.83	0.87	0.91	0.96	1.02	1.09	1.16	1.24	1.34	1.45	1.58	1.74	1.93
-9	0.85	0.89	0.94	1.00	1.06	1.13	1.21	1.30	1.40	1.53	1.67	1.85	2.07
-12	0.88	0.92	0.98	1.03	1.10	1.17	1.26	1.36	1.47	1.61	1.78	1.98	2.24
-15	0.90	0.95	1.01	1.07	1.14	1.23	1.32	1.43	1.56	1.71	1.90	2.13	2.43
-18	0.93	0.99	1.05	1.12	1.19	1.28	1.38	1.50	1.65	1.82	2.03	2.30	2.65

1/ Without Fund Program.

Table13c. Crisisindex for Different Values of R/STD and REER, and a Current Deficit of 3 Percent of GDP, Multiplicative Relation, 1/

Real Eff. Exchange Rate (- is appreciatio	Reserves/Total Short-term Debt												
	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70
-30	40	30	23	19	15	13	11	9	8	7	6	6	5
-25	37	27	21	17	14	11	10	8	7	6	5	5	4
-20	34	25	19	15	12	10	8	7	6	5	4	4	3
-15	31	22	16	13	10	8	7	6	5	4	3	3	2
-10	28	19	14	11	8	7	5	4	3	3	2	2	1
-5	25	17	12	9	7	5	4	3	2	2	1	1	1
0	22	14	10	7	5	4	3	2	1	1	0	0	0
5	19	12	8	5	3	2	1	0	0	-1	-1	-1	-1
10	15	9	5	3	2	0	0	-1	-1	-2	-2	-2	-2
15	12	7	3	1	0	-1	-2	-2	-2	-3	-3	-3	-3
20	9	4	1	-1	-2	-3	-3	-3	-4	-4	-4	-4	-4
25	6	1	-1	-3	-4	-4	-5	-5	-5	-5	-5	-5	-5
30	3	-1	-3	-5	-5	-6	-6	-6	-6	-6	-6	-6	-6

1/ Short-term debt (STD) by remaining maturity (approximation of total debt based on BIS and WEO data).
2/ Without Fund program.

Table 14: Data Replicated from Sachs, Tornell, Velasco (1994) and Tornell (1997), Alternative Data (Bussiere and Mulder).

	Crisis Index				Lending Boom			Real Exchange Rate Depreciation				Reserve Adequacy			
	BM1 1/	BM 2/	Tornell	STV	BM	Tornell	STV	BM 3/	BM 1/	Tornell	STV	BM 1/	BM 4/	Tornell	STV
1 Argentina 1994	20.17	20.26	20.2	20.20	106.52	105.86	57.10	-26.04	-39.79	-39.76	-48.00	406.16	355.07	406.16	360
2 Brazil 1994	19.54	19.51	19.65	17.70	110.89	15.49	68.30	-19.23	19.51	-20.79	-29.60	404.24	364.94	404.46	360
3 Chile 1994	-6.09	-7.41	-5.63	-5.70	43.20	43.20	13.30	-11.58	-10.35	-10.3	-7.50	154.09	154.72	154.09	140
4 Colombia 1994	4.53	3.95	4.31	4.20	42.29	42.29	20.50	-38.30	-23.60	-23.55	9.20	165.84	163.65	196.56	150
5 Hungary 1994	10.28	10.28	10.29	-	-48.90	-49.48	-	2.87	-19.58	-19.57	-	250.33	255.70	261.56	-
6 India 1994	-0.14	-0.99	-0.14	-1.20	15.01	15.01	-3.10	22.80	38.32	38.46	43.00	751.87	593.45	751.87	630
7 Indonesia 1994	1.31	1.20	1.32	1.30	38.02	38.02	0.70	-1.58	-3.70	-3.57	11.80	612.41	587.68	612.41	460
8 Jordan 1994	-1.56	-1.54	-1.56	-1.50	38.60	38.60	4.20	-4.21	0.93	0.98	35.50	385.25	344.19	385.25	250
9 Korea 1994	-3.70	-3.71	-3.7	-3.70	41.97	41.97	8.40	2.74	0.44	0.54	-10.30	665.04	656.16	665.04	650
10 Malaysia 1994	-2.60	-2.55	-2.63	-2.60	55.61	55.61	4.00	-7.73	-5.30	-5.17	9.80	201.59	197.16	213.92	210
11 Mexico 1994	79.06	78.36	79.3	79.10	188.71	171.71	116.20	-20.68	-17.99	-17.95	-28.50	901.51	636.23	924.90	910
12 Pakistan 1994	0.68	0.67	0.68	0.70	17.38	17.38	-7.70	3.14	7.29	7.39	20.40	872.75	610.85	871.39	660
13 Peru 1994	-2.68	-2.70	-2.69	-2.90	244.36	244.36	156.10	-36.83	-17.72	-17.62	-45.40	124.85	119.79	124.85	150
14 Philippines 1994	7.19	7.15	7.19	7.20	55.19	55.19	50.00	-29.00	-18.11	-18.01	-6.70	476.51	362.33	476.51	410
15 Poland 1994	-5.71	-6.10	-5.59	-	-14.04	-14.04	-	-4.82	-40.70	-40.69	-	516.82	552.84	516.82	-
16 South Africa 1994	2.22	0.53	2.22	1.10	19.87	19.87	8.10	-1.30	0.87	0.98	-6.80	5052.17	2397.5	5052.17	2150
17 Sri Lanka 1994	0.74	0.72	0.74	0.70	27.64	28.08	28.90	-1.98	-6.48	-6.39	1.20	185.51	178.0	185.51	200
18 Thailand 1994	-2.16	-2.42	-1.82	-1.80	101.51	101.12	39.20	-1.87	-5.54	-5.51	0.20	378.11	358.4	378.11	370
19 Turkey 1994	-1.86	-12.48	-1.96	-2.50	-13.72	-13.72	-32.80	25.67	35.76	35.8	-12.10	434.55	371.6	434.55	320
20 Venezuela 1994	5.16	3.21	5.16	7.60	-7.88	-7.88	-38.50	-10.22	-7.94	-7.9	16.20	175.43	111.4	175.43	140
21 Zimbabwe 1994	1.58	2.24	1.58	1.60	30.04	30.04	55.70	22.67	40.49	40.6	44.20	308.97	182.4	308.97	260

1/ Replication of STV and Tornell's values from raw data following their methodology.
2/ Crisis index computed with gold at market prices; measurement period starts July 1997 for the second period instead of June.
3/ Real effective exchange rate from INS (positive sign indicates depreciation).
4/ Ratio M2 over Reserves computed using reserves with gold at market price, line ae for the exchange rate and at a different date from STV/T (see detail in data appendix).

Table 14 (continued): Data Replicated from Sachs, Tornell, Velasco (1994) and Tornell (1997), Alternative Data (Bussiere and Mulder).

	Crisis Index				Lending Boom			Real Exchange Rate Depreciation				Reserve Adequacy			
	BM 1/	BM 2/	Tornell	STV	BM	Tornell	STV	BM 3/	BM 1/	Tornell	STV	BM 1/	BM 4/	Tornell	STV
22 Argentina 1997	-2.17	-8.13	-2.14		48.22	47.42		2.33	-4.02	-3.91		358.03	338.89	358.19	
23 Brazil 1997	7.56	11.38	7.38		76.62	-5.34		-45.46	-18.14	-48.8		366.96	357.51	346.53	
24 Chile 1997	-2.14	4.13	-2.06		60.06	60.06		-22.67	-11.71	-11.74		179.83	173.74	179.83	
25 Colombia 1997	15.64	15.90	15.82		76.51	76.51		-42.00	-30.32	-30.27		195.22	191.32	195.22	
26 Hungary 1997	7.37	4.72	7.35		-30.52	-30.40		-0.04	-3.75	-3.74		193.87	191.08	186.33	
27 India 1997	0.76	9.26	0.76		18.48	18.48		-9.76	10.42	10.46		750.85	641.97	729.97	
28 Indonesia 1997	48.23	94.69	48.22		61.38	60.48		-5.90	-7.01	-6.82		616.40	585.17	616.40	
29 Jordan 1997	-0.21	-0.43	-0.21		48.50	48.50		-4.13	1.91	2.12		430.62	368.28	430.62	
30 Korea 1997	3.40	66.10	3.35		52.40	52.40		-2.76	-4.85	-4.63		619.67	618.62	619.67	
31 Malaysia 1997	30.93	45.22	30.92		95.90	65.81		-6.91	-4.67	-4.54		369.68	357.77	351.12	
32 Mexico 1997	-2.22	1.55	-2.21		-39.69	-8.01		15.05	29.19	29.16		419.03	417.05	415.68	
33 Pakistan 1997	5.16	8.79	5.16		15.86	15.86		4.12	6.84	6.9		2090.75	1335.7	2087.50	
34 Peru 1997	-4.26	-1.19	-4.26		216.29	216.29		-14.88	-2.39	-2.15		143.15	138.23	143.15	
35 Philippines 1997	30.57	33.71	30.57		165.46	165.46		-28.44	-15.78	-15.68		486.75	420.12	486.75	
36 Poland 1997	5.51	2.44	-2.73		27.29	26.42		-25.72	-18.20	-18.2		241.75	234.53	264.62	
37 South Africa 1997	5.14	12.37	5.19		26.99	26.99		-33.85	23.30	23.6		1790.03	1364.8	1790.03	
38 Sri Lanka 1997	1.59	6.18	1.59		23.26	23.26		6.99	-5.53	-5.43		258.54	255.07	563.00	
39 Thailand 1997	43.20	2.68	43.41		85.60	85.13		-7.81	-7.11	-7.01		489.59	476.58	498.60	
40 Turkey 1997	15.51	48.07	15.78		35.68	35.68		-11.70	16.54	16.57		311.69	281.66	311.69	
41 Venezuela 1997	-13.39	14.67	-13.36		-37.16	-37.16		14.23	-3.45	-3.36		95.22	73.50	93.70	
42 Zimbabwe 1997	10.00	-4.92	8.65		31.86	31.86		-29.48	-3.58	-3.33		467.68	319.39	467.68	

1/ Replication of STV and Tornell's values from raw data following their methodology.
2/ Crisis index computed with gold at market prices; measurement period starts July 1997 for the second period instead of June.
3/ Real effective exchange rate from INS (positive sign indicates depreciation).
4/ Ratio M2 over Reserves computed using reserves with gold at market price, line ae for the exchange rate and at a different date from STV/T (see detail in data appendix).

APPENDIX I

Table 15: Actual and Fitted Crisis Index, Main Data.

	CrisindGld	RERINS	CA/GDP	STD/Res	FundP	LBC 1/	RER 1/	M2/R 1/	Fitted Crisis Index 2/	Residual 3/
1 Argentina 1994	20.3	-26.0	3.7	119.5	1	111.3	-39.8	355.1	23.2	-2.9
2 Brazil 1994	19.5	-19.2	-0.7	68.2	0	107.0	19.5	364.9	8.0	11.5
3 Chile 1994	-7.4	-11.6	4.6	44.5	0	46.3	-10.3	154.7	7.3	-14.7
4 Colombia 1994	4.0	-38.3	4.5	50.0	0	19.9	-23.6	163.7	18.1	-14.2
5 Hungary 1994	10.3	2.9	11.2	32.4	0	-47.5	-19.6	255.7	10.1	0.2
6 India 1994	-1.0	22.8	0.3	20.4	0	5.0	38.3	593.4	-19.0	18.0
7 Indonesia 1994	1.2	-1.6	1.6	148.7	0	37.2	-3.7	587.7	29.8	-28.6
8 Jordan 1994	-1.5	-4.2	8.7	34.6	1	38.3	0.9	344.2	-1.0	-0.6
9 Korea 1994	-3.7	2.7	0.6	146.6	0	45.1	0.4	656.2	25.9	-29.6
10 Malaysia 1994	-2.5	-7.7	7.0	27.1	0	49.7	-5.3	197.2	5.0	-7.5
11 Mexico 1994	78.4	-20.7	6.6	159.3	0	175.5	-18.0	636.2	48.1	30.3
12 Pakistan 1994	0.7	3.1	2.4	47.1	1	11.7	7.3	610.8	-10.6	11.3
13 Peru 1994	-2.7	-36.8	4.5	30.8	1	275.7	-17.7	119.8	2.0	-4.7
14 Philippines 1994	7.2	-29.0	5.3	36.0	1	39.2	-18.1	362.3	2.2	4.9
15 Poland 1994	-6.1	-4.8	-2.7	82.4	1	-16.5	-40.7	552.8	-6.2	0.1
16 South Africa 1994	0.5	-1.3	-0.1	69.7	0	20.3	0.9	2397.5	3.3	-2.7
17 Sri Lanka 1994	0.7	-2.0	5.3	24.4	1	29.4	-6.5	178.0	-10.6	11.4
18 Thailand 1994	-2.4	-1.9	5.6	91.0	0	94.8	-5.5	358.4	19.4	-21.8
19 Turkey 1994	-12.5	25.7	-0.8	106.0	1	-16.4	35.8	371.6	-6.6	-5.9
20 Venezuela 1994	3.2	-10.2	-2.4	34.6	0	6.6	-7.9	111.4	-8.1	11.3
21 Zimbabwe 1994	2.2	22.7	6.0	90.6	1	16.6	40.5	182.4	1.5	0.7
22 Argentina 1997	-8.1	2.3	1.5	116.5	1	48.9	-4.0	338.9	8.7	-16.8
23 Brazil 1997	11.4	-45.5	3.4	78.6	0	70.8	-18.1	357.5	27.3	-15.9
24 Chile 1997	4.1	-22.7	4.7	43.1	0	48.5	-11.7	173.7	10.9	-6.8
25 Colombia 1997	15.9	-42.0	6.1	66.6	0	67.4	-30.3	191.3	27.1	-11.2
26 Hungary 1997	4.7	0.0	3.2	48.5	1	-17.1	-3.8	191.1	-7.8	12.5
27 India 1997	9.3	-9.8	1.2	25.8	0	20.8	10.4	642.0	-4.5	13.8
28 Indonesia 1997	94.7	-5.9	3.5	162.1	0	69.9	-7.0	585.2	38.4	56.3
29 Jordan 1997	-0.4	-4.1	4.3	30.6	1	30.7	1.9	368.3	-9.8	9.4
30 Korea 1997	66.1	-2.8	5.5	207.4	0	59.1	-4.8	618.6	54.2	11.9
31 Malaysia 1997	45.2	-6.9	5.1	59.3	0	117.6	-4.7	357.8	11.1	34.1
32 Mexico 1997	1.6	15.0	0.7	118.5	0	-33.9	29.2	417.0	13.4	-11.9
33 Pakistan 1997	8.8	4.1	6.8	156.3	1	15.6	6.8	1335.7	28.9	-20.1
34 Peru 1997	-1.2	-14.9	5.8	48.8	1	194.0	-2.4	138.2	2.0	-3.2
35 Philippines 1997	33.7	-28.4	4.5	76.1	1	163.4	-15.8	420.1	12.5	21.3
36 Poland 1997	2.4	-25.7	2.3	20.0	0	38.3	-18.2	234.5	1.1	1.4
37 Russia 1997	12.4	-33.8	-2.8	152.5	1	-27.2	-33.8	291.5	24.6	-12.2
38 South Africa 1997	6.2	7.0	1.5	85.0	0	33.2	23.3	1364.8	7.7	-1.5
39 Sri Lanka 1997	2.7	-7.8	5.6	23.5	0	22.7	-5.5	255.1	1.5	1.2
40 Thailand 1997	48.1	-11.7	7.5	141.5	0	85.2	-7.1	476.6	41.1	7.0
41 Turkey 1997	14.7	14.2	1.8	75.4	0	33.7	16.5	281.7	2.8	11.9
42 Venezuela 1997	-4.9	-29.5	-10.8	20.8	0	-24.5	-3.4	73.5	-19.8	14.9
43 Zimbabwe 1997	45.7	-16.6	4.1	112.4	0	11.3	-3.6	319.4	28.5	17.2

Table 15 (continued).

	CrisindGld	RERINS	CA/GDP	STD/Res	FundP	LBC 1/	RER 1/	M2/R 1/	Fitted Crisis Index 2/	Residual 3/
44 Argentina 1998	-0.9	-3.9	2.9	151.1	1	31.5	-1.2	363.1	23.5	-24.5
45 Brazil 1998	32.4	-37.5	4.2	75.3	0	28.7	-19.5	333.3	24.8	7.5
46 Chile 1998	-0.7	-18.5	5.3	64.5	0	62.4	-19.0	201.3	16.9	-17.6
47 Colombia 1998	13.8	-20.6	7.2	77.4	0	71.5	-32.5	242.3	24.8	-11.0
48 Hungary 1998	-0.3	-2.1	2.7	56.1	0	-4.6	-5.5	191.7	4.3	-4.6
49 India 1998	-2.1	3.2	1.0	25.1	0	26.7	-10.6	689.3	-9.7	7.5
50 Indonesia 1998	-16.7	65.9	2.3	146.7	1	10.1	9.4	198.1	-3.1	-13.6
51 Jordan 1998	0.2	-10.9	-0.4	24.4	1	17.6	-6.7	321.9	-17.3	17.5
52 Korea 1998	-3.4	25.4	1.8	81.0	1	-3.1	6.2	388.2	-9.3	5.9
53 Malaysia 1998	-9.8	19.0	4.3	54.9	0	-8.7	2.0	310.6	-0.7	-9.1
54 Mexico 1998	13.2	6.8	1.9	91.8	0	-35.6	20.0	331.5	10.3	2.9
55 Pakistan 1998	0.1	-5.4	2.9	174.6	1	21.4	0.1	1805.0	31.0	-30.9
56 Peru 1998	4.3	-7.3	5.2	77.7	1	170.6	-12.8	143.4	6.9	-2.6
57 Philippines 1998	2.4	5.4	5.3	96.3	1	-7.7	-11.8	336.9	8.1	-5.8
58 Poland 1998	-0.9	-31.1	3.2	21.1	0	63.8	-20.3	218.7	4.8	-5.6
59 Russia 1998	87.2	-35.7	-0.7	216.0	1	-30.4	-35.7	450.4	47.5	39.6
60 South Africa 1998	-6.7	8.3	1.5	90.8	0	43.4	8.1	1192.2	8.9	-15.5
61 Sri Lanka 1998	1.5	-22.4	2.6	20.2	0	15.1	-11.6	243.6	0.5	1.0
62 Thailand 1998	-7.1	18.3	2.0	104.7	1	-9.6	7.5	401.6	0.5	-7.5
63 Turkey 1998	8.6	-35.0	1.4	73.7	0	105.6	11.6	206.2	18.7	-10.1
64 Venezuela 1998	-0.9	-105.3	-5.3	31.1	0	-42.9	-23.4	107.2	19.0	-19.9
65 Zimbabwe 1998	82.2	-1.9	11.8	243.1	1	18.5	-8.8	451.8	65.4	16.8
Average 1994	5.2	-6.5	3.4	69.7		50.0	-3.5	455.0	6.8	-1.6
Average 1997	18.8	-12.1	3.0	85.0		46.7	-3.9	428.7	13.6	5.1
Average 1998	8.9	-8.4	2.9	90.8		24.7	-7.0	414.9	12.5	-3.6
Average 3 periods	11.0	-9.0	3.1	82.0		40.3	-4.8	432.5	11.0	0.0
Std. Dev. 1994	18.5	17.8	3.7	44.4		71.8	22.4	481.4	16.0	14.9
Std. Dev. 1997	26.1	16.9	3.9	53.8		57.2	15.2	333.6	18.3	18.1
Std. Dev. 1998	26.4	32.2	3.3	61.4		48.8	14.5	384.8	19.1	15.7
Std. Dev. 3 periods	24.3	23.2	3.6	53.7		60.0	17.4	397.3	17.9	16.5

2/ Fitted values obtained with Eq. (1), Table 9: the equation includes the three core variables RERINS, CA/GDP and STD/Res and the dummy variable for Fund programs.