Capital Controls and Foreign Reserve Accumulation: Substitutes or Complements in the Global Financial Crisis?

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Abstract

Based on a panel dataset of 175 countries, this paper aims to address two key questions regarding the accumulation of international reserves: first, have reserves effectively protected countries during the 2008-09 financial crisis? And second, what explains the patterns observed in the aftermath of the crisis, with some emerging market economies accumulating reserves even faster than before the crisis? More in particular, the paper investigates the relation between the precautionary motive of international reserves and the existence of capital controls. We find that the level of reserves matters: countries with high reserves to short-term debt ratio have suffered less from the crisis than others, particularly if this was associated with a less open capital account. This suggests that foreign reserves and capital controls can be complements in opposition to the common wisdom. Next, the use of reserves during the crisis is positively related to the pre-crisis level of foreign reserve holding. Finally, in the immediate aftermath of the crisis, countries that had depleted foreign reserves during the crisis quickly rebuilt their stock of foreign reserves. This fast re-building is however followed by a deceleration of the pace of accumulation in the recent years; the steady increase in foreign currency reserves 'flatten out' in many countries.

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1 Introduction

In the decade preceding the 2008 global financial crisis, emerging market economies have accumulated a large stock of foreign reserves. This unprecedented pace of foreign reserve accumulation was, at least partly, a response to the lessons drawn from previous financial crises. The research on emerging market crises suggested indeed that countries with an insufficient level of reserves, measured against appropriately chosen benchmarks, suffered more from crises in the 1990s [1]. A natural question arising from this observation is therefore to what extent the accumulation of reserves has protected countries from the effects of the crisis: have the countries with more reserves fared better, in terms of output growth performance, than the countries with fewer reserves? And was the use of reserves or that of some alternative policy instruments an important factor to mitigate the effect of any crisis on real activity?

One particular aspect that is worth exploring further is the connection between the accumulation of international reserves and capital account openness. Indeed, one may wonder whether international reserves are more needed in a country with a more open capital account (to the extent that a closed capital account would not expose a country to the type of capital drain that foreign reserves are supposed to cover). According to this view, reserve accumulation and capital account controls can be understood as substitutes to avoid financial crises. Yet, another view is that these two tools can be complementary and reinforce each other.

Finally, several years into the recovery, the pattern of reserve accumulation in the aftermath of the crisis is puzzling in several noticeable aspects. In particular, several countries that used reserves intensely during the crisis have replenished their reserves at an even faster pace in the immediate aftermath of the financial crisis, although in some countries the pace has slowed down.

The aim of this paper is threefold. First, based on the most recent global financial crisis, which can be reviewed as an exogenous financial shock for all countries, we would like to test the hypothesis that international reserves fulfill the protective role they are usually assigned. Our attention particularly focuses on emerging market economies and developing countries. Second, we try to provide empirical evidence on the link between reserve accumulation, capital controls and output growth in the context of the global financial crisis. For this study, we have assembled a yearly dataset of 175 countries, including 27 advanced countries, 32 emerging market economies, and 116 developing countries. Finally, we try to understand why the pace of reserve accumulation slowed down in the most recent years after a strong re-building in 2009. Is it because countries target the stock of foreign reserves to some macroeconomic variables (e.g. short-term

[1] Abundant references with this regard, to cite only a few Mulder and Bussiere (1999) and Radelet and Sachs (1998), etc. For a detailed review of this literature, see Flood and Marion (1999)

debt, m2, etc.) and the underlying variables have just changed the behavior? Or is it simply because reserves just move procyclically with the global economic situation?

We present three sets of regressions. First, we consider a measure of economic activity in the wake of the collapse of Lehman Brothers, based on (detrended) real output growth and regress this measure on a number of explanatory variables, including reserve ratios and a measure of capital controls. The results indicate that when reserves are measured as a percentage of short-term debt, there is a statistically significant link with the dependent variable, but not for the other ratios (i.e. reserves/M2, reserves/imports, reserves/GDP). In addition, capital controls also matter: countries that are more open tend to be more affected by the crisis, ceteris paribus. These two results are robust to the addition of control variables such as trade openness ratio, dummy variables for oil countries or financial centers.

Interestingly, combining reserve ratios and capital controls yields another set of results: when the product of the two is added into the regression, the coefficient of the interacted variables is significantly different from zero. That is, a less open capital account reinforces the positive marginal effect of foreign reserves that we find in the first set of regressions. Figure 1 [2] gives us a general idea of the link between capital controls (inversely measured by a financial openness index) and foreign reserve accumulation in different country groups: emerging economies and developing countries on the one hand and advanced countries on the other hand. We observe that the non-advanced countries have massively accumulated foreign reserves while keeping their capital account relatively closed. At the same time, advanced countries chose to open their capital account with a clear jump towards a greater financial openness around 1992-1993. The foreign reserves there, scaled by the domestic output, remain relatively low at least until the end of 2010.

A last set of regressions aims at identifying the change of behavior in foreign reserve accumulation during and after the global financial crisis. To study this issue, data of higher frequency (i.e. monthly data) are used. We try to identify whether countries which had accumulated a large stock of foreign reserves before the crisis also massively used them during the crisis. Similarly, we try to examine whether countries which saw their foreign reserves depleted during the crisis have stronger incentives to re-build a large stock of foreign reserves in the wake of the crisis.

The rest of the paper is organized as follows. Section 2 reviews relevant literature in the field of our study. Section 3 describes the data and the methodology used. Section 4 presents the effects of foreign reserves and capital controls on countries' economic performance during the crisis and patterns of the relationship between foreign reserves and capital controls. Section 5 examines countries' behavior of accumulating foreign reserves in the wake of the financial crisis. Section 6 discusses the policy implications of the paper

[2] In Figure 1, the y-axis represents the average reserves-to-GDP ratio in a given country group and the x-axis represents the average financial openness.

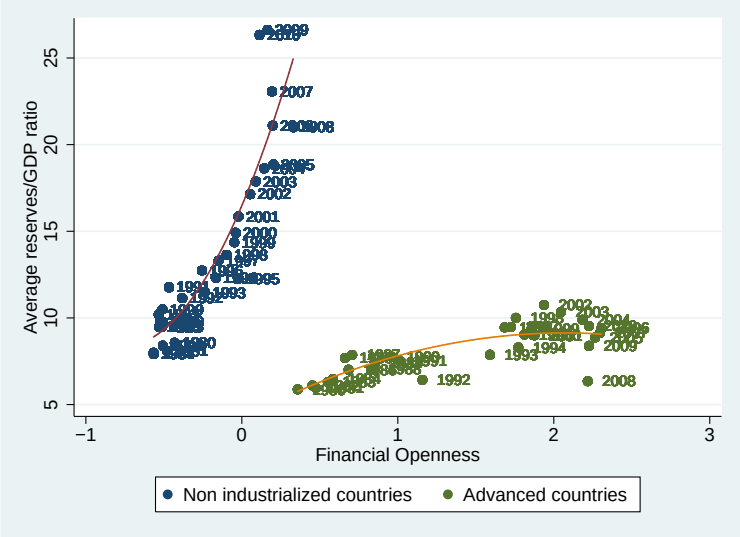


Figure 1: Foreign reserves vs. capital controls

and concludes.

2 Review of the literature

Our research is related to two broad strands of literature: the motives of foreign reserve accumulation and the cross-country evidence of indicators of the 2008-2009 crisis.

2.1 Motives of foreign reserve accumulation

A country may accumulate foreign reserves for reasons of different nature: to constitute a buffer stock for the sake of crisis prevention or/and crisis management (*precautionary approach*), to intervene in the foreign exchange market for the defense of a fixed exchange rate or for preventing the domestic currency for appreciation (*mercantilist approach*), or to passively hold foreign reserves as domestic savings exceed domestic investment for structural reasons (*structural approach*).

2.1.1 Precautionary motive

The precautionary motive is the most understandable reason for holding international reserves. This approach has thus been the focus of the majority of studies on foreign reserves since the collapse of the Bretton Woods system. It seems like whenever the world economy experiences alarming imbalances (between debtor and creditor countries or between trade surplus and deficit countries), the reserve adequacy becomes a popular research topic.

According to the precautionary approach, countries, especially open economies, need to build up a 'war chest' to prevent potential external shocks. The nature of shocks can be diverse. The early literature in the 1970s (Bahmani-Oskooee and Brown (2002) provides a detailed review) focuses on the role of foreign reserves as an instrument to adjust balance-of-payments, especially trade imbalances. From this perspective, foreign reserves need to cover a country's immediate demand for imports. Namely, with sufficient foreign reserves as a buffer stock, a country should be able to import goods necessary for domestic production or final consumption even if all external financing is cut off. The reserves-to-imports ratio as a reserve adequacy metric stems from this viewpoint. This metric has a straightforward economic interpretation but is only relevant for small open economies (which can be constrained for external financing).

The literature in the 1990s studied the precautionary holding of foreign reserves on a different ground: reserves need to be sufficient to cover the immediate repayment of external debt (both public and private). This explanation became relevant with the financial integration of many developing countries into the world capital market (think of the cluster of developing countries which opened up their capital account at the end of 1980s). Including short-term liabilities of a country into account when examining foreign reserve adequacy is very useful for gauging risks associated with adverse developments in

international capital markets. The Greenspan-Guidotti rule [3] developed in the late 1990s is indeed an extended version of the reserves-to-short-term-debt ratio.

In the aftermath of a series of emerging market crises of the late 1980s and the 1990s (e.g. 1994 Mexican crisis, 1997-1998 Asian crisis, etc.), the literature started to look at the adverse effects of financial reversals on a country's output and social welfare. This resulted in a particular attention paid to the stabilizing role that foreign reserves may play to reduce the impact of any capital account shocks (i.e. sudden stop episodes). Foreign reserves, as Jeanne and Rancière (2011) explained, can be interpreted as an insurance contract which can reduce both the magnitude and the probability of occurrence of sudden stops. According to them, an average reserves-to-GDP ratio of 10% is optimal from a purely precautionary motive.

Finally, there is a very recent strand of theoretical papers which find it difficult to explain the build-up in emerging markets' reserves as pure insurance against the risk of sudden stops. Benigno and Fornaro (2012) argue that the precautionary role that foreign reserves play can be understood in terms of the Central Bank's capacity of providing liquid assets to the private sector when the latter is constrained from external financing during a severe crisis. This reflects the lesson learned from the recent global financial crisis where the malfunctioning of financial markets proved that a sufficient stock of foreign reserves reinforces any central bank's financing capacity as the domestic lender of the last resort.

Still based on this precautionary approach, Alfaro and Kanczuk (2009) and Bianchi et al. (2012) shed light on the interaction between accumulation of international reserves and sovereign debt issuing. This is a brand new angle of studying the insurance role of foreign reserves. Although Alfaro and Kanczuk (2009) find that optimal policy is not to hold reserves at all, Bianchi et al. (2012) contradicts this result and argue that reserves provide insurance against future increases in the sovereign borrowing cost. When the borrowing cost is not too high in the current period (even though it is already higher than the return on reserves), a country's government may be willing to convert the borrowing proceeds into foreign reserves. By simultaneously issuing long-duration bonds and buying reserves, the government accumulates resources that it can use in future periods when the sovereign borrowing cost will become higher. A stronger expectation that the borrowing cost will increase reinforces the incentives of a government to hold massive foreign reserves in the current period even if it needs to pay the financial cost of reserve accumulation.

2.1.2 Mercantilist and structural approaches

There are two other motives of holding international reserves which are related to the subject of our study even though they are beyond the scope of this current paper. We

[3] It includes, in the denominator, not only short-term debt but also projected current account deficit, both being external liabilities of a country in a near future.

summarize briefly the literature on the mercantilist and structural approaches.

If the precautionary motive of foreign reserve accumulation proved to be a legitimate 'war chest' to prevent external financial shocks - especially when an international financial safety net is absent -, building foreign reserves based on a pure mercantilist approach is questionable and is more difficult to defend in the international political sphere. According to some authors, especially Dooley et al. (2003), a massive reserve stockpiling is evidence and/or an instrument of deliberately keeping a domestic currency undervalued. They argue that some Asian countries, especially today's China and Japan of the 1970s, have massively bought dollar-denominated assets with newly issued domestic currency, leading to a nominal depreciation of the latter. Accumulating foreign reserves is a disguised way of subsidizing the tradable sector in order to maintain an 'artificial comparative advantage' in international trade. Unfortunately, this approach is neither verified in empirical works nor proved to be welfare-improving on a theoretical ground. Aizenman and Lee (2007) show that precautionary motive is more relevant than mercantilist approach with regard to the foreign reserve accumulation up to 2007. Benigno and Fornaro (2012) theoretically demonstrate that a pure mercantilist building of reserves is welfare-deteriorating and that the mercantilist approach needs to be combined with at least some degree of precautionary motive to be welfare-improving.

A recent strand of literature on macroeconomics tends to argue that foreign reserve accumulation and more importantly persistent current account surplus in some emerging economies stem from institutional constraints in the domestic financial market. As there are strong credit constraints in the banking sector, which lead to a gap between domestic savings and investment, the increase in foreign reserve assets is a mere reflection of the precautionary savings made by domestic firms. Wen (2011) and Song et al. (2011) share this viewpoint.

2.2 Cross-country evidence of the indicators of the 2008-2009 Crisis

Our study is also related to the literature which studies the crisis indicators and empirically tests the impact of reserves holdings during the last crisis. This question has been tackled by numerous economists and in many different ways, leading to sometimes contradictory results.

A first attempt to tackle this issue is suggested by Andrew K. Rose and Mark M. Spiegel in their subsequent papers Rose and Spiegel (2009), Rose and Spiegel (2010) and Rose and Spiegel (2011). They study general causes of the 2008-2009 crisis and its impact. The reserve adequacy ratio is among numerous explanatory variables for their regressions. They find that reserve holdings appear to be significant in some specifications, especially when scaled by the short-term debt. But this result disappears in the

bulk of the regressions. Capital controls are absent from their analysis.

In a 2010 policy paper (IMF (2010)), the IMF tackles the use of reserves during the 2008-2009 crisis, and concludes that holding higher international reserves has allowed emerging countries to limit the crisis impact on their economy, though with diminishing returns. Beyond a certain threshold, the usefulness of reserves is not guaranteed. In the same manner, countries that are more open to international trade as well as international capital flows were subject to a deeper crisis.

Frankel and Saravelos (2012) are in the same vein as the studies on early warning indicators. Foreign exchange reserves are included in their work among many other explanatory variables used as warning signals and explanatory factors for the latest crisis. Reserves turn out to be one of the most significant variables, which coincides with the results of Aizenman and Sun (2009) and Aizenman and Hutchison (2010).

Aizenman and Hutchison (2010) focus on the trade-off between exchange rate depreciation and foreign reserve losses for countries facing a high exchange market pressure during the 2008-2009 crisis. They study emerging market economies only, using an exchange market pressure index as dependent variable. As a result, the reserves are included in both the dependent variable and the explanatory variables. Their contribution highlights the 'fear of losing reserves' - many countries chose to let their currency depreciate rather than to risk a run on their foreign exchange reserves - and the greater vulnerability of countries with a higher ratio of foreign liabilities to GDP. These results corroborate that of Aizenman and Sun (2009) with regard to the preference for exchange rate depreciation among emerging countries. More precisely, they observe that reserve losses seem to fit a logistic curve, so that the amount of lost reserves never reach more than one third of the initial stock prior to the crisis.

Finally, there are a few papers which analyze the role of foreign reserves during and after the recent financial crisis. Dominguez et al. (2012) look at the contribution of foreign reserves to the post-crisis growth instead of the economic performance during the crisis. They find that higher reserve accumulation prior to the crisis is associated with higher post-crisis GDP growth. They also find evidence of 'reserve bounce back': after the crisis many emerging market countries went back to their pre-crisis reserve accumulation trends.

2.3 Our contribution

Our paper is based on the precautionary motive as we mainly study the role of foreign reserves during a crisis period. We need to identify in our analysis through which mechanism described above foreign reserves contribute to maintaining economic growth. Our contribution compared to the existing literature is three-fold.

First, we provide the most recent evidence on the usefulness of reserves on economic

growth during a crisis time. We especially compare the explanatory power of different reserve adequacy ratios.

Second, we focus on the interaction between foreign reserves and capital controls. This is an interesting question which is often absent from studies of foreign reserves. We further argue that these two policy instruments can be complements in selected country groups for mitigating the impact of the crisis on economic growth. This contradicts the common wisdom which thinks that foreign reserves and capital controls are rather substitutes. The importance of taking into account financial openness when examining foreign reserves has so far been emphasized by Obstfeld et al. (2010). However, their paper focuses on the role of foreign reserves as a stabilizer of domestic financial market; this is different from our consideration of the role of foreign reserves based on the precautionary motive. Note that we also aim at explaining why foreign reserves and capital controls are complements or substitutes. This is an ultimate objective of this paper towards which we are working on. Aizenman et al. (2010) and Aizenman et al. (2011) provide us with a useful analytical framework as a starting point to analyze the relationship between foreign reserves and capital controls. They observe that monetary autonomy, exchange rate stability and capital openness are substitutes according to the 'impossible trinity'. Given a degree of capital openness, there is a trade-off between monetary autonomy and exchange rate stability. Foreign reserves can thus be mobilized to reduce the side effects of this trade-off (for example to reduce the investment/output volatility if the exchange rate stability is privileged.)

Finally, our detailed and up-to-date database allows us to study the most recent trend of the foreign reserve accumulation. We confirm that there is an immediate 'bounce back' of foreign reserve re-building in the wake of the 2008-2009 global financial crsis. However, the pace of foreign reserve accumulation seems to stabilize in the last two years. We try to identify the reasons behind this phenomenon.

3 Data and methodology

3.1 Data

Our objective in this current work is to search for broad patterns and explanations of the accumulation and the use of foreign reserves before, during and after the 2008-2009 financial crisis. We start with a detailed description of data sources and measurement.

Our primary sources of the data on annual, quarterly and monthly foreign reserves are the *International Financial Statistics* database (IFS) of the International Monetary Fund (IMF). The macroeconomic data of different frequencies are also retrieved from the *IFS* database and complemented by the *World Development Indicators* (WDI) issued by the World Bank (WB). For selected countries which are absent from the IMF and WB databases (e.g. Taiwan), national data are used.

Our database covers 175 countries. We subdivide the sample by income groups defined by the IMF: advanced countries (AC), emerging market economies (EME) and less developed countries (LDC). We also use the sub-sample of emerging and less developed countries combined; we call it 'non-advanced countries (NAC)'. The details about our country sample can be found in Appendix A.

3.1.1 Foreign exchange reserves

Foreign reserves are defined as the immediately available external assets denominated in foreign currencies that a country's government or monetary authority holds. An external asset must satisfy two conditions to be considered a reserve asset. First, it must be under the direct and effective control of the monetary authority. Secondly, it must be readily available for immediate use (e.g. in case of balance of payments crisis). In our paper, foreign reserves correspond to the 'total reserves minus gold' defined by the IMF (*IFS*, line 1 l.d). It comprises foreign exchange reserves [4], reserve position in the IMF and the U.S. dollar value of SDR holdings of a given country.

A particular attention needs to be paid to the way the IMF credit facilities and the SDR allocation are counted for any country's total foreign reserves. Indeed, the IMF credit facilities (e.g. Precautionary and liquidity line, Flexible credit line, Stand-by facility, etc.) as well as bilateral swap lines between a country's Central Bank and its foreign counterparts are not included in the definition of the foreign reserves used by the *IFS* and in this paper. There are fundamental differences between the self-owned stock of foreign reserves and contingent facility instruments which are short-term in nature, as we argue in Section 5.

In contrast, a country's holding of SDR is counted in its total foreign reserves, as

[4]Foreign exchange reserves refer to the holding of claims on nonresidents in the form of foreign banknotes, bank deposits, treasury bills, short- and long-term government securities.

these are self-owned permanent external assets that a country can mobilize whenever it is necessary. Note that there is a massive issuance of 183 billion of SDR by the IMF in August 2009 (equivalent to 283 billion of U.S. dollars). Member countries that are participants in the Special Drawing Rights Department (currently all 186 members) acquired this new allocation in proportion to their existing quotas in the Fund. This issuance of SDR can be reviewed as an exogenous increase of member countries' stock of foreign reserves. In order to concentrate on a given country's own decision of holding foreign reserves, we subtract this newly issued SDR in 2009 from our data on foreign reserves. This is especially important for our analysis of countries' post-crisis behavior of foreign reserve accumulation in Section 5.

To facilitate cross-country comparison, foreign reserves need to be scaled and relevant reserve indicators need to be constructed. Based on the abundant literature on reserve adequacy, we construct four reserve indicators:

- GDP based indicator : $\frac{\text{Reserves}}{\text{GDP}} \times 100\%$
- Trade based indicator: $\frac{\text{Reserves}}{\text{Imports}} \times 12$
- Debt based indicator: $\frac{\text{Reserves}}{\text{Short-term debt}} \times 100\%$
- Money based indicator: $\frac{\text{Reserves}}{M_2} \times 100\%$

The GDP based indicator describes the fact that the country with higher income is able to purchase more foreign reserves, which can be regarded as a sign of the economic robustness of a country. The trade based indicator is a traditional metric of the reserve adequacy. It reflects the capacity of a country to purchase foreign goods (for production or final consumption) even in case of limited or no access to external financing. The common wisdom requires that foreign reserves cover at least three-month imports. The debt based indicator is developed with the financial integration of emerging market economics and less developed countries. When a country's economic growth is financed by external debt, it is important for that country to insure the service of its debt, at least that coming due in short-term. Sufficient foreign reserves need to cover the payment of all the short-term debt denominated in foreign currencies due within one year. The money based indicator has gained popularity with Obstfeld et al. (2010) who emphasize the role of foreign reserves on stabilizing domestic financial market. A country needs to hold enough foreign reserves to offset the capital flight triggered by a weak confidence of the market on that economy. The amount of immediately available domestic assets which can be drained out during an episode of capital flight is proxied by the monetary aggregate M_2. This amount of assets needs to be coved by foreign reserves.

3.1.2 Financial openness and capital controls

Another important ingredient for our analysis regards the controls on capital flows. We retrieve data on annual capital flows and capital account openness from the Chinn-Ito index Chinn and Ito (2006). The Chinn-Ito index, *kaopen*, is a *de jure* measure of financial openness, and thus an inverse measure of *de jure* regulatory restrictions on capital account transactions. The value of *kaopen* ranges from −1.86 to 2.46; a higher value of the variable *kaopen* corresponds to a more open capital account, thus less capital controls. Table 1 shows that advanced countries are much more open to international flows than non-advanced countries.

Table 1: *kaopen*: Descriptive Statistics (2009)

	Advanced countries	Non-advanced countries		
		EME	LDC	Total
mean	2.23	0.61	0.04	0.16
median	2.46	0.42	-1.16	-0.11
s.d.	0.76	1.50	1.55	1.56
min	-1.16	-1.86	-1.86	-1.86
max	2.46	2.46	2.46	2.46
nb	26	31	110	141

Alternatively, we complement the Chinn and Ito's dataset with the 'External Wealth of Nations' dataset of Lane and Milesi-Ferretti (2007). This is an updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007). It covers annual data on capital flows for 178 economies plus the euro area for the period 1970-2007. We use this dataset to construct indices, such as international financial integration (*ifi*) and international equity integration (*iei*). They are *de facto* indices of the degree of restriction of capital account.

$$ifi_{i,t} = \frac{\text{Total foreign assets}_{i,t} + \text{Total foreign liabilities}_{i,t}}{GDP_{i,t}}$$

$$iei_{i,t} = \frac{\text{Total portfolio equity (assets+liabilities)}_{i,t} + \text{Total FDI (assets + liabilities)}_{i,t}}{GDP_{i,t}}$$

3.2 Specification

We try to examine in this paper to what extent holding foreign reserves *ex ante* might help a country prevent large output losses during the global financial crisis, and how reserve holding and capital controls interact to limit the scope of the output drop.

We decide to use cross-section econometrics at specific time point during the 2008-2009 crisis as this allows us to make cross-country comparison and to homogenize the

shock of the recent global financial crisis. Our benchmark specification is described below:

$$y_{i,09} = \beta_0 + \beta_1 rsv_{i,07} + \beta_2 cc_{i,07} + \beta_3 (rsv_{i,07} \times cc_{i,07}) + \boldsymbol{\beta X_{i,07}} + \epsilon_{i,09} \quad (1)$$

3.2.1 Construction of the dependent variable, $y_{i,09}$

To conduct regression analysis, we need first to construct a dependent variable which measures the economic performance of countries in the sample. Our aim of constructing such a variable is to identify how the crisis has affected the economic growth in a given country in terms of real output losses.

Based on this idea, we conceive two potential dependent variables. The first one - we call it 'detrended real GDP growth' - is calculated by subtracting from the year-on-year real GDP growth rate its six-year historical mean.

$$rydetrend_{i,09} = \Delta ry_{i,09} - \bar{\Delta ry}_{i,03-08}$$

$\Delta ry_{i,09}$ denotes the year-on-year growth rate of the real GDP in a given country i at the end of 2009. And $\bar{\Delta ry}_{i,03-08} = \frac{\sum_{s=03}^{08} \Delta ry_{i,s}}{6}$

Another way to filter the impact of the trend from the growth rate in a given year is to run a preliminary cross-country regression and then to use the individual residual from this preliminary regression as a proxy of the filtered real GDP growth rate for each country in our sample. We call this second dependent variable 'purged real GDP growth.' It is obtained as follows:

$$rgdp\_residual_{i,09} = \Delta ry_{i,09} - \hat{\Delta ry}_{i,09}$$
$$\hat{\Delta ry}_{i,09} = \hat{\alpha}_0 + \hat{\alpha}_1 \bar{\Delta ry}_{i,03-08}$$

The coefficients $\hat{\alpha}_0$ and $\hat{\alpha}_1$ are obtained from the preliminary regression:

$$\Delta ry_{i,09} = \alpha_0 + \alpha_1 \bar{\Delta ry}_{i,03-08} + \epsilon_{i,09}$$

This preliminary regression assumes constant coefficients across countries, namely the contribution of the historical trend to the real economic growth rate at a given time t being identical for all countries in our sample.

3.2.2 Independent variables

In order to deal with the endogeneity issue (further exploration in Section 4.4), all our independent variables are lagged, using a lag of 2 years.

We will use different reserve indicators as described above for the variable rsv_i. The

Chinn-Ito index $kaopen_i$ is used for the capital control variable cc_i in the main regressions and the Lane-Milesi-Ferreti indices (ifi_i and iei_i) will be used for robustness check.

An interactive term ($rsv_i \times cc_i$) is introduced in the regression equation. This is the focal point of our current study. We believe that the contribution of foreign reserves may be conditional on the degree of capital controls in a given country and vice versa.

Therefore, we should be careful when examining the regression results. The marginal effect of foreign reserves and that of financial openness are calculated as follows:

$$\frac{\partial y_i}{\partial rsv_i} = \beta_1 + \beta_3 \times cc_i$$
$$\frac{\partial y_i}{\partial cc_i} = \beta_2 + \beta_3 \times rsv_i$$

4 Cross-country evidence of the usefulness of foreign reserve accumulation and capital controls during the global financial crisis

4.1 Reserve indicators: which one works better?

Based on the 2008-2009 global financial crisis, we first try to examine whether *ex ante* foreign reserve accumulation has played any role in preventing output losses during the crisis. We pay a particular attention to the distinct explanatory power of each of the above-mentioned four reserve indicators.

We find that the reserves-to-short-term-debt ratio [5] is the most useful indicator to predict the real output growth during the crisis. An accumulation of foreign reserves 2 years prior to the crisis scaled by the level of short-term debt is positively and significantly correlated with the real GDP growth deviation from the trend. We illustrate this result with the regression based on the NAC sub-sample and with 'purged real GDP growth' as the dependent variable in Table 2.

Table 2: NAC: Explanatory power of different reserve indicators

	(1)	(2)	(3)	(4)
	rgdp_residual	rgdp_residual	rgdp_residual	rgdp_residual
log reserves/gdp(pct) (t-2)	-0.366			
	(-0.59)			
log reserves/imports(months) (t-2)		0.626		
		(0.98)		
log reserves/m2(pct) (t-2)			-0.0104	
			(-0.02)	
log reserves/short_debt(pct) (t-2)				0.674**
				(2.55)
Constant	1.355	-0.688	0.191	-3.635**
	(0.72)	(-0.64)	(0.09)	(-2.23)
Observations	140	132	136	135
R^2	0.002	0.007	0.000	0.047

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This result is robust if we switch the dependent variable to the 'detrended real GDP growth' for the same NAC sub-sample (Table 13). More results of this exercise using

[5] We use this ratio in logarithm in our regressions because the evolution of foreign reserves, especially in non-advanced countries, is non-linear, displaying an exponential pattern.

different country groups can be found in Appendix B. If we look at the EME sub-sample (Table 14 and 16), we find that both $\frac{\text{Reserves}}{\text{Imports}}$ and $\frac{\text{Reserves}}{\text{Short-term debt}}$ have a positive effect on real economic growth. The coefficient associated with $\frac{\text{Reserves}}{\text{Short-term debt}}$ is more significant and the model has a a better goodness of fit (a higher R^2). However, this result disappears if we look at the LDC sub-sample (Table 15 and 17). It might be because in general the less developed countries had accumulated much less foreign reserves than emerging market economics; they have indeed much less resources to do so.

4.2 Foreign reserves vs. capital controls: complements or substitutes?

The common wisdom reckons that when a country controls international capital flows - inflows, outflows or both - it is insured against risks related to financial reversals. Similarly, if a country decides to accumulate foreign reserves, it constitutes a 'war chest' that it can mobilize facing speculative attacks. Therefore, according to this viewpoint, foreign reserves and capital controls seem to be substitutes as an instrument of crisis prevention. However, we think that the relationship between foreign reserves and capital is more complex. Some countries may choose to accumulate foreign reserves while setting controls on capital flows. We can especially cite the example of China, Chile and Brazil. The joint use of foreign reserves and capital controls can be understood in the context of an extremely strong uncertainty and excessive world liquidity issued by the core economy in the international monetary and financial system. None of these two policy tools seem to be sufficient on its own to prevent a country from potential external financial shocks. There may also be some considerations about the real exchange rate stability behind this combined use of foreign reserves and capital controls (See Jeanne (2012)).

In the following exercise, we try to identify the contribution of foreign reserves conditional on the degree of capital account openness to support economic growth during the crisis time.

We observe from Table 3 that foreign reserves and capital controls both contribute to reduce a country's real GDP losses during the recent financial crisis. Remember that here capital controls are inversely measured by the Chinn-Ito index of financial openness, *kaopen*. The smaller is *kaopen*, the more capital controls there are. Taking into account the interactive term, we can calculate the marginal effects of foreign reserves and capital controls in the NAC sub-sample:

$$\frac{\partial y_i}{\partial rsv_i} = 0.53 - 0.389 \times cc_i$$
$$\frac{\partial y_i}{\partial cc_i} = 1.63 - 0.389 \times rsv_i$$

Table 3: NAC: Foreign reserve accumulation vs. capital controls

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
log reserves/short_debt(pct) (t-2)	0.674**		0.530*	0.530*
	(2.55)		(1.94)	(1.97)
capital controls (t-2)		-0.716***	-0.602**	1.630*
		(-2.74)	(-2.13)	(1.71)
capital controls × reserves (t-2)				-0.389**
				(-2.45)
Constant	-3.635**	0.426	-2.698	-2.932*
	(-2.23)	(1.03)	(-1.58)	(-1.74)
Observations	135	140	129	129
R^2	0.047	0.052	0.081	0.123

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Bearing mind that *kaopen* ranges from -1.86 to 2.46 with a mean of 0.16 for the NAC sub-sample in 2009, we can thus conclude that on average a 1% increase in the pre-crisis reserves-to-short-term-debt ratio leads to an approximate 0.468% $(0.53 + (0.16) \times (-0.389))$ higher growth rate of the real GDP in 2009 compared to the trend. The more open is a country's capital account (higher value of *kaopen*), the less pronounced the marginal effect of the *ex ante* foreign reserves. Notice that the marginal effect of foreign reserves will even become negative when *kaopen* exceeds 1.36. That is, in those countries which are very open to international capital flows, holding foreign reserves will not prevent real GDP losses during the 2008-2009 crisis. Moreover, the marginal effect of capital controls is always negative as the reserves-to-short-term-debt is a very large number in the NAC sub-sample with a mean of 1236.7 [6].

For robustness check, we detail more regression results in Appendix C. Foreign reserves (over short-term debt) are always significantly and positively correlated with the real GDP growth in the EME sub-sample, regardless of the dependent variable we choose to use (Table 19 and 21). However, if we look at the LDC sub-sample, we observe that capital controls and the interactive term are always significant (Table 20 and 22). The holding of foreign reserves by less developed countries still reinforces the marginal effect of their controls on capital flows. The relative usefulness of foreign reserves and capital controls thus changes with the sub-sample we consider. One possible explanation is that emerging economies had accumulated much more foreign reserves before the crisis than

[6] This means that on average foreign reserves are 12 times larger then the stock of short-term debt. For example, the reserves-to-short-term-debt ratio is equal to 1239.6 for Taiwan in 2002

less developed countries while the latter have relatively more closed capital account.

4.3 Results of full specification

Now, we add control variables and test the full specification of our regression equation (1). The control variables include trade openness index, financial center dummy and oil country dummy.

Table 4: NAC: Full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	0.496	0.595*
	(1.48)	(1.96)
Capital controls (t-2)	2.031*	1.824*
	(1.80)	(1.77)
Capital controls × reserves (t-2)	-0.450**	-0.413**
	(-2.42)	(-2.44)
Financial center dummy	0.408	0.910
	(0.07)	(0.16)
Trade Openness (pct) (t-2)	-0.00842	-0.00933
	(-0.80)	(-0.98)
Oil dummy	-1.579	-1.030
	(-1.06)	(-0.76)
Constant	-7.209***	-2.279
	(-2.91)	(-1.01)
Observations	117	117
R^2	0.117	0.141
White χ^2	16.94	13.46
White p-value	0.594	0.814
BP χ^2	2.230	1.751
BP p-value	0.135	0.186

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Using the 'purged real GDP growth' as dependent variable, we find that the accumulation of foreign reserves prior to the crisis positively and significantly contributes to the real GDP growth during the crisis. Capital controls have also a positive contribution to prevent the real GDP losses. The result remains almost the same when using 'detrended real GDP growth' as dependent variable with the exception that the reserves-to-short-term-debt positively is no longer significant.

Appendix D provides details of our regression results using other sub-samples. Similar to what we found in the previous bi-variate regressions, in the EME sub-sample, foreign reserves scaled by the short-term debt have always a positive and significant effect on real GDP growth during the crisis, regardless of the degree of capital account openness. In the LDC sub-sample, the marginal effect of capital controls is negative and significant. Holding foreign reserves reinforces this marginal effect.

We can further ameliorate our results by using robust regressions based on our full specification. Robust regressions aim at assigning a weight smaller than one to potential outliers in the sample. Outliers are identified based on their residuals from a basic OLS regression. From here, some weight functions (e.g. the Huber weights or the Tukey bisquare weights) are used to reduce outliers' influence. We present the results of our robust regressions in Appendix E. We obtain similar but much more significant results compared to the standard regressions. Notice that some control variables become significant when robust regressions are used. Trade openness has a negative and significant coefficient in the LDC sub-sample. This captures the negative impact of global trade collapse during the crisis of 2009.

Finally, using the Lane-Milesi-Ferretti financial integration variable as an alternative measure of capital controls, one finds that the coefficient associated with foreign reserves is always positive and significant at least at 90% significant level for all samples. For details, please refer to Appendix G.

4.4 Accounting for the endogeneity

As above-mentioned, using foreign reserves as an explanatory variable to explain the real economic growth can cause endogeneity issue; foreign reserves might be held by a central bank as in anticipation of a future negative shock to the national economy. So far, we have been using lagged metrics of foreign reserves as our main explanatory variable in order to control the endogeneity issue; this is also the method adopted by most of existing empirical papers on foreign reserves. Now, we go one step further to account for the endogeneity and two-way causality by choosing appropriate instrumental variables for foreign reserve metrics. Remember that an appropriate instrumental variable needs to fulfill two conditions: first, the instrumental variable needs to be correlated with the instrumented variable; second, it must be uncorrelated with the error term in the original OLS regression.

4.4.1 Construction of instrumental variables

Our main candidate of the instrumental variable is the logarithm of real GDP per capita expressed in terms of the purchasing power parity ($rgdppc\_ppp\_log$).

First of all, we think that real GDP (PPP) per capita is correlated with foreign reserve

accumulation, especially when the latter is measured by the reserves to short-term debt ratio, our main dependent variable considered in the previous sections. In fact, real GDP (PPP) per capita is a standard measure of a country's economic development. The higher it is, the maturer a country's economy is, the less strong is the precautionary motive to cover short-term debt position by holding reserves, as alternative financing possibilities may loom large. On the contrary, for less developed countries, they need a large stock of foreign reserves to insure their short-term solvency in order to be credible vis-à-vis the market. The correlation coefficients that we report in Table 5 confirm our intuition. We observe in fact that the instrumental variable we choose is significantly and negatively correlated with the reserves to short-term debt ratio, in all samples considered. Using other reserve ratios, the sign of the correlations remains generally negative, with the exception of the reserves to GDP ratio for non-advanced countries. This reflects rather the non-linearity of the capacity to purchase foreign reserves than the precautionary motive of holding reserves: the richer is a country (measured by real GDP (PPP) per capita), a larger share of GDP can be dedicated to purchase foreign reserves; for the least developed countries, foreign reserves remain a 'luxury good'. This is however out of the scrutiny of our current paper.

Table 5: Correlation coefficients

	log real GDP (PPP) per capita				
	Full	AC	NAC	EME	LDC
log reserves/gdp(pct)	-0.503***	-0.791***	-0.295***	-0.391*	-0.275**
log reserves/imports(months)	-0.419***	-0.822***	-0.170	0.294	-0.213*
log reserves/m2(pct)	-0.185*	-0.702***	0.146	-0.197	0.0964
log reserves/short debt(pct)	-0.166*	-0.732***	0.230*	0.349	0.162

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Moreover, we need to assure that the instrument is orthogonal to the error term in our original OLS regression. Remember that our dependent variable in Equation (1) measures a country's economic performance during the global financial crisis, namely a 'detrended' real GDP growth rate. This is thus a measure of short-term economic growth, mainly affected by circumstantial factors (i.e. temporary external shocks). However, the instrument, real GDP (PPP) per capita, rather measures the level of economic development, which should be more affected by structural factors. Therefore, the error term in the original OLS, which measures temporary disturbances, should be uncorrelated with the instrument we choose.

Furthermore, as there is an interactive term in our original OLS regression, *reserves* × *capital controls*, we need to instrument the interactive term too. There are two ways to

deal with it based on Wooldgidge's textbook Wooldridge (2010) : (1) use the product of real GDP (PPP) per capita and capital controls to instrument the interactive term as a separate explanatory variable; (2) instrument first the reserves to short-term debt ratio with real GDP (PPP) per capita and get the fitted value of the instrumented variable, then instrument the interactive term with the product of the fitted value and capital controls [7]. As the first method is more widely used, we consider it as our benchmark method to instrument the interactive term, but we also report the results using the second method (under the name of 'alternative').

Finally, we provide the benchmark results we obtained from the first-stage regressions using our candidate instrumental variables, real GDP (PPP) per capita (Appendix F Table 28 and 29). We can see that the instruments have an expected and significant sign with respect to the instrumented variables in all samples (except the sub-sample of advanced countries). R^2 is also very large, 41% of the reserves to short-term debt ratio is explained by the contemporaneous real GDP (PPP) per capita in the full sample; and 84.8% of the interactive term is explained by the instruments in the full sample. This findings confirm our choice of instrumental variables. The results of the first stage regressions obtained by using the second method of instrumenting the interactive term are also provided in Appendix F. The significance and the signs of real GDP (PPP) per capita, as well as R^2, remain stable, although the signs of capital controls and interactive term are flipped. This is due to the difference of definition of the instrument used for the interactive term but should not alter the marginal effects of reserves and capital controls.

[7] This method is different from a 'forbidden regression.'

4.4.2 2-stage least square (2SLS) regressions

We will now analyze how the reserves to short-term debt ratio changes once it is appropriately instrumented. Table 6 presents the results of our instrumental variable regressions for the full sample of countries. Column (1) reminds the OLS results, while Column (2) shows the final results of the two-stage procedure and Column (3) shows the second stage regression using the alternative method to instrument the interactive term. Comparing the OLS with the instrumented regressions, the signs of the coefficients are very stable, whereas their magnitudes vary slightly. Using instrumental variables, the coefficient associated with the reserves (scaled by short-term debt) remains highly significant and positive, although the interaction term is not significant any more. Notice that the 2SLS procedure usually yields larger standard errors, therefore if the point estimate remains unchanged, significance is typically lower. This seems to be the case for capital controls, the interactive term and some other control variables. As a result, we are unable to calculate correct marginal effects of foreign reserves and capital controls, given that the coefficient of the interactive term is not statistically different from zero.

However, the statistically significant and negative sign of the reserves to short-term debt ratio suggests that having accumulated foreign reserves before the global financial crisis did help countries to sustain a higher economic growth during the crisis. This result remains robust with our two measurements of the dependent variable and with our different sub-samples (especially with the EME sub-sample). Complementary results can be found in Appendix F.

Table 6: 2SLS with rydetrend as the dependent variable

	(1) OLS	(2) 2SLS	(3) 2SLS alternative
log reserves/short debt(instrumented) (t-2)	0.623**	2.535***	2.441***
	(2.32)	(3.79)	(3.69)
Capital controls (t-2)	1.205	2.172	1.642
	(1.59)	(1.17)	(0.98)
Capital controls reserves (t-2)	-0.312**	-0.302	-0.203
	(-2.45)	(-0.91)	(-0.70)
Financial center dummy	0.300	0.750	0.993
	(0.09)	(0.18)	(0.23)
Trade openness(pct) (t-2)	-0.00980	-0.00625	-0.00680
	(-1.11)	(-0.58)	(-0.63)
Oil dummy	-1.085	-3.050*	-3.041*
	(-0.84)	(-1.87)	(-1.85)
Constant	-7.904***	-18.74***	-18.04***
	(-4.16)	(-4.37)	(-4.28)
Observations	146	145	145

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: 2SLS with *rgdp_residual* as the dependent variable

	(1) OLS	(2) 2SLS	(3) 2SLS alternative
log reserves/short debt(instrumented) (t-2)	0.769***	2.697***	2.647***
	(3.15)	(4.26)	(4.23)
Capital controls (t-2)	0.753	1.696	1.412
	(1.09)	(0.96)	(0.89)
Capital controls reserves (t-2)	-0.246**	-0.227	-0.174
	(-2.11)	(-0.73)	(-0.63)
Financial center dummy	0.561	1.006	1.137
	(0.18)	(0.25)	(0.28)
Trade openness(pct) (t-2)	-0.00852	-0.00497	-0.00526
	(-1.06)	(-0.48)	(-0.51)
Oil dummy	-0.683	-2.685*	-2.680*
	(-0.58)	(-1.74)	(-1.73)
Constant	-3.440**	-14.34***	-13.97***
	(-1.99)	(-3.53)	(-3.51)
Observations	146	145	145

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.4.3 Further thoughts on instrumental variables

We have also considered other instrumental variables to substitute foreign reserves. One is the number of external crises a country had encountered in the past. One may think that the more frequently a country is hit by external shocks, the more willing it is to hold foreign reserves. However, this potential instrument turns out to be not strongly related with foreign reserve accumulation and presents potential correlation with a country's economic growth during the most recent global crisis. It is likely that the number of past crises reflects some fundamental structural weaknesses in a given economy. This country is then inclined to hold a large stock of reserves and is also fragile facing any new crises.

Another candidate to instrument foreign reserves is the regional peer pressure. One may argue that foreign reserve accumulation is correlated with a regional competition; the more a country's neighbors hold foreign reserves, the stronger incentives this country has to increase its own reserve stock. This idea of 'keeping up with the Jonese' is highlighted by the allegory of 'Mrs Machlup's Wardrobe' in the literature. We have considered two metrics to capture this idea:

- A regional imitation index [8] $\frac{\text{Number of countries having increased reserves}_{t-1}}{\text{Total number of countries in a region}}$
- A Jonese index [9] $J_{i,t} = \sum_{j,j \neq i} \frac{\text{Reserves}}{\text{GDP}}_{j,t}$

This instrumental variable may also have a potential endogeneity problem. Moreover, it turns out to be not strongly correlated with our instrumented variable.

We have run 2SLS regressions using regional imitation and both real GDP (PPP) per capita and regional imitation. The results [10] are very similar to what we have showed before using only real GDP (PPP) per capita as an instrument.

4.5 Foreign reserves: gunpowder or nuclear weapons?

We have so far seen that foreign reserves contribute, jointly with capital controls or on their own, to real output growth during the recent global financial crisis. One subsequent question is whether foreign reserves accumulated before the crisis were actively used during the crisis. With this regard, are foreign reserves 'gunpowder' which means that they are actually deployed during a war (crisis) or they are 'nuclear weapons' (the mere existence suffices to demonstrate a deterrent force)?

Based on a regression analysis, we conclude that the countries which have accumulated foreign reserves prior to the crisis have actively used them during the crisis.

First, using yearly data, we compare the change in reserves in log-difference between 2008 and 2009 with the pre-crisis reserves-to-m2 ratio (in log) in 2007 (Table 8).

[8] See Bastourre et al. (2009)
[9] see Cheung and Sengupta (2011)
[10] Available upon request

Note that as we argued before, to better understand how a country's own foreign reserves changed during the trough of the crisis (from the end of 2008 to the mid-2009), we subtract from a country's stock of total reserves in 2009 the amount of SDRs newly issued by the IMF at the end of August 2009.

$$\Delta rsv_{08-09,i} = \gamma_0 + \gamma_1 log(\frac{rsv_{2007,i}}{m2_{2007,i}}) + \epsilon_i \tag{2}$$

Table 8: Reserves depletion during the crisis

	(1) Full	(2) AC	(3) NAC	(4) EME	(5) LDC
log reserves/m2(pct) (t-2)	-11.03***	-25.99**	-10.78***	-8.414	-11.50***
	(-3.48)	(-2.51)	(-3.08)	(-1.03)	(-2.94)
Constant	44.81***	33.01	49.38***	33.23	54.32***
	(3.91)	(1.14)	(3.79)	(1.13)	(3.69)
Observations	150	19	131	30	101
R^2	0.076	0.270	0.068	0.037	0.080

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Alternatively, we compare the change in reserves expressed in log-difference between 2008 and 2009 with the pre-crisis reserve accumulation in log-difference between 2004 and 2008 (Table 9). The regression indicates that countries with more reserves accumulated before the crisis will face a stronger depletion of reserves during the crisis, meaning that they possibly used more their reserves. Hence, accumulating foreign reserves does not only correspond to a building up of dissuasive nuclear bombs: reserves have also been used as gunpowder by the countries trying to mitigate the impact of the crisis. This seems to be true at the level of the whole sample as well as for various sub-samples of advanced, non-advanced, or LDC countries.

$$\Delta rsv_{08-09,i} = \delta_0 + \delta_1 \Delta rsv_{04-08,i} + \epsilon_i \tag{3}$$

Table 9: Reserves depletion during the crisis

	(1) Full	(2) AC	(3) NAC	(4) EME	(5) LDC
$\Delta rsv_{04-08,i}$	-0.0872*	-0.129	-0.169***	-0.118	-0.178***
	(-1.66)	(-0.50)	(-4.10)	(-1.43)	(-3.79)
Constant	12.21**	-9.020	22.13***	11.93	24.69***
	(2.50)	(-0.45)	(5.62)	(1.61)	(5.40)
Observations	159	26	133	30	103
R^2	0.017	0.010	0.114	0.068	0.125

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Foreign reserve re-building after the global financial crisis

From the analysis above, we see that countries which have accumulated foreign reserves before the onset of the global financial crisis are better off during the crisis. Moreover, traditionally, reserves are said to be useful only for emerging economies. Most country authorities and IMF staff did not believe advanced countries needed to hold reserves, either because they have floating exchange rates or because they could borrow from international capital markets in case of a need for foreign exchange liquidity. But the malfunctioning of these markets during the global crisis was to prove otherwise, and even several small advanced countries have since taken a new look at their need for reserves in relation to the international exposures of their financial systems. Furthermore, based on an analysis of the IMF's credit arrangement, we observe that many emerging market economies and small open advanced countries (peripheral European countries) asked for IMF credit facilities during and after the global financial crisis. The shortage of foreign reserve liquidity that these countries experienced during the crisis may also encourage them to build up a 'war chest' of foreign reserves now.

We are thus motivated to have a closer look at the re-building of foreign reserves in the wake of the global financial crisis and its relationship with reserve depletion some countries might have experienced during the crisis. Several questions merit our attention: Are the countries which actively used foreign reserves during the crisis more incline to re-build a 'war chest' of reserves afterwards? Are the countries which asked for the IMF credit facilities during the crisis more incline to re-build a stock of reserves afterwards? What are the patterns of foreign reserve accumulation in recent years?

5.1 Descriptive patterns

5.1.1 Reserve re-building in the immediate aftermath of the global financial crisis

To obtain a more precise view of the use of reserves, we use a monthly database, and compare the evolution of the reserve holdings between the renewed build-up of reserves after the crisis and the drop of reserves during the crisis.

The dependent variable in Equation (4) is the growth rate of foreign reserves from May to December 2009; this corresponds to the 'bounce back' period of foreign reserve accumulation after the crisis. Here again, we subtract the newly allocated SDR when computing the reserve losses during the crisis.

The explanatory variable in Equation (4) is the growth rate of foreign reserves from September 2008 to March 2009. Notice that, since a negative value of the explanatory variable indicates a drop in foreign reserves during the crisis, if the sign of the coefficient α_1 is negative, a larger decrease in reserves during the crisis leads to a stronger re-building of reserves after the crisis. For most countries in our sample, we observe a sharp drop in foreign reserves during the crisis period.

Based on the results presented in Table 10, the behavior of the post-crisis foreign reserve accumulation depends on the sample of countries we consider. In the LDC sub-sample, the countries that lost more reserves during the crisis accumulate more reserves afterwards. This pattern remains for both the NAC sub-sample and the full sample with all countries. However, the pattern disappears when we consider advanced countries and emerging market economies. The coefficients obtained based on these two sub-samples are not significantly different from zero. This may be explained by the fewer observations there are in the AC and EME sub-samples. We conclude thus that the post-crisis behavior in foreign reserve stockpiling varies across country groups. For selected countries, a depletion of foreign reserves during the crisis leads to a fast re-building afterwards.

$$\Delta rsv_{09m5-09m12,i} = \alpha_0 + \alpha_1 \Delta rsv_{08m9-09m3,i} + \epsilon_i \tag{4}$$

5.1.2 IMF facilities and foreign reserve accumulation

Does the supply of credit facilities by IMF reinforce or dampen the re-building of foreign reserves observed in the previous sub-section?

Based on the IMF annual report, we select countries which asked for the IMF credit facilities between 2009 and 2012. We conjecture that if a country resorted to an IMF program during the crisis its willingness to re-build foreign reserves after the financial crisis would be enhanced. This is because the IMF facilities are less direct liquid resources compared to the foreign reserves held in a country's Central Bank's vault. Moreover, there

Table 10: Rebuilding reserves after the crisis

	(1) Full	(2) AC	(3) NAC	(4) EME	(5) LDC
$\Delta rsv_{08m9-09m3}$, w/t SDR	-0.106***	0.112	-0.120***	0.0141	-0.123**
	(-2.68)	(0.75)	(-2.90)	(0.13)	(-2.44)
Constant	8.832***	8.111**	9.557***	7.819***	11.32***
	(4.55)	(2.11)	(4.24)	(3.56)	(3.34)
Observations	107	27	80	30	50
R^2	0.064	0.022	0.097	0.001	0.110

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

may be a strong stigma associated with the IMF facilities: countries which resort to the IMF credits are supposed to have economic problems, sending a signal of weak economic fundamentals to the market.

To test this conjecture, we run again the simple regression used above to see if adding the resort to the IMF facilities changes our previous results. $imfcredit_i$ is a dummy variable indicating whether a country borrowed credit from the IMF between 2009 and 2012. If we compare Table 10 with Table 11, we find that in general the introduction of an IMF credit dummy ameliorates the results of Table 10. The R^2 is larger in Table 11 for those sub-samples where the coefficients have correct and significant signs. The coefficient before $rsv_{08m9-09m3,i}$ in Table 11 is even more negative, leading to a stronger re-building of foreign reserves after the crisis as a response to a depletion of foreign reserves during the crisis, for the full sample as well as the NAC and LDC sub-samples. The fact that a country resorted to the IMF's credit lines further enhances the re-building of foreign reserves, as the coefficient before $imfcredit_i$ is positive and mostly significant.

This result is consistent with the fact that some countries have reconsidered the role of foreign reserves as a useful tool for crisis management in the aftermath of the global financial crisis.

$$\Delta rsv_{09m5-09m12,i} = \alpha_0 + \alpha_1 \Delta rsv_{08m9-09m3,i} + \alpha_3 imfcredit_i + \epsilon_i \tag{5}$$

According to some policy documents on foreign reserve management, we believe that foreign reserves and some alternative liquidity facilities are not perfectly substitutable as Table 12 shows. Therefore, countries may still have incentives to hold foreign reserves even though the IMF has tried to build up a better international liquidity safety net. As Javier Duclaud [11], head of central banking operations at the Bank of Mexico, put forward, '[o]ur experience seems to suggest that even though you have the funds immediately available

[11] He spoke as a panellist at the National Asset-Liability Management symposium in London on March 29, 2012

Table 11: Rebuilding reserves after the crisis (controlling for IMF loans)

	(1) Full	(2) AC	(3) NAC	(4) EME	(5) LDC
$\Delta rsv_{08m9-09m3}$, w/t SDR	-0.108***	0.111	-0.122***	0.00175	-0.125**
	(-2.83)	(0.73)	(-3.14)	(0.02)	(-2.65)
IMF loan	13.42***	5.023	14.91***	5.885	19.79***
	(3.21)	(0.49)	(3.24)	(1.36)	(2.92)
Constant	5.551**	7.361*	5.421**	6.130**	5.754
	(2.62)	(1.76)	(2.18)	(2.46)	(1.56)
Observations	107	27	80	30	50
R^2	0.149	0.032	0.206	0.064	0.247

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[from the IMF], it is not exactly the same as holding the liquidity yourself [...] there is also a stigma more or less implied in having a credit line. So we will probably need to accumulate reserves to a level where the IMF facility is no longer considered an important stability factor.'

Table 12: Comparison of Different Insurance Instruments

Instrument	Advantages	Drawbacks
IMF programs	Alternative source of insurance	Not as efficient as reserves in terms of accessibility, speed, reliability, stigma
Bilateral swaps lines	Alternative source of insurance	Less certain, less flexible, not immediately available
Foreign reserves	Dual role of providing insurance and being able to smooth exchange rate volatility	

5.1.3 Recent deceleration of the pace of foreign reserve accumulation

After the crisis, two patterns can be distinguished with regard to the re-building of foreign reserves. First, immediately after the trough of the reserve losses, countries started to accumulate reserves in what looks like an attempt to bounce back to the pre-crisis level of reserves. Indeed, holding reserves proved to be efficient as a 'war-chest' during the crisis. Second, some countries see a 'flattening' in their pace of reserve accumulation in recent years. That is, their stockpiling of reserves tends to decelerate. This is the case for instance for Argentina, India, China, and also for some countries of Eastern Europe

like Bulgaria, Croatia, Romania and Macedonia.

What drives this 'flattening' in foreign reserve accumulation? We have several possible explanations in mind that we need to further test. First, it is possible that, once a country reached its pre-crisis level of reserves, it slows down the accumulation as foreign reserves are not free lunch and the opportunity cost and exchange risks associated with foreign reserves may be high. Second, as financial openness (thus capital controls) is one of the three elements of the 'impossible trinity', the deceleration of foreign reserve accumulation may reflect a change of policy priority with regard to monetary autonomy, exchange rate stability and financial openness in the wake of the 2008-2009 financial crisis. As Aizenman et al. (2010) argue, countries that deviate from the reserves-debt target post-crisis might be doing so because either they have changed economic conditions, or they are opting for a different trade-off between monetary autonomy and exchange rate stability.

5.2 Case studies

5.2.1 Mexico

Mexico is a very interesting example showing how the global financial crisis changed some countries' view regarding foreign reserve accumulation. Indeed, Mexico started to build up foreign reserve assets after the financial crisis of 1994-95 to improve investor confidence, strengthen the access to external capital markets, and reduce the country's external vulnerability (Figure 2). However, the Mexican Central Bank decided to decelerate the growth rate of their foreign reserves in 2006 due to increasing holding costs and improvement of macroeconomic situation: macroeconomic stability, the development of domestic financial markets, and the substitution of external debt for domestic debt and the choice of going on a floating exchange rate regime (Figure 3).

Figure 2: Mexico: Foreign reserve accumulation after the 1994 crisis

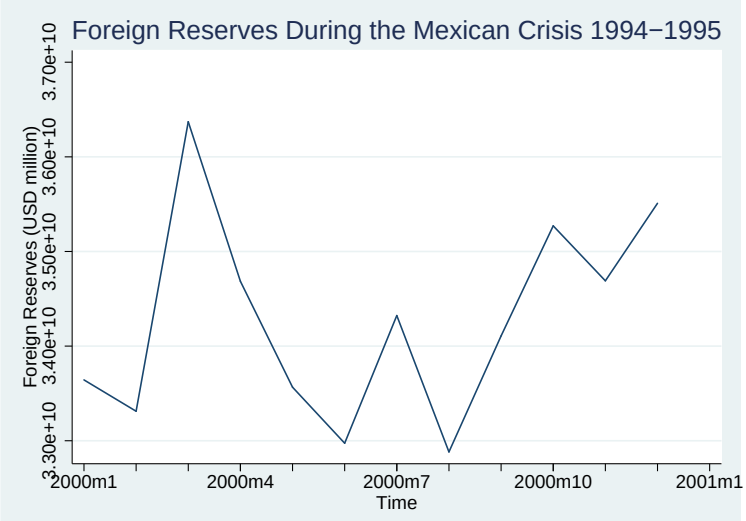


Figure 3: Mexico: Slowing-down of foreign reserve accumulation in 2006

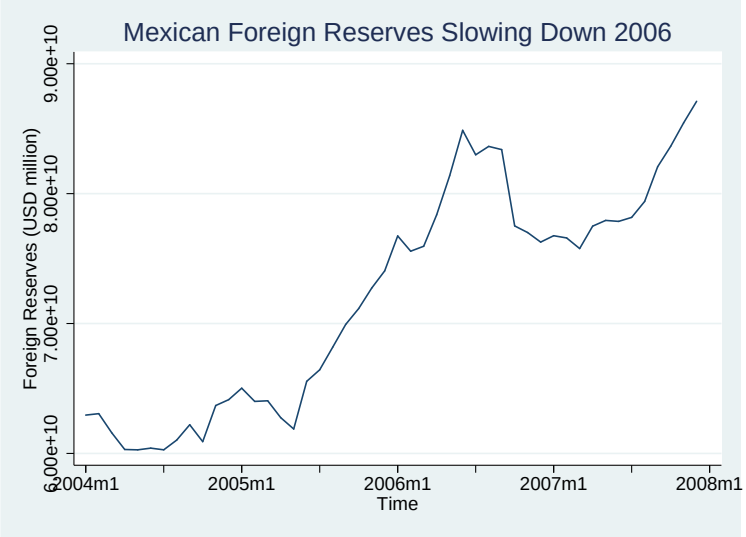


Figure 4: Mexico: Re-building of foreign reserves after the 2008-09 crisis

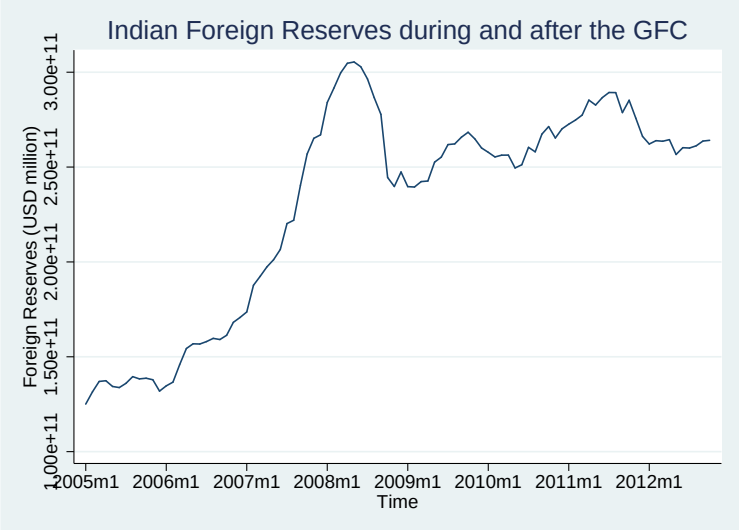
The onset of the recent global financial crisis led to a shortage of foreign exchange liquidity for crisis management in Mexico. During the crisis time, Mexico saw a double-dip in its stock of foreign reserves, in Oct 2008 and June 2009 respectively (Figure 4). The country also turned to the IMF for credit facilities three times from 2009 to 2012:

- A 12-month flexible credit line of 31,528 million of SDR, effective from April 17, 2009
- A 12-month flexible credit line of 31,528 million of SDR, effective from March 25, 2010
- A 24-month flexible credit line of 47,292 million of SDR, effective from January 10, 2011

In the aftermath of the global financial crisis, we observe that the country started focusing anew on the role of reserves in crisis mitigation and management. Foreign reserve stock increases steadily (Figure 4).

5.2.2 India

Figure 5: India: Reserves during and after the crisis



We can see in India an example contrasting with the case of Mexico. During the 2000s, India accumulated foreign reserves at a steeper and steeper pace, with a year-on-year growth rate of reserves reaching more than 40%. Its reserves decreased strongly during the crisis, as India lost about 20% of its reserves in 8 months. However, as opposed to Mexico, India started again to accumulate reserves, but at a slower pace than during the 2000's, and hasn't reached yet its pre-crisis level of reserves (Figure 5).

6 Discussion and conclusion

Based on our regression analysis, we can make a three-fold conclusion. First, the pre-crisis level of foreign reserves has a positive and significant impact on the real GDP growth during the most recent financial crisis. Although the explanatory power of foreign reserves is sensitive to the scaling variable, we provide evidence that international reserves may act as a buffer during crises. In line with the existing literature on early warning signals, the reserves-to-short-term-debt ratio works best as a reserve indicator.

Second, countries that have accumulated foreign reserves before the crisis have actively used them either to defend the domestic currency from massive devaluation, to finance domestic firms which experienced credit crunch or to maintain the market confidence about the solvency of the country. It suggests that foreign reserves are not only 'nuclear weapons' but also 'barrels of gunpowder' which can be actively mobilized during a crisis period.

Finally, as Javier Duclaud, head of central banking operations at the Bank of Mexico put forward, '[o]ne of the learning experiences [of the crisis] was to build more reserves, of course recognising that the build-up of reserves is costly.' Even the Independent Evaluation Office of the IMF seems to have a supporting view of holding foreign reserves to insure against shocks, including those from volatile international capital flows, and to preserve financial stability. IEO (2012) advances that '[a]uthorities in several countries, including some advanced economies, had started focusing anew on the role of reserves in crisis mitigation and management [...] and even several small advanced countries have since taken a new look at their need for reserves in relation to the international exposures of their financial systems.' We observe in fact a strong re-building of foreign reserves after the 2008-2009 global financial crisis. There seem to be new targets with regard to the reserve adequacy. Our next step is to identify these new targets.

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A Country sample

We define the following country groups in our paper:

- Advanced countries (AC): Definition of the IMF
- Non advanced countries (NAC)
  - Emerging market economies (EME): Definition of the IMF and *the Economist*
  - Less developed countries (LDC)

Advanced countries Australia, Austria, Belgium, Canada, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Japan, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland, UK, USA,

Emerging market economies Argentina, Brazil, Bulgaria, Chile, China, Colombia, Czech Republic, Egypt, Hong Kong, Hungary, India, Indonesia, Korea, Latvia, Lithuania, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Singapore, South Africa, Taiwan, Thailand, Turkey, Ukraine, Venezuela,

Less developed countries Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Armenia, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brunei Darussalam, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Congo(Dem), Costa Rica, Cote d'Ivoire, Croatia, Djibouti, Dominica, Dominican Republic, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Iran, Jamaica, Jordan, Kazakhstan, Kenya, Kosovo, Kuwait, Kyrgyz Republic, Lao, Lebanon, Lesotho, Liberia, Libya, Macedonia, Madagascar, Malawi, Maldives, Mali, Mauritania, Mauritius, Moldova, Mongolia, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Oman, Panama, Papua New Guinea, Paraguay, Qatar, Rwanda, Samoa, Sao Tome and Principe, Senegal, Serbia, Seychelles, Sierra Leone, Solomon Islands, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Syrian Arab Republic, Tajikistan, Tanzania, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Uganda, United Arab Emirates, Uruguay, Uzbekistan, Vanuatu, Vietnam, Yemen, Zambia

B Complementary results for Section 4.1

B.1 Using detrended real GDP growth

Table 13: NAC: Explanatory power of different reserve indicators

	(1) rydetrend	(2) rydetrend	(3) rydetrend	(4) rydetrend
log reserves/gdp(pct) (t-2)	-0.699			
	(-1.02)			
log reserves/imports(months) (t-2)		0.190		
		(0.28)		
log reserves/m2(pct) (t-2)			-0.658	
			(-1.06)	
log reserves/short_debt(pct) (t-2)				0.500*
				(1.70)
Constant	-3.168	-5.522***	-2.933	-8.100***
	(-1.55)	(-4.74)	(-1.27)	(-4.47)
Observations	140	132	136	135
R^2	0.008	0.001	0.008	0.021

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: EME: Explanatory power of different reserve indicators

	(1) rydetrend	(2) rydetrend	(3) rydetrend	(4) rydetrend
log reserves/gdp(pct) (t-2)	0.239			
	(0.14)			
log reserves/imports(months) (t-2)		3.474*		
		(1.85)		
log reserves/m2(pct) (t-2)			-3.120	
			(-1.54)	
log reserves/short_debt(pct) (t-2)				3.668***
				(2.95)
Constant	-8.862	-14.63***	2.919	-28.77***
	(-1.66)	(-3.98)	(0.40)	(-4.07)
Observations	32	32	32	32
R^2	0.001	0.102	0.073	0.225

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 15: LCD: Explanatory power of different reserve indicators

	(1) rydetrend	(2) rydetrend	(3) rydetrend	(4) rydetrend
log reserves/gdp(pct) (t-2)	-0.453			
	(-0.63)			
log reserves/imports(months) (t-2)		0.361		
		(0.51)		
log reserves/m2(pct) (t-2)			-0.538	
			(-0.89)	
log reserves/short_debt(pct) (t-2)				0.190
				(0.69)
Constant	-3.047	-4.825***	-2.499	-5.344***
	(-1.45)	(-4.28)	(-1.09)	(-3.05)
Observations	108	100	104	103
R^2	0.004	0.003	0.008	0.005

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.2 Using purged real GDP growth

Table 16: EME: Explanatory power of different reserve indicators

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
log reserves/gdp(pct) (t-2)	0.501			
	(0.31)			
log reserves/imports(months) (t-2)		4.046**		
		(2.26)		
log reserves/m2(pct) (t-2)			-2.655	
			(-1.33)	
log reserves/short_debt(pct) (t-2)				3.826***
				(3.22)
Constant	-4.049	-10.07***	6.905	-24.03***
	(-0.78)	(-2.88)	(0.97)	(-3.56)
Observations	32	32	32	32
R^2	0.003	0.146	0.056	0.257

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 17: LDC: Explanatory power of different reserve indicators

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
log reserves/gdp(pct) (t-2)	-0.114			
	(-0.18)			
log reserves/imports(months) (t-2)		0.776		
		(1.23)		
log reserves/m2(pct) (t-2)			0.148	
			(0.28)	
log reserves/short_debt(pct) (t-2)				0.373
				(1.55)
Constant	1.434	0.0467	0.420	-0.991
	(0.78)	(0.05)	(0.21)	(-0.65)
Observations	108	100	104	103
R^2	0.000	0.015	0.001	0.023

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C Complementary results for Section 4.2

C.1 Using detrended real GDP growth

Table 18: NAC: Foreign reserve accumulation vs. capital controls

	(1) rydetrend	(2) rydetrend	(3) rydetrend	(4) rydetrend
log reserves/short_debt(pct) (t-2)	0.500*		0.337	0.336
	(1.70)		(1.11)	(1.12)
capital controls (t-2)		-0.731**	-0.677**	1.523
		(-2.56)	(-2.15)	(1.43)
capital controls × reserves (t-2)				-0.384**
				(-2.16)
Constant	-8.100***	-5.113***	-7.052***	-7.282***
	(-4.47)	(-11.29)	(-3.71)	(-3.88)
Observations	135	140	129	129
R^2	0.021	0.045	0.057	0.091

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 19: EME: Foreign reserve accumulation vs. capital controls

	(1) rydetrend	(2) rydetrend	(3) rydetrend	(4) rydetrend
log reserves/short_debt(pct) (t-2)	3.668***		3.963**	3.657**
	(2.95)		(2.40)	(2.12)
capital controls (t-2)		-1.069	0.137	-3.469
		(-1.46)	(0.16)	(-0.65)
capital controls × reserves (t-2)				0.666
				(0.69)
Constant	-28.77***	-7.431***	-30.45***	-28.36***
	(-4.07)	(-6.14)	(-3.15)	(-2.78)
Observations	32	31	31	31
R^2	0.225	0.069	0.228	0.241

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 20: LDC: Foreign reserve accumulation vs. capital controls

	(1) rydetrend	(2) rydetrend	(3) rydetrend	(4) rydetrend
log reserves/short_debt(pct) (t-2)	0.190		0.103	0.0864
	(0.69)		(0.36)	(0.32)
capital controls (t-2)		-0.451	-0.462	2.503**
		(-1.51)	(-1.41)	(2.48)
capital controls × reserves(t-2)				-0.505***
				(-3.09)
Constant	-5.344***	-4.402***	-4.848***	-5.037***
	(-3.05)	(-9.45)	(-2.66)	(-2.88)
Observations	103	109	98	98
R^2	0.005	0.021	0.025	0.115

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C.2 Using purged real GDP growth

Table 21: EME: Foreign reserve accumulation vs. capital controls

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
log reserves/short_debt(pct) (t-2)	3.826***		4.074**	3.880**
	(3.22)		(2.59)	(2.35)
capital controls (t-2)		-1.195	0.0449	-2.237
		(-1.70)	(0.06)	(-0.44)
capital controls × reserves (t-2)				0.421
				(0.45)
Constant	-24.03***	-1.686	-25.35**	-24.03**
	(-3.56)	(-1.44)	(-2.76)	(-2.46)
Observations	32	31	31	31
R^2	0.257	0.090	0.266	0.272

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 22: LDC: Foreign reserve accumulation vs. capital controls

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
log reserves/short_debt(pct) (t-2)	0.373		0.303	0.287
	(1.55)		(1.22)	(1.23)
capital controls (t-2)		-0.406	-0.357	2.611***
		(-1.55)	(-1.26)	(3.03)
capital controls × reserves (t-2)				-0.506***
				(-3.62)
Constant	-0.991	1.106***	-0.594	-0.783
	(-0.65)	(2.70)	(-0.38)	(-0.53)
Observations	103	109	98	98
R^2	0.023	0.022	0.039	0.157

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

D Complementary results for Section 4.3

Table 23: EME: Full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	4.979***	5.246***
	(2.82)	(3.16)
capital controls (t-2)	-5.792	-4.617
	(-1.07)	(-0.91)
Capital controls × reserves (t-2)	1.186	0.955
	(1.20)	(1.03)
Financial center dummy	3.029	3.231
	(0.43)	(0.48)
Trade Openness (t-2)	-0.00827	-0.00875
	(-0.54)	(-0.61)
Oil dummy	-7.435**	-7.672**
	(-2.20)	(-2.42)
Constant	-34.08***	-29.92***
	(-3.33)	(-3.12)
Observations	31	31
R^2	0.372	0.419
whitechi2	15.66	15.01
whitep	0.616	0.661
bpchi2	2.085	1.685
bpp	0.149	0.194

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 24: LDC: Full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	0.127	0.215
	(0.41)	(0.79)
capital controls (t-2)	3.296***	3.028***
	(3.12)	(3.29)
capital controls × reserves (t-2)	-0.612***	-0.563***
	(-3.64)	(-3.83)
Trade Openness (t-2)	-0.0175	-0.0193
	(-1.31)	(-1.65)
Oil dummy	-1.012	-0.127
	(-0.68)	(-0.10)
Constant	-3.363	1.600
	(-1.25)	(0.68)
Observations	86	86
R^2	0.170	0.200
whitechi2	22.97	20.88
whitep	0.192	0.285
bpchi2	3.471	2.560
bpp	0.0625	0.110

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

E Robust regressions and results

Table 25: NAC: Robust regression with the full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	0.484*	0.520**
	(1.79)	(2.02)
capital controls (t-2)	2.063**	2.145**
	(2.25)	(2.47)
capital controls × reserves (t-2)	-0.393**	-0.413***
	(-2.60)	(-2.89)
Financial center dummy	1.619	1.417
	(0.32)	(0.30)
Trade Openness (t-2)	-0.0174**	-0.0157*
	(-2.05)	(-1.95)
Oil dummy	-2.431**	-1.671
	(-2.01)	(-1.46)
Constant	-5.549***	-0.617
	(-2.76)	(-0.32)
Observations	117	117
R^2	0.157	0.166

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 26: EME: Robust regression with the full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	3.342**	4.442***
	(2.44)	(3.23)
capital controls (t-2)	-4.857	-3.550
	(-1.16)	(-0.85)
capital controls × reserves (t-2)	0.962	0.747
	(1.26)	(0.98)
Financial center dummy	1.098	10.29
	(0.20)	(1.34)
Trade Openness (t-2)	-0.00719	-0.0343
	(-0.61)	(-1.64)
Oil dummy	-7.236**	-8.072***
	(-2.77)	(-3.10)
Constant	-23.71***	-22.54***
	(-3.00)	(-2.88)
Observations	31	30
R^2	0.371	0.484

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 27: LDC: Robust regression with the full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	0.246	0.281
	(0.86)	(1.09)
capital controls (t-2)	2.642***	2.714***
	(2.72)	(3.11)
Capital controls × reserves (t-2)	-0.464***	-0.474***
	(-3.00)	(-3.41)
Trade Openness (t-2)	-0.0278**	-0.0258**
	(-2.26)	(-2.33)
Oil dummy	-1.470	-0.560
	(-1.07)	(-0.45)
Constant	-2.726	2.101
	(-1.10)	(0.94)
Observations	86	86
R^2	0.172	0.199

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

F Complementary results for Section 4.4

F.1 Results of the 1st-stage regressions

Using the benchmark method to instrument the interactive term

Table 28: 1st stage regression - reserves to short-term debt ratio

	(1) full sample	(2) advanced	(3) non-advanced	(4) emerging	(5) LDC
Capital controls	0.321	-24.24	-1.389*	-0.133	-1.468
	(0.48)	(-0.62)	(-1.96)	(-0.11)	(-1.61)
Financial center	0.859	-1.491	2.177	-0.886	
	(0.73)	(-0.83)	(1.40)	(-0.89)	
Trade openness(pct)	-0.000761	-0.00656	-0.00754**	0.00496	-0.0106**
	(-0.26)	(-0.75)	(-2.25)	(1.58)	(-2.31)
Oil dummy	1.477***	1.970	1.028**	1.035***	1.029**
	(3.52)	(1.41)	(2.62)	(2.99)	(2.02)
log real GDP pc	-0.832***	-9.264	-0.500***	-0.439**	-0.493***
	(-5.63)	(-1.05)	(-3.58)	(-2.10)	(-2.69)
Crossed term	-0.0638	2.320	0.154*	-0.0135	0.172
	(-0.83)	(0.62)	(1.86)	(-0.10)	(1.57)
Constant	12.68***	99.39	10.64***	9.243***	10.86***
	(10.34)	(1.09)	(9.36)	(5.13)	(7.68)
Observations	145	28	117	31	86
R^2	0.414	0.286	0.259	0.549	0.269

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 29: 1st stage regression - interactive term

	(1) full sample	(2) advanced	(3) non-advanced	(4) emerging	(5) LDC
Capital controls	13.20***	-14.71	8.673***	10.55***	8.460***
	(9.25)	(-0.15)	(6.70)	(4.83)	(5.14)
Financial center	1.752	-3.781	4.440	1.928	
	(0.70)	(-0.85)	(1.56)	(1.10)	
Trade openness(pct)	-0.00249	-0.0173	-0.0178***	-0.00118	-0.0253***
	(-0.40)	(-0.80)	(-2.90)	(-0.21)	(-3.07)
Oil dummy	1.003	4.883	-0.373	0.959	-1.000
	(1.13)	(1.42)	(-0.52)	(1.57)	(-1.09)
log real GDP pc	-0.0490	-12.72	0.741***	0.206	1.100***
	(-0.16)	(-0.59)	(2.89)	(0.56)	(3.33)
Crossed term	-0.927***	1.625	-0.350**	-0.573**	-0.315
	(-5.70)	(0.18)	(-2.31)	(-2.40)	(-1.59)
Constant	0.0499	133.8	-4.844**	-2.165	-6.707**
	(0.02)	(0.60)	(-2.33)	(-0.68)	(-2.63)
Observations	145	28	117	31	86
R^2	0.848	0.269	0.927	0.987	0.918

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Using the alternative method to instrument the interactive term

Table 30: 1st stage regression - reserves to short-term debt (alternative measure)

	(1) Full	(2) AC	(3) NAC	(4) EME	(5) LDC
Capital controls	-0.685*	0.990	0.234	-0.610	0.123
	(-1.69)	(0.38)	(0.33)	(-0.56)	(0.14)
Financial center	0.815	-3.541	3.330**	-0.893	
	(0.71)	(-0.77)	(2.30)	(-0.91)	
Trade openness(pct)	-0.000751	-0.0128	-0.00922***	0.00491	-0.0132***
	(-0.26)	(-0.71)	(-2.75)	(1.63)	(-2.91)
Oil dummy	1.406***	5.304	1.046***	0.980**	1.063**
	(3.30)	(0.84)	(2.62)	(2.55)	(2.06)
log real GDP pc	-0.823***	-9.575	-0.450***	-0.446**	-0.439**
	(-5.74)	(-0.86)	(-3.19)	(-2.14)	(-2.28)
Crossed term_full	0.0866				
	(1.15)				
Crossed term_ad		-0.611			
		(-0.51)			
Crossed term_nac			-0.0553		
			(-0.45)		
Crossed term_eme				0.0665	
				(0.33)	
Crossed term_ldc					-0.0293
					(-0.20)
Constant	12.67***	103.7	10.41***	9.345***	10.71***
	(10.67)	(0.88)	(8.98)	(5.16)	(7.18)
Observations	145	28	117	31	86
R^2	0.416	0.282	0.237	0.551	0.247

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 31: 1st stage regression - interactive term (alternative measure)

	(1) full sample	(2) advanced	(3) non-advanced	(4) emerging	(5) LDC
Capital controls	-0.379	2.508	0.00563	-0.967	0.514
	(-0.46)	(0.39)	(0.00)	(-0.57)	(0.36)
Financial center	0.650	-4.432	1.974	1.362	
	(0.28)	(-0.39)	(0.81)	(0.89)	
Trade openness(pct)	-0.00114	-0.0187	-0.00977*	-0.00419	-0.0128*
	(-0.19)	(-0.42)	(-1.73)	(-0.89)	(-1.70)
Oil dummy	0.187	6.083	-0.522	0.00282	-0.883
	(0.22)	(0.39)	(-0.78)	(0.00)	(-1.03)
log real GDP pc	-0.0658	-10.90	0.511**	0.0498	0.654**
	(-0.22)	(-0.40)	(2.16)	(0.15)	(2.04)
crossed term_full	1.061***				
	(6.88)				
crossed term_ad		-0.207			
		(-0.07)			
crossed term_nac			0.989***		
			(4.81)		
crossed term_eme				1.181***	
				(3.72)	
crossed term_ldc					0.903***
					(3.81)
Constant	0.791	115.3	-3.295*	-0.0155	-4.000
	(0.33)	(0.40)	(-1.69)	(-0.01)	(-1.61)
Observations	145	28	117	31	86
R^2	0.860	0.268	0.937	0.990	0.928

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

F.2 Complementary results of the 2SLS procedure

Non advanced countries

Table 32 presents the results of similar regressions using only non-advanced countries. The magnitude of the coefficients obtained from the instrumental variables regression here is surprisingly high, not only for coefficients associated to reserves holdings, but also for control variables.

Table 32: 2SLS with rydetrend as the dependent variable

	(1) OLS	(2) 2SLS	(3) 2SLS alternative
log reserves/short debt(instrumented) (t-2)	0.479	20.46	7.779**
	(1.43)	(0.61)	(2.34)
Capital controls (t-2)	2.088*	-56.35	-5.917
	(1.86)	(-0.50)	(-0.90)
Capital controls reserves (t-2)	-0.457**	10.13	1.109
	(-2.47)	(0.50)	(0.94)
Financial center dummy	0.566	-83.71	-25.17
	(0.10)	(-0.55)	(-1.45)
Trade openness(pct) (t-2)	-0.00939	0.334	0.0896*
	(-0.74)	(0.55)	(1.65)
Oil dummy	-1.429	-16.28	-6.700
	(-0.99)	(-0.59)	(-1.62)
Constant	-7.026***	-150.8	-58.21**
	(-2.67)	(-0.62)	(-2.47)
Observations	118	117	117

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 33: 2SLS with *rgdp_residual* as the dependent variable

	(1) OLS	(2) 2SLS	(3) 2SLS alternative
log reserves/short debt(instrumented) (t-2)	0.566*	19.04	7.295**
	(1.85)	(0.61)	(2.40)
Capital controls (t-2)	1.890*	-51.57	-4.866
	(1.85)	(-0.50)	(-0.81)
Capital controls reserves (t-2)	-0.422**	9.273	0.916
	(-2.50)	(0.50)	(0.85)
Financial center dummy	1.809	-75.94	-21.72
	(0.36)	(-0.54)	(-1.37)
Trade openness(pct) (t-2)	-0.0118	0.305	0.0782
	(-1.02)	(0.54)	(1.57)
Oil dummy	-0.927	-14.67	-5.798
	(-0.71)	(-0.58)	(-1.54)
Constant	-1.846	-134.6	-48.94**
	(-0.77)	(-0.60)	(-2.28)
Observations	118	117	117

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Emerging market economies

Table 34 presents the results for the sample of emerging countries. Results are in line with our expectations for this group of countries. As in the full sample, reserves remain significant, while capital controls and our interaction term are not significant any more.

Table 34: 2SLS with rydetrend as the dependent variable

	(1) OLS	(2) 2SLS	(3) 2SLS alternative
log reserves/short debt(instrumented) (t-2)	5.426***	8.439**	8.702*
	(3.19)	(1.97)	(1.92)
Capital controls (t-2)	-4.538	-12.29	-16.34*
	(-0.87)	(-1.10)	(-1.81)
Capital controls reserves (t-2)	1.003	2.635	3.410**
	(1.07)	(1.25)	(2.06)
Financial center dummy	15.06	15.48	14.81
	(1.69)	(1.62)	(1.45)
Trade openness(pct) (t-2)	-0.0432	-0.0442	-0.0418
	(-1.68)	(-1.56)	(-1.38)
Oil dummy	-8.022**	-12.05**	-13.08***
	(-2.49)	(-2.38)	(-2.67)
Constant	-33.99***	-50.09**	-51.31**
	(-3.51)	(-2.12)	(-2.05)
Observations	31	31	31

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 35: 2SLS with *rgdp_residual* as the dependent variable

	(1) OLS	(2) 2SLS	(3) 2SLS alternative
log reserves/short debt(instrumented) (t-2)	5.741***	8.835**	8.976**
	(3.68)	(2.18)	(2.16)
Capital controls (t-2)	-3.228	-11.24	-13.42
	(-0.68)	(-1.06)	(-1.62)
Capital controls reserves (t-2)	0.754	2.441	2.857*
	(0.87)	(1.22)	(1.88)
Financial center dummy	16.90*	17.33*	16.97*
	(2.06)	(1.91)	(1.80)
Trade openness(pct) (t-2)	-0.0482*	-0.0492*	-0.0479*
	(-2.04)	(-1.84)	(-1.73)
Oil dummy	-8.324***	-12.48***	-13.03***
	(-2.81)	(-2.60)	(-2.89)
Constant	-29.72***	-46.26**	-46.91**
	(-3.34)	(-2.07)	(-2.04)
Observations	31	31	31

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

G Alternative measure of capital controls: the Lane-Milesi-Ferretti indices

Table 36: NAC: Robust regression with the full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	1.006**	1.039***
	(2.38)	(2.69)
ifi (t-2)	1.123*	0.731
	(1.94)	(1.38)
ifi × reserves (t-2)	-0.000143	-0.000155
	(-1.37)	(-1.63)
Financial center dummy	-19.37*	-12.24
	(-1.68)	(-1.16)
Trade Openness (t-2)	-0.0252*	-0.0195
	(-1.74)	(-1.48)
Oil dummy	-1.678	-1.007
	(-1.10)	(-0.72)
Constant	-10.17***	-4.842*
	(-3.44)	(-1.79)
Observations	118	118
R^2	0.084	0.091
White χ^2	6.730	7.269
White p-value	0.997	0.996
BP χ^2	0.0994	0.347
BP p-value	0.753	0.556

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 37: EME: Robust regression with the full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	7.214***	7.780***
	(2.91)	(3.41)
ifi (t-2)	2.455	2.674*
	(1.49)	(1.77)
ifi × reserves (t-2)	-0.00383	-0.00435
	(-1.20)	(-1.48)
Financial center dummy	-24.95	-26.94
	(-1.01)	(-1.18)
Trade Openness (t-2)	-0.0445	-0.0476
	(-1.26)	(-1.47)
Oil dummy	-6.364*	-6.837**
	(-2.04)	(-2.39)
Constant	-45.84***	-43.11***
	(-3.42)	(-3.50)
Observations	32	32
R^2	0.381	0.451
White χ^2	22.64	21.08
White p-value	0.254	0.332
BP χ^2	3.654	3.105
BP p-value	0.0559	0.0781

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 38: LDC: Robust regression with the full specification

	(1) rydetrend	(2) rgdp_residual
log reserves/short_debt(pct) (t-2)	0.714*	0.686*
	(1.70)	(1.85)
ifi (t-2)	1.490**	0.967*
	(2.60)	(1.91)
ifi × reserves (t-2)	-0.000160*	-0.000164*
	(-1.68)	(-1.95)
o.Financial center dummy	0	0
	(.)	(.)
Trade Openness (t-2)	-0.0260	-0.0214
	(-1.65)	(-1.53)
Oil dummy	-0.916	0.0830
	(-0.59)	(0.06)
Constant	-7.941**	-2.060
	(-2.37)	(-0.70)
Observations	86	86
R^2	0.106	0.097
White χ^2	5.881	5.625
White p-value	0.998	0.999
BP χ^2	0.432	0.624
BP p-value	0.511	0.430

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$