Capital Flow Reversals, Sudden Stops, and International Reserve Adequacy: Further Evidence From the Global Financial Crisis

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Abstract

Using a dataset of 39 emerging markets, we examined the role of international reserves during currency and capital flow crises. Our analysis revealed that higher levels of reserves are associated with lower intensity crises where intensity is measured by the magnitude of the change in exchange market pressure (EMP) or size of capital flow reversals. We also find evidence for the cushioning effects of reserves during the crises. When used against capital flow reversals, reserves can help mitigate the negative output effects of the crisis. Finally, our findings show that reserve adequacy should be evaluated based on the nature of the potential crisis. Policy makers may prefer to refrain from using reserves if export competitiveness is more important than potential balance sheet effects of currency depreciation.

Keywords: capital flow reversal, sudden stop, foreign reserves, financial crisis, global financial crisis, capital flow

JEL Classification: F3, F31, F32, F34, F37, F38

1. Introduction

After the Asian Crises of 1997-98 up until the beginning of the global financial crisis in 2008 emerging market countries accumulated massive international reserves (over $4.5 trillion). The global crisis that originated in the US and spread rapidly around the world presents an opportunity to evaluate potential benefits of international reserves during externally as opposed to internally generated crises.

The substantial increases in the international mobility of financial flows has led to a fundamental shift in how we view several of the key elements which go into the calculations of optimal levels of international reserves for emerging market economies. In the following section we develop an analytic framework to incorporate in the analysis the size of potential capital flow reversals to which countries may be subjected, the determinants of countries' willingness to use international reserves to cushion the effects of such capital flow reversals, analysis of the preventive role of international reserves in reducing the probabilities of such reversals and analysis of some of the other key factors that affect the likelihood of reversals such as countries' exchange rate regimes and the characteristics of capital inflows. Such analysis can be used to develop rules of thumb for what proportions of different types of financial inflows should be met by sterilized intervention in the foreign exchange market for the dual purposes of reducing the dislocation that might be forced on exchange rates and domestic financial conditions as a result of temporary capital flows and at the same time accumulating international reserves to reduce the probabilities of major capital flow reversals and to help cushion the effects if they do occur.

We make no pretense of seeking to calculate optimal reserve levels but believe that the issues on which we are focusing provide key components to any efforts to estimate optimal reserves or important clues to adequate levels of international reserves for a range of emerging market economies.

A key point which we stress is that some of the important relationships in this area are quite likely to vary depending on the major sources of capital flow reversals. Our earlier analysis along these lines focused on the case of Asian crises where a large part of the cause of the sudden stops and capital flow reversals was generated by developments in these emerging market economies themselves. In the recent global financial crisis, however, the capital flow reversals were generated primarily by developments in the United States and Western Europe, with the emerging market economies being largely innocent victims of the contagion from crisis originating in the advanced economies (Note 1). Thus in Section 3 we offer a preliminary analysis comparing the capital flow reversals during the Asian crisis with the reversals for the countries during the global financial crisis.

We argue that study of reserve adequacy should take into account three important aspects. First, reserves have a preventive role; i.e. the probability or intensity of a crisis is not independent of the size of reserves. Second, reserves have a protective role; by running down reserves during periods of capital flow reversals governments can cushion the negative effects of capital flow reversals. Third, it is important to take into account the extent to which nations are willing to make use of their reserves during crises.

In this paper, we take advantage of the variation across the earlier emerging market crises and the recent global crisis to examine the role of reserves during these crises based on the framework outlined in Section 2. We present a preliminary empirical analysis using a dataset that covers 39 emerging markets including the nations that had suffered from severe financial crisis during the 1990s and early 2000s. Previous studies have found that there are a number of conditioning variables that are potentially important for determining the likelihood of capital flow reversals and currency crises. The three that our project focuses on particularly are exchange rate regimes, capital controls, and previous capital flow surges. As we discuss there are substantial differences in the frequently used measures of all three of these types of variables as well as for measures of currency crises, capital flow reversals, and sudden stops. Our findings can be summarized as follows: First, the level of pre-crisis reserves is an important determinant of the intensity of crisis where intensity is measured by the magnitude of the change in exchange market pressure (EMP) or size of capital flow reversals. Here, milder crises are associated with higher pre-crisis levels of reserves. Second, when used against capital flow reversals, reserves can mitigate the negative output effects of crisis. Finally, our findings show that reserve adequacy should be evaluated based on the nature of the potential crisis.

The paper is organized as follows: In Section 2, we discuss some of the issues related to the evaluation of reserve adequacy and layout our analytic framework. As identified in Efremidze et al. (2011) there is to our surprise low correlations among many of the different measures of capital flow reversals that have been used in the literature as well as between these and measures of currency crises. Thus in Section 3 we discuss some of the major methodological issues relevant for these measures. In Section 4, we describe our dataset and present a quick comparison of selected macroeconomic data during the earlier emerging market crises and the global financial crisis. Sections 5, 6, and 7 present our empirical analysis of the role of reserves during crises. Section 8 concludes.

2. The Framework for Evaluating Reserve Adequacy Underlying Our Project

Traditional models of optimal international reserve behavior focused on fixed exchange rate models where fluctuations in the balance of payments were taken as exogenous. The benefits of higher reserve holdings derived from the lower probability that reserve losses would be sufficiently large that costly domestic macroeconomic policy adjustments would have to be made to avoid running completely out of reserves. These benefits of cost avoidance were then balanced against the costs of holding reserves as measured by the interest differential lost by holding the reserves in lower interest liquid forms. In empirical applications the need for reserves was measured by the past variability in the balance of payments. In the old view, by providing a less costly means of balance of payments adjustment than domestic macroeconomic policy, a move toward exchange rate flexibility was expected to lead to a substantial drop in the demand for international reserves. That prediction turned out to be quite wide off the mark. Freely floating exchange rates turned out, as many critics had predicted, to frequently carry substantial costs of their own. Thus, most countries that had moved to flexible exchange rate regimes continued to manage their exchange rates through official intervention in the foreign exchange market, sometimes quite heavily.

This contributed importantly to the failure of the demand for international reserves to fall substantially as many countries moved toward greater exchange rate flexibility. Of likely equal or greater importance though were the increases in the international capital mobility that were also occurring. These changed substantially the patterns of variabilities in many countries' balance of payments. Balance of payments problems in many emerging market economies switched from relatively slow moving current account crises to fast moving capital account crises. Frequently instead of a long string of balance of payments deficits and reserve losses, crises were preceded by substantial capital inflows and reserve gains. This phenomenon became known as the problem of capital flow surges and reversals or sudden stops. In such cases the variability of capital flows during good times has become a poor

predictor during bad times (Sula and Willett, 2009). Thus, the traditional methods of evaluating the need for international reserves based on the standard deviation or variance of fluctuations in the balance of payments during normal or good times has become quite deficient.

The problem is similar to that of many of the popular techniques of financial engineering and risk management, based on variances and correlations among assets during good times that proved to be so disastrous in the US subprime crisis and its subsequent spread to the global financial crises of 2008-2009. The problems with such approaches such as Value at Risk measures had been demonstrated as early as the Mexican and Asian crises, but this was generally ignored by financial institutions and regulators in the advanced economies. That outcomes in financial markets frequently have fat tails, i.e. substantially more frequent extreme movements than would be predicted from normal distributions, was well known to empirical financial economists, but in large part because the difficulty of developing formal risk managements dealing with such behavior, this problem was widely ignored by financial institutions except for the sometimes running of scenario analysis where the implications of bad events were analyzed. While insufficient attention was given to such scenario analyses or stress testing before the global financial crisis the importance of taking such analyses seriously has become much more widely recognized since the crisis. This is essentially the approach that we have taken in earlier analysis of the events during the Asian crises. We used the size of reserve losses and capital flow reversals during the Asian crisis as the basis for developing scenarios for the magnitudes of future crises that emerging market economies might have to deal with.

There are three important aspects of our framework for reserve adequacy. One is that unlike the traditional models the probability of capital flow reversals is not independent of the levels of international reserves. This preventive role of substantial reserve levels has been studied with somewhat mixed results in a number of empirical studies and there is still no general agreement of the range of magnitude of such preventive effects. Furthermore, these are likely to vary depending on other factors that influence the potential vulnerability of countries. While studies of the Asian crises generally found an important role for international reserves in preventing crises (see Willett et al., 2005), Blanchard et al. (2010) find little evidence that high reserves mitigated the decline in output as external debt levels affected the magnitude of output losses. Channels of transmission included both financial and trade sectors. On the other hand, high reserve level countries experienced better post-crisis GDP growth (Dominguez et al., 2011). In addition, countries with outsized reserves were more likely to actively utilize some of their reserves during the 2008 crisis, even though this evidence is somewhat hidden by passive changes of interest income and valuation changes (Dominguez, 2011).

A second important factor incorporated into recent analysis is the idea that reserve levels should be sufficient to offset the magnitudes of capital flow reversals during a crisis. By running down reserves during periods of capital flow reversals governments can cushion the effects of the outflows on exchange rates and their domestic financial sectors and thus avoid the worst of the damaging effects observed of currency crises. About half of the emerging market countries with high trade openness depleted reserves, while the countries with relatively high financial linkages and external debt seemed to engage in 'fear of losing international reserves' (Aizenman and Sun, 2009).

This brings us to the third aspect of reserve adequacy, possible reluctance to use reserves. Surprisingly, during the global financial crisis even the countries with large accumulated reserves absorbed much of the exchange rate market pressure by currency depreciation rather than reserve rundowns. It is not clear if the choice was deliberate due to the 'fear of reserve loss' (or mercantilist motive of improving export competitiveness) or that the market pressure was rapid and overwhelmed the policy makers (Aizenman and Hutchison, 2010).

Within our framework we also take into account the roles exchange rate regimes, capital controls, and previous capital inflows. There have of course already been several studies on the role of exchange rate regimes both in affecting the probabilities of domestically generated crisis (Note 3) and in protecting innocent victims from the effects of the global financial crisis (Note 2). The latter studies, however, have often used measures of exchange rate regimes that we believe are insufficient to adequately capture the effects of a number of importantly different types of exchange rate regimes (Willett et al., 2011). Thus, we are conducting further research on this issue. There have also been a number of studies on the relationships between capital controls and crises. As with the studies on the role of exchange rate regimes during the global financial crisis, these have reached conflicting results, in large part we believe because of deficiencies in the measures of capital controls that were available for use in the earlier studies. More recently developed measures hold the purpose of providing better insight. In this paper we used the popular Chinn and Ito (2008) measure of capital restrictions. In a recent study using this data, Chiu et al. (2011) found positive correlations with controls on inflows.

The other issue on which we are concentrating is the role of previous capital surges in influencing the probabilities and likely magnitudes of capital flow reversals. It seems from previous analysis that when faced with substantial

surges in inflows of financial capital, countries should anticipate that a substantial portion of such inflows may be rather quickly reversed. Thus on a number of grounds including avoiding the dislocation cost of temporary effects on exchange rates and domestic financial markets and the increased likelihoods of capital flow reversals, a portion of such inflows should be met with sterilized intervention in the foreign exchange markets which in turn will automatically lead to increased reserve levels. So far, however, there has been relatively little analysis of reasonable ranges of the amount of such inflows to sterilize and to what extent this should vary depending on the nature of the financial inflows and the degree to which these inflows display patterns of capital surges. There is of course a literature on whether some types of financial flows are more stable than others in which we can draw. See, for example, the analysis and references in Sula and Willett (2009) and the case studies of the Asian crisis in Willett et al (2005) and of Korea during the global financial crisis in Willett et al (2009). Likewise there have been a number of studies on capital flow surges and sudden stops but as analyzed by Efremidze et al. (2011) a wide range of measures for both surges and sudden stops or reversals have been adopted by different studies in this area. Thus we plan to undertake a detailed evaluation of a number of different measures for the purpose of helping to delineate adequate levels of external reserves. Some of the methodological issues involved in such measures are discussed in Section 3.

3. Measuring Sudden Stops

Most analyses on reserve adequacy have understandably focused on crises and capital flow reversals (CFR) that were generated largely by developments in the emerging market countries themselves (including the contagion to other emerging markets generated by such crises). There is also a literature on the role of push versus pull or advanced versus emerging markets own country factors in influencing capital flows from advanced to emerging market economies, but most of this literature has not focused specially on cases of capital flow reversals and it seems likely that the relative importance of these factors will vary from case to case (Dominguez, 2011).

The recent global financial crisis gives us a clear case of largely externally generated sudden stops (SS) of the flows from advanced to emerging market economies. Thus, we want to investigate whether there are substantial differences between these largely externally generated capital flow reversals and those generated largely by internal factors.

We would of course expect that different popular methods of measuring currency crises and sudden stops would not be perfectly correlated, but recent research has found a startlingly low degree of correspondence among many of these measures. In their critical survey Efremidze et al. (2011) found that the highest correlation among two of the most common measures of sudden stops and the most widely used measure of currency crises was only 0.30 with the other correlation being 0.28. This is certainly surprising. To some extent the lack of correlation between sudden stops and currency crises is understandable since not all sudden stops cause currency crises and vice versa. There are also methodological problems with the standard method of using precision weights based on the inverse of variances to compare the relative importance of changes in international reserves, exchange rates, and interest rates in measuring currency crises. The problem is that the past variances of these variables can depend heavily on the previous exchange rate regimes being followed and thus may not give good measures of how much a given change in exchange market pressure (the concept on which currency crises measures are based) would generate changes in international reserves under a fixed exchange rate versus change in the exchange rate under a free float (Willett et al., 2005). For our preliminary empirical work we have used precision weights but plan to compare the results with a measure using equal weights.

More surprising is the low correlation among measures of sudden stops. One important point to recognize is that by using net measures of financial flows what is really being measured is capital flow reversals. While the general image of these phenomena is that they reflect the sudden stop and/or reversal of capital inflows from abroad, recent research that separates the behavior of capital flows from domestic versus foreign capital flows. Not infrequently capital flow reversals are due in considerable part by increased outflows of capital by domestic residents (see Schreyer, 2009). This suggests that it is important to look at the behavior of these types of capital flows individually rather than just at net flows. In our empirical work reported here we have looked only at net flows, but we will look at disaggregated flows in our future research, both by domestic versus foreign residents and by categories of capital flows.

A major difference among CFR and SS measures is whether additional criteria are added such as that GDP growth declines or that there is a current account reversal. We are critical of this approach of using such additional criteria in the definition of CFR and SSs since they obscure the interesting question of how frequently and under what conditions do CFRs and SSs cause economic downturn and what are the effects on current account balances.

Another disagreement is whether to base measures on the size of the events relative to GDP or in terms of the size of their previous variance. On this question we would argue strongly for the superiority of scaling measures by GDP. This allows us to directly compare the size of the capital flow event with the magnitudes of its effects on GDP

growth, reserve usage, etc. This gives us a much more straightforward measure of the severity of an event than does the number of its standard deviations above its past history. While most of the research to date has used a binary approach to crisis and capital flow events, there is of course a quite interesting set of issues that have only recently begun to be explored. These involve how the magnitudes of crisis and capital flow events are related to sizes of their effects. For such investigations scaling by variables such as GDP or the size of the financial sector debt are essential (see Schreyer, 2009).

Another interesting requirement sometimes imposed on SS identification method is to have a capital surge prior to the reversal event. This is entirely appropriate for a measure of sudden stops. We argue, however, that the study of SSs should be embedded within the broader framework of the study of large capital flow reversals. This allows us to explore a richer set of issues such as how frequently do capital flow surges lead to capital flow reversals, how do these reversals break down between the behavior of domestic and foreign investors, and what types of measures of capital flow surges give us the best predictors of currency crises, SSs, and CFRs.

Finally, there is the issue of the thresholds to be used to identify these events. Here, there clearly is no one correct answer. It's best to report results for several different thresholds. Again, the use of measures relative to GDP rather than past variability seem more helpful, as the meanings are more intuitive and allow us to distinguish between strong and weak events, and possible gradations in between.

For the reasons given above, in this paper we focus on measures based on the size of the capital flow reversals relative to GDP. For comparative purposes, however, we also use a measure that includes the requirement of there being a decline in GDP growth.

4. EM Crises vs. the Global Crisis: A Quick Comparison

Our empirical approach is to examine the role of reserves conditional on the existence of a crisis. This assumption allows us to pool observations on the well-known episodes of emerging market crises of the 1990s and early 2000s and the 2008-2009 global crisis into one sample. We use a dataset of 39 emerging markets which includes 109 capital flow reversal crises. Each observation represents a shock for a nation during a particular year. 31 observations come from specific emerging market crisis of the 1990's and early 2000s. These crises are identified according to the methodology of Chamon et al. (2007), where a crisis is defined as a large and sudden reversal in net private capital flows. Once a mechanical formula identifies crisis periods, the list is further revised and validated by IMF country desks. The rest of the 78 observations in our sample come from the years 2008 and 2009. Here we are assuming that during these years all emerging markets were subjected to an external shock but of varying magnitudes (Note 4).

Despite their massive reserves, emerging markets on average were affected as strongly as the developed nations (see Figure 1 and Table 1). Interestingly, aggregate reserve accumulation continued during the crisis (see Figure 2). While one can use this fact as an evidence for the insignificant role of reserves to deal with crisis, it should be noted that, on average, emerging markets also had relatively lower debt exposures and better current account positions. Figure 3 shows that since the 1990s the level of external debt fell substantially while the current account balances increased. Furthermore, we see a substantial increase in trade openness and exports. However, these positive developments did not fully protect the emerging markets from the global crisis.
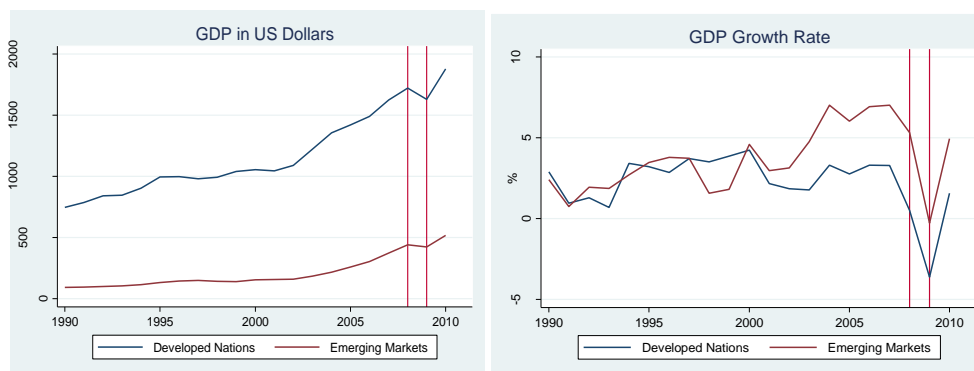

Figure 1. GDP levels and growth rates in developed nations and emerging markets

Table 1. Summary statistics

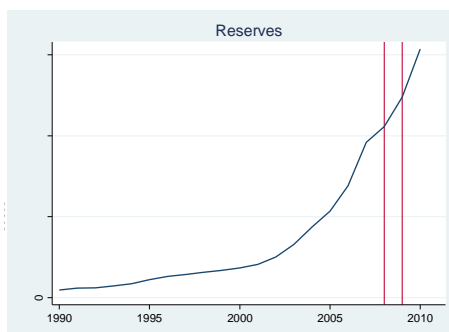|	90's and Early 2000s	2008-09	2008-2009
	Emerging Markets	**Emerging Markets**	**Developed Nations**
Average Growth Rate (%)	0.35	2.52	-1.55
Capital Flow Reversal (% of GDP)	5.13	4.72	31.7
Stock Index Fall (%)	38.9	51.6	51.6
Risk Premium (%)	20.87	5.42	2.88

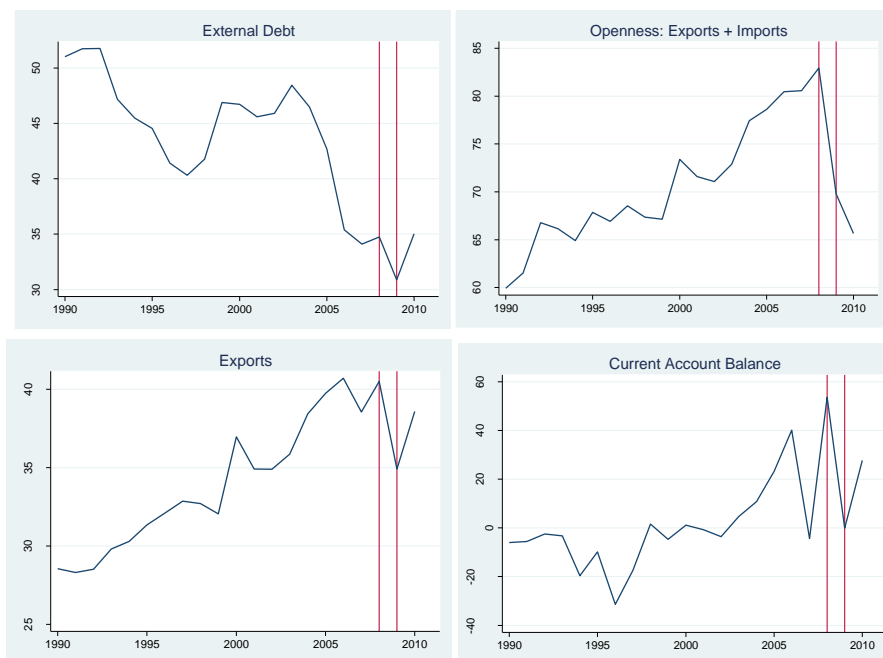Figure 2. Reserve accumulation in emerging markets

Figure 3. Pre-crisis vulnerabilities in emerging markets

In Figures 4 and 5 we report average measures of crises and reserve behavior during the global crisis and earlier emerging market crises. Figure 4 compares the average size of private capital reversals and pre-crisis reserve levels. The size of reversals is defined as the annual change in net private capital flows as a percentage of GDP. A positive value indicates a decrease in inflows (or an increase in outflows). We see that emerging markets almost doubled the size of their reserve holdings in 2007 compared with their holdings during the earlier EM crises. On the other hand,

the amount of reversals was close in size during both crisis periods. The second panel of Figure 4 shows the size of reserve depletion. Reserve depletion is defined as the annual change in reserve holdings as a percentage of GDP. A positive value indicates the sale of reserve assets. Here we see that during the earlier crisis emerging markets depleted their reserves to cushion the capital flow reversals. However during the global crisis on average, they continued to accumulate reserves.
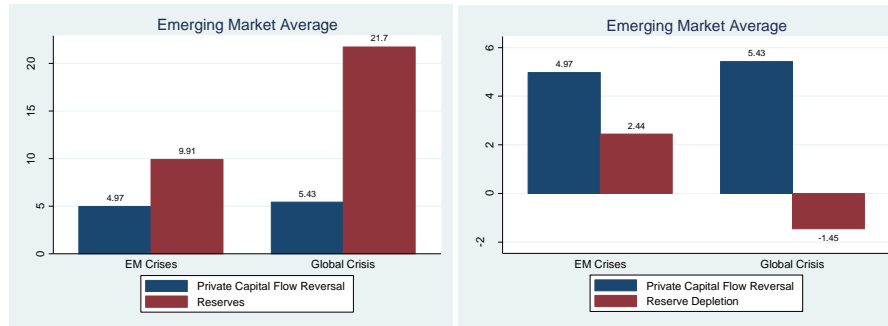

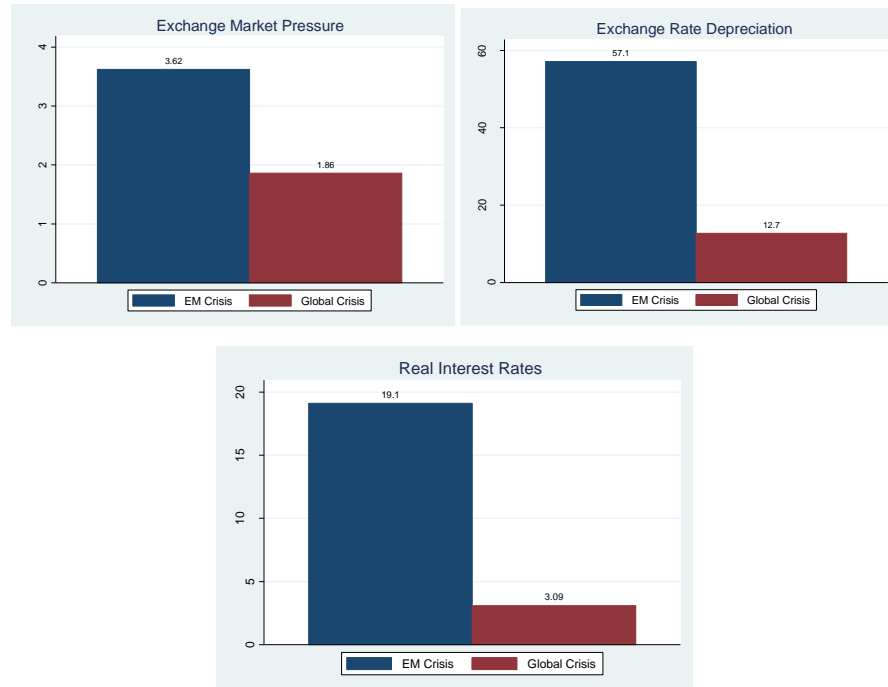Figure 4. Capital flow reversals, pre-crises reserves and reserve changes

Figure 5. EMP and exchange rate depreciation

Figure 5 compares the behavior of three additional variables that are often used to gauge the intensity of crisis. The first, exchange market pressure index (EMP) is defined as a weighted average of monthly exchange rate changes and monthly reserve losses. The weights are inversely related to the variance of changes of each component over the sample of each country. The index is standardized and Z-scores are used in our analysis. We see that all of these measures were significantly higher during the earlier emerging market crises (as a robustness check we will also use crisis indices based on equal weights as suggested in Willett et al. (2005)).

Figures 4 and 5 suggest that during the global crisis, despite the large size of private capital flow reversals, foreign exchange markets and interest rates were not affected as strongly as they were during the earlier EM crises. In addition, reserve responses to the global crisis were also drastically different. The average measures that we present

here may not give the full story how the emerging markets were affected and whether they responded in a diverse manner during the global crisis. Figures 6 to 9 compare the values of various measures for four emerging markets that had severe crisis during the 1990s to their values during the global crisis.
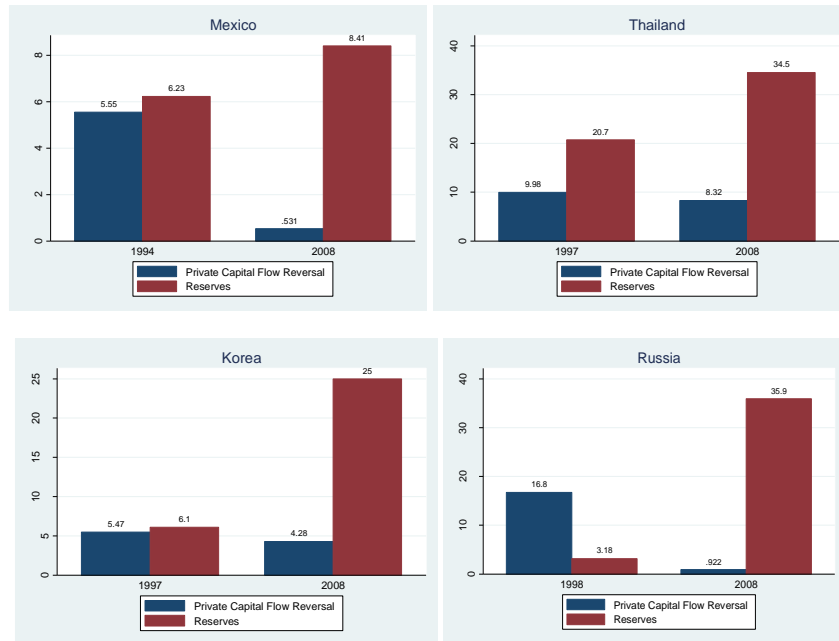

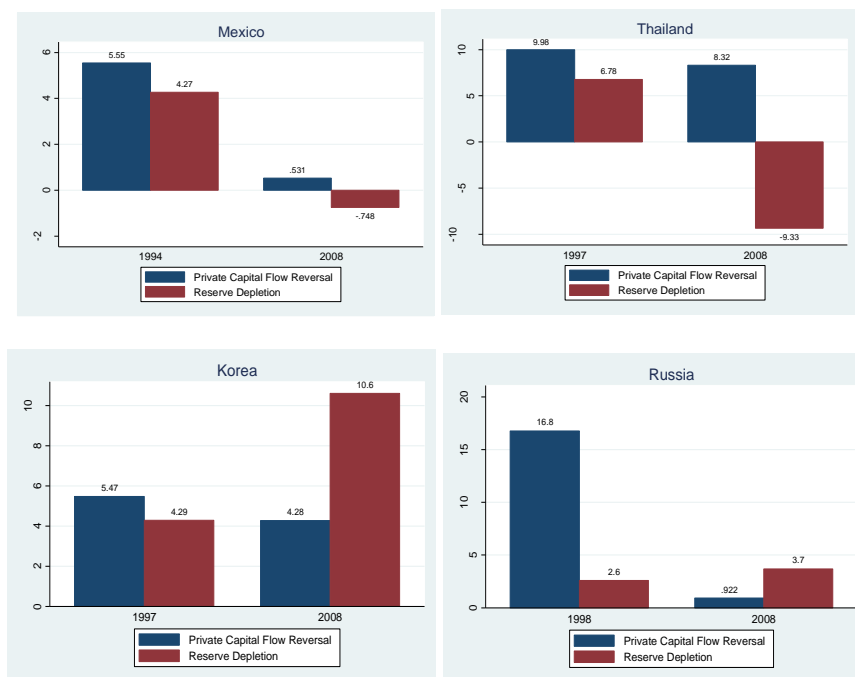Figure 6. Pre-crises reserves and capital flows reversal

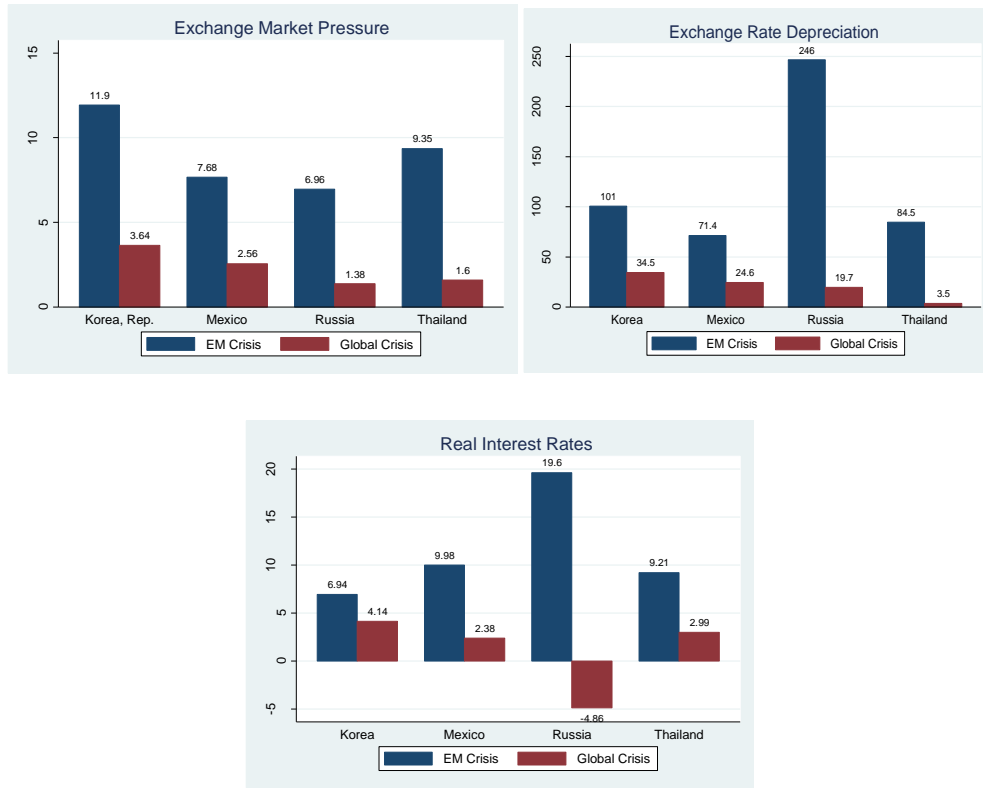Figure 7. Capital flow reversals and reserve changes

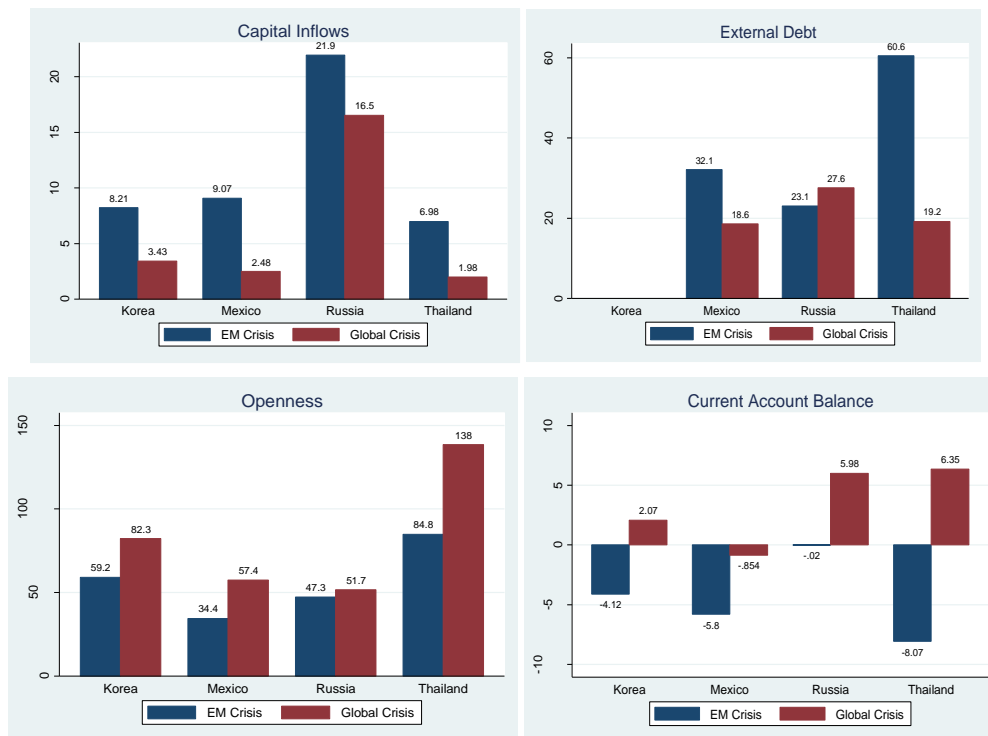Figure 8. EMP, exchange rate depreciation, and interest rates

Figure 9. Capital inflow surges, external debt, trade openness and CA balance

A quick examination of these graphs illustrates the diverse impact of and response to the global crisis. Utilizing this variation, in the next three sections, we present a more systematic analysis of the behavior of reserves during the crises. Using the dataset described above we run ordinary least squares regressions to explore the three aspects of reserve adequacy that we identify in our framework.

5. Reserves and the Intensity of the Crisis

The role of reserves in predicting the probability that a nation will experience a currency or sudden stop crisis has been established by numerous empirical studies. We cannot apply the probability approach to the recent crisis, since for the EM countries the crises were externally generated. However, we can examine whether the level of reserves had any effect on the intensity of the crises that hit different EM countries. Table 2-A presents the regression results for our first intensity measure: Exchange market pressure (EMP) index. In this and the following tables, each regression includes the country fixed effects and the robust standard errors clustered by year are given in parentheses beneath each coefficient.

Table 2-A. Exchange market pressure index (dependent variable)

	(1)	(2)	(3)
Reserves (% of GDP)	**-0.140**	**-0.116**	**-0.114**
	(0.030)	(0.020)	(0.053)
Global Crisis (dummy)		**-0.964**	**-0.416**
		(0.438)	(0.215)
Accumulated Inflows (% of GDP)			**0.088**
			(0.039)
Current Account (% of GDP)			0.037
			(0.039)
Capital Mobility			-0.112
			(0.190)
Intermediate XR Regime			**0.451**
			(0.185)
Constant	**2.298**	**11.914**	-4.940
	(0.292)	(1.002)	(3.706)
Number of Obs.	104	104	89
R Squared	0.665	0.689	0.736

All regressions include country fixed effects. Robust and clustered (on year) standard errors are in parenthesis. All independent variables are lagged one year except Reserves and Global Crisis. Bold numbers indicate significance at 10%.

Table 2-B. Capital flow reversals (as % of GDP, dependent variable)

	(1)	(2)	(3)
Reserves (% of GDP)	**-0.183**	-0.166	**-0.526**
	(0.111)	(0.156)	(0.156)
Global Crisis		-0.346	**1.131**
		(2.889)	(3.371)
Accumulated Inflows			**0.517**
			(0.136)

Current Account			**0.631**
			(0.160)
Capital Mobility			0.841
			(0.509)
Intermediate XR Regime			**3.415**
			(1.837)
Constant	1.229	1.436	-23.536
	(5.496)	(4.692)	(15.721)
Number of Obs.	106	106	94
R Squared	0.382	0.382	0.519

All regressions include country fixed effects. Robust and clustered (on year) standard errors are in parenthesis. All independent variables are lagged one year except Reserves and Global Crisis. Bold numbers indicate significance at 10%.

Table 2-A, column 1 reports the results for the specification that only includes the pre-crisis reserve levels (measured as a percentage of GDP). In the absence of any controls, a ten percentage point increase in reserves is associated with a significant -1.4 standard deviation decrease in the EMP. This effect is both statistically and economically highly significant. Column 2 of Table 2-a adds a dummy variable for the period 2008-2009 to control for the global nature of the crisis. This also yields a significant negative coefficient and presents the important result that we first introduced in Figure 5: Exchange market pressure was much lower during the global crisis compared with the emerging market based crises of the 1990s and early 2000s. Comparing column 2 to column 1, we see that controlling for the global crisis diminished the coefficient on reserves by only 0.024 percentage points. Therefore, pre-crisis reserve levels seem to have a distinct effect on crisis intensity.

Given that the sample mean of EMP is 2.18, the impact of reserves is non-negligible. However, this model is simplistic in that it does not take into account many other factors that are known to be correlated with reserve policy. Moreover, controlling for the other factors may itself be interesting since they provide additional evidence on the determinants of crisis intensity. To this end, in column 3, we include four variables that have been found to be important determinants of crises by previous studies. Accumulated inflows are the sum of the previous five years' net private capital flows. Current account balances have often been a predictor of currency crisis during recent decades. Capital controls have also been found to be correlated with currency crises. Here we use the Chinn-Ito Capital Account Openness index, larger values indicate higher capital mobility (Chinn and Ito, 2008). Finally, based on theories of the unstable middle, we include intermediate exchange rate regimes as a dummy variable, we use the classification of Reinhart and Rogoff (2004). The first two variables are measured as a percentage of GDP. All variables are lagged by one year.

The coefficient of reserves withstands the inclusion of the control variables. We see that the impact of the global crisis is weakened yet it is still negative and significant. Accumulated capital inflows and intermediate exchange rate regimes have the expected signs and significant coefficients. However we fail to find significant estimates for the current account and the capital control variables.

Table 2-B presents the results for our second intensity measure: Capital flow reversals as a percentage of GDP. In column 1 without the controls, the estimated coefficient for reserve holdings is negative and significant. A one percentage point increase in reserves decreases the size of capital flow reversals by 0.18 percentage points. When we add the global crisis dummy in column 2 the reserve coefficient becomes statistically insignificant yet in column 3 when all controls are included in the regression, we get a significant estimate. In this final specification, the coefficient of reserves is highly significant both statistically and economically. Here, $10 billion more in reserve holdings on average decreases country's capital flow reversal by $5.3 billion. Furthermore, with the exception of the current account balance the independent variables have significant coefficients. An interesting result here is the positive estimated coefficient of the global crisis dummy. Once again we see that during the global crisis capital flow reversals were as large as in the earlier emerging market crisis.

Taken together Tables 2-A and 2-B provide two important insights about reserve adequacy: First, the level of pre-crisis reserves has an important role in mitigating the intensity of crisis no matter how it is measured. Second, in both specifications the coefficient estimate on accumulated inflows is close in absolute value to the coefficient on the level of reserves. We argued earlier that measures of reserve adequacy should take the surges in private capital flows

into account. The results confirm this argument. For example, if reserves are increased by one percentage point every time the level of accumulated inflows increase by the same amount then during a crisis, on average, the intensity measured as EMP or capital flow reversal will be lower.

6. Reserves, Reversals and Output Effects

Next we investigate whether reserve depletion to cushion capital flow reversals has any mitigating effect on the subsequent output losses. To examine this protective role of reserves we compute the difference between reserve depletion and capital flow reversal as a percentage of GDP. It should be noted that this measure does not capture the intended cushioning effect if there is an increase in capital flows or accumulation of reserves during a crisis year. In fact, when we use the initial version of this measure we get a negative and insignificant coefficient estimate. To deal with this problem without removing observations from our sample, we create a dummy variable that take the value of one when reversals and reserve depletion take place at the same time. Then we interact this dummy variable with the Depletion-Reversal difference.

In Table 3, column 1 only the aforementioned variables are included in the regression. The coefficient of the interaction variable is highly significant and has a positive sign. In column 2, we added the global crisis dummy to the estimation. The estimate is insignificant indicating that the recent global crisis was no different than early emerging market crisis in terms of its effects on output, holding everything else constant. In the last column we included three other control variables (all are measured as a percentage of GDP). The first two, the current account balance and foreign direct investment, have positive and significant coefficients. Coefficient estimates for external debt, on the other hand, are insignificant.

Table 3. Output changes during crisis (GPD growth rate is dependent variable)

	(1)	(2)	(3)
Depletion – Reversals	0.018	0.023	0.035
	(0.053)	(0.028)	(0.028)
Depletion-Reversal Dummy	0.739	0.992	1.482
	(1.200)	(1.169)	(1.017)
Interaction	**0.415**	**0.411**	**0.385**
	(0.053)	(0.054)	(0.070)
Global Crisis		0.461	0.515
		(3.130)	(3.437)
Current Account / GDP			**0.342**
			(0.109)
FDI / GDP			**0.196**
			(0.081)
External Debt / GDP			0.048
			(0.084)
Constant	0.923	3.953	-5.486
	(2.711)	(3.693)	(5.543)
Number of Observations	106	106	90
R Squared	0.509	0.510	0.547

All regressions include country fixed effects. Robust and clustered (on year) standard errors are in parenthesis. Current Account, FDI and External Debt are lagged one year. Bold numbers indicate significance at 10%.

The coefficient on the interaction variable is barely affected by the inclusion of other variables. In column 3, the estimate is 0.38. Every one percentage point increase in the reserve-reversal difference increases the GDP growth rate by 0.38 percentage points. This is a very large effect that arouses suspicion. Figure 10 shows the relation between output growth and the interaction variable. The outlier observation that lies on the very left side of the graph

belongs to Uruguay's 2002 crisis. Estimating the specification in column 4 without the outlier observation yields a statistically significant coefficient estimate of 0.276, smaller yet still economically important. Hence, Table 3 adds more insight to the question of reserve adequacy. When used against capital flow reversals, reserves can mitigate the negative output effects of the crises.
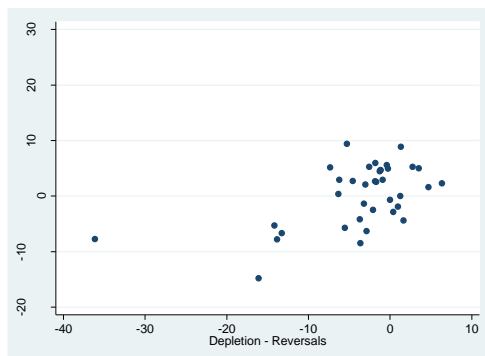

Figure 10. Scatter-plot of reserve declines and post-crisis GDP growth rate

7. Determinants of Reserve Depletion

Finally, we examine the factors that affect the size of reserve depletion during the crises. The dependent variable is the annual difference in reserve levels as a percentage of GDP. We fail to find a significant relationship between the initial reserve levels and reserve depletion during crises (see Table 4).

Table 4. Reserve Depletion as % of GDP (dependent variable)

	(1)	(2)	(3)	(4)
Reserves	-0.054	**0.154**	0.231	0.116
	(0.079)	(0.074)	(0.145)	(0.126)
Global Crisis		**-4.249**	**-2.795**	**-2.118**
		(1.308)	(1.359)	(1.039)
Trade Openness			**-0.127**	**-0.154**
			(0.045)	(0.067)
External Debt			0.045	**0.087**
			(0.042)	(0.035)
Intermediate XR Regime			-0.283	0.468
			(0.736)	(0.865)
Capital Mobility			0.181	0.323
			(0.346)	(0.386)
Capital Flow Reversal			**0.220**	
			(0.099)	
Constant	-1.319	1.219	-21.843	-11.858
	(4.357)	(4.350)	(19.111)	(17.242)
Number of Obs.	106	106	87	87
R Squared	0.4959	0.5734	0.6896	0.620

All regressions include country fixed effects. Robust and clustered (on year) standard errors are in parenthesis. All independent variables are lagged one year except Reserves, Global Crisis and capital flow reversal. Bold numbers indicate significance at 10%.

Several recent studies have indicated that nations were reluctant to use reserves during the global crisis. Adding the global crisis dummy into the regression in Table 4, column 2 results in a highly significant coefficient estimate. Holding everything else constant, the reserve depletion was 4.25 percentage points less during the global crisis. In column 3 we add five other factors that could affect the reserve usage decision. First, trade openness is measured as the sum of exports and imports as a percentage of GDP. Nations that have a higher exposure to international trade may be more likely to let their exchange rate depreciate instead of depleting reserves. The second factor is the ratio of external debt to GDP which captures the external debt exposure of a country. Nations with higher external debt are more likely to defend their currency to protect their financial sector from the balance sheet effects of currency depreciation. The third factor is capital controls. The expected sign is unclear. The fourth factor is the existence of an intermediate exchange rate regime. This would likely increase reserve depletion if the government is committed to protect the regime. Thus, we expect a positive sign. Finally, to control for the intensity of the crisis, we included the size of the capital flow reversal in the regression. Bigger reversals should lead to faster depletion. All of the additional variables are lagged by one year except the capital flow reversal.

Table 4, column 3 shows that the initial level of reserves continues to be an insignificant determinant of reserve depletion. The effect of the global crisis, on the other hand, is still significant but the magnitude of the estimate is diminished. Some of the factors that we added to the regression must have been captured by this dummy variable in the earlier result. We find a significant effect of trade openness on the size of reserve depletion. This might explain some of the emerging markets' reluctance to use reserves during the recent crisis. We fail to find a significant effect of external debt, capital controls or the exchange rate regime.

The coefficient estimate on capital flow reversal has the expected positive sign and it is statistically significant. A one percentage point increase in the size of the reversal increases the use of reserves by 0.22 percentage points. According to our findings from the previous section, this ratio of coverage is not enough to fully prevent output loss but the positive significant coefficient illustrates the impact of reversals on the size of reserve usage. However, it should be noted that this variable is very likely to be endogenous. The amount of reserve depletion during a crisis could affect the size of reversals. For this reason we also report the regression results without the reversal measure in column 4. While the results from the previous specification didn't substantially change, the estimate on the effect of the external debt become significant with the expected sign.

Reserve adequacy should be evaluated based on the nature of the potential crisis. The recent global crisis affected emerging markets via two channels: falling exports due to an overall decrease in demand from the rest of the world and financial panic that led to capital flow reversals. The relative importance of these channels is likely to be determined by the relative vulnerabilities of emerging markets. In Figure 3 we show that in general emerging markets were in a much better shape in terms of their debt exposure and had higher levels of trade with the rest of the world. We also see the negative impact of the global crisis on emerging market exports. Considering these facts together, it is not surprising that many nations let their exchange rates depreciate to maintain competiveness instead of relying on reserve depletion.

8. Conclusion

Using a dataset of 39 emerging markets, we examined the role of international reserves during the currency and capital flow crises. Our analysis revealed that higher levels of reserves are associated with lower intensity crises where intensity is measured by the magnitude of the change in exchange market pressure (EMP) or size of capital flow reversals. We also find evidence for the cushioning effects of reserves during the crises. When country is facing capital flow reversals, reserves can mitigate the negative output effects of the crisis. Finally, our findings show that reserve adequacy should be evaluated based on the nature of the potential crisis. Our results suggest that policy makers have refrained from using reserves if export competitiveness was more important than the potential balance sheet effects of currency depreciation.

References

Aizenman, J., & Hutchison, A. (2010). Exchange Market Pressure and Absorption by International Reserves: Emerging Markets and Fear of Reserve Loss During the 2008-09 Crisis. *NBER Working Paper No. 16260.* https://doi.org/10.3386/w16260

Aizenman, J., & Sun, Y. (2009). The financial crisis and sizable international reserves depletion: From 'fear of floating' to the 'fear of losing international reserves'?. *NBER Working Paper No. 15308.* https://doi.org/10.3386/w15308

Angkinand, A., Chiu, E., & Willett, T. (2009). Testing the unstable middle and two corners hypotheses about exchange rate regimes. *Open Economies Review, 20,* 61-83. https://doi.org/10.1007/s11079-007-9066-0

Berkman, P, Gelos, G., Rennhack, R., & Walsh, J. P. (2009). The global financial crisis: Explaining cross-country differences in the output impact. *International Monetary Fund Working Paper WP/09/280*.

Blanchard, O., Faruqee, H., & Das, M. (2010). The Initial Impact of the Crisis on Emerging Market Countries. *Brookings Papers on Economic Activity*, 263-323. https://doi.org/10.1353/eca.2010.0005

Chamon, M., Manasse, P., & Prati, A. (2007). Can We Predict the Next Current Account Crisis?. *IMF Staff Papers, 54*(2), 270-305. https://doi.org/10.1057/palgrave.imfsp.9450012

Chinn, M., & Ito, H. (2008). A New Measure of Financial Openness. *Journal of Comparative Policy Analysis, 10*(3), 309-322. https://doi.org/10.1080/13876980802231123

Chiu, E., Kim, J., Dechsakulthorn, S., & Willett, T. D. (2011). Classifying International Aspects of Currency Regimes. *Journal of Financial Economic Policy, 3*(4), 288-303. https://doi.org/10.1108/17576381111182882

Dominguez, K. (2011). Foreign Reserve Management during the Global Financial Crisis. *Working Paper*, University of Michigan and NBER.

Dominguez, K., Hashimoto, Y., & Ito, T. (2011). International Reserves and the Global Financial Crisis. *NBER Working Paper No. 17362*. https://doi.org/10.3386/w17362

Efremidze, L., Schreyer, S. M., & Sula, O. (2011). Sudden Stops and Currency Crises. *Journal of Financial Economic Policy, 3*, 304-21. https://doi.org/10.1108/17576381111182891

Frankel, J. A., & Saravelos, G. (2010). Are Leading Indicators of Financial Crises Useful for Assessing Country Vulnerability? Evidence from the 2008-09 Global Crisis. *NBER Working Paper No. 16047*. https://doi.org/10.3386/w16047

Kim, J., Li., J., Rajan, R., Sula, O., & Willett, T. (2004). Reserve Adequacy in Asia Revisited: New Benchmarks Based on the size and Composition of Capital Flows. In Y. Oh, D. R. Yoon, & T. D. Willett (Eds.), *Monetary and Exchange Rate Arrangements in East Asia* (pp. 161-189).

Lane, P., & Milesi Ferretti, G. (2011). External Adjustment and the Global Crisis. *NBER Working Paper No. 17352*. https://doi.org/10.3386/w17352

Reinhart, C., & Rogoff, K. (2004). The Modern History of Exchange Rate Arrangements: A Reinterpretation. *Quarterly Journal of Economics, 119*(1), 1-48. https://doi.org/10.1162/003355304772839515

Schreyer, S. M. (2009). Essays on the heterogeneity of sudden stop crises. *Working Paper*, Claremont Graduate University.

Sula, O., & Willett, T. (2009). The reversibility of different types of capital flows to emerging markets. *Emerging Markets Review*, *10*(4), 296-310. https://doi.org/10.1016/j.ememar.2009.08.001

Sula, O. (2010). Surges and sudden stops of capital flows to emerging markets. *Open Economies Review*, *21*(4), 589-605. https://doi.org/10.1007/s11079-008-9103-7

Tsangarides, C. (2010). Crisis and Recovery: Role of the Exchange Rate Regime in Emerging Market Economies. *IMF Working Paper WP/10/242*. https://doi.org/10.5089/9781455209422.001

Willett, T., & Sula, O. (2009). *International reserve adequacy in Global Crisis and Korea's International Financial Policies*, pp. 48-57. Korea Economic Institute, Korea.

Willett, T., Chiu, E. M. P., Dechsakulthorn, S., Ghosh, R., Kibesse, B., Kim, K., … Ouyang, A. (2011). Classifying international aspects of currency regimes. *Journal of Financial Economic Policy, 3-4,* 288-303. https://doi.org/10.1108/17576381111182882

Willett, T., Nitithanprapas, E., Nitithanprapas, I., & Rongala, S. (2005). The Asian crises reexamined. *Asian Economic Papers, 3*, 32-87. https://doi.org/10.1162/1535351054825184

Notes

Note 1. We are aware that there have been many allegations that most of the East Asian economies that were hard hit were innocent victims of contagion from the Thai crisis. Our previous analyses find that the unjustified contagion

hypothesis explains only a minor part of the contagion compared with the wake up call hypothesis. See Willett et al. (2005).

Note 2. See the analysis and references in Angkinand et al (2009) and Chiu et al. (2011).

Note 3. See, for example, Berkman et al. (2009), Frankel and Saravelos (2010), Blanchard et al. (2010), and Tsangarides (2010).

Note 4. Most of the negative impact of the global crisis on emerging markets started in October 2008 with the bankruptcy of Lehman Brothers and continued through the first months of 2009. Due to the annual frequency of our dataset we chose to include the year 2009 in our analysis. We also used a sample that excludes the observations from 2009 and confirmed the robustness of our main conclusions.

Appendix

Sample: 39 Emerging markets. 109 total observations. 31 observations come from country specific crisis for the period 1990 to 2005 identified by Chamon et al. (2007). A sudden stop crisis is defined as large and sudden reversal in net private capital flows. Once the mechanical formula identifies crisis periods, the list is further revised and validated by IMF country desks. The rest of the 78 observations in the sample come from 2008 and 2009. One year lagged values of selected variables are also used.

Exchange Market Pressure Index (EMP): defined as a weighted average of monthly exchange rate changes, monthly reserve losses and interest rate changes. The weights are inversely related to the variance of changes of each component over the sample of each country. The index is standardized and Z-scores are used in the analysis. A second EMP index is also computed excluding the interest rates. Monthly data that is used to compute the indices come from International Financial Statistics, IMF.

Reserve Holdings: Defined as reserves excluding gold as a percentage of GDP. Annual data is from International Financial Statistics, IMF.

Current Account: Defined as the current account balance as a percentage of GDP. Annual data is from International Financial Statistics, IMF.

Trade Openness: defined as the sum of exports and imports as a percentage of GDP. Annual data is from World Development Indicators, World Bank.

Reserve Depletion: Defined as the annual change in reserve holdings as a percentage of GDP. A positive value indicates the sale of reserve assets.

External Debt: Total external debt as a percentage of GDP. Annual data is from World Development Indicators, World Bank.

Private Capital Flow Reversal: Annual Change in net private capital flows as a percentage GDP. A positive value indicates a decrease in inflows (or an increase in outflows). Private capital flows are defined as the sum of net portfolio flows, bank loans and other sector loans. Foreign Direct investment and other official flows are excluded. Annual data for portfolio flows come from World Development Indicators. For measuring the bank and other sector loans, quarterly data is used from the Balance of Payments Statistics, IMF and then converted into annual frequency.

FDI: Foreign direct investment inflows as a percentage of GDP. Annual data is from World Development Indicators.

GDP Growth: Annual percentage change in real GDP. Annual data is from World Development Indicators.

GDP: Defined in current US dollars. Annual data is from World Development Indicators, World Bank.

Capital Mobility: Data is from Chinn and Ito (2008). The Chinn-Ito Capital Account Openness index has a scale from -1.84 to 2.48, where higher numbers denote a higher degree of capital mobility.

Intermediate Exchange Rate Regime: Data is from Reinhart and Rogoff (2008) where exchange rate regimes are first grouped into 15 categories. The range of regimes from pre-announced horizontal bands to moving bands is categorized as intermediate regimes.