The role of foreign exchange reserves for emerging markets: the cost-benefit analysis

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Abstract

Most countries, especially the emerging economies, have increased their levels of foreign exchange reserves rapidly over the past 25 years. The global reserves, being number one cushion against global crises, grew significantly from one trillion dollars in 1990 to more than five trillion dollars in 2009. Considering international reserves as a main instrument for mitigating crises' probability and overall cost of crises, the research is focused on cost-benefit of international reserves. After evaluating benefits of reserves from the point of their influence on crises, the results show that higher level of reserves really decreases the cost and probability of a crisis. Analyzing the required and sufficient level of reserves on the basis of Ben-Bassat and Gottlieb's model, we conclude that current level of reserves accumulated by most emerging countries (with the exception of Brazil) is the optimal level from the cost-benefit viewpoint – cost of these reserves and the cost of a crisis.

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Table of contents

List of Tables

List of Figures

Chapter 1

INTRODUCTION

The level of international reserves increased rapidly for most countries over the past two decades. They changed more than five times in 1990 - 2009. However, this increase was not symmetrical between countries: the ratio Reserves / GDP remained stable and around 4% for industrial countries while it increased dramatically for developing countries, from 5% to 27%. Particularly, one can see that this increase in reserves to GDP ratio happened with greater intensity in the Asian countries, where ratio moved from 5% in 1980 to 32% in 2006 (including China the ratio raised to 37%).

The financial crises of the 90th demonstrated the importance of countries to accumulate international reserves, i.e. to remain flexible to reduce vulnerability to external changeability. In some papers, for example by Jeanne and Rancière (2006), focus is on international reserves that could soften the effects of sudden withdrawal of the net inflow of capital, call of sudden stop crises of capital, either by fall outside entrance, increased domestic output, or both of them. Other authors such as Garcia and Soto (2003) show the importance of accumulating the reserves in balance of payments crises, in order to maintain the solvency of the country, compared with its international obligations.

Among developing countries, we regard the emerging countries, which have different access to international financial markets. This advantage in term of external changeability leads to risks, since these countries may be more adversely affected

when the flow of capital becomes scarce. Therefore, emerging countries tend to keep higher level of reserves as a precaution against possible international financial crises.

Numerous studies are concerned only with the international reserves benefits to demonstrate that the accumulation of reserves reduces the probability of speculation and capital flight. However, it is important to note that there are potentially high costs associated with the accumulation of reserves.

Although the debt of country is raised, the reserves are invested in low-return liquid assets such as U.S. Treasury Bonds. Therefore, the cost of reserves is mainly due to the difference between internal and external interest rates. For some emerging countries, this cost is extremely high, given the high domestic interest rates. Thus, analysis of the optimal level of international reserves, which takes into account both the costs and benefits of reserve accumulation becomes extremely important

The most popular indicators of adequacy of reserves are the ratio between international reserves and money supply (usually M2), the Reserves and Gross Domestic Product ratio and more recently, the ratio between reserves and Short-term external debt by residual maturity. The analysis of the reserves for a given country is traditionally conducted comparing these indicators to other similar countries or through rules of thumb suggested by studies such as the Guidotti/Greenspan rule, who prescribes a level of reserves equal to short-term external debt by residual maturity.

While these rules may be practical, they do not take into account the costs and benefits from holding the stocks of reserves. The optimal level is one that equates the marginal benefits of accumulating reserves to its marginal cost. Some studies try to establish this optimal stock of reserves; however, none of them adequately quantifies the costs and benefits[1].

In this thesis work we make a cost-benefit analysis of foreign exchange reserves and consider its role in weakening both the probability of a crisis and the cost of crisis once it happens. By quantifying the benefits of reserves, we will analyze its optimal level, taking into consideration the burden of keeping reserves against the crisis perspective of the magnitude.

The paper is divided into three parts. The first part based on the literature of the Early Warning System (EWS) to evaluate the role of international reserves to reduce the probability of crisis. The results indicate that higher reserves, represented by the ratio Reserves / Short-Term External Debt, are statistically significant to reduce the probability of crisis. This variable indicates the reserve capacity to stop the foreign capital flight, while the time of financial market turmoil.

On the second part, we evaluate the other benefit of reserves, to reduce the cost of the crisis once it happens. In this part, we use the IMF methodology to calculate the costs of crises identified previously. The results show that countries with higher levels of reserves suffer less from crises, for the accumulation of these allows the smoother adjustment in consumption and investment. The results demonstrate that when the

[1] Based on Garcia and Soto (2004) and Jeanne and Rancière (2006)

reserves increase to 10% in the short-term external debt then the cost of the crisis decreases on average by 1.2% of GDP.

Finally, on the third part we used the calculated parameters of predecessors to analyze the optimal level of reserves. This step is based on literature about the models of demand for reserves, using the applied methodology by Ben-Bassat and Gottlied (1992). The results show that the levels of reserves accumulated to 80% in analyzed emerging countries are great for crisis cost up to 5% of GDP. However, the Brazilian case is an exception, because the accumulation of international reserves over the past two years appears to be excessive and can not be explained by the estimated model.

In terms of the organization by chapters, this work is organized as follows: Chapter 2 reviews the literature, helping to situate appropriately for our contribution. In Chapter 3, we evaluate empirically the role of reserves in the probability of crisis. Then, in Chapter 4, we analyze the role of reserves on the cost of crisis. Chapter 5 is based on parameters previously estimated to develop a cost-benefit analysis and estimate the optimal level of reserves for analyzed emerging markets. Finally, in Chapter 6, the conclusions are summarized the development of the study, its boundary conditions, as well as their concluding remarks.

Chapter 2

LITERATURE REVIEW

The interest in estimating the appropriate level of international reserves becomes a central point in the 60's and 70's. During this period, given the early stage of the international financial market, the trade balance was the most relevant component of the Balance of Payments and the benefit was intended to accumulate reserves to provide stability in consumption and investment, even in case of deficit in balance of payments. With the controlled exchange rate at the time, the adjustment of the external balance was achieved primarily through changes in inventory reserves. Thus, the basic rule of thumb established is a stock of international reserves equivalent to three months of imports. This rule, however, lost much of its relevance because, currently, the external vulnerability is no longer defined only by trade shocks. During this time the work by Heller (1966), one of the first authors who develop a cost-benefit analysis, was the basic one and enhanced later by some other studies. The work is important because it introduces the notion that the optimal level of reserves can be estimated by comparing costs and benefits of the accumulated stock.

In the late 90's, interest in developing techniques for analyzing the level of international reserves rose because of observed accelerated accumulation. Since the Mexican crisis (1994) and Asian one (1997), two proposals were presented as famous rules for reserves adequacy. Pablo Guidotti, a former Argentine finance minister, is first who considered to suggest that countries should manage their foreign assets and liabilities so as to be independent of foreign loans for up to one

year. Thus, Guidotti argued that reserves should exceed the minimum repayment schedule for the period of one year. Soon, Alan Greenspan adds to the Guidotti's rule such option: he proposed that the average maturity of the country's external liabilities should exceed a certain level of three years. Greenspan also adds a standard liquidity at risk, with the appropriate level of reserves that it generates a high probability (say 95%) that external liquidity will be sufficient to avoid needs for new loans for a period of one year.

Recently, the role of international reserves in financial crises has been widely studied, both empirically and theoretically. Bussiere and Mulder's (1999) results suggest that higher liquidity (represented by the level of reserves in relationship with short-term external debt) can offset weak fundamentals (represented by current account deficits and an appreciated exchange rate) and limit the vulnerability of countries periods of financial turbulence. The work of these authors is based on the methodology presented in paper by Sachs, Tornell and Velasco (1996), which examines the fragility during periods of generalized crises and analyzes which countries are most vulnerable to contagion. The results found by Bussiere and Mulder suggest that countries with modest current account deficits, whose real exchange rates are not significantly misaligned, should adopt a rule of thumb presented by Guidotti / Greenspan to avoid contamination. In case of misaligned real exchange rate or high current account deficits, higher levels of reserves are suggested.

Based on the argument of preventing financial crises, Redrado et al. (2006) argue that reserve accumulation is the second best solution. However, Feldstein (1999)

argues that emerging economies that wish to avoid the effects of crises should seek to be protected, since they can not depend on organizations like the International Monetary Fund as a lender of last resort. The author argues that, as demonstrated by the Asian crisis in 1997, it is necessary to protect more than just avoiding bad policy; high liquidity is the key to self-protection. Rodrick (2006) points out that there are three ways for economies to increase their liquidity: (i) reducing the short-term debt, (ii) accumulating reserves, and (iii) obtaining external credit lines for moments of turbulence. The author questions the strategy adopted by developing countries to obtain reserves only through increased liquidity, with no intention to reduce foreign debt. For Rodrick, the accumulation of reserves may leave the country even more fragile, because it generates return for issuing debt. The author argues that this strategy must be accompanied by a fiscal adjustment that allows the reduction of short-term debt.

Some recent literature suggests that the main advantage to accumulate reserves comes from the reduction of costs of crisis, once it happens. Jeanne and Rancière (2006) present a model of optimal level of reserves for a small open economy which vulnerable to sudden stops in capital flows. The study finds empirical evidence indicating that the stock of reserves is important to smooth the adjustment in terms of GDP, in case of crisis. The authors conclude that the levels of reserves accumulated by most emerging economies can be explained by the model. However, the reserves made by Asian economies appear to be excessive in relation to the appropriate level of reserves in the model about the effect of mitigating the crisis.

Unlike Jeanne and Rancière, De Rezende (2005) finds no evidence that increasing in the level of reserves reduces the probability of sudden stops of capital flows. Furthermore, their results indicate that the higher reserves of the earlier year are more costly at period of crises, because the availability of reserves could accelerate the speed of capital outflows. Caballero and Panagia (2004) also focus on the capacity of holding reserves and sudden stops. They suggest the use of instruments and non-state contingent reserve to handle the economy compared to sudden stops in capital flows.

De Gregorio and Lee (2003) evaluate the role of reserves in mitigating the cost of balance of payments crises. The authors use the IMF methodology for assessing the cost of crises and their results indicate that high reserves, expressed by the ratio Reserves / Short-term external debt, are significant in reducing the cost of balance of payments crises.

Other authors focus on the role of reserves to reduce the probability of crisis. Garcia and Soto (2004) estimate the optimal level of international reserves for a number of countries in East Asia and Chile. The authors first assess the role of reserves to reduce the probability of crises, finding that the largest reserves represented by Reserves / Short-term external debt, reduce the probability of crises. In the second part of the work, the authors make cost-benefit analysis, taking into account the role of reserves on the cost of crises using the parameters estimated by De Gregorio and Lee (2003). The main problem of this study is that it uses parameters estimated by two different samples to assess the optimal level of reserves, which generates inconsistencies in the estimated values. The study also assumes that the cost of

reserves equivalent to the value of the spread of the EMBI +, which is not true for many countries, as in the case of Brazil, where this cost is much higher. In this thesis we make a similar analysis as performed by Garcia and Soto, taking into account the above observations and correcting inconsistencies. The main differences between our analysis and that performed by Garcia and Soto are: (1) sample: this study examines a larger number of countries, with a semiannual frequency data, which makes the effects of the reserve more significant; in addition, the study period is 1991-2006, (2) methodology for the identification of crises: they used a different corrects for possible problems and will explained later, (3) estimation of parameters for the cost of crisis: the estimation with the same sample probability used in generating consistency in the estimated value, (4) estimating the optimal level of reserves: we evaluate different scenarios, with various combinations of cost of reserves and cost of crisis.

Also in the line of reducing the probability of crisis, Wijnholds and Kapteyn (2001) are based on the rule of Guidotti / Greenspan: this rule is focused entirely on the external leakage of the reserves, excluding the internal leakage, via capital flight by residents. The authors suggest a new rule that is the sum of short-term external debt by residual maturity (foreign capital flight) with a break to the possibility of domestic capital flight, taking in account the country risk and exchange rate regime. They defend the following rule of thumb: reserves must be equivalent to the stock of short-term external debt over 10.5% of the stock of M2 to floating exchange rate regime and 10-20% of the stock M2 schemes for "dirty float" or fixed exchange rate, adjusted by country risk.

Finally, other studies followed the suggestions of Bilson and Frenkel (1979) analyze the adequacy of reserves by estimation of a demand function. The most recent contribution along these lines is made by Aizenman and Marion (2003): using a sample of 125 countries, the authors show that the levels of reserves accumulated in the period 1980-1996 seem to be explained by some important factors such as the size of international transactions, their volatility, the exchange rate regime, and policy considerations.

Although they can bring benefits of reduced costs and probability of crisis, the reserves are considered to be very expensive insurance, since while accumulating reserves the government issues domestic bonds in return. Thus, the costs of keeping reserves stem from the fact that the government pays an interest rate on domestic bonds as high as that received in the reserves, which are generally held in low-return U.S. bonds - this is called the fiscal cost of reserves.

Recently researchers are interested in determining the costs relevant to accumulate reserves. Hauner (2005) analyzes the cost and tax opportunity of reserves, arguing that stocks have cost of opportunity because they can alternatively be used for financing public investments and paying its foreign debt. He argues that if reserves and interest difference between domestic and foreign are negatively correlated, reserves can bring the added benefit of reducing the government expenditure on interest payments. The author develops a measure of opportunity cost of crude, considering the potential savings in government by keeping reserves high. The results suggest that although the countries saved money to accumulate reserves in 1990-2001, paying out these costs is positive over the period 2002-2004, with an

estimated net cost of up to 0.4% of GDP in 2004. Naudon (2004) challenges the theory that stocks carry the added benefit of reducing the differential interest defended by Hauner. In a study for emerging economies Naudon shows that changes in short interest differential term are much more related to market conditions than with fundamentals. Rodrick (2006) estimates that the accumulated reserves by developing countries have a cost of lost product approximately 1% of GDP per year.

In the last decade, central banks diversified assets they had invested in reserves, so as to increase the return. Feldstein (1999) argues that countries could reduce net cost of reserves in liquid assets whose returns are higher than those of U.S. bonds. Although this strategy potentially reduces the cost, it might increase the risk of portfolios of reserves. However, cost reduction via diversification is very limited, since, according to IMF definition, the assets of the reserves must be liquid, marketable and have a reliable value for a carrier. In addition there may be institutional constraints in the types of assets in which central banks can invest.

In addition to precautionary motives noted earlier, another reason for keeping international reserves is to gain strength. This argues that the accumulation of international reserves is activated by concerns about the competitiveness in international trade. This strategy, characterized by Aizenman and Lee (2005) as a modern incarnation of mercantilism, advocated by Dooley, Folkerts-Landau and Garber (2003) mainly in the context of China. Given the political wish to prevent or to slow down the appreciation of the exchange rate aimed at promoting exports responsible for creating the jobs needed to absorb the abundant labor force that comes from the Chinese agricultural sector, the accumulation of reserves is

interpreted as a byproduct of the development strategy. The long-term viability of this interpretation is still under debate. Aizenman and Lee (2005) compare the reasons of crisis prevention and mercantilist strategy as explanations for the accumulation in reserves in developing countries. The results support the reason for crisis prevention, however found limited support for the mercantilist motive.

Chapter 3

THE ROLE OF RESERVES ON THE PROBABILITY OF CRISIS

In this chapter we empirically analyze the role of reserves in mitigating the probability of crisis. As was noted earlier, this part of the study is based on the literature of the Early Warning System aiming to identify the crises and to assess the role of reserves in preventing crises' occurrence. This methodology was developed by the International Monetary Fund after the Mexican crisis. The statistical methods within this methodology were applied to predict the probability of the country suffering a currency crisis or balance of payments crisis.

Typically, according to the literature mentioned above, we model a variable pressure on the changes of increases in interest rates, exchange rate depreciation, and rapid reduction in the stock of international reserves. This variable pressure captures all possible sources of shocks in the exchange, not restricted to situations when there are breaks in the fixed exchange rate regime.

From the mentioned variable pressure clears up another specific binary form, with the aim to identify the occurrence of a crisis, explained when the pressure exceeds a pre-specified cutoff value.

To identify the crises we need to regresses the binary variable on a series of variables, which traditionally include the deviation of real exchange rate and International Reserves / Short-Term External Debt ratio.

The first section of this chapter intends to describe the sample and to make some observations regarding the data. In the following section, we describe the methodology used to identify the nature of crises. The third section of the chapter demonstrates the econometric approach, its methods and results, and, eventually, we analyze the robustness of the results.

3.1 COMMENTS ON SAMPLE AND DATA

The optimal level of reserves for crisis prevention is an issue for any country, so it is reasonable to work with data from several countries. Research activities that seek to analyze the role of reserves to find out the probability of crises and their costs need to be conducted together with the panel data in order to increase the number of events (observations), since each country had few crises. Thus, it imposes alternatives for the following items:

- Which countries should be taken into the sample?
- What should be the frequency of observations?
- Which period to consider?

As was noted earlier, we would be focused on so-called “emerging countries”. Generally, the access to international financial markets means that at moments of foreign turmoils these countries will be most affected by the fall of capital flows. Thus, emerging economies keep stocks of the highest international reserves as a precaution against possible international financial crises. The choice of the sample of countries was limited by the availability of the data, which are more accessible for the largest emerging countries; as a result, this fact has significantly influenced in

sample's composition. Also, the largest emerging economies seem to have more access to these markets, becoming more fragile in times of turmoil and therefore seeking greater protection via higher level of reserves. It is therefore possible that such a sample of the largest emerging economies will cause a bias, enhancing the role of precautionary reserves. The analysis is made on the basis of data from 27 countries: Argentina, South Africa, Bolivia, Brazil, Kazakhstan, Chile, Colombia, Hong Kong, Hungary, India, Indonesia, Israel, Jordan, Malaysia, Mexico, Pakistan, Paraguay, Peru, Philippines, Poland, Singapore, Czech Republic, Russia, Thailand, Turkey, Uruguay and Venezuela.

An important note must be made with respect to the absence of China in the sample. The reason for its exclusion is not theoretical, but rather reasonable: Chinese data are not consistent with the data used for the other countries because China currently is the economy with the largest level of foreign reserves, which exceeded one trillion dollars by the end of 2006[2]. However, being aware about the importance of the Chinese economy, we try our best to reconcile the Chinese data with other economies, and the results of this attempt are presented in Appendix A of this paper. There, in Tables 30 and 31 we can obviously see that the results do not change significantly when China is added to the sample.

The choice of frequency was determined by half-year data which available for short-term external debt. These data are fundamental to our analysis, since the short-term external debt determines the potential flights of foreign capital. Data from short-term

[2] The information about consumer price index for China is not compatible with those used in other countries. This fact creates problems in calculating the real exchange rate which is fundamental in our analysis.

external and total debt are available only in half-yearly frequency, determining the frequency of the study[3].

Because of the loss in observations due to usage of half-yearly data, we decided to use the longest period of data possible to maximize the sample size. However, once again we struggle here with the restriction of data availability: for example, the data for the rate inflation[4] in Germany are available only after 1991; these are used to calculate the real exchange rate. Thus, the analysis period extends from 1991 until 2007.

The description of sources and steps for calculation of each data series are presented in Appendix A.

3.2 IDENTIFYING THE CRISIS

In this section we describe the methodology used to identify the crises. According to the IMF definition there are different kinds of financial crises[5]. A currency crisis may occur when the domestic currency suffers from the speculative attack, which results in overall currency depreciation. Balance of payments crisis is a broader concept that involves insufficient reserves to cover country's obligations. Many papers include currency crises in the definition of balance of payments' crises; generally, countries suffering attacks on their currencies reduce their stock reserves, selling them in the

[3] After 2000, data on short-term external debts become quarterly, however if we will use the series from 2000, it would lose the 90's, during which the reserves played an important role in crisis.
[4] The inflation rate data for Germany are not available consistently for the period before 1991. These data are essential for calculating the real exchange rate for some developing countries, given the importance of Germany in international trade.
[5] Financial Crises: Characteristics and Indicators of Vulnerability - IMF (1998)

hope to avoid strong currency devaluation. One more type of crises, a banking crisis, occurs at the time when bank runs or failures are expected to occur, forcing banks to suspend the internal conversion of its liabilities or forcing the government to intervene in their operations.

This work is concerned with the tasks defined by the IMF as foreign exchange and balance of payments, which are here called "Balance of payments crises." To identify such crises, most studies construct an index pressure on the exchange rate and when this ratio exceeds a certain threshold value there is a crisis.

Some indicators and alternative methods were used in the literature to identify the dates of crises. Frankel and Rose (1996), Barro (2001) and Park and Lee (2002) use the nominal depreciation rate as the index and date each crisis when the index increase sharply over an exogenous threshold rate of depreciation common to all countries.

However, strong speculative pressure does not always result in large currency depreciations, especially when the authorities can successfully intervene in the foreign exchange market. Thus, Eichengreen, Rose and Wyplosz (1995), Kaminsky and Reinhart (1999) and Glick and Hutchison (2001) use an alternative index of currency pressure that combines the depreciation rate with additional variables such as losses in international reserves and domestic interest rate. According to this approach, a balance of payments crisis is identified when the index exceeds a certain value defined in terms of its mean and standard deviation.

However, this procedure is also a subject of potential problems; for instance, in the case of this index has normal distribution, when the mean and standard deviations vary among countries, this method would indicate an expected number of crises which is equal for all countries. Moreover, this method indicates that all countries have identified at least one crisis, which for some countries may not be a case.

Thus, we adopted the strategy proposed by De Gregorio and Lee (2003) that incorporates two identification methods described above. At first, build an index of currency pressure (ICP) - eq. (1) below - which incorporates variations found in the series of real exchange rate and the loss of international reserves. The weights are determined so that both series have the same volatility. We try to add movement in domestic interest rates, but data for this is not available for most of the observations and their inclusion leads to the loss of most of the observations.

$$ICP_{i,t} = w_{r.exchange\_rate} \frac{r.exchange\_rate_{i,t} - r.exchange\_rate_{i,t-1}}{r.exchange\_rate_{i,t-1}} - w_{reserves} \frac{reserves_{i,t} - reserves_{i,t-1}}{reserves_{i,t-1}} \quad \textbf{(1)}$$

where r.exchange_rate, is the real exchange rate for the country i in the period t, and reserves are reserves to the country i at the time t. The weights correspond to the inverse of the standard deviation of each series for each country throughout the period. This index is constructed separately for each country sample, and then the mean and standard deviation of each index are calculated. We determine these

cases when index is higher than average plus one standard deviation - indicate crises[6].

However, as explained above, this method tends to identify roughly the same number of crises for all countries. This actually happens: we find 90 crises for 27 countries, with the average of 3.3 crises per country. Looking at the results we found that 19 countries surveyed have between three and five crises identified. In the Chilean case we have five crises identified, but only one of these crises is explained by variation greater than 10% of reserves or real exchange rate.

Thus, on the second stage of the identifying crises process we add several rules to address the following issues:

- In the case where this index has low volatility, as a country with little or no crisis, the index will end up identifying crises that in fact occurred;
- In the case of a turbulent country, with high volatility, moments where the pressure was high, but not enough to exceed the cutoff point, are not identified as the crisis despite the fact they are.

So, to remedy the “bad” situations it's chosen to insert a filter level to the crises identified by the ICP and identified a crisis remains true and considered as a crisis only if the real exchange rate depreciation or the loss of reserves has been larger or equal to 10%. The filter excluded brought initially identified 28 crises.

[6] There is no consensus on the choice of the cutoff value; many studies used two or even three standard deviations above the mean as the cutoff point. However, this choice depends on the frequency of the data analyzed in our case, noting the crises identified, we believe that our choice is appropriate.

For the fixing of the second problem we add the following rule: for the losses of reserves or real exchange rate the depreciations is greater or equal to 25%, which are considered necessary in a crisis situation, even if this is not identified by the ICP higher than the mean plus one standard deviation. This problem is much less frequent than before and adds 10 crises which were ignored before as a result of this extra added rule.

Thus, for initial 90 crises we considered for analysis 72 cases.

To demonstrate that our method actually identifies all crises correctly, we add Tables 27-29 in Appendix A that show exactly what happens in each of the crises identified, removed and added. In these tables we reported what was the loss of reserves, how much the real and nominal exchange rate change as well as interest rate and what was the behavior of these variables. Describing what happened during the periods removed and added helps to understand the importance of having adopted these rules.

3.3 ECONOMETRIC ANALYSIS

After identifying the crises we empirically analyze the role of international reserves in the Balance of Payments' crisis. This analysis is based on a binary choice model via the estimation a panel LOGIT model, using a dummy dependent variable indicating the crises occurrence. That is, for the periods in which crises are identified by the methodology described in the previous section[7], the dummy takes the value one; in periods where crises have not been identified it takes the value of zero. In practice,

[7] Including both steps.

since the dependent variable is binary, the time series theory and stationarity are not applicable. The regressions are performed with random effects; we find no support in the literature for the usage of fixed effects[8].

$$\Pr(X_i, t=1) = F[\beta_{i,t-1}\psi + z_{i,t-1}\lambda - \varepsilon_{i,t}] \quad \textbf{(2)}$$

The estimated equation is represented by eq. (2) below which relates to the macroeconomic variables with the probability of crisis for the country i in the period t, where X represents the crisis dummy calculated by the methodology described in the previous section. The variable ψ represents the main explanatory variables we are interested in, for example, measures the level of international reserves that are explained the subsequent paragraph; λ represents the set of controls to be added, as described throughout this section. As previously stated, for the estimation we assume that F is a logistic function.

Among the different variables of the crises, this work is especially interested in international reserves. We use a relative value, considering the stock of reserves for short-term external debt in order to capture the power of the reserves on potential flights of capital and foreign reserves also weighted by the stock of M2-dollars to capture the power of the reserves on potential domestic capital flights. Both variables are evaluated at the pre-crisis period. This lag is necessary to evaluate the agents' expectations regarding the liquidity of the economy. Also, this study was adopted not only for the reserves, but also for all the variables that enter this test, and the results are presented in Table 1.

[8] Note that all studies in this 'line' used random effects.

The regression identified in Column (1), uses the basic model from the literature. Here, besides stocks weighted by short-term external debt by M2 and converted to U.S. dollars, we add the deviation of real exchange rate and a measure of trade openness[9]. As usually found in the literature, a positive deviation (which by the way it was calculated indicates an appreciation exchange rate), significantly increases the probability of a crisis. Greater trade openness significantly reduces the probability of a crisis, given the negative and significant coefficient of trade openness variable. The ratio between reserves and short-term external debt by residual maturity affects negatively and significantly the probability of a crisis[10]. Since the reserve ratio and M2 are nominated in dollar terms, despite having the correct sign, they are not significant in any of the specifications[11].

Because this period is characterized by practice of different exchange rate regimes by individual countries, it is important to identify the type of exchange regime and control it in the regression to capture the role of reserves. A controlled exchange rate regime should generate a direct relationship between movements in the reserves and movements in the exchange rate adjustment, while floating exchange rate reserves must move more independently of currency fluctuations. We therefore added a dummy that indicates the presence of exchange controls. In this work, we decided not to distinguish between fixed exchange rates and quasi-fixed (dirty fluctuations, bands and other schemes) to support that in the case of a speculative attack, what matters most is whether the central bank has or wants to have some control over

[9] See Appendix A for description of how these variables were calculated.
[10] Reserves without weighting is not significant in any of the specifications, this is a common result in the literature.
[11] Brussiere and Mulder (1999) among others have also found that the ratio of reserves and short-term external debt significantly reduces the probability of a crisis, but the ratio of M2 and reserves in dollars is not significant.

exchange, or the leaves float freely. We based on the methodology by Reinhart and Rogoff (2002) with some modifications. We test the variable exchange rate regime with a lag of one year so as not to create problems of simultaneity. As it is seen in the regression identified in the Column (2) in the Table 1, in fact a controlled exchange rate regime raise the probability of crisis. The reserves are still significant in reducing the probability of crisis and the magnitudes of coefficients vary very little.

As represented in the regression in the Column (3), we also add a dummy to control the occurrence of banking crises in accordance to the paper by Kaminsky and Reinhart that showed that a currency crisis is often preceded by a banking crisis (1999). Then, with the help of the World Bank's method in identifying bank crises, we mention dummy indicating the occurrence of a year earlier banking crisis. Kaminsky and Reinhart noted that banking crises affect significantly the probability of a crisis. The occurrence of a banking crisis raises the probability of occurrence a balance of payments crisis. The reserves are still significant in affecting the probability and magnitude of the crisis.

The ratio of reserves remains significant even when we add a measure of the economy solvency. In the steady decline in the Column (4) we add the total external debt ratio to GDP in U.S. dollars, which represents the level of the indebtedness of the country. Despite having the correct sign, this variable does not seem to affect significantly the probability of a crisis.

Logically, one should expect that crises are more likely to occur in cases when external conditions deteriorate. We so far will only include variables related to the

domestic sector of the economy, wondering if the stocks picked up have some relationship with the external sector with the economy, creating a possible omitted variable bias. Then we add the variation of the basic interest rate of U.S. bonds, in order to capture a more international interest rate increase may affect the probability of crisis. As we see in the regression in the Column (6), there are no significant effects for this variable.

Finally, some studies conclude that higher export growth reduces the current account deficit, reducing the probability of crisis. In the regressions in the Column (7), we test this hypothesis by adding the growth rate of exports. Despite showing the expected signal, this variable does not seem to affect significantly the probability of crisis. The reserves ration variable, however, remains quite significant.

In summary, the results show that stocks of reserves weighted by short-term external debt by residual maturity are significant in reducing the probability of crisis. The reserve divided by short-term external debt captures the ability of international agents to achieve their short-term assets in the economy.

3.4 ROBUSTNESS OF RESULTS

In this section, we analyze the results of other measures for crisis identification. The way we do that is by using the flexible methodology for identifying crises. For this, we avoid the second step of crises identification, i.e. analyzing only the crises identified by the ICP. Identifying the crisis only by pressure index leads to many problems as

described above; however, as some studies use this measure to identify the crisis, we believe this exercise is valid.

As can be seen in the Table 2, there is a little change in the results compared with those obtained in previous stages of this paper. The reserves are still significant: higher reserves are still strengthening the probability of a crisis via the variable reserves divided by short-term external debt. The deviation of the real exchange rate remains significant, but the variables for the banking and currency crisis lose significance. This occurs because of the inclusion crises with low growth of reserves and real exchange rate, which weakens the result. All significant variables keep the expected sign.

Table 1 - Panel LOGIT Model: The Role of Reserves on Probability of Crisis

Dependent Variable: Balance of Payments Crisis (dummy)
In parentheses: p-values

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-1.04	-1.3	-1.8	-1.82	-2	-1.8	-1.8
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Deviation of Real Exchange Rate t-1	0.039	0.04	0.09	0.093	0.09	0.09	0.1
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Trade openness t-1	-9.01	-10	-8.1	-14	-13	-14	-13
	(0.026)**	(0.011)**	(0.047)**	(0.053)*	(0.064)*	(0.053)*	(0.068)*
Controlled Exchange Rate (dummy) t-2		0.63	0.62	0.606	0.63	0.61	0.6
		(0.027)**	(0.051)*	(0.061)*	(0.051)*	(0.060)*	(0.059)*
Banking Crisis (dummy) t-2			0.58	0.598	0.64	0.6	0.6
			(0.097)*	(0.092)*	(0.070)*	(0.091)*	(0.060)*
ΔTBill t-1						-0.1	-0
						(0.841)	(0.849)
Growth of Exports t-1							-0
							(0.727)
Total External Debt / GDP t-1				1.064	0.7	1.05	1
				(0.267)	(0.421)	(0.272)	(0.286)
Reserves / Short-term External Debt t-1	-0.5	-0.5	-0.5	-0.38	-0.5	-0.4	-0.4
	(0.001)***	(0.001)***	(0.004)***	(0.036)**	(0.007)***	(0.037)**	(0.035)**
Reserves / M2 t-1	-0.4	-0.4	-0.4	-0.94		0.9	-1.2
	(0.654)	(0.688)	(0.675)	(0.406)		(0.409)	(0.320)
Number of Observations	732	723	672	672	677	672	669
Pseudo R-squared	0.216	0.23	0.35	0.35	0.35	0.35	0.4

* significant at 10%
** significant at 5%
*** significant at 1%

Table 2 – Panel LOGIT Model: The Role of Reserves on Probability of Crisis

Dependent Variable: Balance of Payments Crisis (dummy)
In parentheses: p-values

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-1.46	-1.54	-1.84	-1.83	-1.88	-1.84	-1.79
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Deviation of Real Exchange Rate t-1	0.03	0.03	0.08	0.08	0.08	0.08	0.077
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Trade openness t-1	-3.3	-3.84	-2.67	-4.34	-4.24	-4.33	-3.65
	(0.195)	(0.137)	(0.314)	(0.290)	(0.299)	(0.292)	(0.370)
Controlled Exchange Rate (dummy) t-2		0.26	0.124	0.113	0.13	0.11	0.094
		(0.301)	(0.647)	(0.677)	(0.637)	(0.675)	(0.734)
Banking Crisis (dummy) t-2			0	0	0.02	0	0.019
			(0.997)	(0.999)	(0.946)	(0.994)	(0.950)
ΔTBill t-1						-0.15	0.038
						(0.841)	(0.952)
Growth of Exports t-1							-0.7
							-0.351
Total External Debt / GDP t-1				0.347	0.29	0.34	0.339
				(0.573)	(0.602)	(0.577)	(0.583)
Reserves / Short-term External Debt t-1	-0.25	-0.25	-0.2	-0.16	-0.17	-0.16	-0.15
	(0.011)**	(0.010)**	(0.052)*	(0.161)	(0.100)*	(0.161)	(0.161)
Reserves / M2 t-1	-0.06	-0.05	0.049	-0.15		-0.14	-0.3
	(0.926)	(0.938)	(0.947)	(0.859)		(0.863)	(0.720)
Number of Observations	732	723	672	672	677	672	669
Pseudo R-squared	0.15	0.16	0.26	0.26	0.26	0.26	0.27

* significant at 10%
** significant at 5%
*** significant at 1%

Chapter 4

THE ROLE OF RESERVES ON THE COST OF CRISIS

In this chapter we empirically analyze the role of reserves in mitigating the cost of crisis when it occurs. We believe that the GDP is the best variable for measuring this cost, since it is influenced by the crisis through a series of channels besides being one of the major determinants of wellbeing. As previously mentioned about this section, the analysis is based on the IMF methodology for calculating the cost of crisis and De Gregorio and Lee's (2003) econometric approach.

The first section of this chapter is intended to describe the methodology used to calculate the cost of crisis in terms of GDP loss. The following section presents the econometric approach, presenting its methodology and results. In the last section we analyze the robustness of the results.

4.1 CALCULATING THE COST OF CRISES

According to the literature, we measure the cost of crisis in terms of GDP loss, as the cumulative loss of real output growth in the period between the year the crisis begins until the year when output growth returns to its trend. As can be seen in the following equation:

$$Cost\_of\_Crisis = \sum_{i=0}^{n} (trend - real\_GDP\_growth_{t+i}) \quad \textbf{(3)}$$

De Gregorio and Lee (2003), Eichengreen and Bordo (2001), IMF (1998) use the same measure of loss of output growth for the cost of crises. In Eichengreen and Bordo (2001) the loss of GDP is measured by the period, in which the output returns

to the trend growth, like in the case of De Gregorio and Lee (2003), a three-year period is allowed, the crisis year and two more years.

In this work, following this rule, we set a period of three years, as in Gregorio and Lee (2003). However, if the country has a faster recovery and return to trend before the triennium, we calculate the loss of output until its recovery. This measure is used in order to avoid calculating the negative costs (increase of product relative to trend) of a crisis if the country has a faster recovery than three years.

For this calculation, we use data of gross domestic product, measured in domestic currency in real terms. It is vitally important to use this data in domestic currency, since in cases of balance of payments crisis the exchange rate depreciates considerably, consequently overestimating the cost of crisis. The decision to use the GDP in real rather than nominal terms is necessary due to the fact that most of the countries in a sample were in times of high inflation, and the usage of nominal output growth could underestimate the cost of crisis.

The growth trend used for comparison was calculated as the average of GDP growth of years without a crisis times for each country, a year in which the country was not a subject to a crisis and the preceding two years. This type of calculation was also used by most studies of this genre.

4.2 ECONOMETRIC ANALYSIS

In this analysis we will adopt the method of Ordinary Least Squares (OLS), restricting the sample to the observations of crisis identified in section 3.2. This method is appropriate in this case, since we are only working in the observations of crisis, where each observation is treated as independent. Moreover, we consider only attacks separated by the period of three years.

We believe that a number of factors affect the cost of balance of payments crisis. The nature of the shock, the initial conditions, the external situation and the policy decisions taken must affect the behavior of output growth after the period of crisis. Therefore, we evaluated two types of factors that may affect the cost: certain factors in the pre-crisis period and certain factors in the later period.

Among the pre-crisis factors there are: (i) pre-crisis real growth rate, (ii) measure of international liquidity, two types of liquidity included: bookings / short-term external debt and converted reservas/M2 for dollars, and (iii) a variable health of the banking system. The real pre-crisis growth rate indicates the imbalance of the economy. De Gregorio and Guidotti (1995) and Sachs, Tornell and Velasco (1996) show that credit booms and excessive lending booms during the pre-crisis are likely to deepen the recession after the crisis and slow growth. Furthermore, countries with high growth are more vulnerable to severe loss of GDP higher after the crisis.

Appropriate measures of liquidity are also important to mitigate the loss of output because of crisis effect. Low liquidity often results in massive international crisis and

contraction of the GDP and healthy banking sector is also important to prevent illiquidity. The vulnerability of the banking sector in most cases increases the shock, especially when a currency crisis is associated with the banking crisis, they become costlier.

The post-crisis factors are: growth of number of major trading partners and the depreciation of the real exchange rate. Strong growth of trading partners has a positive effect on export growth by collaborating in a quicker recovery in crisis-hit countries. The size of the depreciation after the crisis can also influence the rate of export and output growth after the crisis.

The equation to be estimated is specified in eq. (4) below,

$$Cost\_of\_Crisis = \beta_0 + \beta_1 pre\text{-}crisis\_growth_{t-2\sim t-5} + \beta_2 \frac{\text{Reserves}}{ST\_ext\_debt_{t-1/2}} + \beta_3 \frac{\text{Reserves}}{M2}_{t-1/2} + \beta_4 banking\_crisis_{t-2\sim t} + \beta_5 trade\_partners\_growth_{t\sim t+2} + \beta_6 real\_depreciation_t + e_t \quad \textbf{(4)}$$

where $pre-crisis\_growth_{t-2\sim t-5}$ is the average growth rate of two years before the crisis to five years before the crisis. $\frac{\text{Reserves}}{ST\_ext\_debt}_{t-1/2}$ and $\frac{\text{Reserves}}{M2}_{t-1/2}$ represent the values of the ratio reserves / short-term external debt and reserves / M2, both six months before the crisis. $banking\_crisis$ is the dummy variable and it is equal to one if there is a banking crisis in the crisis year or even two years earlier. The average growth of number of major trading partners in the crisis year or two subsequent years is represented by variable $trade\_partners'\_growth$. Finally, $real\_depreciation$ represents the depreciation of the currency crisis.

Table 3 shows the results. Again we are working in a sequence of setbacks. The results confirm our expectations. In the regression presented in Column (1), a real growth in the larger product generates crises costlier, since this coefficient is positive and significant. According to the regressions, an average increase of 1% real pre-crisis GDP growth increases the cost of crisis by 0.7% on average, ceteris paribus. In Columns (7) and (8), we use an alternative specification of this variable, calculating the deviation from the pre-crisis growth relative to trend, the variable is not significant in any of the specifications, and other results remain the same. The international liquidity, represented by reserves in relation to short-term external debt, reduces the cost of crisis, since this variable is negative and significant in all specifications. According to estimated coefficients, if the reserves increased by 10% of short-term external debt, the cost of crisis is reduced on average by 1.2% ceteris paribus. Just as it was found in the regression of the probability of crisis, the ratio reserves / M2 does not appear to be significant in any of the specifications.

In the regression in Column (2) we add the dummy variable for banking crisis. Again, the results are expectable: when two crises occur together, the loss of output growth is significantly higher. The estimated coefficient implies that under the presence of twin crises the cost of the crisis increases by about 3%.

As it can be seen in the regression specifications of Columns (3), (4) and (5), one of the fastest growing trading partners does not seem to affect significantly the cost of the crisis. Major depreciation of the real exchange rate reduces the cost of the crisis, where a positive value of the variable indicates that the exchange rate is effective and popular indicator. Therefore, given negative coefficient implies that, as was

expected, if the exchange rate depreciates in time of crisis, it becomes less expensive.

4.3 ROBUSTNESS OF RESULTS

In this section we analyze the robustness of results in relation to the role of reserves on the costs of crises. Just as we did in the section 3.4, we make the estimation using only the crises identified by the ICP, i.e. only the first phase of the identification process. In this exercise the number of crises identified increases, thus increasing the number of observations in the sample. In the previous year there were 45 observations at the most, using only the first phase of the identification process, this number rises to 53 (of 90 different crises, due to the criterion of three-year separation from crisis, which eventually merge two or more attacks, previously identified individually).

The results of this exercise are shown in Table 4. The ratio of reserves to short-term external debt becomes slightly less significant than in the previous cases in some of the specifications, although still remaining significant at 10%. Moreover, despite still having the effect of reducing the cost of the crisis, the magnitude of the ratio between reserves and short-term external debt is reduced. Based on this test we increase the sample by 20%, add observations of crisis to low variation of real exchange reserves, and expect that these observations will show no strong relationship between the reserves and the cost. Thus, it is natural that the role of the reserves becomes less significant with the smaller magnitude.

Table 3 - Cost of Crisis

Dependent Variable: Cost of crisis Real GDP
In parentheses: p-values
Note: s ~ v means the average values of the period s to v

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0643	0.04	0.06	0.06	0.067	0.07
	(0.005)***	(0.005)***	(0.124)	(0.131)	(0.059)*	(0.056)*
Growth rate, t-2 ~ t-5	0.5645	0.78	0.85	0.858	0.601	0.641
	(0.081)*	(0.155)	(0.146)	(0.143)	(0.300)	(0.215)
Growth rate (Deviation from Trend), t-2 ~ t-5						
Banking Crisis (dummy), t-2 ~ t		0.032	0.03	0.03	0.025	0.024
		(0.098)*	(0.111)	(0.116)	(0.150)	(0.165)
Growth rate of trade partners, t~t+2			-0.01		-0.009	-0.008
			(0.524)		(0.503)	(0.543)
Real growth rate of trade partners, t~t+2				-0.01		
				(0.525)		
Real Depreciation Rate, t					0.002	0.002
					(0.010)***	(0.008)***
Reserves / Short-term External Debt, t-1/2	-0.013	-0.01	-0.01	-0.01	-0.014	-0.014
	(0.010)***	(0.017)**	(0.019)**	(0.019)**	(0.002)***	(0.001)***
Reserves / M2, t-1/2	0.0479	0.033	0.038	0.037	0.025	
	(0.375)	(0.573)	(0.539)	(0.543)	(0.638)	
Number of Observations	45	43	43	43	43	43
Pseudo R-squared	0.1563	0.205	0.212	0.212	0.322	0.328

* significant at 10%
** significant at 5%
*** significant at 1%

Table 4 - Cost of Crisis (ICP)

Dependent Variable: Cost of crisis Real GDP (Crisis ICP)
In parentheses: p-values
Note: s ~ v means the average values of the period s to v

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0531	0.029	0.06	0.058	0.069	0.082
	(0.010)***	(0.126)	(0.045)**	(0.066)*	(0.024)**	(0.010)***
Growth rate, t-2 ~ t-5	0.6234	0.793	0.91	0.901	0.809	0.871
	(0.056)*	(0.060)*	(0.046)**	(0.049)**	(0.069)*	(0.037)**
Banking Crisis (dummy), t-2 ~ t		0.031	0.03	0.031	0.034	0.032
		(0.111)	(0.123)	(0.119)	(0.090)*	(0.131)
Growth rate of trade partners, t~t+2			-0.02		-0.02	-0.019
			(0.148)		(0.105)	(0.116)
Real growth rate of trade partners, t~t+2				-0.02		
				(0.221)		
Real Depreciation Rate, t					0.001	0.002
					(0.180)	(0.130)
Reserves / Short-term External Deb	-0.01	-0.01	-0.01	-0.01	-0.01	-0.009
	(0.064)*	(0.125)	(0.116)	(0.120)	(0.064)*	(0.064)*
Reserves / M2, t-1/2	0.0635	0.062	0.06	0.063	0.056	
	(0.155)	(0.205)	(0.169)	(0.181)	(0.228)	
Number of Observations	54	53	53	53	53	53
Pseudo R-squared	0.1448	0.192	0.22	0.213	0.259	0.239

* significant at 10%
** significant at 5%
*** significant at 1%

Chapter 5

COST BENEFIT ANALYSIS OF RESERVES

Once evaluated and quantified the benefits of reserves to reduce the probability and costs of balance of payments crises, we can perform a cost-benefit analysis of reserves in order to estimate the optimal level of reserves for the same countries. As previously mentioned, this part of the work is based on literature about the models of demand for international reserves, using the methodology applied in Ben-Bassat and Gottlied (1992). We develop a cost-benefit analysis, taking into account both the cost of reserves, such as the effect on the cost and probability of crisis. We analyze various scenarios with different combinations of expected costs of crisis and costs from reserves accumulation.

In the section 5.1 we will derive and explain the model used in this part of thesis. Already in the section 5.2 we will calculate the optimal level of reserves for countries for which data are available, detailing the cases of Chile and Mexico using a cost-benefit analysis to adjust its level of international reserves. Thereafter we will do the same analysis for other counties from our sample.

5.1 THE MODEL FOR COST-BENEFIT ANALYSIS

Consider the problem of the government that decides how much to maintain reserves in period t, minimizing an expected loss function, which takes into account the effects of reserves on the probability and costs of the crisis, as well as the opportunity cost of reserves.

We assume that the loss function minimized by the government has the following form:

$$\Omega_t = p_t C_t + (1 - p_t)\rho_{t-1} R_{t-1} \quad \textbf{(5)}$$

where p_t is the probability of a crisis in period t, which according to the estimates of Chapter 3, depends on the reserves and short-term external debt ratio, a measure of liquidity in the economy, and also the total external debt to GDP ratio, a measure of solvency. Already C_t is the cost of a crisis, as demonstrated this in Chapter 4, depends on the ratio between reserves and short-term external debt of the previous period. The variable ρ_{t-1} expresses the unit cost of maintaining reserves and R_{t-1} symbolizes the stock of reserves. These variables are defined in the previous period, because they characterize the cost paid for the stock of reserves held in t-1 that generated the cost and the probability of crisis in t.

The probability p_t is given by eq. (6), i.e. defined by a logistic distribution:

$$p_{i,t} = \frac{\exp(\beta_0 \frac{R_{i,t-1}}{Short-term\_ext\_Debt_{i,t-1}} + \beta_1 \frac{Total\_ext\_Debt_{i,t-1}}{GDP_{i,t-1}} + Z_{i,t-1}\lambda - \varepsilon_{i,t})}{1 + \exp(\beta_0 \frac{R_{i,t-1}}{Short-term\_ext\_Debt_{i,t-1}} + \beta_1 \frac{Total\_ext\_Debt_{i,t-1}}{GDP_{i,t-1}} + Z_{i,t-1}\lambda - \varepsilon_{i,t})} \quad \textbf{(6)}$$

The government makes the decision about the level of stock of reserves from period to period, minimizing eq. (5), subject to the following restriction:

$$K_t - W_t + R_t = D_t \quad \textbf{(7)}$$

where K_t is the capital stock of the economy, W_t is the total wealth, and D_t is the stock of debt of the economy, which is composed of short-term, medium and long term debt[12].

Thus the first order condition of the problem is given by eq. (8), below:

$$p_{R,t}C_t + p_t \frac{\partial C_t}{\partial R_{t-1}} + (1-p_t)\rho_{t-1} - p_{R,t}R_{t-1} = 0 \quad \textbf{(8)}$$

where variable $p_{R,t}$ is given by:

$$p_{R,t} = (1-p_t)p_t(\beta_0 \frac{1}{Short-term\_ext\_Debt_{t-1}} + \beta_1 \frac{1}{GDP_{t-1}}) \quad (9)$$

Combining eq. (8) and eq. (9) we obtain the following nonlinear equation in R, which implicitly generates the optimal level of reserves:

$$(1-p_t)p_t(\beta_0 \frac{Y_{t-1}}{Short-term\_ext\_Debt_{t-1}} + \beta_1)(\frac{C_t}{Y_{t-1}} - \rho_{t-1}\frac{R_{t-1}}{Y_{t-1}}) + \\ + p_t \eta \frac{Y_{t-1}}{Short-term\_ext\_Debt_{t-1}} + (1-p_t)\rho_{t-1} = 0 \quad \textbf{(10)}$$

[12] Note that we assume the hypothesis that short-term foreign debt is predetermined, and the reserve is financed with medium and long term debt. This hypothesis is important to ensure the existence of interior solutions, i.e. non-zero values for the optimal stock of reserves.

Where $\eta = \frac{\partial C_t}{\partial(\frac{R_{t-1}}{Short-term\_ext\_Debt_{t-1}})}$ **(11)** corresponds to variation in the cost of the crisis associated with the change in the ratio between reserves and short-term external debt in the previous period. Notice that in eq. (10) all variables excluding the probability and cost of crisis are defined in the previous period. This is generated by the fact that the probability is dependent on the reserves / short-term external debt ratio and other variables in the previous period, as shown in eq. (6).

5.2 THE OPTIMAL LEVEL OF INTERNATIONAL RESERVES

In the next two sub-sections we make an analysis of adequate reserves for Chile and Mexico. These countries are special case because they have implemented policies to reducing or slowing of reserve accumulation. In sub-section 5.2.3 we will do the analysis of the remaining countries in the sample for which data are available[13].

5.2.1 THE CHILEAN CASE

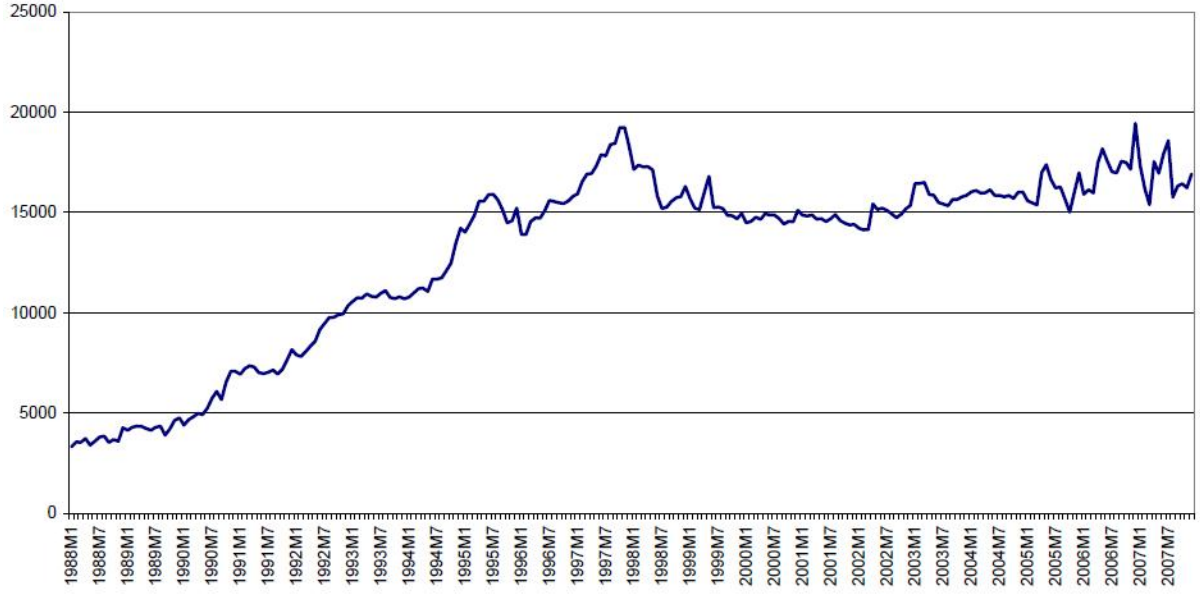
During most of the nineties, the Chilean level of reserves has increased substantially, as seen in Figure 1. During this period, the Central Bank of Chile (BCC) aimed to gradually reduce the high and persistent inflation by keeping domestic interest rates high. At the same time, the BCC sought to limit the pressure on the exchange rate, generated by large capital inflows. As part of the flow of capital was held by capital controls, the BCC intervened heavily in order to reduce the supply of foreign currency

[13] All calculations of adequate reserves made in this study were performed with the parameters estimated by Column (5) of Table 1 and Column (6) of Table 2. The use of other specifications does not significantly change the result.

in the economy. The monetary effects of reserves accumulation were sterilized by issuing debt. Since the interest paid by debt was significantly higher than the interest earned by the reserves, the cost paid for this policy was substantial.

Since the floating of the peso in 1999, questions about the accumulation of excess reserves by the BCC have intensified. If the BCC adopt a regime where the rule was not to intervene in the exchange, it became obvious that the level of reserves should not be the same. However this change did not mean that the BCC should sell its entire stock of reserves, given that economies with floating exchange rates should keep stock of reserves that allow them to intervene in exchange for special occasions. Thus it became important to evaluate the optimal level of reserves.

Figure 1 - International Reserves of Chile



In agreement with the Central Bank of Chile, as Jadresic (2007), from cost-benefit analysis, in 2003 the government implemented a program to reduce the stock of international reserves. The program was to offer to the holders of domestic debt

denominated in dollars (titles called BCD or PRD), but paid in domestic currency, the chance to exchange them for securities denominated and paid in dollars (titles called BXC). The program also included the payment with reserves bonds at maturity, reducing both the stock of reserves and the liability of the BCC.

However, the voluntary exchange of securities by BCX BCD was not very significant. Thus, the BCC decided to supplement this program with the policy not to renew the bonds at maturity BCDs, offering trading during 2004 and 2005, these securities BCXs for one year. These BCXs are being paid at maturity by using the reserves. Thus, in late 2006, the reduction of reserves through this program was approximately 3.7 billion dollars.

However, until May 2006, this program has not generated a significant reduction in the level of reserves maintained by the BCC. The reduction provided by the program was offset by the increase in the reserves generated by a buildup of deposits in foreign currency and swap transactions undertaken by the banking system and government with the central bank. The increase in reserves, however, was funded by the increase in short-term liabilities of the BCC.

In Table 5, we show the results of our simulation of optimal reserves, calculated by eq. (10) for the Chilean data in June 2007, using various cost scenarios of crisis and reserves.

Table 5 - Optimal Reserves for Chile

Chile

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	96 067	5 790	-18 622	-29 514	-36 456	-42 084	-45 576	-49 702	-52 040	-54 014
2	96 067	5 790	-12 849	-24 399	-32 446	-37 984	-42 327	-45 885	-48 759	-51 184
3	96 067	13 584	-8 866	-19 934	-28 027	-34 129	-38 757	-42 492	-45 579	-48 185
4	96 067	17 795	-3 647	-15 934	-24 944	-30 583	-35 421	-39 338	-42 592	-45 349
5	97 027	19 752	-1 058	-12 317	-20 870	-27 317	-32 324	-36 395	-39 790	-42 675
6	107 700	25 579	2 231	-9 026	-17 695	-24 312	-29 444	-33 644	-37 158	-40 153
7	107 700	28 393	5 601	-6 228	-14 795	-21 638	-26 758	-31 066	-34 681	-37 771
8	107 700	31 516	9 577	-3 187	-12 108	-19 258	-24 246	-28 644	-32 345	-35 518
9	119 548	31 831	12 276	-924	-9 607	-16 416	-21 889	-26 364	-30 139	-33 383
10	119 548	35 333	13 626	1 781	-7 271	-14 610	-19 672	-24 212	-28 051	-31 356
11	119 548	39 219	16 974	3 045	-5 080	-12 008	-17 581	-22 176	-26 071	-29 429
12	119 548	39 219	18 841	5 208	-3 505	-9 975	-15 647	-20 247	-24 189	-27 594
13	119 548	43 387	20 914	8 098	-1 068	-8 066	-13 926	-18 414	-22 397	-25 844
14	120 743	43 387	23 030	8 989	545	-6 256	-12 394	-16 668	-20 688	-24 172
15	121 950	47 134	24 836	11 715	2 239	-4 536	-10 239	-15 004	-19 056	-22 572
16	135 365	47 134	25 085	13 004	3 828	-3 130	-9 113	-13 414	-17 494	-21 038
17	135 365	47 606	27 844	14 435	5 015	-1 323	-7 086	-11 938	-15 997	-19 567
18	135 365	51 915	29 682	16 022	6 569	-384	-5 595	-10 625	-14 560	-18 153
19	135 365	51 915	29 682	17 785	8 605	1 610	-4 178	-9 456	-13 179	-16 792
20	135 365	52 434	32 489	19 420	9 552	2 753	-2 883	-7 680	-11 850	-15 482

The reserves in Chile in June 2007 were just under 18 billion[14]. The BCC estimates that the unit cost of reserves can be approximated by the Chilean sovereign spread, i.e. the difference between the return on U.S. treasury bond and debt issued by the Chilean government internationally[15]. Thus, we can assume that the unit cost is a penny per dollar. As we can see in Table 5, for a cost of reserves a penny per dollar and a cost crisis of five, ten and fifteen[16] percent of GDP would be adequate reserves respectively 19, 35 and 47 billion dollars. In bold are the combinations for which the Chilean reserves of approximately $ 18 billion in June 2007 would be the optimum level. We can observe that the costs of a penny per dollar, Chilean reserves are adequate for a cost of crisis 4%.

[14] This figure excludes the sovereign funds

[15] See Management of Foreign Exchange Reserve at Central Bank of Chile 2006.

[16] These values are about what the IMF considers crisis as light, medium and serious. See IMF (1998)

If we use cost as the difference between the interest rate in Chile and U.S., this cost drops to zero[17] and the optimal levels of reserves are 97,120, 121 billion for a cost of crisis of five, ten and fifteen percent of GDP[18] respectively.

Note that for some combinations of cost, the optimal reserves are negative, indicating that for high cost of reserves we have low-cost crisis, it would be better to sell insurance, or hold negative reserves. As this is impossible, the reserves would be zero. However, a minimum stock of reserves is always indicated for economies with floating exchange rates, this result should prescribe a low stock of reserves, given the high cost and / or low benefit.

5.2.2 THE MEXICAN CASE

During recent years the Mexican reserves have grown considerably, as shown in Figure 2. Between December 1997 and April 2003, the stock of reserves nearly doubled, from 28 billion to 52 billion dollars. On March 20, 2003, the Mexican Foreign Exchange Commission announced the implementation of a mechanism to slow the accumulation of reserves by the Bank of Mexico. This mechanism stipulates that a portion of foreign currency could potentially be used to increase role of reserves for the market purposes.

[17] Excluding the income tax of 15%, this cost becomes negative.
[18] Following a policy of transparency, the BCC reports the composition of the reserves in Chile and its costs, so find it more appropriate to use the value of a penny per dollar, since that is the value calculated by the BCC.

Figure 2 - International Reserves of Mexico

The mechanism provides that the Bank of Mexico sale directly to the U.S. dollar market, according to the following rules:

- In anticipation of a quarter, the Bank of Mexico says that the volume of dollars puts in a public offering on the market. The stock of U.S. dollars to be auctioned is equivalent to 50% of the flow of reserves accumulated in the previous quarter.
- Depending on the stock of dollars being offered, the Bank of Mexico auctions off a fixed quota of dollars every day on a predetermined schedule. The daily quota is determined by the number of working days in the quarter in which the auction will be held.
- The credit card companies in the country are the only players allowed in the auction.
- If the volume to be offered in the quarter is less than $ 125 million, the auction will be suspended temporarily. Moreover, the mechanism will only be resumed if the reserves reach a level above 250 million worth of last quarter in which the mechanism was triggered.

An important feature is that the Bank of Mexico said the auctions would be held regardless of market conditions at the time of the auction. This implies that this mechanism will not affect the floating exchange rate regime adopted by the bank.

In Table 6, we show the results of our simulation of optimal reserves, calculated by eq. (10) for the Mexican data in June 2007. Just as in the case of Chile, we put various scenarios for costs of reserves and crisis.

Reserves in Mexico in June 2007 were just around 78 billion dollars. The average cost in June 2007 issue of government debt was approximately 7% as a return of U.S. government bonds of 5% we can estimate that the cost of reserves in Mexico for the period was two cents per dollar[19] . As we can see in Table 6, for a cost of reserves two cents per dollar and a crisis cost of five, ten and fifteen percent of GDP would be great reserves respectively: 75, 100 and 115 billion dollars. In bold are the combinations for which the Mexican reserves a little below 78 billion in June 2007 would be approximately optimal.

[19] Excluding the income tax, this difference drops to about 1 cent per dollar.

Table 6 - Optimal Reserves for Mexico

Mexico

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar 1	2	3	4	5	6	7	8	9	10
1	**79 394**	42 366	20 817	5 844	-3 864	-12 618	-19 836	-26 323	-31 337	-35 805
2	87 491	52 005	31 420	17 063	5 850	-3 659	-10 492	-16 712	-22 504	-27 253
3	96 453	61 211	40 227	25 775	14 434	5 391	-2 062	-8 680	-14 253	-19 481
4	104 395	67 944	48 086	33 244	22 012	12 774	5 200	-1 438	-7 294	-12 337
5	111 298	**75 418**	53 375	40 019	28 522	19 344	11 549	4 886	-953	-6 205
6	117 368	**81 590**	60 867	46 037	34 483	25 100	17 338	10 579	4 640	-566
7	118 541	87 025	66 078	51 101	39 853	30 425	22 499	15 771	9 806	4 515
8	127 160	91 927	70 957	56 061	44 237	35 274	27 313	20 451	14 513	9 180
9	128 432	96 398	**75 428**	60 533	48 961	39 155	31 735	24 844	18 795	13 481
10	135 852	100 509	**79 543**	64 645	53 086	43 462	35 225	28 909	22 836	17 428
11	135 852	104 314	83 353	68 454	56 892	47 436	39 100	32 089	26 599	21 170
12	143 151	107 854	86 900	72 002	60 437	50 988	42 983	35 619	30 113	24 672
13	143 151	108 933	90 218	75 322	63 756	54 303	46 314	39 374	33 321	27 958
14	149 635	114 118	93 334	**78 441**	66 875	57 420	49 428	42 509	36 416	30 977
15	149 635	115 260	96 272	81 383	69 817	60 361	52 366	45 444	39 344	33 894
16	151 131	119 859	99 051	84 166	72 602	63 145	55 148	48 222	42 117	36 662
17	157 877	121 058	101 686	86 805	75 243	65 787	57 789	50 861	44 753	39 293
18	157 877	125 026	102 703	89 317	**77 757**	68 301	60 302	53 373	47 262	41 799
19	159 456	125 026	106 509	91 711	**80 154**	70 699	62 700	55 769	49 657	44 191

5.2.3 OPTIMAL LEVEL OF RESERVES FOR OTHER COUNTRIES

In most cases, taking into account the different costs of reserves, countries maintain optimal levels of reserves for crisis costs up to 5%. Figure 3 shows which combinations of expected cost of the crisis and reserves, the reserves accumulated by the countries in June 2007 or December 2006 (depending on data availability), are roughly optimal.

We note that for most countries in the figure[20], the reserves are great for a crisis to cost of 5% of GDP. Even for China, whose reserves are larger than a trillion dollars, the accumulated reserves are approximately optimal for an expected cost of the crisis to 5% of GDP. The exceptions are Jordan, Pakistan, Venezuela and Brazil.

[20] Singapore, Hong Kong, Hungary and Turkey are not in the picture, because for these countries the optimal estimated reserves are negative for the relevant reservation costs.

In the case of Jordan, the cost of the reserves is low, 1.5 cents per dollar. The volume of reserves in June 2007 was 7 billion dollars, the model estimates optimal reserves stock of 2.5 billion dollars for reserves cost of 1.5 cents per dollar and a crisis cost of 5% of GDP.

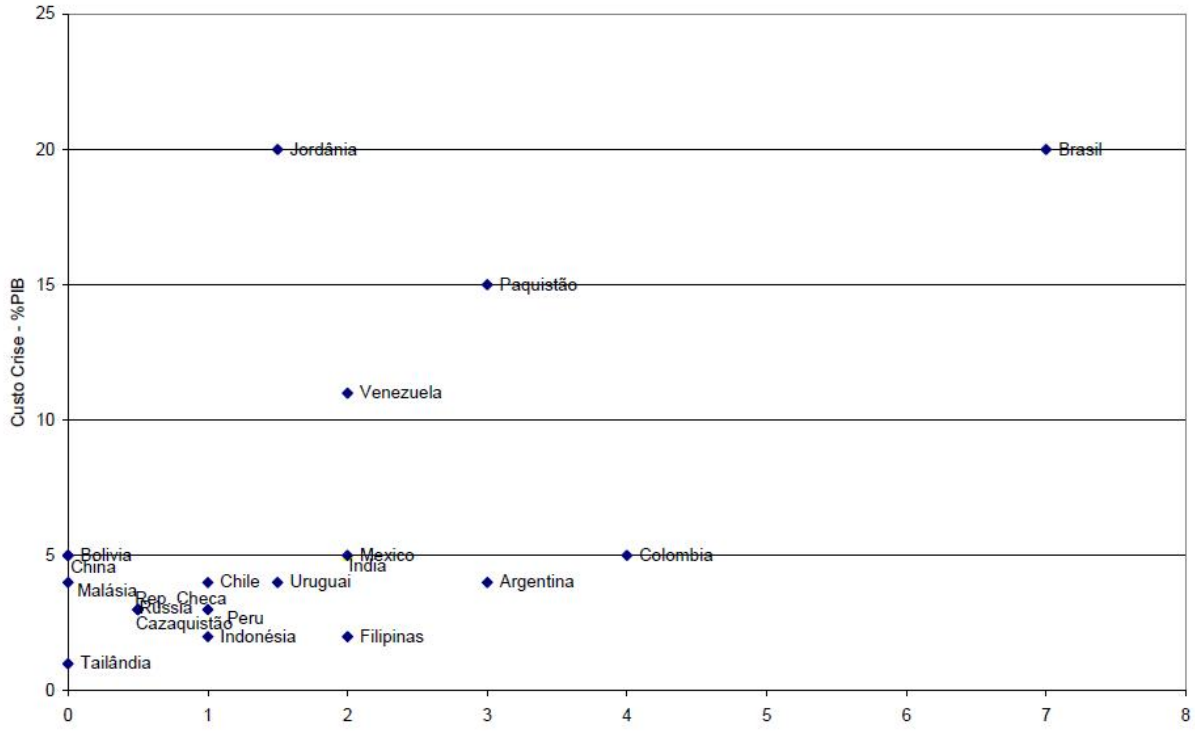
The reserves accumulated by December 2006 were 12 billion dollars for Pakistan. The cost of these reserves was approximately three cents per dollar. The model estimates an optimal level of 9 billion for an expected crisis cost 5% of GDP.

In December 2006, Venezuela's reserves reached $ 30 billion. The estimated cost of these reserves is approximately two cents per dollar. For a cost of two cents per dollar and for a crisis cost of 5% of GDP, the model estimates optimal reserves of 25 billion dollars.

Finally for the Brazilian case, the cost is very high. The Brazilian reserves in June 2007 exceeded 147 billion dollars, the model estimated for cost a reserve of seven cents per dollar and cost of a crisis of 5% of GDP, a reserve stock about 42 billion dollars.

In order to organize the results we separate sections for groups of countries. In the next section there are the results for the countries of South America. Then we present the results for Asian countries, and at last for the remaining countries.

Figure 3 – Estimated level of optimal reserves for all countries from sample



South America

Tables 7, 8, 9, 10, 11, 12 and 13 are the results estimated for optimal reserves respectively for: Argentina, Bolivia, Colombia, Peru, Uruguay, Brazil and Venezuela.

In June 2007, the Argentinean reserves were approximately $ 42 billion. The stock of Argentinean reserves showed a huge growth in the last two years, beginning in 2006, this was approximately $ 19 billion, doubling in volume in two years. The basic interest rate in Argentina in June 2007 was around 8% per annum, thus the cost of reserves is approximately three cents per dollar. As can be seen in Table 7, the optimal stock of reserves for cost of reserves of three cents per dollar and crisis costs of five, ten and fifteen percent of GDP is respectively 46, 57, 64 billions. According to

the estimated model reserves of 42 billion dollars are great for keeping reserves for a cost of three cents per dollar and a crisis cost of 4% of GDP.

Table 7 - Optimal Reserves for Argentina

Argentina

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	113 035	74 140	54 934	46 378	40 004	35 666	30 963	27 189	24 101	21 517	19 325
2	125 468	74 140	60 660	51 348	44 404	39 512	35 402	31 717	28 556	25 798	23 357
3	125 468	80 570	65 055	55 576	48 756	43 527	39 226	35 206	32 597	29 784	27 277
4	125 468	81 375	68 658	59 162	52 366	47 079	42 742	39 016	35 901	33 060	30 741
5	125 468	87 180	71 741	62 258	55 475	50 183	45 840	42 151	38 962	36 136	33 630
6	139 270	87 180	72 458	64 981	58 210	52 924	48 584	44 899	41 700	38 872	36 341
7	139 270	92 352	76 606	67 411	60 652	55 376	51 041	47 361	44 162	41 332	38 797
8	139 270	92 352	77 372	69 606	62 860	57 592	53 265	49 589	46 393	43 566	41 030
9	139 270	93 276	80 852	70 302	64 873	59 615	55 295	51 625	48 433	45 608	43 074
10	139 270	98 282	80 852	73 329	66 723	61 474	57 161	53 497	50 310	47 489	44 958
11	139 270	98 282	84 344	74 062	67 390	63 194	58 889	55 231	52 049	49 231	46 703
12	139 270	98 282	84 344	76 648	69 949	64 794	60 496	56 844	53 666	50 853	48 329
13	140 663	103 016	87 431	77 415	70 648	65 442	61 998	58 352	55 179	52 371	49 849
14	142 069	103 016	87 431	78 189	72 857	67 641	63 408	59 767	56 600	53 795	51 278
15	143 490	103 016	88 305	80 808	73 586	68 317	64 042	61 101	57 938	55 138	52 624
16	144 925	104 046	91 336	80 808	75 438	70 230	65 955	62 362	59 203	56 407	53 897
17	146 374	105 086	91 336	83 233	76 193	70 932	66 615	62 985	60 403	57 610	55 103
18	146 374	106 137	92 250	83 233	76 955	72 556	68 289	64 667	61 007	58 754	56 250
19	147 838	107 199	93 172	84 066	78 802	73 282	68 972	65 313	62 606	59 844	57 344
20	149 316	108 271	94 104	86 428	78 802	74 014	70 407	66 791	63 232	60 442	58 387

The Bolivian reserves in June 2007 were approximately $ 3 billion, the growth trend is also observed in Bolivia in early 2006, the stock was about one billion dollars. The basic interest rate in June 2007 was around 5% a year, so the cost of reserves in Bolivia was approximately zero. As it can be seen in Table 8, with no cost and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are 2.5, 2.6 and 2.8 billion dollars respectively.

Table 8 - Optimal Reserves for Bolivia

Bolivia

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	2 324	1 556	1 296	1 139	1 027	940	869	809	757	705	666
2	2 324	1 572	1 363	1 209	1 099	1 013	943	884	832	793	752
3	2 324	1 680	1 431	1 277	1 168	1 083	1 013	954	902	858	817
4	2 580	1 697	1 490	1 337	1 227	1 142	1 073	1 013	962	917	876
5	2 580	1 792	1 541	1 388	1 279	1 194	1 124	1 065	1 014	969	928
6	2 580	1 792	1 556	1 433	1 324	1 239	1 169	1 111	1 059	1 014	973
7	2 580	1 877	1 622	1 473	1 364	1 279	1 210	1 151	1 100	1 055	1 014
8	2 580	1 877	1 638	1 487	1 400	1 315	1 246	1 187	1 136	1 091	1 051
9	2 580	1 896	1 691	1 539	1 433	1 348	1 279	1 221	1 170	1 124	1 084
10	2 606	1 976	1 691	1 555	1 447	1 379	1 310	1 251	1 200	1 155	1 115
11	2 632	1 976	1 748	1 598	1 490	1 407	1 338	1 279	1 228	1 183	1 143
12	2 658	1 976	1 748	1 614	1 505	1 421	1 364	1 305	1 254	1 210	1 169
13	2 685	1 995	1 799	1 630	1 540	1 456	1 377	1 330	1 279	1 234	1 194
14	2 685	2 015	1 799	1 671	1 556	1 471	1 410	1 343	1 302	1 257	1 217
15	2 712	2 096	1 817	1 671	1 571	1 501	1 424	1 374	1 315	1 279	1 239
16	2 739	2 096	1 835	1 712	1 605	1 516	1 453	1 387	1 344	1 292	1 259
17	2 766	2 096	1 854	1 712	1 621	1 531	1 467	1 414	1 357	1 318	1 272
18	2 766	2 096	1 872	1 729	1 637	1 546	1 482	1 428	1 382	1 332	1 297
19	2 794	2 117	1 891	1 747	1 654	1 576	1 497	1 442	1 395	1 355	1 310
20	2 794	2 138	1 910	1 764	1 670	1 592	1 524	1 457	1 409	1 368	1 332

In the Colombian case, the reserves in June 2007 reached approximately 20 billion dollars in the last two years, they have been growing smoothly at the beginning of 2006 reserves were just under 15 billion. The interest rate was about 8.8% per annum in the period, thus the cost of reserves was approximately four cents per dollar. As it can be seen in Table 9 for a cost of four cents per dollar, and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 20, 29 and 35 billion dollars respectively. According to the estimated model reserves of 20 billion dollars are great for keeping the reserves with costs of four cents per dollar and a cost of crisis of 5% of GDP.

Table 9 - Optimal Reserves for Colombia

Colombia

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	92 109	51 788	35 723	26 750	21 736	16 901	13 222	10 452	8 108	5 530	3 616
2	92 109	51 788	38 494	29 693	24 126	20 359	16 744	13 692	11 309	8 998	7 082
3	92 109	52 306	41 804	32 959	28 118	23 710	20 063	16 996	14 385	11 787	10 138
4	92 109	57 829	44 769	36 571	30 950	26 318	22 973	19 880	17 215	14 849	12 809
5	93 030	57 829	47 360	39 266	33 522	29 027	25 403	22 067	19 735	17 372	15 273
6	103 263	62 776	49 646	41 571	35 814	31 331	27 668	24 494	21 895	19 283	17 497
7	103 263	62 776	50 143	43 625	37 870	33 388	29 718	26 606	23 923	21 404	19 421
8	103 263	66 838	53 361	45 483	39 732	35 253	31 582	28 472	25 778	23 389	21 276
9	103 263	66 838	53 895	47 180	41 435	36 958	33 288	30 178	27 481	25 100	22 971
10	103 263	67 506	56 651	47 652	43 002	38 529	34 861	31 752	29 054	26 671	24 539
11	103 263	71 469	56 651	50 093	44 453	39 985	36 319	33 211	30 514	28 131	25 997
12	114 622	71 469	59 411	50 594	44 898	41 340	37 678	34 572	31 876	29 493	27 358
13	114 622	71 469	59 411	52 722	47 004	42 609	38 950	35 847	33 151	30 769	28 635
14	114 622	72 184	61 870	53 250	47 474	43 801	40 146	37 045	34 351	31 970	29 836
15	114 622	76 260	61 870	55 043	49 328	44 239	41 273	38 175	35 483	33 103	30 970
16	114 622	76 260	62 488	55 043	49 821	45 949	42 340	39 244	36 554	34 176	32 044
17	114 622	76 260	65 005	57 072	51 408	46 408	42 763	40 258	37 570	35 194	33 063
18	114 622	76 260	65 005	57 072	51 922	47 927	44 284	41 223	38 538	36 163	34 033
19	114 622	77 022	65 655	58 940	52 441	48 406	44 727	41 635	39 460	37 086	34 959
20	114 622	80 992	66 311	58 940	54 132	49 724	46 085	42 999	40 341	37 969	35 843

Peru reserves in June 2007 were approximately $ 21 billion. In early 2006, they were lower 14 billion and by the end of 2007 continued to grow, reaching 24 billion. The cost paid for this level of reserves was approximately zero in the period, since the interest rate was about 4.5% per year, below the return on U.S. bonds. As it can be seen in Table 10 for a zero cost of maintaining reserves, and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 66, 74 and 76 billion dollars respectively. In the Peruvian case, the reserves are great for a reserves cost of penny per dollar and a cost of crisis of 3% of GDP.

Table 10 - Optimal Reserves for Peru

Peru

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	59 484	30 830	18 939	13 883	9 553	6 552	3 497	1 306	-552	-2 154	-3 489
2	59 484	30 830	22 612	16 550	12 180	8 583	5 979	4 029	2 118	460	-1 012
3	66 028	34 221	25 099	18 371	14 708	11 244	8 646	6 352	4 418	2 717	1 222
4	66 028	37 713	27 408	20 392	16 326	13 498	10 734	8 321	6 463	4 646	3 067
5	66 028	37 713	29 387	22 635	18 827	14 983	12 639	10 279	8 267	6 540	4 953
6	66 688	41 316	31 131	24 856	20 507	16 631	14 029	11 980	9 941	8 155	6 489
7	74 024	41 316	31 443	26 477	22 062	18 460	15 572	13 298	11 465	9 663	8 054
8	74 024	44 381	33 961	27 900	23 478	20 028	17 212	14 761	12 726	10 726	9 434
9	74 024	44 381	34 301	29 197	24 776	21 337	18 525	16 142	14 087	12 310	10 472
10	74 024	44 825	36 481	29 489	25 973	22 535	19 721	17 341	15 281	13 468	11 624
11	74 024	47 912	36 481	31 420	27 083	23 645	20 831	18 450	16 387	14 569	12 902
12	74 024	47 912	38 608	31 734	28 117	24 681	21 867	19 485	17 420	15 600	13 970
13	74 764	47 912	38 608	33 436	28 398	25 652	22 839	20 456	18 390	16 568	14 938
14	75 512	48 392	40 498	33 771	29 949	26 564	23 752	21 370	19 304	17 480	15 849
15	76 267	51 589	40 498	35 220	30 249	27 426	24 615	22 233	20 167	18 343	16 711
16	77 029	51 589	40 903	35 220	31 632	27 700	25 431	23 050	20 984	19 160	17 527
17	77 800	51 589	42 900	36 784	31 948	28 984	26 207	23 826	21 761	19 937	18 304
18	78 578	51 589	42 900	36 784	33 149	29 274	26 469	24 565	22 501	20 677	19 044
19	79 363	54 598	43 329	38 222	33 149	30 429	27 624	25 270	23 206	21 383	19 750
20	80 157	54 598	43 762	38 222	34 504	30 734	27 901	25 944	23 881	22 058	20 425

The stock of reserves in Uruguay in June 2007 was lower than $ 4 billion. The cost paid for these was approximately zero during the period because the Uruguayan interest rate was approximately 3% per year, below the return on U.S. bonds. As it can be seen in Table 11 for a no cost and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 23, 25, 26 billion dollars respectively. Uruguayan reserves are great for a cost of reserves of 1.5 cents per dollar and a cost of crisis 4% of GDP.

As we can see in Table 12 for Brazil, for a cost of keeping the reserves of five cents per dollar and for a cost of crisis of five, ten and fifteen percent of GDP, great reserves would be respectively: 73, 117, 147 billion dollars. In June 2007, the interest rate was approximately seven cents per dollar, the volume of reserves that minimizes the loss function of the government crisis to cost of five, ten and fifteen percent of GDP is respectively 42, 86, 116 billion dollars.

Table 11 - Optimal Reserves for Uruguay

Uruguay

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	18 425	7 924	4 097	1 516	-513	-1 671	-2 577	-3 213	-3 915	-4 487	-4 951
2	18 609	7 924	4 097	1 985	262	-747	-1 778	-2 521	-3 192	-3 765	-4 261
3	20 656	8 796	5 367	3 016	1 075	72	-943	-1 785	-2 484	-3 084	-3 607
4	20 656	9 763	5 958	3 801	1 838	807	-273	-1 232	-1 826	-2 450	-2 996
5	22 928	10 837	6 613	4 219	2 785	1 381	415	-470	-1 260	-1 860	-2 423
6	22 928	10 837	7 341	5 137	3 415	2 085	1 011	118	-645	-1 310	-1 888
7	22 928	12 029	8 148	5 702	3 791	2 644	1 563	483	-187	-904	-1 386
8	22 928	12 029	8 229	6 257	4 511	2 935	2 048	1 153	372	-312	-956
9	23 157	13 318	9 135	6 753	4 997	3 638	2 546	1 510	835	143	-467
10	25 705	13 318	9 135	7 211	5 451	4 038	2 826	1 978	1 267	569	-135
11	25 705	13 318	10 061	7 283	5 876	4 482	3 403	2 471	1 660	970	286
12	25 705	14 594	10 061	8 008	6 274	4 906	3 777	2 743	2 055	1 270	717
13	25 705	14 594	10 850	8 088	6 648	5 280	4 163	3 227	2 281	1 664	1 079
14	25 705	14 594	10 850	8 741	6 714	5 631	4 514	3 572	2 760	2 049	1 413
15	25 705	14 740	11 545	8 741	7 316	5 964	4 846	3 902	3 063	2 274	1 738
16	25 962	15 966	11 545	9 390	7 389	6 281	5 161	4 216	3 398	2 683	1 929
17	26 221	15 966	11 661	9 390	7 937	6 582	5 461	4 515	3 697	2 978	2 337
18	26 483	15 966	12 434	9 982	8 016	6 648	5 748	4 801	3 982	3 261	2 594
19	26 748	15 966	12 434	9 982	8 503	7 132	6 022	5 074	4 254	3 532	2 879
20	27 016	16 126	12 559	10 522	8 503	7 203	6 285	5 336	4 515	3 792	3 147

Table 12 - Optimal Reserves for Brazil

Brazil

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar									
	1	2	3	4	5	6	7	8	9	10
1	156 241	97 405	60 847	34 568	15 512	569	-14 018	-24 906	-33 098	-41 997
2	173 427	115 924	78 104	52 169	32 155	15 084	2 466	-9 068	-18 675	-27 225
3	192 504	128 675	94 399	67 586	47 510	30 987	17 102	4 625	-5 416	-13 804
4	210 006	142 830	108 549	81 490	60 703	44 254	29 244	18 044	7 654	-1 495
5	222 947	157 779	120 211	93 712	72 744	55 757	41 753	29 444	18 807	9 545
6	233 931	169 074	131 042	104 020	83 504	66 384	52 013	39 909	29 000	19 489
7	236 271	178 895	140 808	113 741	92 689	76 004	61 536	49 088	37 990	28 631
8	251 610	187 742	149 658	122 572	101 554	84 364	70 240	57 713	46 706	36 945
9	254 126	195 813	157 743	130 651	109 618	92 440	77 966	65 662	54 615	44 778
10	267 258	203 234	165 183	138 093	117 050	99 855	85 334	72 794	61 934	52 055
11	267 258	210 102	172 073	144 990	123 942	106 735	92 193	79 615	68 553	58 836
12	280 372	212 203	178 488	151 415	130 368	113 153	98 598	86 000	74 906	65 012
13	280 372	222 156	184 489	157 428	136 384	119 167	104 603	91 992	80 880	70 957
14	292 044	224 377	190 125	163 078	142 040	124 822	110 254	97 634	86 509	76 570
15	292 044	233 142	195 439	168 405	147 375	130 159	115 588	102 962	91 829	81 878
16	294 964	235 473	200 464	173 445	152 423	135 211	120 640	108 010	96 871	86 911
17	306 917	242 971	202 469	178 226	157 213	140 005	125 436	112 805	101 661	91 694
18	306 917	245 401	209 623	182 773	161 770	144 568	130 001	117 369	106 223	96 252
19	309 986	247 855	211 719	187 109	166 114	148 919	134 355	121 725	110 577	100 602
20	313 086	255 838	218 108	191 251	170 266	153 077	138 517	125 888	114 740	104 764

In Venezuela, data for June 2007 were not available, so we did the calculation for December 2006. The stock was 30 billion dollars. The cost paid for the reserves was approximately two cents per dollar in the period since the Venezuelan interest rate of about 7% per annum. As it can be seen in Table 13 for a cost of two cents per dollar, and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 25, 29, $ 31 billion dollars respectively. Venezuela's reserves are adequate reserves for a cost of two cents per dollar and a cost of crisis of 11% of GDP.

Table 13 - Optimal Reserves for Venezuela

Venezuela

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	47 112	29 591	25 504	22 016	19 572	17 375	15 955	14 734	13 664	12 708	11 847
2	47 112	32 275	26 960	23 579	21 174	19 243	17 710	16 607	15 478	14 480	13 587
3	47 583	34 052	28 430	25 071	22 676	20 800	19 271	18 006	16 880	15 885	14 994
4	52 817	34 052	29 711	26 361	23 972	22 108	20 580	19 289	18 164	17 169	16 278
5	52 817	36 246	30 818	27 475	25 090	23 231	21 706	20 412	19 288	18 294	17 403
6	52 817	36 246	31 126	28 452	26 070	24 215	22 692	21 401	20 278	19 286	18 396
7	52 817	38 136	32 573	29 321	26 944	25 091	23 572	22 282	21 162	20 170	19 282
8	52 817	38 136	32 899	29 615	27 732	25 882	24 365	23 077	21 959	20 969	20 082
9	53 346	38 518	34 094	30 773	28 449	26 602	25 087	23 802	22 685	21 697	20 811
10	53 879	40 285	34 094	31 080	28 733	27 263	25 750	24 467	23 352	22 365	21 480
11	54 418	40 285	35 337	32 052	29 688	27 874	26 363	25 082	23 968	22 983	22 099
12	54 962	40 285	35 337	32 373	29 984	28 153	26 933	25 653	24 541	23 557	22 675
13	55 512	40 688	36 440	32 696	30 793	28 955	27 466	26 187	25 076	24 094	23 213
14	56 067	42 452	36 440	33 636	31 101	29 244	27 740	26 688	25 579	24 597	23 717
15	56 627	42 452	36 804	33 636	31 412	29 929	28 424	26 955	26 052	25 072	24 193
16	56 627	42 452	37 172	34 545	32 198	30 228	28 708	27 596	26 312	25 520	24 642
17	57 194	42 876	37 544	34 545	32 520	30 531	29 295	27 872	26 914	25 775	25 068
18	57 766	42 876	38 645	34 890	32 846	31 192	29 588	28 424	27 183	26 341	25 318
19	57 766	43 305	38 645	35 742	33 174	31 504	29 884	28 709	27 704	26 604	25 851
20	58 343	43 738	39 031	35 742	33 506	31 819	30 443	28 996	27 981	27 096	26 110

Asia

Tables 14, 15, 16, 17, 18, 19, 20, 21 shows the results estimated for optimal reserves respectively for: Kazakhstan, China, India, Indonesia, Malaysia, Pakistan, Philippines, Thailand.

The stock of reserves in Kazakhstan in June 2007 was lower than $ 21 billion. The cost paid for these reserves was approximately zero in the period, since the interest rate was approximately 3% per year, below the return on U.S. bonds. As it can be seen in Table 14, for a no cost, and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 79, 87.97 billion dollars respectively. In the case of a cost of 0.5 cents per dollar, reserves would be great for a cost of crisis of 3% of GDP.

The stock of reserves in China in June 2007 was approximately 1.33 trillion. The cost paid for these reserves was approximately zero in the period since the interest rate was below the return on U.S. bonds. As it can be seen in Table 15 for a no cost and a cost crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 1.34, 1.37, 1.53 trillion dollars respectively.

Table 14 - Optimal Reserves for Kazakhstan

Kazakhstan

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
1	64 132	23 515	1 165	-8 201	-13 297	-19 020	-22 823	-25 305	-28 378	-30 374	-32 093
2	71 187	23 515	4 787	-3 649	-10 381	-15 467	-20 312	-22 726	-25 464	-27 762	-29 754
3	71 187	23 515	8 185	-1 058	-7 163	-12 117	-16 288	-20 226	-22 663	-24 978	-27 088
4	79 017	30 702	13 449	2 233	-4 943	-9 074	-13 318	-16 837	-20 170	-22 370	-24 577
5	79 017	30 702	14 928	5 604	-1 433	-6 302	-10 638	-14 985	-17 951	-19 942	-22 228
6	79 017	34 079	19 217	9 001	731	-4 349	-8 174	-11 867	-14 963	-17 749	-20 030
7	87 709	37 828	21 331	9 991	3 004	-1 422	-5 897	-9 613	-13 317	-15 796	-17 969
8	87 709	37 828	23 677	13 088	5 138	725	-4 069	-7 544	-10 773	-14 059	-16 032
9	87 709	41 989	23 914	14 528	8 382	1 821	-1 796	-5 612	-8 859	-11 698	-14 268
10	87 709	41 989	26 544	16 126	9 304	4 570	-521	-3 872	-7 078	-10 411	-12 699
11	97 357	46 608	29 464	17 900	12 046	5 987	1 099	-2 672	-5 401	-8 298	-11 302
12	97 357	46 608	29 464	19 869	13 372	7 843	2 758	-775	-3 815	-6 720	-9 303
13	97 357	46 608	32 705	22 055	14 842	8 706	4 716	395	-2 632	-5 237	-8 280
14	97 357	51 735	32 705	24 184	16 475	11 043	6 178	2 488	-883	-3 828	-6 448
15	97 357	51 735	35 949	24 184	18 190	12 257	7 789	3 260	450	-2 641	-5 108
16	97 357	51 735	35 949	26 844	18 372	13 606	8 645	5 163	1 131	-1 195	-3 839
17	98 331	52 252	36 309	26 844	20 393	15 043	9 596	5 731	2 838	-347	-2 649
18	99 314	57 282	39 741	29 374	22 004	16 258	11 553	7 508	3 718	732	-1 828
19	100 307	57 282	39 741	29 374	22 004	16 421	12 709	8 334	4 870	1 836	-530
20	101 310	57 282	40 138	31 662	24 225	18 227	13 812	9 251	6 380	3 140	270

Table 15 - Optimal Reserves for China

China

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	1 079 385	633 719	489 921	410 395	331 497	272 419	226 457	184 118	158 415	132 363	110 269
2	1 198 117	703 428	543 812	453 751	384 393	327 979	282 338	241 195	214 515	185 553	159 981
3	1 198 117	768 062	600 582	502 363	426 677	378 609	332 725	293 637	261 080	231 754	205 682
4	1 210 099	775 743	644 866	545 038	472 880	418 427	369 324	336 457	302 897	273 285	246 876
5	1 343 209	843 172	681 564	581 605	510 102	454 626	408 562	370 692	336 216	309 375	282 796
6	1 343 209	843 172	713 154	613 331	542 012	486 444	440 810	402 259	368 629	339 327	312 834
7	1 343 209	903 301	720 285	641 322	570 129	514 620	469 074	430 462	396 921	367 329	340 808
8	1 343 209	903 301	763 281	666 370	595 297	539 870	494 387	455 801	422 286	392 667	366 132
9	1 356 641	952 662	770 914	689 040	618 080	562 740	517 322	478 782	445 297	415 693	389 161
10	1 370 208	952 662	807 181	695 930	638 894	583 638	538 286	499 797	466 351	436 772	410 257
11	1 383 910	962 189	807 181	727 569	658 051	602 875	557 589	519 153	485 748	456 202	429 710
12	1 536 140	971 810	843 461	734 845	664 631	620 695	575 473	537 089	503 727	474 215	447 751
13	1 536 140	1 024 328	843 461	762 032	691 486	637 292	592 129	553 796	520 478	491 002	464 567
14	1 536 140	1 024 328	875 570	769 652	698 401	643 665	607 716	569 432	536 156	506 716	480 311
15	1 536 140	1 024 328	875 570	792 214	721 718	666 831	622 360	584 123	550 888	521 483	495 109
16	1 536 140	1 034 571	884 326	792 214	728 936	673 499	628 583	597 976	564 780	535 410	509 066
17	1 536 140	1 044 917	916 249	818 354	748 601	693 769	648 818	611 081	577 923	548 587	522 272
18	1 536 140	1 055 366	916 249	818 354	756 087	700 706	655 306	617 192	590 392	561 087	534 802
19	1 536 140	1 065 920	925 412	842 395	763 648	718 012	673 115	635 041	602 252	572 978	546 720
20	1 536 140	1 076 579	934 666	842 395	783 663	725 193	679 847	641 391	608 274	584 315	558 084

In the Indian case, data for June 2007 were not available, so we did the calculation for December 2006. The stock was 170 billion dollars. The cost paid for the reserves was approximately two cents per dollar in the period since the Indian interest rate was approximately 7% per annum. As it can be seen in Table 16, for a cost of two cents per dollar, and a cost crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 167, 214, 245 billion dollars respectively.

Table 16 - Optimal Reserves for India

India

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	458 354	258 960	179 192	134 483	107 978	85 128	66 921	52 948	41 370	28 346	18 659
2	458 354	258 960	192 403	149 276	124 594	102 430	84 463	69 362	57 398	45 806	36 224
3	458 354	261 550	208 605	165 697	138 299	119 005	100 912	85 688	72 694	60 006	51 545
4	458 354	288 153	223 163	182 720	153 512	132 096	115 293	99 962	86 740	75 003	64 836
5	462 937	288 153	235 901	195 847	167 264	145 208	127 250	110 957	99 208	87 495	77 075
6	513 860	312 358	247 152	207 172	178 671	156 522	138 408	122 976	109 853	97 119	88 092
7	513 860	312 358	249 624	217 280	188 803	166 644	148 504	133 142	119 854	107 802	97 683
8	513 860	332 342	265 462	226 429	197 974	175 822	157 679	142 315	128 997	117 223	106 747
9	513 860	332 342	268 116	234 788	206 357	184 219	166 080	150 714	137 388	125 624	115 104
10	513 860	335 665	281 689	237 136	214 077	191 955	173 825	158 462	145 134	133 365	122 833
11	513 860	355 218	281 689	249 157	221 230	199 125	181 007	165 651	152 324	140 553	130 016
12	570 385	355 218	295 317	251 649	223 442	205 807	187 702	172 353	159 031	147 262	136 723
13	570 385	355 218	295 317	262 130	233 808	212 061	193 969	178 631	165 315	153 549	143 011
14	570 385	358 770	307 464	264 752	236 146	217 939	199 861	184 533	171 224	159 464	148 928
15	570 385	378 923	307 464	273 592	245 277	220 118	205 418	190 101	176 801	165 046	154 514
16	570 385	378 923	310 539	273 592	247 730	228 535	210 677	195 371	182 079	170 331	159 804
17	570 385	378 923	322 972	283 613	255 547	230 820	212 784	200 372	187 089	175 348	164 826
18	570 385	378 923	322 972	283 613	258 103	238 296	220 270	205 130	191 857	180 122	169 606
19	570 385	382 712	326 202	292 853	260 684	240 679	222 472	207 182	196 403	184 676	174 166
20	570 385	402 370	329 464	292 853	269 007	247 172	229 160	213 894	200 748	189 029	178 525

The stock of reserves for Indonesia in June 2007 was lower than $ 50 billion. The cost paid for these reserves was approximately one cent per dollar in the period since the interest rate was approximately 6% per annum. As it can be seen in Table 17, for a cost of one cent per dollar, and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 88, 125, $ 181 billion dollars respectively. Reserves are great for a cost of reserves of penny per dollar and a cost of crisis of 2% of GDP.

Table 17 - Optimal Reserves for Indonesia

Indonesia

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
1	154 556	61 916	14 968	-7 647	-22 787	-33 695	-41 898	-48 287	-53 428	-57 650	-61 201
2	202 468	81 110	43 840	21 402	4 977	-6 009	-15 948	-23 288	-29 492	-34 817	-39 441
3	202 468	102 203	64 729	42 200	26 092	12 679	3 601	-4 207	-11 551	-17 408	-22 557
4	224 740	113 445	79 955	55 282	41 168	28 646	18 772	8 877	2 843	-3 234	-9 027
5	224 740	125 924	88 750	69 230	53 154	40 970	30 508	21 814	14 671	8 253	2 341
6	249 461	139 599	98 512	76 845	63 430	50 744	39 966	31 902	24 298	17 816	12 039
7	249 461	140 995	109 349	85 298	70 407	59 387	48 939	40 218	31 831	26 187	20 208
8	249 461	154 894	117 844	94 681	78 152	65 920	56 482	47 689	40 010	33 402	27 628
9	251 956	154 894	124 492	101 815	85 609	73 053	62 695	52 934	46 680	39 975	33 999
10	279 671	167 284	125 737	107 723	91 583	79 005	68 687	58 757	51 815	45 882	39 881
11	279 671	167 284	134 992	113 001	96 896	84 336	74 033	65 198	57 514	50 929	44 268
12	279 671	168 957	136 342	117 804	101 728	89 189	78 902	70 171	62 593	55 915	49 138
13	279 671	181 360	144 278	118 982	106 166	93 648	83 376	74 662	67 097	60 416	54 379
14	279 671	181 360	144 278	126 008	110 268	97 770	87 513	78 811	71 254	64 576	58 593
15	279 671	181 360	152 064	127 268	114 083	101 603	91 360	82 670	75 121	68 449	62 471
16	282 468	192 765	152 064	133 412	115 223	105 184	94 955	86 276	78 736	72 070	66 097
17	285 292	192 765	158 973	134 746	120 824	108 544	98 329	89 661	82 129	75 469	69 501
18	288 145	192 765	158 973	139 939	122 032	109 630	101 507	92 849	85 326	78 673	72 710
19	291 027	194 693	160 562	139 939	126 990	114 576	104 510	95 862	88 347	81 701	75 744
20	293 937	196 640	167 747	145 642	128 260	115 722	107 357	98 719	91 212	84 573	78 621

The stock of reserves for Malaysia in June 2007 was around $ 100 billion. The cost of these reserves in the period is zero, since the interest rate was approximately 3.5% per year. As it can be seen in Table 18, for a cost of zero cents per dollar, and a cost crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 114, 141, 157 billion dollars respectively. Reserves are great for a zero cost of reserves and a cost of crisis of 4% of GDP.

Table 18 - Optimal Reserves for Malaysia

Malaysia

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	103 488	12 027	-22 752	-35 585	-47 472	-56 115	-62 669	-69 224	-72 951	-76 710	-80 018
2	103 488	12 027	-15 699	-31 671	-42 903	-51 550	-58 301	-63 851	-68 362	-72 229	-75 567
3	103 488	15 755	-10 832	-24 875	-38 184	-45 907	-52 933	-58 665	-63 449	-67 529	-71 058
4	103 488	26 941	-3 141	-19 128	-31 385	-40 857	-47 929	-53 874	-58 862	-63 128	-66 829
5	114 871	27 210	1 602	-13 988	-27 932	-36 363	-43 329	-49 449	-54 603	-59 023	-62 870
6	114 871	35 645	6 585	-9 652	-21 942	-32 363	-39 087	-45 350	-50 640	-55 189	-59 158
7	127 507	39 566	11 260	-6 660	-19 528	-28 803	-35 159	-41 539	-46 941	-51 599	-55 671
8	127 507	43 919	14 750	-1 931	-13 999	-23 665	-31 508	-37 983	-43 479	-48 228	-52 388
9	127 507	44 358	19 323	985	-12 459	-21 062	-28 099	-34 653	-40 228	-45 054	-49 290
10	141 533	49 237	21 448	4 048	-8 597	-16 925	-25 008	-31 527	-37 168	-42 060	-46 360
11	141 533	54 653	23 808	6 923	-5 932	-15 064	-22 257	-28 581	-34 279	-39 227	-43 584
12	141 533	54 653	26 426	9 069	-1 720	-11 035	-19 809	-25 799	-31 545	-36 542	-40 947
13	141 533	60 665	29 333	11 880	-499	-9 821	-17 630	-23 163	-28 951	-33 990	-38 438
14	141 533	60 665	32 560	15 563	2 649	-6 777	-13 868	-20 661	-26 485	-31 561	-36 046
15	157 101	67 338	36 142	17 274	6 649	-4 676	-12 342	-18 389	-24 136	-29 244	-33 761
16	157 101	67 338	36 503	22 090	7 380	-1 356	-9 162	-16 366	-21 893	-27 029	-31 576
17	157 101	67 338	40 518	22 090	9 668	-393	-8 154	-14 566	-19 748	-24 909	-29 481
18	157 101	74 746	40 923	24 519	12 666	2 088	-5 626	-12 963	-17 693	-22 877	-27 472
19	157 101	74 746	45 425	27 217	14 059	3 571	-3 882	-9 792	-15 747	-20 925	-25 540
20	157 101	74 746	45 425	30 210	15 605	6 106	-1 126	-8 715	-14 015	-19 049	-23 682

In the case of Pakistan, data for June 2007 were not available, so we did the calculation for December 2006. The stock of reserves of Pakistan in December 2006 was around $ 12 billion. The cost paid for these reserves was approximately three cents per dollar in the period since the interest rate was approximately 8% per annum. As it can be seen in Table 19, for a cost of three cents per dollar, and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 9, 10, 12 billions respectively. Reserves are optimal for a cost of three cents per dollar and cost of crisis of 15% of GDP.

The stock of reserves in the Philippines in June 2007 was around 24 billion dollars. The cost paid for these reserves was approximately two cents per dollar in the period since the interest rate was approximately 7% per annum. As it can be seen in Table 20, for a cost of two cents per dollar, and a cost of crisis of five, ten and fifteen

percent of GDP, the optimal reserves are: 34, 45, 51 billion dollars respectively. Reserves are optimal for a cost of two cents per dollar and for cost of crisis of 2% of GDP.

Table 19 - Optimal Reserves for Pakistan

Pakistan

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP \ Unit Cost of Reserves cents per dollar	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	19 067	12 378	10 490	9 146	8 201	7 472	6 879	6 292	5 887	5 526	5 200
2	19 067	13 188	11 047	9 744	8 818	8 098	7 510	7 065	6 633	6 250	5 907
3	19 067	13 319	11 618	10 323	9 401	8 684	8 097	7 609	7 177	6 796	6 454
4	21 164	14 215	12 117	10 824	9 904	9 189	8 602	8 107	7 676	7 295	6 953
5	21 164	14 215	12 548	11 257	10 338	9 623	9 038	8 542	8 111	7 731	7 390
6	21 164	15 031	12 673	11 636	10 718	10 004	9 420	8 924	8 494	8 114	7 773
7	21 164	15 031	13 231	11 974	11 057	10 344	9 760	9 265	8 835	8 455	8 115
8	21 164	15 701	13 363	12 093	11 362	10 649	10 066	9 572	9 142	8 763	8 423
9	21 164	15 701	13 822	12 537	11 640	10 928	10 345	9 851	9 423	9 044	8 704
10	21 376	15 858	13 822	12 663	11 756	11 184	10 601	10 108	9 680	9 301	8 962
11	23 727	16 017	14 305	13 034	12 120	11 420	10 838	10 345	9 917	9 539	9 201
12	23 727	16 177	14 305	13 164	12 242	11 534	11 059	10 566	10 138	9 761	9 422
13	23 727	16 873	14 733	13 296	12 549	11 839	11 169	10 772	10 345	9 968	9 629
14	23 727	16 873	14 733	13 649	12 674	11 957	11 452	10 880	10 539	10 162	9 824
15	23 727	16 873	14 880	13 649	12 801	12 216	11 567	11 143	10 721	10 345	10 007
16	23 727	17 042	15 029	14 001	13 094	12 338	11 808	11 255	10 829	10 517	10 180
17	23 727	17 213	15 180	14 001	13 225	12 461	11 926	11 481	11 055	10 622	10 344
18	23 727	17 385	15 331	14 141	13 357	12 705	12 046	11 596	11 165	10 834	10 447
19	23 727	17 385	15 485	14 282	13 490	12 832	12 274	11 711	11 359	10 943	10 646
20	23 727	17 559	15 639	14 425	13 625	12 961	12 397	11 925	11 473	11 126	10 753

Table 20 - Optimal Reserves for Philippines

Philippines

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP \ Unit Cost of Reserves cents per dollar	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	98 792	54 037	36 426	26 109	20 604	16 382	11 912	8 886	5 700	3 331	1 261
2	98 792	54 037	40 108	31 039	24 652	19 733	15 605	12 444	9 518	7 094	4 906
3	98 792	59 214	43 942	34 454	28 478	23 422	19 308	15 895	13 065	10 483	8 199
4	99 780	59 214	47 327	38 098	31 611	25 998	22 564	19 079	16 092	13 472	11 233
5	110 756	65 147	50 278	41 086	34 543	28 858	25 046	21 925	18 892	16 234	13 880
6	110 756	65 147	52 883	43 700	37 147	31 986	27 801	24 336	20 970	18 739	16 351
7	110 756	70 223	53 412	46 038	39 487	34 379	30 202	26 676	23 277	20 800	18 612
8	110 756	70 223	57 108	48 155	41 608	36 505	32 325	28 788	25 696	23 015	20 621
9	110 756	70 926	57 679	50 088	43 548	38 448	34 267	30 725	27 653	24 947	22 529
10	122 939	75 930	60 853	50 589	45 334	40 238	36 058	32 515	29 441	26 729	24 304
11	122 939	75 930	60 853	53 404	46 988	41 897	37 719	34 177	31 102	28 387	25 957
12	122 939	75 930	63 998	53 938	48 529	43 443	39 269	35 727	32 652	29 936	27 504
13	122 939	80 542	63 998	56 398	49 014	44 890	40 719	37 180	34 106	31 389	28 956
14	122 939	80 542	66 794	56 962	51 259	46 249	42 082	38 546	35 473	32 757	30 324
15	122 939	80 542	66 794	59 041	51 772	46 711	43 368	39 835	36 764	34 049	31 616
16	122 939	81 347	67 462	59 041	53 758	48 695	44 584	41 054	37 986	35 272	32 840
17	122 939	82 160	70 353	61 352	54 295	49 182	45 030	42 211	39 146	36 434	34 002
18	122 939	82 982	70 353	61 352	56 006	50 949	46 799	43 312	40 249	37 539	35 109
19	124 168	87 494	71 056	63 477	56 566	51 459	47 267	44 362	41 301	38 593	36 165
20	124 168	87 494	71 767	63 477	57 131	52 998	48 853	44 805	42 307	39 601	37 174

The stock of reserves for Thailand in June 2007 was around 72 billion dollars. The cost paid for these reserves was approximately zero in the period, since the interest rate of about 4% per year, below the return on U.S. bonds. As it can be seen in Table 21 for a case with no cost, and a crisis cost of five, ten and fifteen percent of GDP, the optimal reserves are: 90, 100, 102 billion dollars respectively.

Table 21 - Optimal Reserves for Thailand

Thailand

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
1	80 057	40 396	25 348	18 077	12 210	7 394	3 746	643	-2 036	-4 174	-5 993
2	80 057	40 800	28 136	21 680	15 808	11 394	7 804	4 699	2 191	-75	-2 146
3	80 857	45 288	33 321	24 065	19 335	14 793	11 235	8 035	5 463	3 178	1 094
4	89 752	50 112	36 396	28 199	22 412	17 838	14 130	11 100	8 384	6 072	3 957
5	89 752	50 112	39 089	30 821	24 878	19 800	16 768	13 628	10 911	8 604	6 462
6	89 752	55 042	41 465	33 188	27 298	22 811	18 613	15 960	13 231	10 839	8 465
7	90 649	55 042	41 880	35 311	29 426	24 866	20 660	17 715	15 326	12 919	10 753
8	100 621	59 224	45 301	37 233	31 349	26 780	22 933	19 664	17 012	14 817	12 661
9	100 621	59 224	45 754	38 988	33 105	28 534	24 789	21 621	18 884	16 447	14 054
10	100 621	59 816	48 716	39 378	34 721	30 151	26 412	23 251	20 513	18 099	15 600
11	100 621	64 019	48 716	41 986	36 218	31 648	27 910	24 748	22 009	19 594	17 316
12	100 621	64 019	51 592	42 406	37 612	33 044	29 306	26 143	23 403	20 986	18 818
13	100 621	64 019	51 592	44 706	37 988	34 349	30 612	27 450	24 708	22 290	20 127
14	101 627	64 659	54 145	45 153	40 075	35 576	31 840	28 678	25 936	23 518	21 354
15	102 643	69 000	54 145	47 110	40 476	36 733	32 998	29 836	27 095	24 676	22 512
16	103 669	69 000	54 687	47 110	42 339	37 101	34 094	30 933	28 192	25 773	23 608
17	104 706	69 000	57 386	49 215	42 762	38 825	35 134	31 974	29 233	26 814	24 649
18	105 753	69 000	57 386	49 215	44 377	39 213	35 485	32 964	30 224	27 805	25 640
19	106 811	73 074	57 960	51 150	44 821	40 764	37 034	33 908	31 169	28 750	26 586
20	106 811	73 074	58 539	51 150	46 227	41 172	37 404	34 811	32 072	29 654	27 489

Finally, remaining in our sample the following Asian countries: Hong Kong and Singapore. The stock of reserves of Hong Kong in June 2007 was approximately $ 137 billion, Singapore's stock of reserves was $ 144 billion. For these two countries, with all costs of reserves and crisis, estimated results of optimal reserves are negative. This situation indicating that for any non-negative cost of maintaining reserves, the optimal stock of reserves is zero. The interest rate is lower than both the return on U.S. bonds. In the case of Hong Kong, the interest rate is about 4%, as in the case of Singapore, the interest rate is about 2.5%.

Other Countries

Tables 22, 23, 24, 25 and 26 show the results of optimal reserves estimated respectively for: Hungary, Jordan, Czech Republic, Russia, and Turkey.

The stock of reserves for Hungary in June 2007 was around $ 23 billion. The cost paid for these reserves was approximately three cents per dollar in the period since the interest rate was approximately 8% per annum. As it is shown in Table 22, for a cost of three cents per dollar the estimated optimal reserves are negative. Reserves are optimal for a cost of 1.5 cents per dollar and for cost of a crisis of 19% of GDP.

Table 22 - Optimal Reserves for Hungary

Hungary

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	89 834	4 961	-22 356	-42 751	-55 997	-63 408	-71 412	-77 023	-81 468	-84 246	-88 594
2	99 716	5 507	-22 356	-38 048	-50 104	-59 176	-66 357	-72 107	-76 865	-80 865	-84 361
3	110 685	13 823	-15 425	-33 863	-44 593	-53 733	-61 185	-67 222	-72 245	-76 507	-80 183
4	110 685	23 638	-10 644	-25 635	-39 688	-48 614	-56 342	-62 630	-67 880	-72 349	-76 210
5	122 860	26 238	-3 087	-22 815	-35 322	-43 865	-51 822	-58 322	-63 766	-68 411	-72 436
6	122 860	34 371	1 574	-15 742	-31 436	-39 452	-47 598	-54 275	-59 884	-64 682	-68 849
7	136 375	34 715	6 470	-14 011	-24 913	-35 339	-43 641	-50 467	-56 216	-61 147	-65 438
8	136 375	45 477	8 476	-9 667	-22 173	-31 493	-39 925	-46 877	-52 747	-57 793	-62 192
9	136 375	45 477	14 493	-3 196	-17 195	-28 028	-36 426	-43 485	-49 459	-54 605	-59 100
10	137 738	50 479	16 087	-2 845	-15 304	-24 945	-33 125	-40 275	-46 338	-51 571	-56 150
11	152 890	50 479	21 075	1 451	-10 560	-22 201	-30 002	-37 231	-43 371	-48 680	-53 333
12	152 890	56 032	23 393	3 642	-9 398	-19 759	-27 042	-34 338	-40 546	-45 921	-50 639
13	152 890	56 032	25 966	9 140	-6 485	-15 407	-24 229	-31 583	-37 850	-43 284	-48 060
14	152 890	62 196	28 822	10 146	-1 881	-13 712	-21 564	-28 956	-35 274	-40 760	-45 588
15	152 890	62 196	31 993	13 291	-1 298	-10 082	-19 192	-26 446	-32 810	-38 341	-43 215
16	154 419	69 037	35 512	14 753	2 738	-8 973	-17 081	-24 044	-30 448	-36 020	-40 934
17	171 405	69 037	39 418	19 326	3 587	-6 191	-15 202	-21 742	-28 181	-33 790	-38 741
18	171 405	69 037	39 418	19 520	6 133	-4 272	-13 530	-19 533	-26 003	-31 644	-36 628
19	171 405	76 631	43 754	21 667	8 034	-1 239	-9 859	-17 409	-23 907	-29 577	-34 591
20	171 405	76 631	43 754	24 050	10 525	-359	-8 774	-15 494	-21 888	-27 584	-32 624

The stock of reserves of Jordan in June 2007 was around $ 7 billion. The cost paid for these reserves was approximately 1.5 cents per dollar in the period since the interest rate was approximately 6.6% per year. As it is shown in Table 23, for a cost

of 1.5 cents per dollar, and a cost crisis of five, ten and fifteen percent of GDP, the optimal reserves are 2.5, 3, 4 billion respectively.

Table 23 - Optimal Reserves for Jordan

Jordan

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
1	6 768	3 391	1 913	1 096	451	-2	-355	-626	-853	-1 053	-1 229
2	7 513	3 391	2 124	1 423	771	407	52	-246	-491	-726	-906
3	7 513	3 764	2 586	1 767	1 183	696	376	74	-185	-407	-625
4	8 339	4 178	2 870	1 961	1 478	1 029	643	304	90	-140	-341
5	8 339	4 559	3 153	2 325	1 741	1 283	917	605	337	71	-104
6	8 339	4 559	3 391	2 557	1 932	1 514	1 140	793	559	293	116
7	8 339	4 989	3 425	2 768	2 145	1 681	1 348	1 029	732	501	290
8	9 257	4 989	3 773	2 959	2 363	1 866	1 496	1 219	944	708	493
9	9 257	5 039	3 811	3 134	2 541	2 071	1 660	1 353	1 118	876	646
10	9 257	5 502	4 114	3 296	2 702	2 241	1 843	1 502	1 240	1 035	818
11	9 257	5 502	4 114	3 329	2 852	2 391	2 013	1 668	1 377	1 149	966
12	9 257	5 502	4 404	3 575	2 991	2 530	2 153	1 833	1 528	1 275	1 072
13	9 257	5 926	4 404	3 611	3 122	2 661	2 284	1 965	1 687	1 415	1 231
14	10 275	5 926	4 660	3 830	3 153	2 784	2 407	2 088	1 812	1 567	1 351
15	10 275	5 926	4 660	3 830	3 354	2 900	2 522	2 204	1 927	1 684	1 466
16	10 275	5 985	4 706	4 054	3 388	3 009	2 632	2 313	2 037	1 793	1 576
17	10 275	6 380	4 984	4 054	3 569	3 039	2 737	2 418	2 141	1 897	1 679
18	10 275	6 380	4 984	4 259	3 605	3 209	2 836	2 517	2 240	1 996	1 778
19	10 275	6 380	5 034	4 259	3 764	3 241	2 931	2 612	2 335	2 091	1 873
20	10 275	6 380	5 271	4 445	3 764	3 395	2 960	2 702	2 426	2 182	1 963

The stock of reserves in Czech Republic in June 2007 was 31 billion dollars. The cost paid for these reserves was approximately zero in the period, since the interest rate was 3% per annum. As it is shown in Table 24, for a zero reserves cost and a cost of crisis of five, ten and fifteen percent of GDP, the optimal reserves are: 96, 106, 120 billion respectively. The reserves are approximately optimal for a cost of reserves of 0.5 cents per dollar and a crisis cost of 3% of GDP.

The stock of reserves in Russia in June 2007 was 398 billion dollars. The cost paid for these reserves was approximately zero in the period, since the interest rate was approximately 3.4% per annum. As it is shown in Table 25, for a zero cost of reserves, and a crisis cost of five, ten and fifteen percent of GDP, the optimal

reserves are: 227, 815, 824 billion dollars respectively. The Russian reserves are approximately optimal for a cost of reserves of 0.5 cents per dollar and crisis cost of 3% of GDP.

Table 24 - Optimal Reserves for Czech Republic

Czech Republic

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	86 481	28 310	378	-10 424	-15 992	-23 153	-27 718	-31 527	-34 335	-37 542	-39 904
2	86 481	28 310	5 184	-4 400	-12 350	-18 473	-23 244	-27 170	-30 615	-33 492	-35 958
3	86 481	28 310	12 034	-1 276	-8 522	-14 124	-19 053	-23 125	-27 247	-29 808	-32 285
4	86 481	36 369	15 765	2 692	-3 878	-10 245	-15 291	-19 476	-23 063	-26 529	-28 923
5	95 994	36 369	17 499	6 757	-1 125	-7 069	-11 901	-16 171	-20 527	-23 611	-25 840
6	95 994	40 369	22 923	11 288	2 373	-3 566	-8 822	-13 157	-16 894	-20 100	-22 999
7	95 994	44 810	25 445	12 530	5 806	-1 034	-6 087	-10 393	-14 146	-17 889	-20 469
8	106 553	44 810	28 244	16 414	7 606	1 924	-4 200	-7 843	-11 635	-14 960	-18 218
9	106 553	49 739	31 351	18 220	9 964	3 290	-1 218	-5 478	-9 303	-13 315	-16 214
10	106 553	49 739	31 351	20 224	13 052	5 627	621	-3 780	-7 126	-10 522	-13 499
11	106 553	55 210	34 799	22 449	14 488	8 694	2 553	-1 208	-5 088	-8 478	-12 014
12	107 619	55 210	37 909	24 918	16 082	9 650	4 366	616	-3 511	-6 580	-9 625
13	108 695	55 210	37 909	27 659	17 851	12 481	7 100	2 532	-1 353	-4 788	-7 832
14	120 651	61 283	41 484	27 659	19 814	13 854	7 881	4 297	371	-3 304	-6 149
15	120 651	61 283	41 484	30 701	21 994	15 378	10 323	5 629	1 525	-1 470	-4 551
16	120 651	61 283	44 756	31 008	24 119	17 070	11 459	7 373	3 530	-426	-3 140
17	120 651	61 896	44 756	34 136	24 360	18 947	12 720	8 185	4 624	899	-2 167
18	120 651	67 893	45 203	34 136	26 996	20 398	14 119	10 349	6 057	2 925	-628
19	120 651	67 893	48 974	36 952	26 996	20 602	15 672	11 487	7 742	3 832	1 148
20	120 651	67 893	48 974	36 952	29 654	22 868	17 396	12 751	8 593	5 020	1 963

Table 25 - Optimal Reserves for Russia

Russia

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
1	655 608	345 859	226 445	161 715	121 528	83 623	58 504	29 885	10 007	-7 113	-22 196
2	655 608	345 859	251 354	191 659	146 041	109 546	82 746	58 872	38 272	21 106	5 275
3	655 608	383 904	279 002	212 741	172 611	136 540	107 629	84 087	62 945	45 096	29 171
4	727 724	416 447	306 207	236 143	191 598	159 952	130 538	105 906	82 457	66 676	49 883
5	727 724	416 447	327 589	261 480	212 674	177 546	150 892	125 973	104 314	85 746	69 530
6	727 724	453 675	346 104	280 535	233 665	197 076	167 490	139 830	122 386	103 424	86 579
7	735 002	453 675	349 565	297 150	250 485	214 208	184 592	160 096	135 848	119 529	102 524
8	815 852	485 885	376 055	312 155	265 518	229 252	199 596	174 569	150 792	132 677	117 171
9	815 852	485 885	379 816	325 867	279 253	242 986	213 307	188 207	166 316	147 250	130 059
10	815 852	490 744	402 692	329 126	291 908	255 649	225 962	200 838	179 062	159 882	142 738
11	815 852	523 189	402 692	349 373	303 639	267 396	237 710	212 576	190 790	171 577	154 404
12	815 852	523 189	425 134	352 866	314 571	278 348	248 670	223 533	201 737	182 506	165 309
13	815 852	523 189	425 134	370 669	317 717	288 604	258 938	233 805	212 005	192 763	175 549
14	815 852	528 421	445 081	374 375	333 935	298 246	268 595	243 469	221 669	202 422	185 198
15	824 010	562 008	445 081	389 496	337 274	307 342	277 708	252 591	230 796	211 547	194 317
16	832 250	562 008	449 532	389 496	351 704	310 415	286 334	261 229	239 440	220 193	202 961
17	840 573	562 008	470 457	405 990	355 221	323 810	294 521	269 430	247 648	228 406	211 174
18	848 979	562 008	470 457	405 990	367 712	327 048	297 467	277 234	255 462	236 226	218 996
19	857 468	593 735	475 162	421 161	367 712	339 065	309 503	284 679	262 917	243 688	226 462

Finally, the stock of reserves for Turkey in June 2007 was around 69 billion dollars. The cost paid for these reserves was high in the period since the interest rate was approximately 17% per annum. The results of optimal reserves are estimated in Table 26.

Table 26 - Optimal Reserves for Turkey

Turkey

Optimal level of Reserves in Millions of Dollars

Cost of the Crisis % of GDP	Unit Cost of Reserves cents per dollar									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	116 468	52 340	8 514	-17 220	-35 709	-48 242	-61 206	-71 517	-80 676	-86 822
2	129 279	65 426	25 686	-1 358	-21 388	-37 101	-49 720	-60 193	-69 085	-77 271
3	143 500	81 108	40 430	12 514	-8 455	-25 600	-38 236	-49 325	-58 766	-66 935
4	159 285	95 343	52 964	25 241	3 574	-13 437	-27 453	-39 073	-48 998	-57 599
5	176 806	105 830	65 808	36 813	14 661	-3 897	-17 208	-29 419	-39 753	-48 734
6	191 003	117 472	76 948	47 297	24 881	6 966	-7 798	-20 331	-31 010	-40 316
7	192 913	129 038	85 412	57 137	32 594	16 167	1 091	-11 675	-22 742	-32 324
8	210 141	138 564	94 807	66 237	42 698	24 751	7 977	-3 642	-15 692	-24 737
9	212 242	147 227	104 498	73 523	51 419	32 424	17 226	4 030	-7 458	-17 530
10	227 037	155 231	112 528	81 610	57 075	40 278	24 637	10 115	-391	-10 612
11	227 037	162 673	119 946	89 599	66 337	47 417	31 542	17 297	6 288	-4 108
12	241 336	169 623	126 885	96 524	73 065	52 633	38 153	24 524	12 632	2 095
13	241 336	171 319	133 404	103 010	79 485	60 451	44 421	30 636	18 669	8 061
14	254 043	181 948	139 550	109 133	85 563	66 389	49 307	36 505	24 398	13 723
15	254 043	183 768	145 360	114 930	91 327	72 101	54 731	42 100	29 917	19 177
16	256 583	193 300	150 869	120 433	96 806	77 541	60 751	46 731	35 195	24 340
17	270 205	195 233	156 105	125 670	102 025	82 730	66 451	51 871	39 066	29 333
18	270 205	203 549	161 092	130 662	107 006	87 688	71 397	57 328	45 067	34 128
19	272 907	203 549	162 703	135 432	111 770	92 434	76 117	62 033	49 674	37 882
20	275 636	212 729	170 262	139 997	116 332	96 983	80 645	66 533	54 140	42 049

Chapter 6

6. CONCLUSION

The thesis aims to make a contribution to the literature concerning international reserves. Therein we propose a cost-benefit analysis of reserves for emerging economies. The analysis takes into account the role of reserves for mitigating both the probability of occurrence and the cost of the crisis, when it happens. Our goal is to identify the actual benefits and costs of reserves, and to suggest their optimal level for analyzed countries.

We start with an empirical analysis of the role of reserves in mitigating the probability of crisis. We find evidence that higher levels of reserves in relation to the stock of short-term external debt in the previous period reduce the probability of crisis.

Then we empirically evaluate the other benefits of reserves, to reduce the cost of the crisis, once it happens. The regressions show that crises bring less damage for the countries with higher levels of reserves relative to short-term external debt. This result indicates that the accumulation of these reserves allows the adjustment in consumption and investment, which reduces the costs of crisis. The results demonstrate that when the reserves are increased by 10% of short-term external debt then the cost of crisis is reduced on average by 1.2% of GDP.

Finally, we conduct a cost-benefit analysis of reserves, taking into account the benefits calculated in the empirical analysis and using various cost scenarios of crisis and expected reserves. The higher the expected cost of crisis, the greater the

protection that the country will seek the higher the level of accumulated reserves. The results showed that the levels of reserves accumulated by most developing countries are great for crisis cost up to 5% of GDP.

APPENDICES

APPENDIX A

7.1 DATA SOURCE AND CALCULATION

To calculate the real exchange rate we rely as suggested by Rogoff et al. (2006), where we use the series consumer price index and nominal exchange rate on monthly basis from the International Finance Statistics (IFS). As the consumer price index of the database is normalized to 100 in 2000 for all countries in the sample then we get a real exchange rate by the following formula:

$$\mathrm{Re}\,alExchange_i = \prod_{j=1}^{J} \left(\frac{CPI_i}{No\min alExchange_{i,j}} CPI_j\right)^{W_{i,j}}$$

countries where the J are the main global trading partners, which according to Rogoff et al. (2006), are: South Africa, Argentina, Australia, Brazil, France, Italy, Netherlands, Singapore, Spain, United States, United Kingdom. The weights are related to the trade flow between countries i and j, with respect to trade flow between country i and all countries j. To calculate the deviation of real exchange rate, we use a Hodrick-Prescott filter.

Most data is taken from the base of the IFS and Bank of International Settlements (BIS). Data on external debt (both short term and total) were obtained from BIS, which calculates the external debt of countries whose owners report to the BIS. This finding in some cases does not reflect the total stock debt, since there may be holders who do not report to the BIS, however, this is the data used for all studies of this type.

From the IFS data we obtained total reserves minus gold stock (Line 1E), exports (line 77AA), imports (row 78AB), GDP in local currency (line 99BZ), M2.

There are two indices that we calculated in accordance with other articles. To open trade, we use the sum of imports and exports divided by GDP. As for the classification of exchange rate regime we rely on Reinhart and Rogoff (2002) with some modifications. First to get fixed exchange rate regimes of short duration, we classified as controlled exchange those periods when the exchange rate was zero for more than four months. Then we added to this classification the periods for which the exchange rate remained a variation of less than 2% for more than 80% of windows for a year.

For real GDP data, we use the IMF's WEO. The calculation GDP growth of trading partners was conducted by a weighted average growth of 13 partners for which we calculate the real exchange rate; the weights were the same as for the exchange rate calculation. Finally, banking crisis data were extracted from the Banking Crises World Bank Database.

Table 27 - Crisis Identified by two steps of the identification method

Country	Period	Δ Exch.Rate Nom	1	2	Δ Exch.Rate Real	1	2	Δ Reserves	1	2	Δ Int.Rate	1	2
ARGENTINA	1995M6	-0.05	1.00	1.00	-4.29	4.14	3.96	-24.31	14326.90	10843.70	-47.35	13.98	7.36
ARGENTINA	2001M12	0.00	1.00	1.00	-3.40	1.76	1.70	-30.95	21077.50	14553.10	n.a	n.a	n.a
ARGENTINA	2002M6	-73.35	1.00	0.27	-65.03	1.70	0.60	-33.71	14553.10	9647.29	n.a	n.a	n.a
BOLIVIA	1991M12	-4.27	0.28	0.27	-4.50	0.42	0.40	-45.27	194.36	106.37	n.a	n.a	n.a
BOLIVIA	1992M12	-5.37	0.26	0.24	-0.02	0.40	0.40	-27.83	251.90	181.79	n.a	n.a	n.a
BOLIVIA	1993M6	-3.99	0.24	0.23	-2.60	0.40	0.39	-18.15	181.79	148.80	n.a	n.a	n.a
BOLIVIA	1998M6	-2.72	0.19	0.18	0.76	0.41	0.42	-25.00	1086.64	821.21	8.16	12.50	13.52
BOLIVIA	2002M6	-4.75	0.15	0.14	9.09	0.27	0.29	-25.00	886.42	672.78	26.00	6.65	8.39
BOLIVIA	2002M12	-4.41	0.14	0.13	-5.23	0.29	0.28	-13.72	672.78	580.46	-33.61	8.39	5.57
BOLIVIA	2003M6	-2.09	0.13	0.13	-10.00	0.28	0.25	10.78	580.46	643.01	-48.29	5.57	2.88
BRAZIL	1991M12	-70.79	8807.86	2572.98	-26.16	3.25	2.40	-4.24	8388.22	8032.95	1008.68	224.98	2494.26
BRAZIL	1998M12	-4.29	0.86	0.83	-9.53	3.47	3.14	-38.84	69615.00	42579.80	48.62	21.02	31.24
BRAZIL	1999M6	-31.69	0.83	0.57	-25.90	1.22	0.90	-7.04	42579.80	39582.20	-29.55	31.24	22.01
BRAZIL	2002M12	-19.48	0.35	0.28	-16.96	0.80	0.66	-9.96	41851.90	37683.50	27.27	18.10	23.03
CHILE	1998M6	-5.46	0.00	0.00	-2.40	0.01	0.01	-12.65	17573.20	15350.30	n.a	n.a	n.a
CHILE	2001M6	-8.61	0.00	0.00	-2.90	0.00	0.00	-3.51	15034.90	14506.80	n.a	n.a	n.a
COLOMBIA	1995M6	-5.67	0.00	0.00	1.24	0.00	0.00	-10.00	7990.53	7200.73	n.a	n.a	n.a
COLOMBIA	1997M12	-15.69	0.00	0.00	-10.00	0.00	0.00	-3.87	10197.40	9802.63	9.43	23.22	25.41
COLOMBIA	2002M12	-16.29	0.00	0.00	-16.00	0.00	0.00	0.16	10715.10	10732.40	-5.41	5.36	5.07
COLOMBIA	2006M6	-13.25	0.00	0.00	-14.73	0.00	0.00	-3.10	14787.00	14328.60	10.34	5.80	6.40
CZECH REPUBLIC	1997M6	-14.73	0.04	0.03	-3.79	0.12	0.11	-13.14	12351.80	10728.80	105.13	12.67	25.99
HONG KONG	1998M12	-0.03	0.13	0.13	-9.75	0.85	0.77	-7.08	96483.00	89650.10	-10.28	6.13	5.50
HUNGARY	1994M6	-1.36	0.01	0.01	-1.22	0.03	0.03	-10.69	6699.99	5983.83	n.a	n.a	n.a
INDIA	1993M6	-16.40	0.04	0.03	-16.08	0.10	0.09	22.26	5757.13	7038.39	-28.67	11.23	
INDIA	1995M12	-10.69	0.03	0.03	-4.73	0.09	0.09	-10.52	20029.20	17921.80	16.22	14.43	14.43
INDONESIA	1997M12	-47.31	0.00	0.00	-39.21	0.00	0.00	-18.44	20336.30	16586.90	197.51	13.67	40.67
INDONESIA	1998M6	-68.79	0.00	0.00	-52.65	0.00	0.00	8.22	16586.90	17949.90	58.81	40.67	64.59
ISRAEL	1992M12	-11.58	0.41	0.36	-1.12	0.98	0.97	-21.29	6514.07	5127.40	n.a	n.a	n.a
ISRAEL	1998M12	-11.87	0.27	0.24	-10.83	1.13	1.01	6.34	21322.00	22674.30	n.a	n.a	n.a
ISRAEL	2003M12	-1.53	0.23	0.23	-10.00	0.32	0.29	7.12	24565.20	26315.10	n.a	n.a	n.a
JORDAN	1991M12	1.93	1.45	1.48	-6.28	8.56	8.02	-35.84	1287.02	825.77	n.a	n.a	n.a
JORDAN	1994M6	2.18	1.42	1.45	-4.05	8.65	8.30	-21.13	1637.38	1291.42	n.a	n.a	n.a
JORDAN	1998M12	0.00	1.41	1.41	-4.70	9.32	8.89	-17.50	2121.70	1750.38	n.a	n.a	n.a
KAZAKHSTAN	1998M12	-8.17	0.01	0.01	-15.99	0.41	0.35	0.56	1453.14	1461.23	n.a	n.a	n.a
KAZAKHSTAN	1999M6	-36.03	0.01	0.01	-22.98	0.35	0.01	-30.70	1461.23	1012.58	n.a	n.a	n.a
MALAYSIA	1997M12	-35.13	0.40	0.26	-28.72	1.96	1.40	-21.81	26586.30	20788.20	15.49	7.18	8.30
MEXICO	1994M6	-8.43	0.32	0.29	-7.63	0.15	0.14	-34.25	25109.60	16509.00	41.04	12.45	17.56
MEXICO	1994M12	-36.30	0.29	0.19	-35.00	0.14	0.09	-61.97	16509.00	6278.24	50.57	17.56	26.44
PAKISTAN	1993M6	-5.38	0.04	0.04	-3.56	0.15	0.15	-58.95	850.19	349.01	5.03	11.54	12.12
PAKISTAN	1995M12	-9.46	0.03	0.03	0.01	0.14	0.14	-36.90	2746.00	1732.81	23.52	11.69	14.44
PAKISTAN	1996M12	-12.51	0.03	0.02	-6.20	0.14	0.13	-70.88	1882.65	548.29	97.23	9.02	17.79
PAKISTAN	1998M6	-4.24	0.02	0.02	0.14	0.14	0.14	-29.40	1194.84	843.56	10.99	13.19	14.64

Table 28 - Crisis added by the second step of the identification method

Country	Period	Δ Exch.Rate Nom	1	2	Δ Exch.Rate Real	1	2	Δ Reserves	1	2	Δ Int.Rate	1	2
PARAGUAY	1992M12	-9.89	0.00	0.00	-1.86	0.00	0.00	-40.40	942.11	561.53	76.02	17.10	30.10
PARAGUAY	1997M12	-8.39	0.00	0.00	-6.05	0.00	0.00	-13.90	970.63	835.68	16.82	14.98	17.50
PARAGUAY	1999M6	-12.24	0.00	0.00	-14.77	0.00	0.00	-25.61	864.74	643.29	2.93	17.04	17.54
PARAGUAY	2001M12	-14.48	0.00	0.00	-11.31	0.00	0.00	4.94	679.95	713.51	75.82	8.56	15.05
PARAGUAY	2004M12	-5.60	0.00	0.00	-13.96	0.00	0.00	9.02	1071.36	1168.05	1.00	1.00	1.01
PERU	1998M12	-7.28	0.34	0.32	-10.64	1.40	1.25	-13.97	11118.90	9565.49	-34.88	19.87	12.94
PHILIPPINES	1997M12	-34.00	0.04	0.03	-27.89	0.18	0.13	-25.62	9810.44	7297.48	-5.34	14.37	13.61
POLAND	2002M6	-1.37	0.25	0.25	-11.36	0.31	0.27	5.66	25648.40	27099.40	230.92	11.60	9.93
RUSSIA	1997M12	-2.99	0.17	0.17	1.48	0.45	0.46	-36.78	20395.70	12894.70	76.40	16.10	28.40
RUSSIA	1998M12	-69.99	0.16	0.05	-50.44	0.46	0.23	-30.10	11160.50	7801.38	-50.45	56.10	27.80
RUSSIA	1999M6	-14.74	0.05	0.04	-79.12	0.23	0.05	4.98	7801.38	8189.51	-69.78	27.80	8.40
SINGAPORE	1997M12	-14.65	0.70	0.60	-9.51	4.79	4.33	-11.62	80661.30	71288.80	147.93	3.63	9.00
SOUTH AFRICA	1993M6	-8.24	0.33	0.30	-4.29	1.00	0.96	-40.68	991.62	588.24	-10.32	12.01	10.77
SOUTH AFRICA	1994M6	-6.96	0.29	0.27	-10.10	0.99	0.89	-53.46	1019.72	474.54	8.13	9.59	10.37
SOUTH AFRICA	1996M6	-15.85	0.27	0.23	-10.99	0.93	0.82	-62.09	2819.87	1068.97	8.09	14.84	16.04
SOUTH AFRICA	1998M6	-17.03	0.21	0.17	-13.59	0.87	0.76	-3.95	4799.41	4609.95	21.20	15.00	18.18
SOUTH AFRICA	2001M12	-33.50	0.12	0.08	-33.82	0.29	0.19	-0.22	6058.60	6045.28	-6.05	9.11	8.56
THAILAND	1997M6	-0.70	0.04	0.04	1.74	0.31	0.32	-16.88	37731.20	31361.00	24.59	12.12	15.10
THAILAND	1997M12	-45.41	0.04	0.02	-37.83	0.32	0.20	-16.52	31361.00	26179.50	-43.71	15.10	8.50
TURKEY	1992M6	-26.11	196.85	145.45	-8.32	9.45	8.67	-14.71	5144.17	4387.66	59.87	68.49	
TURKEY	1994M6	-53.61	69.10	32.06	-30.87	10.25	7.09	-31.77	6271.51	4279.15	-22.53	69.63	53.94
TURKEY	1998M12	-15.56	3.77	3.18	3.87	9.37	9.73	-26.33	26455.60	19488.80	20.11	65.75	78.97
TURKEY	2001M6	-46.38	1.49	0.80	-24.58	2.21	1.67	-26.24	22488.40	16587.90	-65.61	183.20	63.00
URUGUAY	2002M6	-20.17	0.07	0.05	12.60	0.11	0.12	-53.15	3097.08	1451.06	0.00	42.67	108.32
URUGUAY	2002M12	-31.99	0.05	0.04	-21.25	0.12	0.10	-46.99	1451.06	769.15	-40.55	108.32	64.40
URUGUAY	2006M12	-2.46	0.04	0.04	-3.48	0.09	0.09	-11.88	3501.11	3085.26	-45.12	1.98	1.09
VENEZUELA	1994M6	-46.74	0.01	0.01	-33.14	0.00	0.00	-41.17	9215.81	5421.57	n.a	n.a	n.a
VENEZUELA	1995M12	-41.38	0.01	0.00	-24.76	0.00	0.00	-11.61	7108.64	6283.09	n.a	n.a	n.a
VENEZUELA	2002M6	-42.05	0.00	0.00	-34.70	0.00	0.00	-17.30	9239.49	7641.52	-15.47	26.50	22.40

Table 29 - Crisis removed by the second step of identification method

Country	Period	Δ Exch.Rate Nom	1	2	Δ Exch.Rate Real	1	2	Δ Reserves	1	2	Δ Int.Rate	1	2
BOLIVIA	1992M12	-5.37	0.26	0.24	-0.02	0.40	0.40	-27.83	251.90	181.79	n.a	n.a	n.a
BOLIVIA	1998M6	-2.72	0.19	0.18	0.76	0.41	0.42	-25.00	1086.64	821.21	8.16	12.50	13.52
BOLIVIA	2002M6	-4.75	0.15	0.14	9.09	0.27	0.29	-25.00	886.42	672.78	26.00	6.65	8.39
PAKISTAN	1995M12	-9.46	0.03	0.03	0.01	0.14	0.14	-36.90	2746.00	1732.81	23.52	11.69	14.44
PAKISTAN	1998M6	-4.24	0.02	0.02	0.14	0.14	0.14	-29.40	1194.84	843.56	10.99	13.19	14.64
PARAGUAY	1999M6	-12.24	0.00	0.00	-14.77	0.00	0.00	-25.61	864.74	643.29	2.93	17.04	17.54
RUSSIA	1999M6	-14.74	0.05	0.04	-79.12	0.23	0.05	4.98	7801.38	8189.51	-69.78	27.80	8.40
SOUTH AFRICA	1993M6	-8.24	0.33	0.30	-4.29	1.00	0.96	-40.68	991.62	588.24	-10.32	12.01	10.77
TURKEY	1998M12	-15.56	3.77	3.18	3.87	9.37	9.73	-26.33	26455.60	19488.80	20.11	65.75	78.97
URUGUAY	2002M6	-20.17	0.07	0.05	12.60	0.11	0.12	-53.15	3097.08	1451.06	0.00	42.67	108.32

8.2 RESULTS WITH INCLUDING CHINA

China's economy currently has the largest foreign reserves. Chinese reserves have exceeded one trillion dollars by the end of 2006. Given the importance of the Chinese economy we try our best to match the Chinese data for the data of the other economies surveyed[21]. Tables 13 and 14 show the results where China is included.

Only one crisis was identified in December 1992, where reserves fell by 55%. As we can see from tables below, the results remain virtually the same for both the regression for probability of crisis and for the cost.

[21] Data on consumer price index for China are not compatible, causing problems in calculating the real exchange rate.

Table 30 - Panel LOGIT Model: Probability of Crisis including China

Dependent Variable: Balance of Payments Crisis (dummy)
In parentheses: p-values

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-1.11	-1.47	-1.46	-1.44	-1.52	-1.52	-1.50
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Deviation of Real Exchange Rate t-1	0.0009	0.0008	0.0007	0.0007	0.0007	0.0006	0.0006464
	(0.022)**	(0.046)**	(0.074)*	(0.085)*	(0.070)*	-0.138	-0.125
Trade openness t-1	-9.799	-10.89	-10.2	-14.563	-14.31	-14.1	-12.83983
	(0.011)**	(0.003)***	(0.007)***	(0.025)**	(0.026)**	(0.028)**	(0.045)**
Controlled Exchange Rate (dummy) t-2		0.7503	0.722	0.6966	0.7213	0.7104	0.7069514
		(0.007)***	(0.013)**	(0.017)**	(0.013)**	(0.016)**	(0.018)**
Banking Crisis (dummy) t-2			0.204	0.206	0.2363	0.2452	0.2995779
			-0.504	-0.501	-0.436	-0.428	-0.338
ΔTBill t-1						-1.244	-1.096071
						(0.069)*	-0.137
Growth of Exports t-1							-0.729589
							-0.379
Total External Debt / GDP t-1				0.7866	0.6612	0.7188	0.6710742
				-0.366	-0.409	-0.405	-0.443
Reserves / Short-term External Debt t-1	-0.469	-0.473	-0.485	-0.4145	-0.435	-0.399	-0.407056
	(0.001)***	(0.000)***	(0.000)***	(0.007)***	(0.002)***	(0.008)***	(0.010)***
Reserves / M2 t-1	0.1902	0.3039	-0.009	-0.341		-0.312	-0.494655
	-0.813	-0.697	-0.992	-0.72		-0.743	-0.617
Number of Observations	763	754	703	703	708	703	700
Pseudo R-squared	0.1676	0.186	0.25	0.26	0.26	0.26	0.26

* significant at 10%
** significant at 5%
*** significant at 1%

Table 31 - Cost of Crisis including China

Dependent Variable: Cost of crisis Real GDP (Crisis IPC)
In parentheses: p-values
Note: s ~ v means the average values of the period s to v

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.07	0.0465	0.062	0.062	0.06	0.06467
	(0.004)***	(0.028)**	-0.111	-0.116	-0.136	-0.117
Growth rate, t-2 ~ t-5	0.52	0.6689	0.716	0.722	0.8527	0.91999
	-0.101	-0.21	-0.206	-0.203	-0.151	(0.080)*
Banking Crisis (dummy), t-2 ~ t		0.0271	0.025	0.025	0.0295	0.02902
		-0.137	-0.151	-0.157	-0.123	-0.132
Growth rate of trade partners, t~t+2			-0.007		-0.01	-0.0087
			-0.619		-0.535	-0.577
Real growth rate of trade partners, t~t+2				-0.01		
				-0.618		
Real Depreciation Rate, t					-0.00003	-0.00003
					(0.026)**	(0.001)***
Reserves / Short-term External Debt	-0.02	-0.014	-0.013	-0.01	-0.01	-0.01
	(0.007)***	(0.018)**	(0.021)**	(0.021)**	(0.020)**	(0.014)**
Reserves / M2, t-1/2	0.05	0.0456	0.049	0.049	0.0382	
	-0.313	-0.427	-0.409	-0.412	-0.539	
Number of Observations	46	44	44	44	44	44
Pseudo R-squared	0.17	0.2024	0.207	0.207	0.2298	0.2208

* significant at 10%
** significant at 5%
*** significant at 1%

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