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Measuring International Reserve Adequacy: Further Evidence from the Global Financial Crisis

Levan Efremidze[*] Ozan Sula[+] Thomas Willett[Δ]

Abstract

Using a dataset of 39 emerging markets, we examined the role of international reserves during crisis. Our analysis revealed that higher levels of reserves are associated with lower intensity crisis 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 crisis. 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. Nations may prefer to refrain from using reserves if export competitiveness is more important than potential balance sheet effects of currency depreciation.

[*] Claremont Institute for Economic Policy Studies and Pepperdine University
[+] Claremont Institute for Economic Policy Studies and Western Washington University
[Δ] Claremont Institute for Economic Policy Studies and Claremont Graduate University and Claremont McKenna College

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 various aspects of the usefullness and uses 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.

This analytic framework forms the basis for a major set of studies being carried out by associates of the Claremont Institute for Economic Policy Studies. In addition to the present authors, participants include Claremont dissertation students Kafui Nukunya, Sungsoo Kim, and Wahyu Nugroho, and Professor Jie Lie, Director of the Center for Research on Foreign Exchange Reserves at the Central University of Finance and Economics in Beijing. We welcome comments on this framework to help us in our ongoing research. 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 at calculations of optimal reserves and in the meanwhile will give important clues as 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 crisis 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.[1] Thus in section III 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 (recent studies find that surprising little use of reserves was made by emerging market countries to cushion effects of the global financial crisis.

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 an 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. 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. In Section 3, 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 4, 5 and 6 present our empirical analysis of the role of reserves during crises. Section 7 concludes.

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

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. substantial 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 serious 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 crisis. 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 not 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 crisis generally found an important role for international reserves in preventing crises (see the analysis and references in Willett et. al. (2005)),Blanchard et al. (2010) find little evidence that high reserves mitigated the decline in output while 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 and of 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[2] and in protecting innocent victims from the effects of the global financial crisis. 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.

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 clear from previous analysis that 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.

[2] See the analysis and references in Angkinand et al ( ) and Chiu and Willett ( ).

Most analyses on reserve adequacy have understandably focused on crisis and capital flow reversals 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 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 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.

3. 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.[3]

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

[3] 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 choose to include the year 2009 to our analysis. We also used a sample that excludes the observations from 2009 and confirmed the robustness of our main conclusions.

level of external debt fell substantially while the current account balances i. 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.

In Figures 4 and 5 we report average measures of crisis 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 (in further work we will also look at the ratios of reserves to short term debt). The size of reversals is defined as the annual change in net private capital flows as a percentage 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 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 5 compares the behavior of three additional variables that is generally 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 as the emerging markets were affected and 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 (more countries will be analyzed separately in the full study).

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

reserves during crisis. 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.

4. 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,

Tables 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 (yet not reported due to space constraints) and the robust standard errors clustered by year are given in parentheses beneath each coefficient.

Column 1 reports the results for the specification that only includes the pre-crisis reserve level (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 column2 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. (in further research we will also use new measures available from the IMF. See Chiu and Willett, 2010). Finally based on theories of the unstable middle we include intermediate exchange rate regimes as a dummy variable. Here we use the classification of Reinhart and Rogoff (2004). (in further work we will also use the judgmental classifications provided by the IMF. See Willett et al., 2011).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 (in further research we will also try the composite current account deficit-currency appreciation variable used in willett et al., 2005).

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. 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 of the 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.

5. 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.

Table 3 presents the results. In 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 controls 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.

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.

To sum up, Table3 adds another insight about reserve adequacy. When used against capital flow reversals, reserves can mitigate the negative output effects of crises.

6. Determinants of Reserve Depletion

Finally, we examine the factors that affect the size of reserve depletion during crises. The dependent variable is the annual difference in reserve levels as a percentage of GDP.

Table 4 presents the results. We fail to find a significant relationship between the initial reserve levels and reserve depletion during crises.

Several recent studies have indicated that nations were reluctant to use reserves during the global crisis. To account for this fact, we added the global crisis dummy into the regression in column 2 and get a very significant coefficient estimate. Holding everything else constant 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 debt exposure of the nation. 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.

Column 3 presents the results. The initial level of reserves continues to be an insignificant determinant of reserve depletion. The effect of 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 lead 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.

7. Conclusion

Using a dataset of 39 emerging markets, we examined the role of international reserves during crisis. Our analysis revealed that higher levels of reserves are associated with lower intensity crisis 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 crisis. 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. Nations may prefer to refrain from using reserves if export competitiveness is more important than the potential balance sheet effects of currency depreciation.

This preliminary investigation leaves much more research to do. We hope that others find the directions for research sketched out in this paper as exciting and relevant for policy as we do.

Partial List of References

Aizenman, J. and 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.

Aizenman, J. and 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.

Blanchard, O. Faruqee, H., and Das., M., 2010. "The Initial Impact of the Crisis on Emerging Market Countries", Brookings Papers on Economic Activity, pp. 263-323

Chamon, M., Manasse P., and Prati, A., 2007. "Can We Predict the Next Current Account Crisis?" IMF Staff Papers, v. 54, No. 2, pp. 270-305.

Chinn, M., and Ito H., 2008. "A New Measure of Financial Openness", *Journal of Comparative Policy Analysis,* Volume 10, Issue 3, p. 309 – 322.

Chudik, A. and Fratzscher, M. 2011. "Identifying the Global Transmission of the 2007-09 Financial Crisis in a GVAR Model"**,** European Central Bank, Working Paper Series, NO 1285.

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

Dominguez, K., Hashimoto, Y., and Ito. T., 2011. "International Reserves and the Global Financial Crisis"**,** NBER Working Paper No. 17362.

Kim, J. Li., J. Rajan, R., Sula, O., and Willett, T., 2004 "Reserve Adequacy in Asia Revisited: New Benchmarks Based on the size and Composition of Capital Flows," in Yonghyup Oh, Deok Ryong Yoon, and Thomas D. Willett, eds. Monetary and Exchange Rate Arrangements in East Asia (Korea: KIEP, 2004): 161-189.

Lane, P. and Milesi Ferretti. G., 2011. "External Adjustment and the Global Crisis" NBER Working Paper No. 17352.

Reinhart, C., and Rogoff, K., 2004 "The Modern History of Exchange Rate Arrangements: A Reinterpretation", *Quarterly Journal of Economics,* 119(1):1–48.

Sula, O. and Willett, T., 2009, "The reversibility of different types of capital flows to emerging markets", *Emerging Markets Review*, Vol. 10 No. 4, pp. 296-310.

Sula, O., 2010, "Surges and sudden stops of capital flows to emerging markets." *Open Economies Review*, Vol. 21 No. 4, pp. 589-605.

Willett, T., And Sula, O., 2009, "International Reserve Adequacy" in Global Crisis and Korea's International Financial Policies (Korea: Korea Economic Institute, 2009): 48-57.

Data 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.

Figure 1

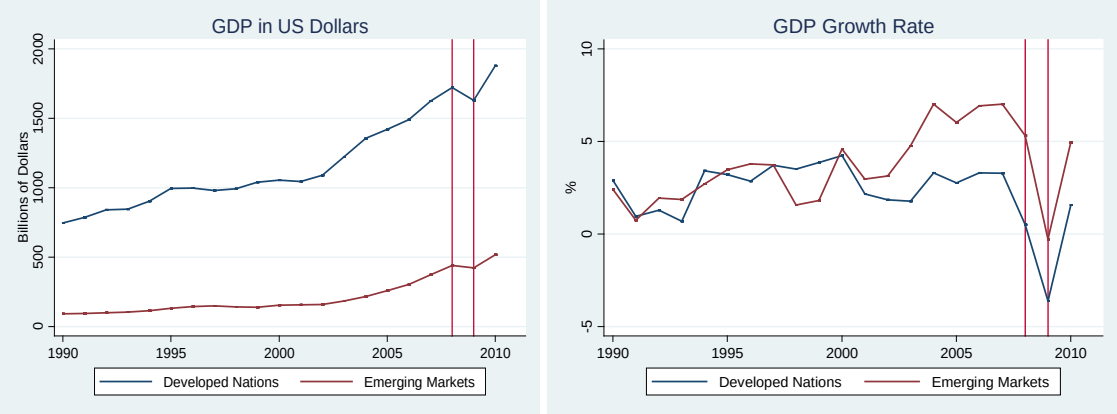

Figure 2

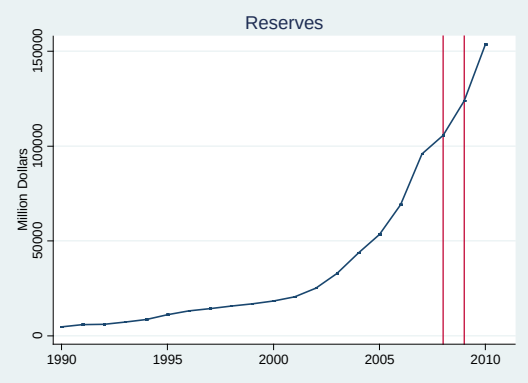

Figure 3

Figure 4

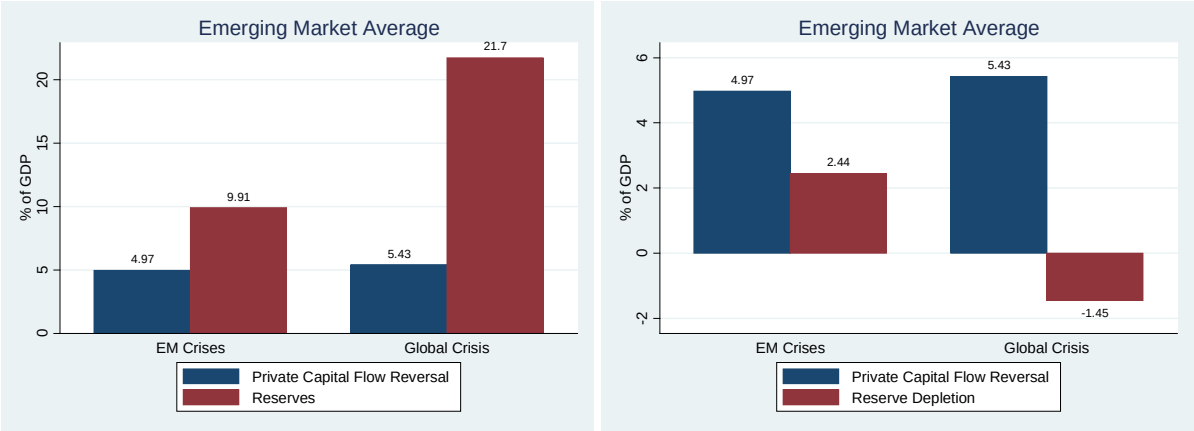

Figure 5

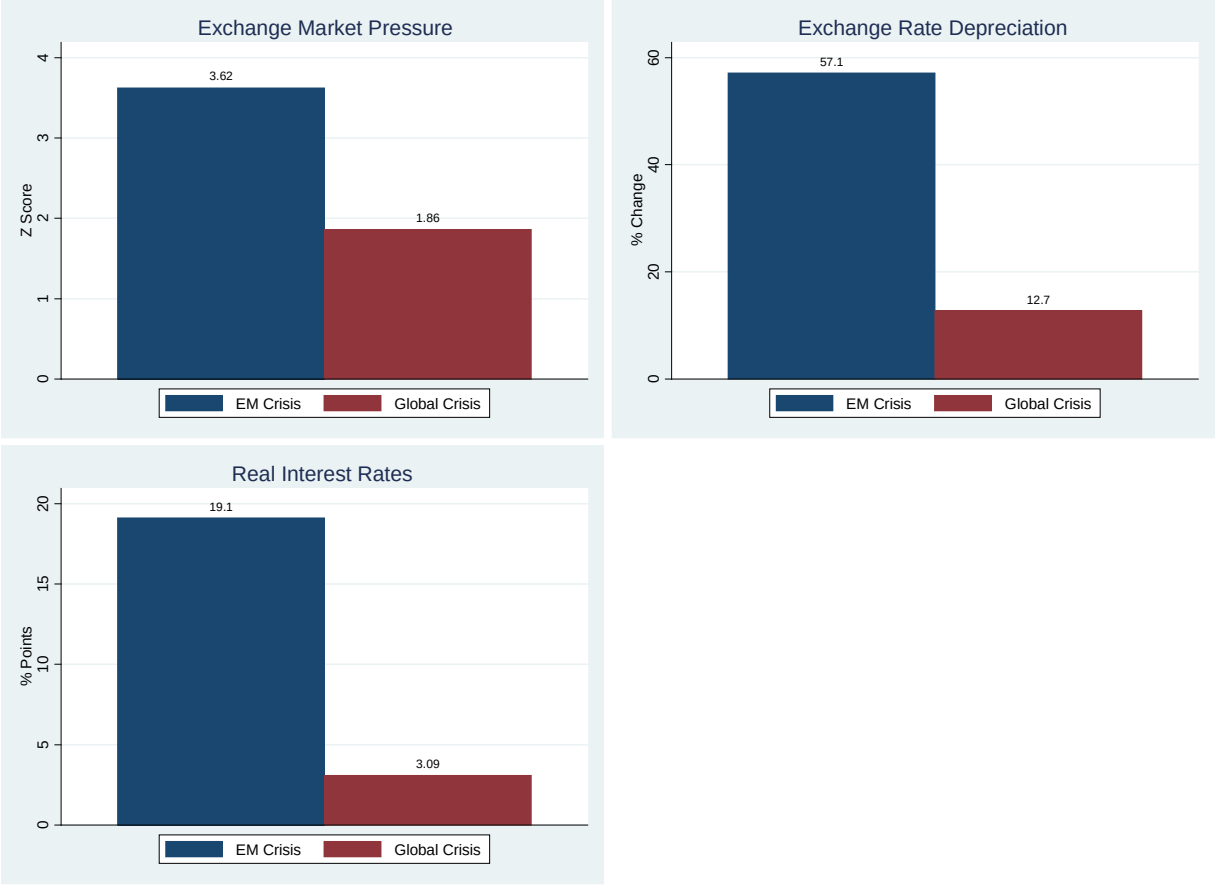
Exchange Market Pressure
Z Score
0
1
2
3
4
3.62
1.86
EM Crisis
Global Crisis
Exchange Rate Depreciation
% Change
0
20
40
60
57.1
12.7
EM Crisis
Global Crisis
Real Interest Rates
% Points
0
5
10
15
20
19.1
3.09
EM Crisis
Global Crisis

Figure 6

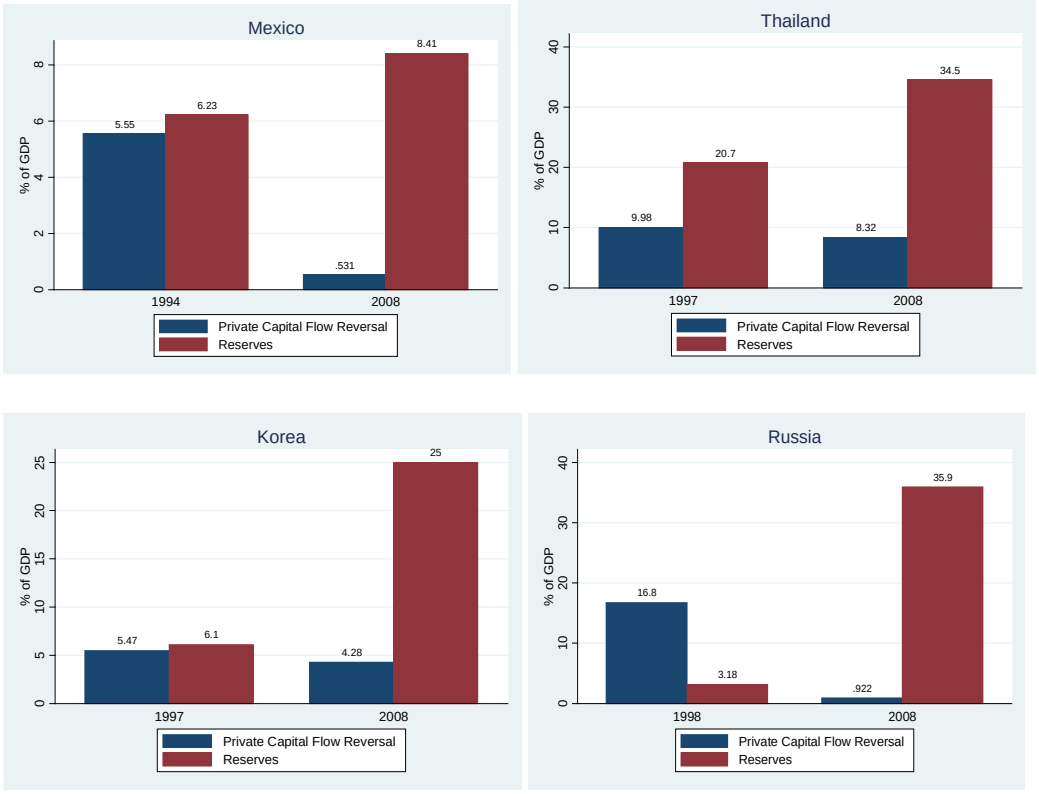
Mexico
% of GDP
0
2
4
6
8
5.55
6.23
.531
8.41
1994
2008
Private Capital Flow Reversal
Reserves
Thailand
% of GDP
0
10
20
30
40
9.98
20.7
8.32
34.5
1997
2008
Private Capital Flow Reversal
Reserves
Korea
% of GDP
0
5
10
15
20
25
5.47
6.1
4.28
25
1997
2008
Private Capital Flow Reversal
Reserves
Russia
% of GDP
0
10
20
30
40
16.8
3.18
.922
35.9
1998
2008
Private Capital Flow Reversal
Reserves

Figure 7

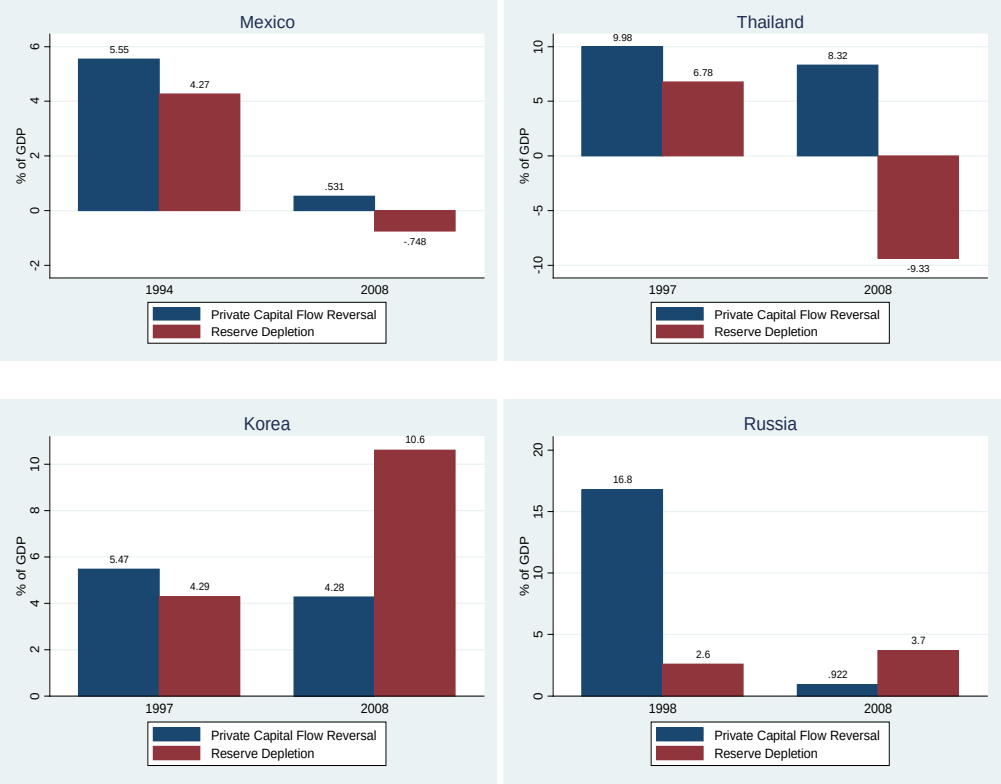
Mexico
% of GDP
6
4
2
0
-2
5.55
4.27
.531
-.748
1994
2008
Private Capital Flow Reversal
Reserve Depletion
Thailand
% of GDP
10
5
0
-5
-10
9.98
6.78
8.32
-9.33
1997
2008
Private Capital Flow Reversal
Reserve Depletion
Korea
% of GDP
10
8
6
4
2
0
5.47
4.29
4.28
10.6
1997
2008
Private Capital Flow Reversal
Reserve Depletion
Russia
% of GDP
20
15
10
5
0
16.8
2.6
.922
3.7
1998
2008
Private Capital Flow Reversal
Reserve Depletion

Figure 8

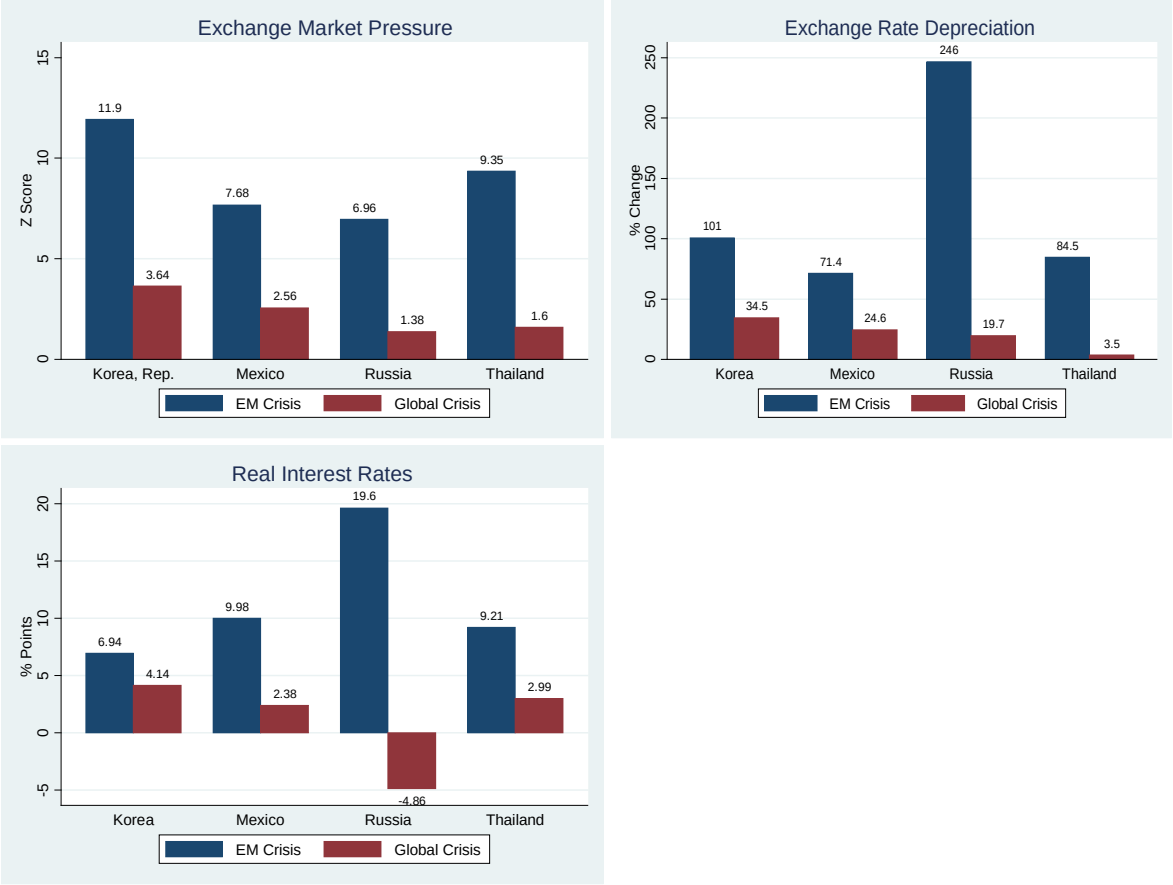
Exchange Market Pressure
Z Score
0
5
10
15
11.9
3.64
7.68
2.56
6.96
1.38
9.35
1.6
Korea, Rep.
Mexico
Russia
Thailand
EM Crisis
Global Crisis
Exchange Rate Depreciation
% Change
0
50
100
150
200
250
101
34.5
71.4
24.6
246
19.7
84.5
3.5
Korea
Mexico
Russia
Thailand
EM Crisis
Global Crisis
Real Interest Rates
% Points
-5
0
5
10
15
20
6.94
4.14
9.98
2.38
19.6
-4.86
9.21
2.99
Korea
Mexico
Russia
Thailand
EM Crisis
Global Crisis

Figure 9

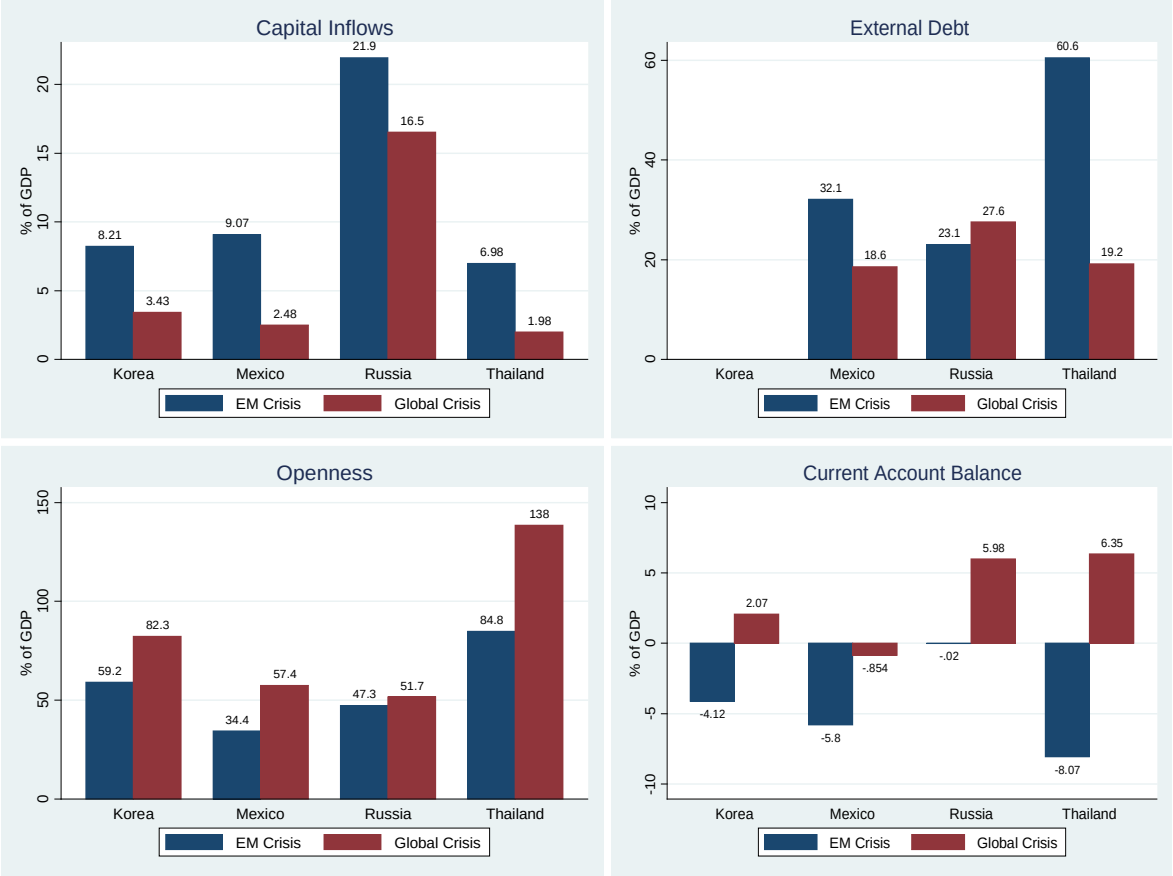

Figure 10

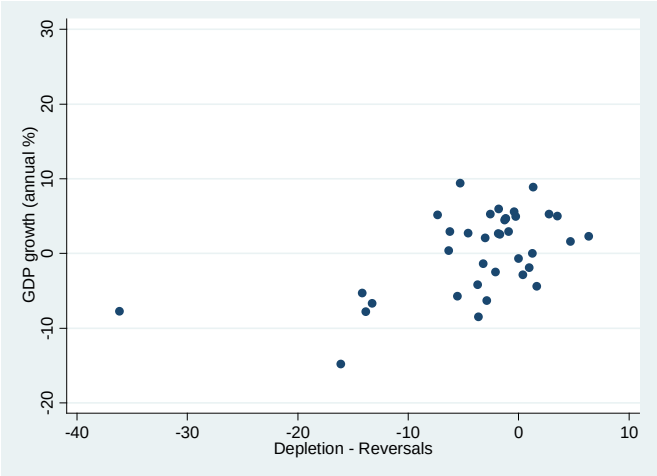

Table 1

	90's and Early 2000s Emerging Markets	2008-09 Emerging Markets	2008-2009 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

Table 2-a

	(1)	(2)	(3)
Reserves	**-0.140**	**-0.116**	**-0.114**
	(0.030)	(0.020)	(0.053)
Global Crisis		**-0.964**	**-0.416**
		(0.438)	(0.215)
Accumulated Inflows			**0.088**
			(0.039)
Current Account			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

	(1)	(2)	(3)
Reserves	**-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 3

	(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%.

Table 4

	(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%.