Large Hoarding of International Reserves: Are they worth it? *

[Preliminary Version]

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August 4, 2004

Abstract

We empirically evaluate the contribution of international liquidity via-a-vis institutional variables in reducing the risk of a currency crisis. We find that the ratio of reserves to short-term debt is robust in explaining international crisis, even after controlling for financial development and political variables. Based on our estimates on crisis probabilities we compute the optimal level of reserves for a set of East Asian economies and for Chile. The results indicate that the current stocks of reserves for most of the cases is in line with reasonable cost of crisis. We conclude by observing that the recent process of large reserves accumulation by some of the East Asian economies seems to be a sensible policy.

1 Introduction

Over the last few years, several Asian economies have accumulated large stocks of international reserves. This motivates the question we ambitiously attempt to answer from an empirical point of view. Are these large increases in reserves an efficient crisis-prevention strategy? Or are they rather a second-best to other options, such as improving governance and the development of better institutions in the financial markets? The current literature has not reached a firm consensus.

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While it has been argued that reserve accumulation allows to reduce the likelihood of self-fulfilling speculative attacks,[1] it has also been stressed that reserve accumulation is a relatively costly self-insurance strategy, and it can be actually counterproductive, while crises are likely to be deeper in the presence of weak financial systems.[2]

In this paper we first estimate a model to quantify the impact of international liquidity on the probability of a crisis. Our goal is to evaluate how robust are reserves –or the lack of them– in explaining crisis. In particular, after controlling for the quality of political institutions and the soundness of the financial system. We then utilize our estimates to evaluate the optimal level of reserves from a cost-benefit analysis for a selected group of East Asian economies and for Chile.

Our results lead us to the conclusion that recent trends in reserve accumulation by some Asian economies are a sensible approach to dealing with the current macroeconomic conditions in the world economy. The empirical evidence we present indicates that the probability of crisis is still strongly related to this ratio of reserves to short term debt even when controlling for political and financial system variables, while the actual size of the reserve stock observed today is not far from what would be implied by the usual cost of crises.

Our work is framed around two existing strands of the literature on international reserves. The first one is the role of reserves as an indicator for financial or currency crisis in the context of the Early Warning System (EWS) literature.[3] Typically in this literature, an exchange market pressure variable is constructed combining increases in interest rates, the exchange rate and rapid reserve depletion. This variable attempts to summarize the magnitude of speculative behavior over a wide range of possible policy responses and regimes, and therefore is not restricted to specific circumstances, such as depreciations after periods of fixed exchange rates. An indicator variable is created, and it takes the value of 1 if exchange market pressure is above a pre-specified crisis threshold. The second step in this procedure is to regress this indicator on a set of right-hand-side variables, typically including the ratio of reserves to short term debt and the misalignment of the real exchange rate. Thus, in this framework an observer of these variables should be able to assess the likelihood of a currency crisis.

Although we follow the logic of this basic approach in our work, we extend the empirical methodology in two directions. The first one is the inclusion of different variables to capture the effect of financial depth on the likelihood of a crisis. We test whether a more deep and liquid domestic financial system is related to a lower probability of crisis. The second one is the inclusion of governance variables. Weaker political institutions are more prone to deal feebly with financial stress, as either they do not have the correct incentives (because

[1] See, for example, Sachs, Tornell and Velasco (1996), Chang and Velasco (1998), and Jeanne and Wyplosz (2001).

[2] These points have been particularly noted in Caballero and Krishnamurthy (1998), (2000) and (2004).

[3] See Frenkel and Rose (1996), Berg and Patillo (1998), Sachs, Tornell and Velasco (1996), and Borenzstein, Berg, Millesi-Ferretti and Pattillo (1999).

of corruption), technical expertise, or because their policy actions are not credible to market participants. Our results indicate that the effect of the ratio of reserves to short term debt on crisis probability is robust to the inclusion of these two sets of variables, and that the selected financial and political variables have an ambiguous or weak relationship with the probability of a crisis.

The second strand of the literature on which we base our work is the standard model of reserves demand. We use a simple model that relates the optimal level of reserves to their opportunity cost as well as the expected cost of crises. By assuming reasonable values for the latter, we compute theoretical optimal levels for reserves and compare them to actual recent stocks hold by a number of Asian countries and for Chile. We find that for cost of crises between 5 and 15% of GDP the actual ratio of reserves to short term debt in some of these selected Asian countries is below to the optimal level derived from the model. At the same time, the implicit cost of a crisis that is consistent with the actual level of reserves hold for those countries is in the range of a soft to mild crisis.

The paper is organized as follows. The next section describe some recent trends in reserves accumulation by emerging economies. Section three presents the empirical methodology utilized to estimate the probability of a crisis and discusses the main results. Section four computes the optimal level of reserves for a selected group of Asian countries and for Chile. Finally, section five concludes.

2 Recent trends in reserve accumulation

Figures 1 through 4 present some recent trend in reserves accumulation by a group of emerging economies.[4]

[TO BE COMPLETED]

3 Reserve accumulation and crisis probability

Recent literature on international crisis emphasizes the role of international reserves in preventing financial or currency crisis.[5] Rather than being a buffer to absorv current account transitory shock –as it was emphasizes in the literature on reserves adequacy of the 50s and 60s– reserves are perceive as a mean to reduce the incidence of international crisis.

The role of international reserves as a key determinant of financial and currency crisis has been widely analyzed in recent years both, theoretically and empirically. However, it has been only during recent years that the quantitative contribution of reserves in terms of reducing the risk of a crisis has been analyzed. Bussiere and Mulder (1999), for example, find that the short-term

[4] The emerging market economies included in our sample are: Turkey, South Africa, Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela, Israel, Egypt, Hong Kong, India, Indonesia, South Korea, Philippines, Singapore, Thailand, China, Czech Republic, Hungary, and Poland.

[5] See for example, Chang and Velasco (1998), Jeanne and Wyplosz (2001), ****

debt to reserves ratio is significant on predicting crisis. Moreover, these authors quantify how much liquidity (reserves) countries should have in order to counteract weak fundamentals and avoid crisis.

In this section we follow the EWS literature to estimate quantitatively the contribution of reserves to reducing the probability of an international crises.

3.1 Empirical Approach

Usually the literature posits a specification that relates the probability of a crisis to the ratio of reserves to a selected scaling variable and a number of other variables. Consistent with recent theoretical and emphasis on liquidity to explain crisis we consider as a scaling variable the short-term debt of the country.

For the sake of simplicity, we denominate $p_{i,t}$ this probability of a crisis in country i at time t, and assume that it is a function of a linear combination of the reserves to short-term debt ratio at the beginning of period t, $R_{i,t}/S_{i,t}$, the total debt to GDP ratio, D_t/Y_t, another set of variables contained in vector $\mathbf{Z}_{i,t}$, and a crisis shock $\epsilon_{i,t}$.

$$p_{i,t} = p\left[\beta_0 \frac{R_{i,t}}{S_{i,t}} + \beta_1 \frac{D_{i,t}}{Y_{i,t}} + \mathbf{Z}_{i,t}\boldsymbol{\gamma} - \epsilon_{i,t}\right] \tag{1}$$

In this formulation the ratio reserves to short-term debt is a measure of the liquidity of the economy, and the ratio total debt to GDP is a proxy for solvency. Therefore, we have that $\beta_0 < 0$, and $\beta_1 > 0$.

We estimate the crisis probability by using a panel of countries with yearly observations. To define a crisis episode we use the standard measure of exchange market pressure (EMP), by constructing a weighted average of the first differences in real exchange rate, and the level of reserves.[6]

$$EMP_{i,t} = \omega_{rer} \frac{rer_{i,t} - rer_{i,t-1}}{rer_{i,t-1}} - \omega_R \frac{R_{i,t} - R_{i,t-1}}{R_{i,t-1}} \tag{2}$$

where $rer_{i,t}$ is the average real exchange of country i during year t, and where $R_{i,t}$ is the level of reserves (real) at the end of year t. Weights correspond to the inverse of the variance of each variable for all countries over the full sample. A crisis episode occurs in period t in country if $EMP_{i,t}$ exceeds a predetermined threshold value $\overline{X}$. In particular, we define a crisis index as follows:

$$Y_{i,t} = \begin{cases} 1 & \text{if } EMP_{i,t} > \overline{EMP}_i + 2SD\left(EMP_i\right) \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

In this framework, the crisis probability corresponds to the probability of the event $Y_{i,t} = 1$. This probability cannot be measured ex-ante, as only the

[6] Bussiere and Fratzscher (2002) utilize a similar measure. However, they also consider pressures absorbed by interest rate movements. In our case, since we utilize a longer time span, and annual data incorporating interest rate movements would have decreased significantly the data. Other works that utilize a similar crisis indicator are Kamin and Babson (1999), and Krueger, Oskwe and Page (1998).

effective ex-post occurrence of crises can be observed. Moreover, the latter hinges on the particular definition of the threshold value $\overline{X}$. For the sake of our main argument, we will abstract from these considerations for now, and assume that there is a well defined function that relates macroeconomic variables to this probability of crisis for country i in period t

$$\Pr\left(Y_{i,t}=1\right)=F\left[\beta\frac{R_{i,t}}{S_{i,t}}+\mathbf{Z_{i,t}}\boldsymbol{\gamma}-\epsilon_t\right]. \tag{4}$$

Equation 4 indicates that the probability of a crisis occurring in period t is a non-linear function F of a linear combination of the reserves to short-term debt ratio and other variables included in vector $\mathbf{Z_{i,t}}$, among which the real exchange rate deviation from its fundamental or long run value turns out to be a very important one.

For the empirical application we assume F is a logistic function. In other words, we have that

$$p_{i,t}=\frac{\exp\left(\beta_0\frac{R_{i,t}}{S_{i,t}}+\beta_1\frac{D_{i,t}}{Y_{i,t}}+\mathbf{Z_{i,t}}\boldsymbol{\gamma}-\epsilon_{i,t}\right)}{1+\exp\left(\beta_0\frac{R_{i,t}}{S_{i,t}}+\beta_1\frac{D_{i,t}}{Y_{i,t}}+\mathbf{Z_{i,t}}\boldsymbol{\gamma}-\epsilon_{i,t}\right)} \tag{5}$$

3.2 Quantifying the effect of reserves on crisis probability

This subsection presents benchmark estimates of crisis probability. Estimations were made using a logit model with yearly observations for the period 1975-2003. From these estimates two of the results found in the literature stand out most clearly, despite of the lower frequency of our data an the longer time span. First, a lower ratio of reserves to STD and other measures of liabilities, by the end of a year, increases the probability of a crisis in the subsequent year. Second, a larger deviation of the real exchange rate from trend in a given year increases the probability of crisis in the subsequent year. The magnitudes involved are large.

Tables 1 to 3 present the results of a number of estimates using three scaling variables for reserves. Tables 1 and 2 present the results from using short-term debt from different sources (BIS and WDI database), while table 3 uses total external debt.[7] Although usually short-term debt has been used as the scaling variable for reserves in models of crisis, in circumstances of financial stress, a liquidation of assets held by investors (both local an foreign) need not be constrained to short term external debt. Domestic agents can liquidate their own holdings of money (a Central Bank liability) while holders of external debt can attempt to shift their portfolio away from all external liabilities. This justify trying other definitions of the relevant scaling variables for reserves.

[7] The main difference between the data on short-term debt from the BIS with respect to that of the World Bank is that the first comprises not only debt with maturity of up to one year but also amortizations due within the year. Unfortunately, this database starts during the 90s and is available only for emerging economies.

In Table 1 the coefficient of reserves to short term debt are statistically significant at 10% in all specifications, while in table 2 this is so in 18 out of 26 cases. In table 3 (using total external debt) half the specifications lead to a statistically significant estimate for the effect of reserves over total debt. Moreover, in essentially all the specifications in Tables 1 to 3 the exchange rate deviation from trend is related statistically to the probability of crisis.

We expanded these basic estimates with a number of other variables that have been included in the literature. The effect of the inclusion of these variables as well as their estimated incidence is discussed in turn in what follows

- The effect of different measures of liabilities

Including as an additional explanatory variable the total stock of external debt, as percentage of GDP, does not affect either the size or significance of the effect of the ratio of reserves to short term debt and exchange rate deviations from trend, in tables 1 through 3. It doesn't either appear to significantly affect the probability of crisis. In Table 3, the inclusion of the structure of external debt does not either have a significant incidence. However, if the ratio of reserves to total debt is instead used, the magnitude of the estimated coefficient is an order of magnitude larger than the one that accompanies in previous specifications the ratio of reserves to short term debt.

This result must be interpreted with caution, as it is a product of the scaling of the variables and not a marginal contribution to the crisis probability. When incorporating additionally the structure of external debt, the ratio between short term to long term debt appears to increase the crisis probability but not with a statistically significant coefficient.

- Economic growth and credit booms

Economic growth, both aggregate GDP growth and export growth, appears to strongly influence in the expected way the probability of crisis.

This can stem from a number of reasons. A quicker pace of economic growth can provide for a lower demand of publicly provided assistance programs and allow for increased tax revenue over the cycle, while faster export growth, given aggregate demand growth, reduces the current account deficit. Including both export growth and GDP growth indicates that the latter is the most significantly related to crisis probability.

Domestic credit expansion, on the other hand, does have a positive impact on crisis probability. However, is not statistically significant at conventional levels.

- External conditions

In principle one should expect that crises are more likely whenever external conditions deteriorate. Declining terms of trade, higher international interest rates, and the interaction of the latter with the outstanding stock of external debt should make for difficult circumstances.

However, the results from our estimations are mixed. When controlling for the ratio of reserves to short term debt as well as the deviation of the real exchange rate from trend, the effect of the terms of trade on crisis probability is far from being clear cut. In several exploratory specifications (not reported) actually the effect of positive terms of trade shocks (identified either by the change over previous periods or the deviation from an HP trend) seems to increase the probability of a crisis. Moreover, another result that is somewhat striking is the lack of a statistical significant direct relation between changes in international interest rates (proxied here by the TBILL rate and crisis probability.

These odd results, if they stand closer scrutiny, could result from correlations with our main variables that relate to the crisis probability: the ratio of reserves to short term debt as well as the exchange rate deviations from trend. On the one hand, a fall in the terms of trade or an increase in international interest rates could influence crisis probability through the impact it has on reserve policy. Evidence on this front is suggestive.[8]

The interaction term between international interest rates and the stock of total external debt, a usual measure of the financial burden of external debt, is statistically related to crisis probability only in one specification.[9]

3.3 Financial development, political variables and crisis probability

One of the hypothesis presented in this paper is that the probability of a crisis may be affected by the incidence of institutional aspects. In particular we are interested in evaluating the incidence of financial market development on crisis, and the role of polítical institutions in determining the vulnerability of countries to external shocks.

We expect that more developed financial systems should allow for a lower need for reserves to stave off crises. A deeper or better functioning financial system should allow to funnel domestic resources to prevent the costly adjustments in the face of crises. At the same tieme, we expect that better political institutions, in the sense of being more transparent and accountable, reduce the likelihood of "crony capitalism", allow market participants to see economic policy measures as credible, and are themselves better suited to face in a prompt and efficient manner financial turbulences.

To analyze the implications of financial develpment on crisis probability of we use the database on financial system indicators presented by Demigurc and Kunt (2001), from which we select four indicators. Two are intended to reflect the size of the financial market, and two capture the efficiency of the financial sector.

- Efficiency of the financial sector.

[8] Garcia (1999) finds that, in contrast to the predictions of standard models of reserve demand, the correlation between reserves an international interest rates is negative for emerging economies. Exploring regressions that include the ratio of short-term debt lead to a positive but slightly significant effect of the international interest rate on crisis probability.

[9] This result can be found in previous work: REFERENCES

We expect that more efficiency reduces the probability of crisis by increasing the informational content of price signals and therefore allowing for a smoother adjustment by the private sector. The variables selected are the net interest margin and the stock market turnover. The net interest margin is measured as the accounting value of bank's net interest revenues as a share of total assets. A lower reliance on this type of income reflects narrower spreads between lending and borrowing rates, and therefore, is indicative of a more competitive banking system, a financial market where the informational asymmetries are smaller, or a financial market where the heterogeneity of agents with respect to their idiosyncratic risk is more muted. Meanwhile, a bigger stock market turnover is indicative of lower transaction costs or a larger degree of liquidity is stocks.

- Size of the financial sector

A larger financial sector should allow the fiscal or monetary authorities to tap the required resources to stave off liquidity shocks, instead of having to draw international reserves. The variables selected are total private credit by banks and similar institutions, and stock market capitalization.

- Political system

It is inherently difficult to select a particular variable that summarizes the implication of political institutions on the vulnerability of a country. Therefore, we draw from other work and use an index of institutional development, constructed as the first principal component of four indicators: Prevalence of law and order, quality of burocracy, absence of corruption, accountability of public officials.[10] We denominate this index Governance.[11]

Tables 4 to 6 present the effect of including the financial system variables and governance, both individually and with an interaction term, in the four benchmark set of estimates (one for each scaling variable for reserves). These variables are lagged two years to mitigate simultaneity bias.

It is noteworthy that the main results highlighted in the previous section still stand out. Economic growth, real exchange rate misalignment and the ratio of reserves to the different scaling variables are all statistically related to the crisis probability.

The effect of the financial and political system variables is much less clear cut, which is rather surprising. When included individually, in all specifications governance variables (both the aggregate measure and two single indicators: prevalence of law and order and absence of corruption) are far from statistical significance. Financial system variables too are far from having a statistically significant effect on crisis probability when included alone, except for the case of net interest margin, which has a negative effect on crisis probability (columns

[10] We are thankful to Cesar Calderon for providing us with this dataset. The original source is Political and Risk Services (PRS) Group. International Country Risk Guide. Various Issues.

[11] Aizenman and Marion (2003) show that the quality of political institution may affect the optimal level of reserves holdings.

1 to 8). Interaction terms improve only slightly the results. The specifications that fit our hypothesis better are the ones in columns 13, 14 and 16 in Tables 4 to 6. The results in column 13 indicate that better public institutions, measured by the governance variable, reduce the probability of crisis, but that this effect is bigger for economies with small financial systems (measured by the amount of private credit). This last variable seems to actually increase the probability of crisis. The results in column 14, on the other hand, indicate that a bigger stock market capitalization reduces eventually the probability of crises but only for countries with high standards of governance. The latter variable, in this specification, seems to be related to more likely crises. Finally, column 16 show that a larger net interest margin increases the probability of crises but only for high values of the governance variable, which is by itself negatively, although not statistically, related to this probability.

Tables 7 to 9 present the results using only the initial value, for each country, of political and financial system variables. At the cost of losing variability this is likely to better prevent simultaneity bias, in case it exists. The results however are only slightly different from those already commented.

As a conclusion, political and financial variables are far from being strongly related to crisis probabilities. The effects are not always statistically significant, and the signs are often opposite to our priors. In contrast to this, the results of the benchmark estimates remain. The ratio of short term debt to several measures of liabilities, the rate of growth and exchange rate misalignment are all still strong determinants of crisis probability.

4 An assessment of recent trends in reserve accumulation

In the context of the recent debate on reserves accumulation in East Asian it has been argue that, while reserves may be useful as a tool to avoid crisis, there is a limit for level of reserves needed to actually prevent a financial crisis. It has been argue that a ratio of reserves to STD above one would reduce considerably the crisis vulnerability of a country but a ratio much above one would do nothing to reduce the risk of a crisis (see for example IMF, 2003). While theoretical arguments can be made to justify such an assertion, there is no sistematic quantitative evaluation of the contribution of reserves to reduce the crisis vulnerability.

In this secction we take at face value our estimates of crisis probability from the previous sections to evaluate recent trends in reserves accumulation by some East Asian emerging economies and for Chile. Importantly, our model for crisis probability encompass non-linear effects of liquidity measures. While these non-linear effect may not be enough to capture a possible threshold level for the reserves to short-term debt ratio above which its marginal contribution to reduce the risk of a crisis is nil, at least the quantitative magnitud arise from the data.

We perform two types of exercises. First, we determine the optimal level of the reserves for each country under different assumptions about the cost of a crisis. Second, we establish the implicit cost of a crisis that underlines actual holding of reserves under the assumption that the level of reserves is determined in each countries optimally through a cost-benefit analysis.

To determine the optimal level of reserves we follow closely the cost-benefit analysis of Ben Bassat and Gottlieb (1992). Consider the problem of a Central Bank that decides the amount of reserves it will carry over period t by minimizing an expected loss function that considers both the effects of reserve accumulation in terms of reducing the expected cost of a crisis, and the opportunity cost of reserves.[12]

We assume the loss function for the authority takes the following form:

$$\Lambda_t = p_t C_t + (1 - p_t)\, \rho_t R_t \tag{6}$$

where p_t is the probability of a crisis, which depends on the reserves to short-term debt ratio and which is given by expression (5), C_t is the cost of a crisis, R_t is the level of reserves and ρ_t is the unit cost of reserves. The authority decides period by period the optimal amount of reserves by minimizing (6) subject to

$$K_t - W_t + R_t = D_t \tag{7}$$

where K_t is the capital stock of the economy, W_t is total wealth, and $D_t = S_t + LTD_t$ is the total debt of the country composed by short-term debt, S_t, and medium and long term debt, LTD_t. We assume that short-term debt is predetermined and any change in reserves is financed with medium and long term borrowing. This assumption is important in order to have an interior solutions for the optimal amount of reserves. To understand this point suppose reserves are completelly financed with short-term debt. That means that any change is reserves conveys a one-to-one change in short term debt, and the ratio between these two variables is never modified. This implies that the authority can not affect the probability of crisis by adjusting reserves. Since carrying reserves is costly and reports no benefit then the optimal amount would tend to be zero.

We assume that reserves not only affect the probability of a crisis but also the cost of crises. Depending on how reserves are utilized, and in cases where a crisis has its origins in a liquidity shock, larger amounts of international reserves could imply that countries avoid costly liquidation of assets. This, in turn, would reduce the impact of the shock on domestic output. De Gregorio and Lee (2004), for example, find a statistically significant effect of liquidity –measured as reserves relative to either domestic liabilities (M2) or short term debt— to reduce the cost of a BoP crisis.[13]

[12] It has been shown by De Gregorio and Lee (2004) and Park and Lee (2002) among others that real output growth follows typically a `V` pattern over the period before and after a crisis. However, the post-crisis growth rate for those countries do not exceed the pre-crisis period average. That means that a crises entail a permanent output loss.

[13] De Gregorio and Lee (2004) also find that financial soundness, real exchange rate depreciation and the monetary policy play a critical role in reducing output losses associated with BoP crises.

In our case, we assume that the cost of a crisis –as a fraction of GDP– is a function, amongst other variables, of the reserves to short-term debt ratio :

$$\frac{C_t}{Y_t} = C\left(\frac{R_t}{S_t}, ...\right).$$

The first order condition for the problem of the authority is given by the following expression,

$$p_{R,t}C_t + p_t\frac{\partial C_t}{\partial R_t} + (1-p_t)\,\rho_t - p_{R,t}\rho_t R_t = 0, \tag{8}$$

where the partial derivative of the crisis probability with respect to R is given by $p_{R,t} = (1-p_t)\,p_t\left(\beta_0\frac{1}{S_t} + \beta_1\frac{1}{Y_t}\right)$.

Notice that we have assumed that the opportunity cost of reserves is independent from the reserves to short-term debt ratio. In theory, this opportunity cost corresponds to the difference between the marginal productivity of capital in the economy and the yield on reserves —which is typically lower than then productivity of capital. In our empirical application below we take as a proxy for this opportunity cost the sovereign spread of each country in our sample. These sovereign spreads depend, among other things, on the perceived risk of each country and, therefore, could be affected their international liquidity. However, empirical estimations of the determinants of sovereign spread for emerging economies show that the effect of reserves is negligible and in many cases statistically not significant. Moreover, some recent empirical studies for emerging markets show that short-run movements in spreads are explained by changes in market conditions rather than fundamentals (Naudon, 2004). By not considering possible effects of reserves on spreads our results would tend to underestimate the optimal level of reserves.

Combining the previous two expressions we obtain the following non-linear equation in R_t:

$$\begin{aligned} 0 = (1-p_t)\,p_t\left(\beta_0\left(\frac{S_t}{Y_t}\right)^{-1} + \beta_1\right)\left(\frac{C_t}{Y_t} - \rho_t\frac{R_t}{Y_t}\right) \\ + p_t\eta\left(\frac{S_t}{Y_t}\right)^{-1} + (1-p_t)\,\rho_t \end{aligned} \tag{9}$$

where $\eta = \frac{\partial C}{\partial(R_t/S_t)}$ corresponds to the change in the cost of a crisis associated with an change in the reserves to short-term debt ratio.

4.1 Optimal level of reserves for selected economies

We compute the optimal level of reserves derived from equation (9) for four Asian economies: China, Korea, Malaysia, and Thailand, and for Chile. As a proxy of the opportunity cost we take data on sovereign spreads from EMBI global. We utilize two of our benchmark estimates of crisis probability from

the previous section: One that utilizes BIS data to construct the reserves to short-term debt ratio (specification 7, table 1), and another that utilizes WB data (specification 7 in table 2). Finally, we assume that $\eta = -0.0025$ which is the value estimated by De Gregorio and Lee (2004) for the marginal effect of the reserves to short-term debt ratio on the cost of a crisis.

Table 7 presents the estimates of the optimal level of reserves for three possible crisis cost: 5% GDP, 10% GDP and 15% GDP. These figures correspond roughly to the cost of three different types of crisis according to the estimates in IMF (1998): A currency crisis, a currency crash, and a banking crisis.[14]

From the results based on the BIS data we conclude that the amount of reserves hold by Malaysia, Thailand and Korea by 2003 is not above what would be optimal for those countries.[15] For these three countries, even if the cost of a crisis is low, the amount of reserves being hold would be justified. In fact, for mild cost of crisis the optimal amount of reserves could be up to 100% above what is actually being hold.

If we consider the results based on the WB data, however, then the amount of reserves hold by Thailand and Korea would be roughly consistent with the optimal amount for a mild crisis. On the contrary, for Malaysia there would be a clear excess of reserves.

In the case of China, no matter how strong is the crisis, actual reserves would be at least twice as much as it would be optimal with the BIS estimates. Using these estimates the optimal level of reserves during 2003 should be approximately 12.3 % of GDP if we consider a crisis cost of 15% of GDP. This number is 85% less than the amount of reserves being hold currently by China. Now, if we consider the WB estimates then China's reserves would be consistent with a cost of a crisis that ranges from mild to strong.

In the case of Chile, actual reserves are systematically above its optimal level except in the case of the optimal level based on BIS data but only for the last 3 years and when the cost of a crisis is 15% of GDP. For moderate cost (10% of GDP) reserves are above its optimal level between 40% and 100%.

4.2 Implicit cost of crisis

An alternative way of evaluating reserves consist in determining what is the implicit cost of a crisis that is behind the actual level being hold. In table 8 we present such estimates assuming that this level of reserves is determined optimally according to equation (9).

The implicit cost of a crisis ranges from 4.9 to 11.6% of GDP in the case of Thailand and 2.9 to 6.6% GDP for Korea. In order words, the level of reserves of these two countries is consistent with a soft to mild crisis. In the

[14] According the figures reported by the IMF (1998), the average cost of a currency crisis, a currency crash, and a banking crisis in emerging markets –in terms of loss of output relative to trend– is approximately 7.6% of GDP, 10.7% of GDP, and 14.0% of GDP, respectively.

[15] Optimal level of reserves for the years 2000 and 2001 for these three countries are not well defined because the crisis probability those years is polluted by the recovery period after the Asian crisis.

case of Malaysia, the implicit cost of a crisis could be very low if we utilize the estimates using BIS data (2.8%), or relatively high, if we consider WB data (21.7%). Therefore, our conclusion with respect to the adequacy of reserves for this country are more mixed.

The cost of a crisis that is implicit in the level of reserves hold by China is extremely high when considering the estimate based on BIS data. According to our calculation, the cost of a crisis that would justify the amount of reserves hold should be approximately 150% GDP, clearly larger than any actual crisis. If consider, the estimated based on WB data, then the implicit cost of a crisis is consistent with a mild crisis (approximately 11% of GDP).

To understand why the level of reserves hold by countries such as Thailand and Korea does not seem to be above what should be the optimal for those countries, it is necessary to consider both the cost of holding reserves and the probability of a crisis. For these two countries, the probability of a crisis the last two years was not extremely high (2.5% - 5% in the case of Thailand, and 2.6% - 5.9% in the case of Korea) but much larger than the crisis probability of countries like China (between 0% and 1%). At the same time the cost of carrying reserves for these two economies has been very low (around 100 basis points over the last two years). Therefore, the cost benefit analysis that is implicit in equation (**??**) implies that the optimal level of reserves should be relatively high.

The clear excess of reserves in the case of China with the BIS data is due to the fact that the crisis probability is very low. In fact, the cost of reserves for China is the lowest for all the countries in our sample (less than 100 basis points the last two years). In other words, the excess of reserves for this country is not due to the high cost of carrying reserves but is explained by the low benefits of them. Notice that the low spread in the case of China reflects in part the low risk of a crisis for this country.

Finally, the implicit cost of a crisis in the case of Chile corresponds to the cost of a mild to severe crisis. However, this implicit cost is much lower that the cost of the Chilean crisis in at the beginning of the 80's which was in the range of 20% to 40% of GDP approximately.

5 Conclusions

It has been argued that reserve accumulation allows to reduce the likelihood of self-fulfilling speculative attacks. Also, it has been stressed that reserve accumulation is a relatively costly self-insurance strategy, and it can be actually counterproductive. Large reserves stocks may create moral hazar problems that could weaken the financial system of a country. This, in turn, could make crises to be deeper in those economies.

In this paper we estimate the impact of reserves on the probability of a crisis. Our goal is to evaluate how robust are reserves –or the lack of them– in explaining crisis after controlling for set of indicators, including the quality of political institutions and the soundness of the financial system. The empirical

evidence we present indicates that the probability of crisis is still strongly related to this ratio of reserves to short-term debt even when controlling for institutional variables.

We then utilize our estimates of crisis probabilities to evaluate the optimal level of reserves from a cost-benefit analysis for a selected group of East Asian economies and for Chile. In this exercise we show that the actual size of the reserve stock observed today in some of those countries is not far from what would be implied by the usual cost of crises. Our results lead us to the conclusion that recent trends in reserve accumulation by Asian economies could be a sensible approach to dealing with the current macroeconomic conditions in the world economy.

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Figure 1: Reserves to M2

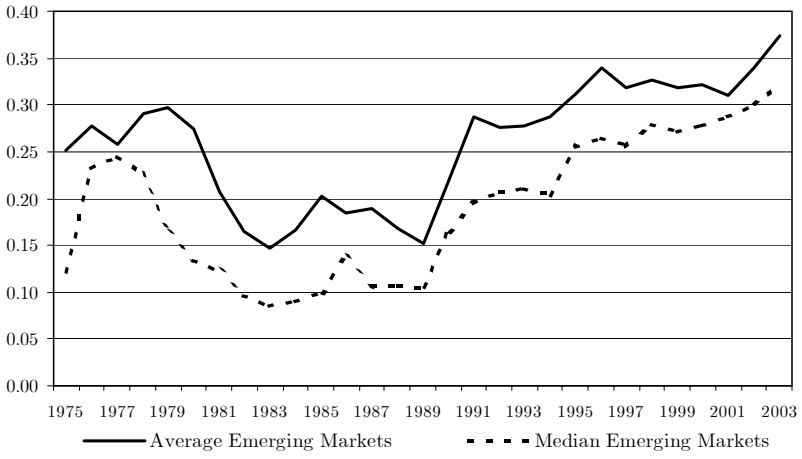

Figure 2: Reserves to STD

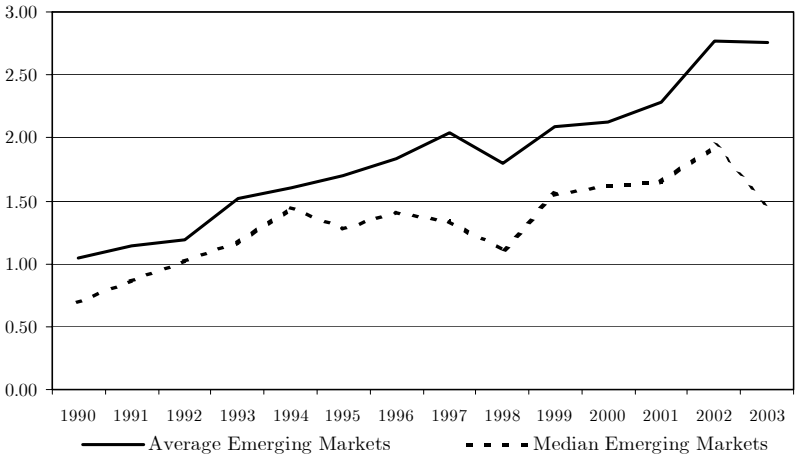

Figure 3: Reserves to GDP

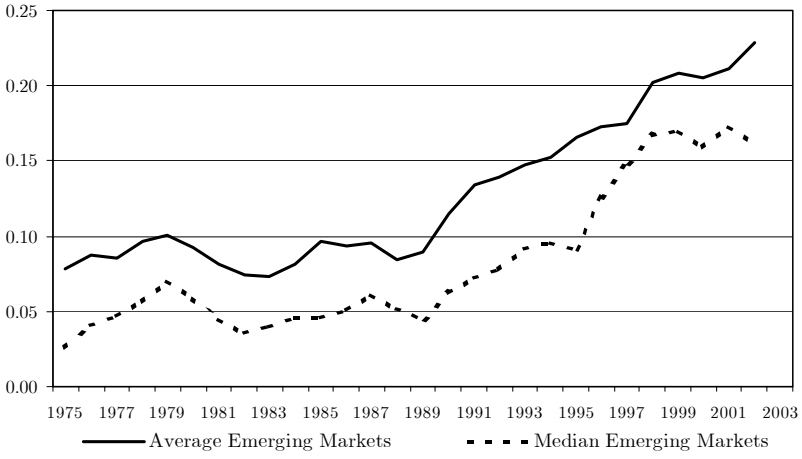

Figure 4: STD (Residual-BIS) to GDP

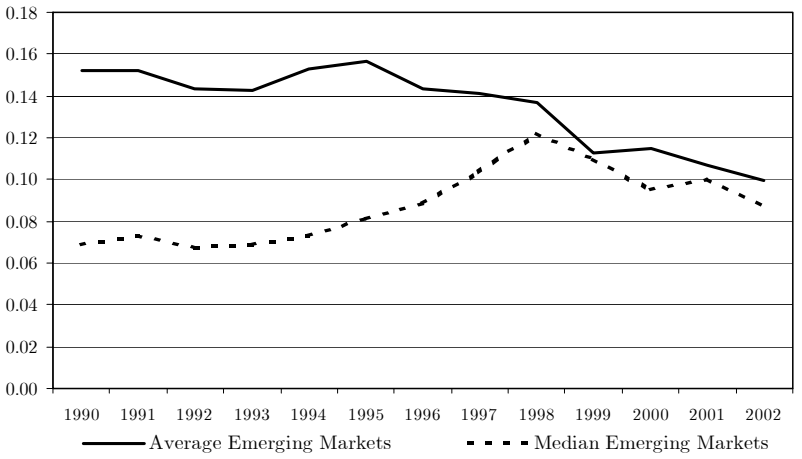

Table 1: Benchmark Estimation of Crisis Probability. Liquidity Measure: Reserves to Short Term Debt from BIS.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
REER MIS	-5.388	-5.759	-8.515	-8.689	-5.384	-5.786	-8.592	-8.781	-8.73	-8.809	-5.427	-5.801	-8.743
	[3.94]**	[3.99]**	[4.64]**	[4.63]**	[3.82]**	[3.85]**	[4.48]**	[4.39]**	[4.65]**	[4.63]**	[3.83]**	[3.85]**	[4.51]**
OPEN	1.88	2.747	3.226	3.842	2.36	3.397	3.459	4.217	3.267	3.951	2.345	3.413	3.471
	[1.14]	[1.70]*	[1.91]*	[2.25]*	[1.39]	[2.00]*	[2.02]*	[2.40]*	[1.93]*	[2.29]*	[1.38]	[2.01]*	[2.02]*
R/STD	-0.357	-0.424	-0.427	-0.532	-0.419	-0.527	-0.454	-0.585	-0.449	-0.548	-0.425	-0.528	-0.468
	[1.82]*	[1.88]*	[1.88]*	[1.93]*	[1.96]*	[2.08]*	[1.94]*	[2.00]*	[1.92]*	[1.94]*	[1.97]*	[2.08]*	[1.96]*
TD/GDP	-0.552		-1.655		-0.635		-1.602		-1.636		-0.622		-1.58
	[0.74]		[2.04]*		[0.85]		[2.01]*		[1.99]*		[0.82]		[1.96]*
CRED	0.323	0.343	0.497	0.532	0.44	0.502	0.562	0.625	0.51	0.546	0.444	0.504	0.566
	[1.13]	[1.18]	[1.26]	[1.29]	[1.46]	[1.59]	[1.37]	[1.43]	[1.31]	[1.34]	[1.47]	[1.60]	[1.39]
PUB. DEBT		-1.312		-2.307		-1.47		-2.245		-2.3		-1.465	
		[1.39]		[2.39]*		[1.52]		[2.35]*		[2.35]*		[1.51]	
Growth			-13.367	-12.865			-12.964	-12.281	-13.758	-13.199			-13.298
			[3.90]**	[3.80]**			[3.71]**	[3.51]**	[3.94]**	[3.84]**			[3.74]**
Exports					-2.964	-3.836	-1.878	-2.588			-2.911	-3.77	-1.678
					[1.61]	[1.96]*	[1.00]	[1.29]			[1.57]	[1.92]*	[0.88]
TBILL									-0.175	-0.202	-0.073	-0.069	-0.145
									[0.88]	[0.81]	[0.38]	[0.30]	[0.71]
ΔTBILL													
TBILL*TD/GDP													
Constant	-3.207	-3.233	-2.616	-2.766	-3.072	-3.07	-2.602	-2.743	-1.82	-1.832	-2.741	-2.756	-1.949
	[5.24]**	[5.37]**	[4.22]**	[4.55]**	[4.98]**	[5.02]**	[4.17]**	[4.40]**	[1.67]*	[1.43]	[2.60]**	[2.27]*	[1.77]*
Observations	512	480	511	479	506	474	505	473	511	479	506	474	505
pseudo R2	0.12	0.14	0.21	0.23	0.13	0.16	0.21	0.23	0.21	0.23	0.13	0.16	0.22
N crisis	24	23	24	23	24	23	24	23	24	23	24	23	24

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 1 (concluded)

	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]
REER MIS	-8.83	-9.224	-9.342	-5.467	-5.854	-9.234	-9.345	-8.602	-8.595	-5.371	-5.662	-8.644	-8.655
	[4.41]**	[4.75]**	[4.73]**	[3.87]**	[3.90]**	[4.63]**	[4.54]**	[4.62]**	[4.56]**	[3.80]**	[3.76]**	[4.48]**	[4.30]**
OPEN	4.264	3.517	4.248	2.425	3.496	3.667	4.499	3.245	3.706	2.366	3.077	3.47	4.042
	[2.42]*	[2.06]*	[2.43]*	[1.43]	[2.05]*	[2.13]*	[2.53]*	[1.92]*	[2.12]*	[1.40]	[1.79]*	[2.02]*	[2.27]*
R/STD	-0.592	-0.461	-0.569	-0.419	-0.523	-0.48	-0.612	-0.435	-0.517	-0.418	-0.481	-0.458	-0.567
	[2.00]*	[1.97]*	[1.97]*	[1.95]*	[2.06]*	[1.99]*	[2.01]*	[1.90]*	[1.87]*	[1.95]*	[1.90]*	[1.94]*	[1.93]*
TD/GDP		-1.715		-0.643		-1.656		-1.067		-0.851		-1.218	
		[2.07]*		[0.85]		[2.04]*		[0.61]		[0.51]		[0.70]	
CRED	0.627	0.59	0.631	0.452	0.511	0.631	0.691	0.503	0.538	0.438	0.527	0.564	0.638
	[1.45]	[1.40]	[1.42]	[1.50]	[1.64]	[1.45]	[1.50]	[1.28]	[1.29]	[1.45]	[1.65]*	[1.38]	[1.44]
PUB. DEBT	-2.233		-2.449		-1.496		-2.358		-2.855		-3.234		-3.011
	[2.31]*		[2.44]*		[1.54]		[2.40]*		[1.58]		[1.81]*		[1.67]*
Growth	-12.511	-14.205	-13.619			-13.928	-13.217	-13.507	-12.62			-13.068	-11.908
	[3.53]**	[4.05]**	[3.94]**			[3.92]**	[3.72]**	[3.91]**	[3.67]**			[3.71]**	[3.34]**
Exports	-2.368			-2.656	-3.489	-1.364	-1.934			-2.987	-4.061	-1.825	-2.719
	[1.16]			[1.40]	[1.72]*	[0.73]	[0.97]			[1.62]	[2.04]*	[0.97]	[1.34]
TBILL	-0.139												
	[0.55]												
ΔTBILL		-0.361	-0.383	-0.136	-0.14	-0.336	-0.341						
		[1.73]*	[1.78]*	[0.68]	[0.66]	[1.58]	[1.54]						
TBILL*TD/GDP								-0.116	0.097	0.043	0.301	-0.075	0.132
								[0.37]	[0.37]	[0.15]	[1.26]	[0.24]	[0.51]
Constant	-2.101	-2.84	-2.99	-3.176	-3.174	-2.818	-2.949	-2.638	-2.802	-3.066	-3.159	-2.621	-2.782
	[1.60]	[4.37]**	[4.65]**	[4.98]**	[5.00]**	[4.33]**	[4.52]**	[4.19]**	[4.58]**	[4.97]**	[5.17]**	[4.14]**	[4.47]**
Observations	473	511	479	506	474	505	473	511	479	506	474	505	473
pseudo R2	0.24	0.22	0.24	0.13	0.16	0.23	0.25	0.21	0.23	0.13	0.17	0.21	0.24
N crisis	23	24	23	24	23	24	23	24	23	24	23	24	23

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 2: Benchmark Estimation of Crisis Probability. Liquidity Measure: Reserves to Short Term Debt from WB.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
REER MIS	-5.271	-5.293	-5.756	-5.807	-5.246	-5.26	-5.725	-5.763	-5.711	-5.779	-5.187	-5.211	-5.699
	[6.28]**	[6.28]**	[6.33]**	[6.34]**	[6.08]**	[6.07]**	[6.24]**	[6.23]**	[6.26]**	[6.27]**	[6.01]**	[6.01]**	[6.19]**
OPEN	0.081	0.441	-0.067	0.225	0.294	0.62	0.029	0.3	-0.134	0.188	0.167	0.52	-0.014
	[0.06]	[0.34]	[0.05]	[0.17]	[0.22]	[0.47]	[0.02]	[0.23]	[0.10]	[0.14]	[0.12]	[0.39]	[0.01]
R/STD	-0.267	-0.293	-0.241	-0.257	-0.262	-0.286	-0.236	-0.251	-0.228	-0.249	-0.241	-0.269	-0.229
	[1.92]*	[2.07]*	[1.77]*	[1.85]*	[1.90]*	[2.04]*	[1.73]*	[1.81]*	[1.66]*	[1.77]*	[1.74]*	[1.90]*	[1.65]*
TD/GDP	-0.016		-0.392		-0.043		-0.344		-0.338		0.03		-0.315
	[0.03]		[0.75]		[0.08]		[0.66]		[0.63]		[0.06]		[0.59]
CRED	0.191	0.203	0.371	0.397	0.277	0.29	0.409	0.431	0.376	0.399	0.285	0.295	0.411
	[0.74]	[0.78]	[1.37]	[1.44]	[1.06]	[1.11]	[1.50]	[1.56]	[1.38]	[1.45]	[1.09]	[1.13]	[1.50]
PUB. DEBT		-0.49		-0.942		-0.495		-0.86		-0.902		-0.418	
		[0.77]		[1.43]		[0.78]		[1.31]		[1.33]		[0.64]	
Growth			-5.927	-6.21			-5.431	-5.703	-5.771	-6.117			-5.354
			[3.29]**	[3.43]**			[2.96]**	[3.08]**	[3.15]**	[3.32]**			[2.88]**
Exports					-2.06	-2.066	-1.281	-1.208			-1.909	-1.944	-1.233
					[2.00]*	[2.01]*	[1.20]	[1.13]			[1.84]*	[1.87]*	[1.15]
TBILL									0.026	0.015	0.04	0.032	0.015
									[0.46]	[0.27]	[0.74]	[0.59]	[0.26]
ΔTBILL													
TBILL*TD/GDP													
Constant	-2.918	-2.8	-2.486	-2.39	-2.889	-2.778	-2.518	-2.422	-2.697	-2.511	-3.198	-3.019	-2.636
	[6.60]**	[6.69]**	[5.41]**	[5.51]**	[6.47]**	[6.54]**	[5.44]**	[5.53]**	[4.14]**	[4.02]**	[5.18]**	[5.07]**	[4.04]**
Observations	897	897	874	874	891	891	868	868	874	874	891	891	868
pseudo R2	0.16	0.16	0.19	0.19	0.17	0.17	0.19	0.19	0.19	0.19	0.17	0.17	0.19
N crisis	55	55	54	54	55	55	54	54	54	54	55	55	54

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 2 (concluded)

	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]
REER MIS	-5.755	-5.806	-5.863	-5.271	-5.294	-5.754	-5.799	-5.664	-5.701	-5.167	-5.193	-5.646	-5.668
	[6.19]**	[6.36]**	[6.36]**	[6.08]**	[6.07]**	[6.25]**	[6.25]**	[6.24]**	[6.24]**	[6.03]**	[6.03]**	[6.16]**	[6.16]**
OPEN	0.286	0.007	0.312	0.336	0.677	0.073	0.356	-0.288	-0.131	-0.045	0.099	-0.175	-0.039
	[0.21]	[0.01]	[0.23]	[0.25]	[0.51]	[0.05]	[0.27]	[0.21]	[0.10]	[0.03]	[0.07]	[0.13]	[0.03]
R/STD	-0.249	-0.246	-0.262	-0.265	-0.289	-0.239	-0.255	-0.21	-0.199	-0.216	-0.205	-0.21	-0.2
	[1.76]*	[1.78]*	[1.87]*	[1.91]*	[2.05]*	[1.74]*	[1.82]*	[1.56]	[1.47]	[1.60]	[1.52]	[1.55]	[1.47]
TD/GDP		-0.407		-0.058		-0.356		-0.971		-0.85		-0.832	
		[0.77]		[0.11]		[0.68]		[1.27]		[1.13]		[1.09]	
CRED	0.431	0.376	0.402	0.278	0.291	0.41	0.432	0.384	0.42	0.295	0.321	0.416	0.444
	[1.56]	[1.39]	[1.47]	[1.06]	[1.11]	[1.50]	[1.57]	[1.41]	[1.51]	[1.13]	[1.22]	[1.51]	[1.60]
PUB. DEBT	-0.848		-0.967		-0.522		-0.881		-1.768		-1.585		-1.607
	[1.26]		[1.46]		[0.81]		[1.34]		[2.07]*		[1.87]*		[1.86]*
Growth	-5.678	-5.877	-6.146			-5.429	-5.696	-5.496	-5.531			-5.104	-5.165
	[3.03]**	[3.26]**	[3.38]**			[2.96]**	[3.07]**	[2.98]**	[2.97]**			[2.73]**	[2.73]**
Exports	-1.192			-2.003	-1.993	-1.207	-1.122			-1.792	-1.692	-1.15	-0.992
	[1.10]			[1.91]*	[1.90]*	[1.11]	[1.03]			[1.73]*	[1.63]	[1.08]	[0.92]
TBILL	0.005												
	[0.09]												
ΔTBILL		-0.056	-0.06	-0.028	-0.035	-0.034	-0.039						
		[0.57]	[0.62]	[0.29]	[0.37]	[0.34]	[0.40]						
TBILL*TD/GDP								0.108	0.138	0.144	0.174	0.09	0.123
								[1.08]	[1.56]	[1.52]	[2.04]*	[0.91]	[1.38]
Constant	-2.46	-2.5	-2.405	-2.895	-2.786	-2.525	-2.43	-2.563	-2.596	-2.953	-2.985	-2.577	-2.598
	[3.92]**	[5.43]**	[5.53]**	[6.48]**	[6.56]**	[5.45]**	[5.54]**	[5.48]**	[5.64]**	[6.53]**	[6.73]**	[5.48]**	[5.63]**
Observations	868	874	874	891	891	868	868	874	874	891	891	868	868
pseudo R2	0.19	0.19	0.19	0.17	0.17	0.19	0.2	0.19	0.2	0.17	0.18	0.19	0.2
N crisis	54	54	54	55	55	54	54	54	54	55	55	54	54

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 3: Benchmark Estimation of Crisis Probability. Liquidity Measure: Reserves to Total Debt from WB.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
REER MIS	-4.487	-5.336	-6.764	-5.75	-4.401	-5.304	-6.809	-5.726	-6.955	-5.695	-4.438	-5.247	-6.995
	[3.68]**	[6.39]**	[4.20]**	[6.35]**	[3.47]**	[6.19]**	[4.11]**	[6.26]**	[4.21]**	[6.27]**	[3.48]**	[6.12]**	[4.13]**
OPEN	1.034	0.331	1.183	-0.196	1.231	0.473	1.397	-0.06	1.26	-0.233	1.235	0.402	1.482
	[0.61]	[0.26]	[0.71]	[0.15]	[0.72]	[0.37]	[0.83]	[0.05]	[0.75]	[0.18]	[0.73]	[0.31]	[0.87]
R/TD	-1.359	-2.929	-0.406	-2.185	-1.395	-2.83	-0.527	-2.189	-0.544	-2.081	-1.453	-2.692	-0.655
	[0.93]	[2.46]*	[0.28]	[1.83]*	[0.94]	[2.36]*	[0.35]	[1.82]*	[0.36]	[1.74]*	[0.97]	[2.25]*	[0.43]
STD/TD	0.361		0.657		0.532		0.757		0.694		0.537		0.792
(BIS)	[0.51]		[0.89]		[0.73]		[0.98]		[0.93]		[0.73]		[1.02]
CRED	0.328	0.178	0.455	0.348	0.413	0.256	0.495	0.383	0.466	0.357	0.416	0.266	0.501
	[1.16]	[0.70]	[1.33]	[1.28]	[1.40]	[0.99]	[1.43]	[1.40]	[1.37]	[1.31]	[1.41]	[1.02]	[1.44]
STD/TD		2.085		2.248		2.008		2.095		2.103		1.836	
(GDF)		[1.41]		[1.52]		[1.36]		[1.41]		[1.40]		[1.22]	
Growth			-10.41	-5.324			-10.197	-4.875	-10.763	-5.19			-10.573
			[3.44]**	[3.02]**			[3.32]**	[2.71]**	[3.47]**	[2.92]**			[3.35]**
Exports					-2.21	-1.944	-1.442	-1.268			-2.166	-1.815	-1.321
					[1.26]	[1.89]*	[0.81]	[1.19]			[1.23]	[1.75]*	[0.73]
TBILL									-0.142	0.034	-0.063	0.039	-0.133
									[0.76]	[0.60]	[0.34]	[0.72]	[0.70]
ΔTBILL													
TBILL*TD/GDP													
Constant	-3.495	-3.218	-3.565	-3.044	-3.454	-3.186	-3.544	-3.023	-2.924	-3.255	-3.163	-3.423	-2.951
	[5.90]**	[6.81]**	[5.96]**	[6.44]**	[5.80]**	[6.70]**	[5.89]**	[6.35]**	[2.87]**	[5.51]**	[3.06]**	[5.89]**	[2.89]**
Observations	512	897	511	874	506	891	505	868	511	874	506	891	505
pseudo R2	0.1	0.16	0.16	0.19	0.11	0.17	0.17	0.19	0.16	0.19	0.11	0.17	0.17
N crisis	24	55	24	54	24	55	24	54	24	54	24	55	24

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 3 (concluded)

	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]
REER MIS	-5.688	-7.29	-5.795	-4.495	-5.322	-7.351	-5.75	-7.94	-5.751	-4.626	-5.262	-7.995	-5.737
	[6.20]**	[4.32]**	[6.36]**	[3.53]**	[6.18]**	[4.26]**	[6.26]**	[4.42]**	[6.30]**	[3.53]**	[6.14]**	[4.34]**	[6.22]**
OPEN	-0.095	1.26	-0.148	1.294	0.494	1.467	-0.034	3.198	-0.191	2.144	0.133	3.403	-0.007
	[0.07]	[0.76]	[0.11]	[0.76]	[0.38]	[0.88]	[0.03]	[1.59]	[0.13]	[1.12]	[0.09]	[1.69]*	[0.01]
R/TD	-2.121	-0.399	-2.186	-1.375	-2.825	-0.529	-2.189	-2.752	-2.192	-2.505	-2.435	-2.853	-2.254
	[1.75]*	[0.27]	[1.83]*	[0.93]	[2.36]*	[0.36]	[1.81]*	[1.36]	[1.60]	[1.34]	[1.79]*	[1.40]	[1.62]
STD/TD		0.699		0.544		0.787		0.593		0.509		0.68	
(BIS)		[0.95]		[0.75]		[1.03]		[0.67]		[0.65]		[0.73]	
CRED	0.387	0.537	0.353	0.429	0.256	0.557	0.383	0.503	0.348	0.418	0.264	0.533	0.382
	[1.41]	[1.49]	[1.30]	[1.45]	[0.99]	[1.54]	[1.40]	[1.34]	[1.28]	[1.41]	[1.02]	[1.40]	[1.40]
STD/TD	2.008		2.292		2.028		2.125		2.248		1.996		2.096
(GDF)	[1.33]		[1.54]		[1.37]		[1.42]		[1.52]		[1.35]		[1.41]
Growth	-4.799	-11.187	-5.29			-11.136	-4.879	-13.535	-5.329			-13.413	-4.927
	[2.65]**	[3.61]**	[3.00]**			[3.54]**	[2.72]**	[3.84]**	[2.88]**			[3.74]**	[2.62]**
Exports	-1.199			-1.94	-1.902	-1.02	-1.202			-2.251	-1.878	-1.269	-1.273
	[1.12]			[1.08]	[1.81]*	[0.57]	[1.10]			[1.27]	[1.81]*	[0.70]	[1.19]
TBILL	0.022												
	[0.40]												
ΔTBILL		-0.306	-0.051	-0.138	-0.02	-0.299	-0.029						
		[1.53]	[0.52]	[0.70]	[0.20]	[1.47]	[0.29]						
TBILL*TD/GDP								-0.383	-0.001	-0.189	0.04	-0.367	-0.007
								[1.95]*	[0.01]	[1.05]	[0.57]	[1.92]*	[0.10]
Constant	-3.162	-3.779	-3.071	-3.571	-3.2	-3.763	-3.039	-2.614	-3.041	-2.997	-3.314	-2.636	-2.997
	[5.32]**	[6.07]**	[6.45]**	[5.76]**	[6.67]**	[6.01]**	[6.34]**	[3.48]**	[5.61]**	[4.14]**	[6.27]**	[3.51]**	[5.49]**
Observations	868	511	874	506	891	505	868	511	874	506	891	505	868
pseudo R2	0.19	0.17	0.19	0.11	0.17	0.18	0.19	0.19	0.19	0.11	0.17	0.19	0.19
N crisis	54	24	54	24	55	24	54	24	54	24	55	24	54

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 4: Crisis Probability and Institutional Development (Political and Financial Variables). Liquidity Measure: Reserves to Short Term Debt from BIS.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
REER MIS	-7.249	-7.191	-7.345	-8.434	-7.601	-7.646	-8.698	-11.196
	[4.46]**	[4.40]**	[4.43]**	[4.43]**	[3.55]**	[3.58]**	[3.85]**	[3.63]**
R/STD	-0.327	-0.309	-0.325	-0.445	-0.705	-0.722	-0.817	-1.221
	[1.78]*	[1.66]*	[1.73]*	[1.84]*	[1.85]*	[1.87]*	[1.98]*	[2.18]*
Growth	-9.469	-9.454	-9.727	-9.645	-5.581	-5.654	-6.191	-1.657
	[3.24]**	[3.10]**	[3.23]**	[2.79]**	[1.30]	[1.30]	[1.49]	[0.30]
Exports	-1.331	-1.341	-1.366	-1.821	-3.066	-3.158	-4.506	-6.201
	[0.77]	[0.78]	[0.81]	[0.87]	[1.09]	[1.12]	[1.54]	[1.92]*
OPEN	0.553	0.552	0.136	3.362	0.815	1.481	0.634	1.409
	[0.50]	[0.48]	[0.12]	[1.94]*	[0.49]	[1.28]	[0.43]	[1.11]
CRED	0.52	0.521	0.501	-0.901	0.75	0.729	0.878	1.011
	[1.47]	[1.47]	[1.36]	[0.73]	[1.49]	[1.45]	[1.59]	[0.72]
Corrupt		0.004						
		[0.02]						
L&O			0.23					
			[1.14]					
Governance				0.33				
				[1.21]				
Capitalization					0.381			
					[0.57]			
Turnover						0.177		
						[0.22]		
Credit							1.13	
							[1.19]	
Net int. Margin								-25.195
								[1.53]
Constant	-2.98	-2.998	-3.674	-3.346	-3.251	-3.336	-3.569	-2.556
	[6.55]**	[3.57]**	[4.69]**	[5.96]**	[4.83]**	[4.53]**	[5.09]**	[2.35]*
Observations	567	550	550	416	287	291	364	286
pseudo R2	0.18	0.18	0.19	0.19	0.25	0.25	0.29	0.36
N crisis	24	24	24	22	13	13	14	11

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 4 (concluded)

	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
REER MIS	-12.004	-11.121	-10.804	-19.573	-14.193	-11.82	-10.668	-25.175
	[4.11]**	[3.67]**	[3.73]**	[3.47]**	[4.12]**	[3.64]**	[3.65]**	[3.23]**
R/STD	-1.539	-1.132	-1.159	-2.51	-1.822	-1.011	-1.17	-2.946
	[2.59]**	[2.23]*	[2.19]*	[2.27]*	[2.84]**	[1.99]*	[2.18]*	[2.05]*
Growth	-5.173	-5.313	-5.873	-5.05	-7.171	-6.922	-5.593	-7.082
	[1.20]	[1.15]	[1.23]	[0.72]	[1.48]	[1.38]	[1.16]	[0.83]
Exports	-6.126	-5.655	-5.534	-15.396	-6.155	-6.2	-5.551	-18.043
	[1.89]*	[1.69]*	[1.61]	[2.54]*	[1.90]*	[1.74]*	[1.62]	[2.31]*
OPEN	7.469	7.418	6.974	10.611	8.91	5.893	6.856	12.587
	[2.73]**	[2.56]*	[2.77]**	[2.79]**	[2.94]**	[1.91]*	[2.71]**	[2.74]**
CRED	-0.346	-0.077	-0.209	1.556	-0.985	-0.045	-0.242	1.435
	[0.23]	[0.05]	[0.12]	[0.71]	[0.64]	[0.03]	[0.15]	[0.59]
Governance	0.101	0.715	0.514	0.969	-1.731	1.554	0.36	-1.358
	[0.21]	[1.31]	[1.09]	[1.69]*	[1.76]*	[1.86]*	[0.65]	[1.07]
Capitalization		-0.194				2.277		
		[0.27]				[1.42]		
Turnover			0.561				0.088	
			[0.63]				[0.07]	
Credit	0.737				-0.42			
	[0.64]				[0.31]			
Net int. Margin				-37.621				-68.202
				[1.87]*				[2.04]*
Credit*Gov.					0.657			
					[1.99]*			
Capit.*Gov.						-2.583		
						[1.49]		
Turnover*Gov.							0.506	
							[0.53]	
Net Marg.*Gov.								61.619
								[1.92]*
Constant	-4.701	-4.73	-4.718	-4.389	-4.993	-4.953	-4.575	-3.942
	[4.86]**	[4.59]**	[4.77]**	[2.70]**	[4.97]**	[4.23]**	[4.50]**	[2.34]*
Observations	308	248	252	231	308	248	252	231
pseudo R2	0.33	0.3	0.3	0.5	0.37	0.33	0.3	0.55
N crisis	13	12	12	10	13	12	12	10

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 5: Crisis Probability and Institutional Development (Political and Financial Variables). Liquidity Measure: Reserves to Short Term Debt from WB.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
REER MIS	-5.709	-6.212	-6.209	-5.986	-4.931	-4.676	-5.966	-6.739
	[6.25]**	[5.09]**	[5.11]**	[6.37]**	[4.25]**	[4.02]**	[6.00]**	[2.65]**
R/STD	-0.211	-0.202	-0.207	-0.197	-1.157	-1.072	-0.333	-1.58
	[1.67]*	[1.39]	[1.40]	[1.50]	[2.75]**	[2.49]*	[1.74]*	[2.09]*
Growth	-5.118	-8.388	-8.382	-4.217	-0.487	-0.572	-4.207	0.909
	[2.93]**	[3.58]**	[3.63]**	[2.19]*	[0.22]	[0.25]	[2.15]*	[0.16]
Exports	-1.319	-0.576	-0.621	-1.265	-3.4	-3.017	-1.625	-7.629
	[1.24]	[0.42]	[0.45]	[1.14]	[2.13]*	[1.84]*	[1.34]	[1.90]*
OPEN	-0.252	0.781	0.739	-0.038	1.537	2.534	-0.377	6.598
	[0.20]	[0.55]	[0.52]	[0.03]	[0.89]	[1.42]	[0.25]	[2.20]*
CRED	0.397	0.431	0.429	-1.056	0.763	0.722	0.585	2.175
	[1.46]	[1.40]	[1.39]	[1.26]	[2.22]*	[2.01]*	[1.87]*	[1.14]
Corrupt		0.03						
		[0.15]						
L&O			0.043					
			[0.25]					
Governance				0.126				
				[0.85]				
Capitalization					0.886			
					[1.89]*			
Turnover						0.115		
						[0.17]		
Credit							1.584	
							[2.47]*	
Net int. Margin								-21.985
								[1.22]
Constant	-2.683	-2.992	-3.02	-2.539	-2.711	-2.891	-3.261	-3.238
	[6.79]**	[4.39]**	[4.97]**	[6.16]**	[4.95]**	[4.58]**	[6.55]**	[2.32]*
Observations	868	623	623	777	438	430	710	251
pseudo R2	0.19	0.19	0.19	0.19	0.25	0.23	0.22	0.38
N crisis	54	35	35	53	28	26	44	11

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 5 (concluded)

	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
REER MIS	-6.094	-5.448	-5.463	-9.079	-6.854	-5.833	-5.147	-12.379
	[6.04]**	[4.52]**	[4.39]**	[3.09]**	[4.90]**	[4.68]**	[4.05]**	[3.13]**
R/STD	-0.315	-1.125	-1.134	-1.824	-0.468	-1.428	-1.085	-1.684
	[1.59]	[2.68]**	[2.60]**	[1.98]*	[1.62]	[2.97]**	[2.49]*	[1.82]*
Growth	-2.823	0.466	-0.257	-0.962	-6.047	-0.919	0.077	-0.518
	[1.32]	[0.20]	[0.11]	[0.15]	[1.83]*	[0.37]	[0.03]	[0.07]
Exports	-1.452	-3.481	-3.218	-8.587	0.275	-3.395	-3.086	-10.877
	[1.16]	[2.18]*	[1.94]*	[1.95]*	[0.16]	[2.08]*	[1.86]*	[1.99]*
OPEN	-0.367	1.874	2.818	7.873	1.157	0.332	2.506	7.914
	[0.24]	[1.06]	[1.57]	[2.25]*	[0.60]	[0.17]	[1.36]	[2.23]*
CRED	-0.814	-0.915	-0.654	2.471	-0.841	-0.893	-0.596	3.074
	[0.86]	[0.77]	[0.54]	[1.10]	[0.70]	[0.73]	[0.49]	[1.25]
Governance	-0.118	0.17	0.42	1.362	-1.325	0.488	0.261	-0.733
	[0.64]	[0.65]	[1.67]*	[2.60]**	[2.93]**	[1.53]	[0.88]	[0.62]
Capitalization		0.692				2.954		
		[1.27]				[2.61]**		
Turnover			0.043				-0.49	
			[0.06]				[0.50]	
Credit	1.634				0.727			
	[2.14]*				[0.74]			
Net int. Margin				-18.406				-54.099
				[1.03]				[1.75]*
Credit*Gov.					0.48			
					[2.73]**			
Capit.*Gov.						-1.905		
						[2.22]*		
Turnover*Gov.							0.693	
							[0.95]	
Net Marg.*Gov.								54.317
								[1.78]*
Constant	-3.232	-2.633	-2.725	-4.158	-3.65	-2.276	-2.611	-3.289
	[5.65]**	[4.78]**	[4.37]**	[2.63]**	[5.08]**	[3.99]**	[4.12]**	[2.06]*
Observations	653	420	412	222	439	420	412	222
pseudo R2	0.22	0.24	0.23	0.43	0.26	0.27	0.24	0.48
N crisis	43	27	25	10	25	27	25	10

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 6: Crisis Probability and Institutional Development (Political and Financial Variables). Liquidity Measure: Reserves to Total Debt from WB.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
REER MIS	-5.951	-6.613	-6.615	-6.179	-5.544	-5.245	-6.345	-6.527
	[6.60]**	[5.48]**	[5.50]**	[6.66]**	[4.78]**	[4.52]**	[6.38]**	[2.86]**
R/TD	-1.642	-0.843	-0.907	-2.09	-5.446	-3.913	-3.668	-1.441
	[1.50]	[0.69]	[0.70]	[1.74]*	[2.62]**	[1.92]*	[2.29]*	[0.59]
Growth	-5.327	-9.219	-9.203	-3.961	-0.761	-0.919	-3.417	-2.781
	[2.98]**	[3.86]**	[3.89]**	[2.04]*	[0.34]	[0.40]	[1.71]*	[0.43]
Exports	-1.189	-0.386	-0.423	-1.334	-3.267	-3.007	-1.596	-3.766
	[1.13]	[0.29]	[0.32]	[1.19]	[2.06]*	[1.83]*	[1.32]	[1.33]
OPEN	-0.534	0.314	0.288	0.034	0.942	2.141	-0.283	3.959
	[0.42]	[0.22]	[0.20]	[0.03]	[0.58]	[1.25]	[0.19]	[1.60]
CRED	0.352	0.397	0.394	-1.031	0.485	0.475	0.528	0.649
	[1.30]	[1.29]	[1.28]	[1.23]	[1.53]	[1.40]	[1.68]*	[0.95]
Corrupt		0.024						
		[0.12]						
L&O			0.037					
			[0.22]					
Governance				0.151				
				[0.99]				
Capitalization					1.206			
					[2.44]*			
Turnover						0.17		
						[0.24]		
Credit							2.138	
							[3.14]**	
Net int. Margin								-13.559
								[0.85]
Constant	-2.641	-3.034	-3.061	-2.494	-2.867	-3.182	-3.385	-3.918
	[6.72]**	[4.62]**	[5.19]**	[5.90]**	[5.34]**	[5.04]**	[6.68]**	[2.98]**
Observations	925	672	672	802	446	438	733	255
pseudo R2	0.19	0.18	0.18	0.19	0.22	0.2	0.24	0.27
N crisis	55	36	36	53	28	26	44	11

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 6 (concluded)

	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
REER MIS	-6.439	-6.028	-6.014	-9.939	-7.414	-6.422	-5.707	-13.137
	[6.41]**	[4.99]**	[4.83]**	[3.40]**	[5.25]**	[5.11]**	[4.56]**	[3.42]**
R/STD	-3.449	-4.983	-4.357	-4.15	-3.359	-6.429	-4.543	-4.144
	[2.14]*	[2.42]*	[2.04]*	[1.29]	[1.47]	[2.78]**	[2.04]*	[1.29]
Growth	-2.111	0.133	-0.803	-1.5	-5.413	-1.158	-0.313	-0.994
	[0.98]	[0.06]	[0.33]	[0.23]	[1.58]	[0.47]	[0.13]	[0.13]
Exports	-1.487	-3.481	-3.141	-7.564	0.05	-3.431	-3.068	-8.539
	[1.19]	[2.15]*	[1.88]*	[1.81]*	[0.03]	[2.08]*	[1.85]*	[1.85]*
OPEN	-0.253	1.316	2.275	5.077	1.186	-0.08	1.952	5.897
	[0.16]	[0.80]	[1.34]	[1.91]*	[0.62]	[0.05]	[1.11]	[2.12]*
CRED	-0.724	-1.064	-0.896	1.623	-0.706	-1.129	-0.81	1.938
	[0.76]	[0.92]	[0.76]	[1.03]	[0.59]	[0.94]	[0.69]	[1.10]
Governance	-0.103	0.157	0.407	1.572	-1.152	0.471	0.219	-0.413
	[0.55]	[0.60]	[1.57]	[2.74]**	[2.69]**	[1.46]	[0.76]	[0.38]
Capitalization		0.96				3.183		
		[1.69]*				[2.84]**		
Turnover			0.278				-0.41	
			[0.37]				[0.40]	
Credit	2.104				1.354			
	[2.65]**				[1.36]			
Net int. Margin				-19.392				-51.168
				[1.14]				[1.92]*
Credit*Gov.					0.426			
					[2.50]*			
Capit.*Gov.						-1.813		
						[2.21]*		
Turnover*Gov.							1.026	
							[1.37]	
Net Marg.*Gov.								52.868
								[1.91]*
Constant	-3.336	-2.817	-2.978	-4.4	-3.963	-2.507	-2.802	-3.859
	[5.73]**	[5.15]**	[4.70]**	[2.92]**	[5.40]**	[4.54]**	[4.30]**	[2.73]**
Observations	676	428	420	226	455	428	420	226
pseudo R2	0.23	0.21	0.2	0.35	0.25	0.24	0.21	0.4
N crisis	43	27	25	10	25	27	25	10

* significant at 10%; ** significant at 1%
Absolute value of z statistics in brackets

Table 7: Actual and Optimal Reserves

	Actual Reserves (%GDP)	Optimal Reserves: Crisis cost 5% GDP BIS	WB	Crisis cost 10% GDP BIS	WB	Crisis cost 15% GDP BIS	WB
Chile							
2000	20.0	7.77	9.10	10.16	13.39	11.58	16.05
2001	19.9	0.00	1.81	13.84	11.72	27.57	17.93
2002	21.6	0.12	0.66	19.20	10.66	30.94	16.93
2003	23.9	0.00	0.00	16.18	11.34	31.62	19.66
China							
2000	15.9	4.45	6.63	6.58	10.48	7.87	12.86
2001	15.6	5.89	6.31	8.98	9.21	10.83	11.01
2002	18.3	6.88	8.74	9.67	17.52	11.35	22.96
2003	23.0	7.51	12.15	10.48	21.54	12.28	27.36
Malaysia							
2000	38.6	–	–	–	–	–	–
2001	32.7	–	–	–	–	–	–
2002	34.6	41.49	0.00	57.43	11.64	66.75	20.12
2003	36.1	51.12	2.01	69.17	17.38	79.70	27.04
Thailand							
2000	27.8	–	–	–	–	–	–
2001	26.1	–	–	–	–	–	–
2002	28.0	38.37	0.00	53.27	19.31	62.10	35.77
2003	30.0	30.31	1.40	43.34	24.82	51.11	39.50
Korea							
2000	18.2	–	–	–	–	–	–
2001	20.8	–	–	–	–	–	–
2002	24.1	21.80	0.33	34.85	18.87	42.65	30.52
2003	25.5	37.06	17.14	52.08	38.53	60.98	51.86

Table 8: Implicit Cost of a Crisis and Crisis Probability

	Actual Reserves (%GDP)	Spread (b.p.)	Crisis Probability (%)		Implicit Cost (%GDP)	
			BIS	WB	BIS	WB
Chile						
2000	20.0	197	4.31	0.49	7.6	27.0
2001	19.9	192	3.53	1.66	12.0	17.0
2002	21.6	177	3.30	1.35	10.9	20.1
2003	23.9	126	2.53	1.39	12.3	18.4
China						
2000	15.9	136	0.13	0.34	48.8	24.9
2001	15.6	127	0.14	0.15	41.8	40.7
2002	18.3	89	0.05	1.07	77.7	10.6
2003	23.0	57	0.02	0.73	159.6	11.1
Malaysia						
2000	38.6	217	–	–	–	–
2001	32.7	237	–	–	–	–
2002	34.6	187	8.84	1.33	3.7	29.3
2003	36.1	151	10.01	1.57	2.8	21.7
Thailand						
2000	27.8	163	–	–	–	–
2001	26.1	160	–	–	–	–
2002	28.0	103	5.05	2.87	3.0	12.4
2003	30.0	91	2.60	2.49	4.9	11.6
Korea						
2000	18.2	216	–	–	–	–
2001	20.8	211	–	–	–	–
2002	24.1	121	3.04	2.61	5.7	12.0
2003	25.5	106	5.87	4.61	2.9	6.6

Appendix: Variable Definition.

REER MIS	Lag of real efective exchange rate deviation from Hodrick-Prescott tendency (IFS)
R/STD	Lag of Real Reserves to Real Short Term Debt (IFS/BIS, IFS/WB)
Growth	Real GDP growth Average of Lags 1 and 2 (WDI)
Exports	Lag of Real Exports growth (IFS)
Corrupt	2^{nd} lag of Corruption Annual Average ICRG(106)
L&O	2^{nd} of law and Order Annual Average ICRG(113)
Governance	2^{nd} Lag of Governance (CC)
Capitalization	2^{nd} lag of Stock Market Capitalization to GDP (Levine et al)
Turnover	2^{nd} lag of Stock Market Turnover to GDP (Levine et al)
Credit	2^{nd} lag of Private Credit by deposit money banks and other financial inst.s to G
Net int. Margin	2^{nd} lag of Net interest margin (Levine et al)
Credit x Gov.	2^{nd} Lag of Interaction between Governance and Private Credit (CC*Levine et al)
Capit. x Gov.	2^{nd} Lag of Interaction between Governance and Stock Market Cap (CC*Levine et al)
Turnover x Gov.	2^{nd} Lag of Interaction between Governance and Stock Market Turn (CC*Levine et al)
Net Marg x Gov.	2^{nd} Lag of Interaction between Governance and Net i Margin (CC*Levine et al)