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For a Few Dollars More: Reserves and Growth in Times of Crises*

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Résumé

Cette étude aborde la question de l'accumulation de réserves internationales, et de leur rôle protecteur pendant la crise financière de 2008-09, en se fondant sur un panel de 112 pays émergents ou en développement. Plus spécifiquement, cet article étudie la relation entre le niveau de réserves internationales et la présence de contrôles des capitaux. Les résultats indiquent que le niveau de réserves joue un rôle important : les pays ayant un niveau de réserves élevé (en proportion de leur dette à court terme) ont relativement moins souffert de la crise, particulièrement quand leur compte de capital est moins ouvert. Cela suggère une certaine complémentarité entre accumulation de réserves et contrôles des capitaux.

Mots clés: Réserves de change, contrôle des capitaux, crises financières, croissance économique.
Codes JEL: F31, G01.

Abstract

Based on a dataset of 112 emerging economies and developing countries, this paper addresses the question whether the accumulation of international reserves has effectively protected countries during the 2008-09 financial crisis. More specifically, the paper investigates the relation between international reserves and the existence of capital controls. We find that the level of reserves matters: countries with high reserves relative to short-term debt suffered less from the crisis, particularly when associated with a less open capital account. This suggests some degree of complementarity between reserve accumulation and capital controls.

Keywords: Foreign reserves, capital controls, financial crises, economic growth
JEL classifications: F31, G01

Non-technical summary

Can international reserves effectively protect countries against external shocks ? The present paper tackles this long-standing question by focusing on the 2008-09 financial crisis. Given the unprecedented amounts of international reserves accumulated by some emerging market and developing countries in the run-up to the crisis, we test the proposition that countries holding more reserves have fared better, in terms of GDP growth.

To this aim, we use a database of 112 emerging economies and developing countries. Our dependent variable is a measure of the extent of the crisis (proxied here by two different measures of output collapse, which control for idiosyncratic factors). We test whether this measure is statistically related to the level of reserves before the crisis, controlling for other factors. Given the debate on what constitutes the most appropriate metrics for international reserves, we construct a set of reserve ratios, expressing reserves as a percentage of GDP, imports, M2 and short-term debt. The results indicate that when reserves are measured as a percentage of short-term debt, there is a statistically significant relationship with the dependent variable, but not for the other reserve adequacy ratios. This result is robust to using alternative definitions of the crisis variable, different subsamples (EME only or combined with least developed countries (LDC)) or introducing additional control variables. In this set of regressions we also use an instrumental variable approach to account for a potential endogeneity bias.

Next, we focus on the interaction between international reserves and capital account openness by introducing an interaction term involving these two variables. We find that the coefficient of the interacted term is significantly different from zero, although this result is sensitive to the sample composition. The magnitude of the marginal effects of reserves depends on the degree of capital controls; that is, a less open capital account reinforces the positive marginal effect of reserves that we find in the first set of regressions. This suggests that foreign reserves and capital controls are complementary, reinforcing each other.

1 Introduction

In the decade preceding the 2008 global financial crisis (GFC), emerging market economies (EME) accumulated large stocks of international reserves (Figure 1). The unprecedented pace of reserve accumulation was, at least partly, a response to the lessons drawn from previous financial crises, which predominantly affected emerging markets. Most research on emerging market crises suggests 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 to what extent the accumulation of international reserves has protected countries from the negative shock of the latest crisis: have countries with more reserves fared better, in terms of output growth performance, than countries with less reserves? Are there, in addition, other policy tools that can strengthen or dampen the effects of reserves on growth performance?

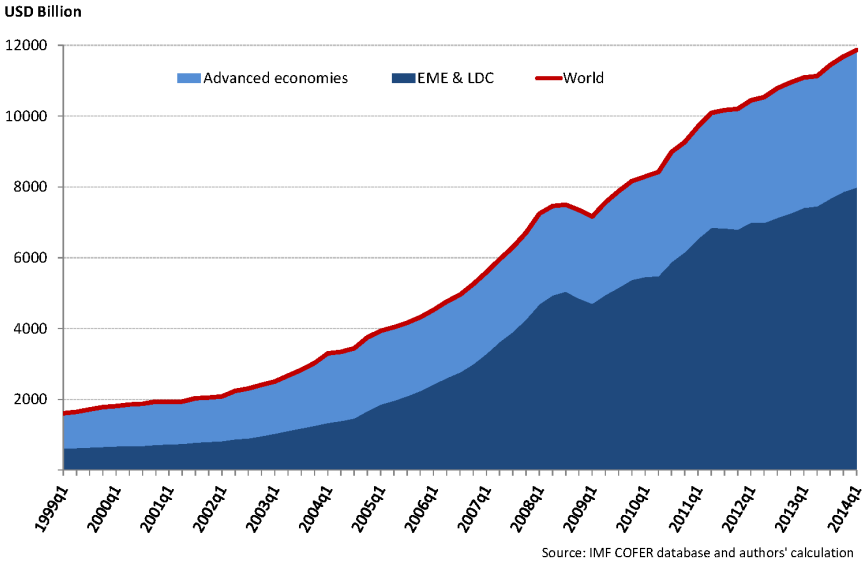


Figure 1: World international reserves

To answer the above questions, this paper aims at identifying the relationship between pre-crisis foreign reserve accumulation and economic growth during the GFC; the latter

[1]For a detailed review of this literature, see Flood and Marion (1999), Berg and Pattillo (1999), Kaminsky and Reinhart (1999), Bussière and Mulder (1999), Gourinchas and Obstfeld (2012), Catao and Milesi-Ferretti (2014) and Obstfeld (2014).

can be viewed as an ultimate test for the usefulness of reserves as an insurance mechanism.

Against this background, the paper presents two sets of findings. First, we test the hypothesis that international reserves fulfill the protective role they are often assigned to, by testing whether the extent of the crisis (proxied here by two different measures of output collapse, which control for idiosyncratic factors) are related to the level of reserves before the crisis. More specifically, given the debate on what constitutes the most appropriate metrics for international reserves, we construct a set of reserve ratios, expressing reserves as a percentage of GDP, imports, M2 and short-term debt. The results indicate that when reserves are measured as a percentage of short-term debt, there is a statistically significant relationship with the dependent variable, but not for the other reserve adequacy ratios. This result is robust to using alternative definitions of the crisis variable, different sub-samples (EME only or combined with least developed countries (LDC)) or introducing additional control variables. In this set of regressions we also use an instrumental variable approach to account for a potential endogeneity bias. We develop two main instruments for our reserve ratio, focusing on reserve accumulation in neighboring countries as an alternative accumulation motive.

Second, we focus on the interaction between international reserves and capital account openness by introducing an interaction term involving these two variables. We find that the coefficient of the interacted term is sometimes significantly different from zero. The magnitude of the marginal effects of reserves depends on the degree of capital controls; that is, a less open capital account reinforces the positive marginal effect of reserves that we find in the first set of regressions[2]. This suggests that foreign reserves and capital controls are complementary, reinforcing each other.

We choose to focus only on non-advanced countries (NAC) in this paper, as they have very different reserve and capital account policies compared to advanced countries. As Figure 2[3] illustrates, developing and emerging market economies have accumulated

[2]The relationship between capital controls and foreign reserve accumulation is complex. Several parallel stories can be advanced regarding why the stock of reserves is larger in an economy with capital controls (for keeping the domestic currency undervalued, or for social welfare concerns). We provide an analysis of the subject in Section 3.3. In any case, the multiple motives for reserve accumulation do not preclude testing the usefulness of reserve holdings during the crisis, alone or with capital controls.

[3]In Figure 2, the y-axis represents the average reserves to GDP ratio and the x-axis represents the

more international reserves and have kept their capital account more closed. Advanced countries, by contrast, chose to open their capital account with a clear jump towards greater financial openness around 1992-1993, but typically do not hold large amounts of reserves.

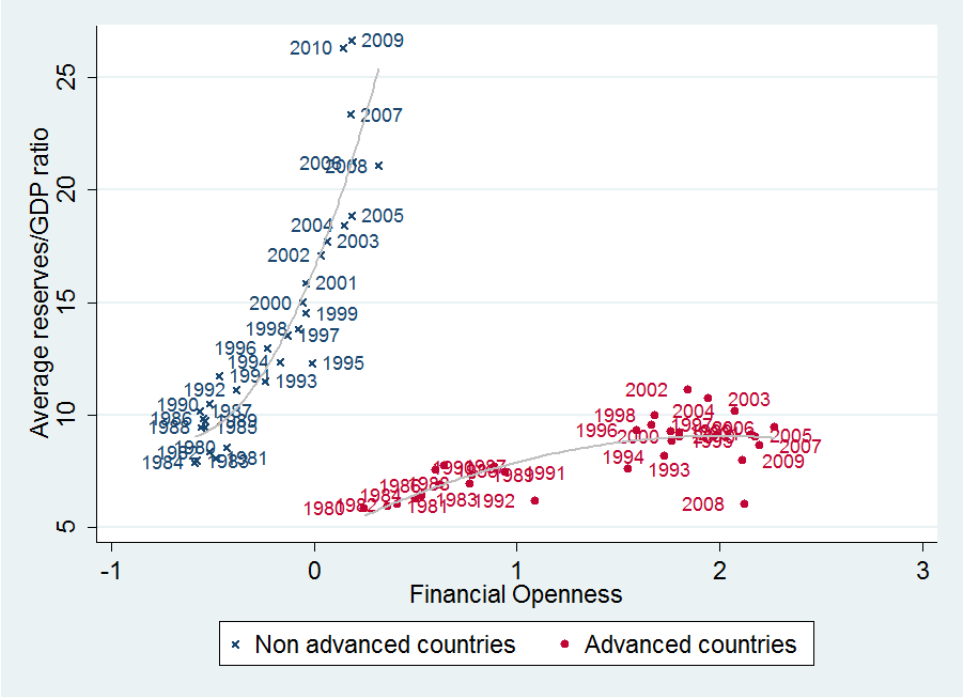


Figure 2: International reserves vs. capital controls

Our paper follows three strands of literature: the motives of foreign reserve accumulation, the impact of foreign reserve accumulation on real economic growth during crisis times and the behavior of reserve holding during the GFC. Foreign reserve accumulation in this paper is, in fact, closely associated with the theoretical papers underpinning the precautionary motive, which suggests that a sufficient stock of reserves is useful to purchase foreign imports and to repay external debt coming due when no external borrowing is possible[4]. Jeanne and Rancière (2011) in particular suggests that an average country needs to hold a stock of reserves equivalent to 9.1% of its GDP to offset the negative impact of the financial account reversal on domestic economy. Our paper aims at provide some empirical evidence to this literature.

average financial openness in a given country group.

[4]See Jeanne and Rancière (2011), Benigno and Fornaro (2012) and Bianchi et al. (2012)

In terms of empirical evidence, Rose and Spiegel (2009), Rose and Spiegel (2010), Blanchard et al. (2010), Llaudes et al. (2010) and Frankel and Saravelos (2012) are among the first papers looking at the impact of the GFC on emerging market economies by regressing a set of crisis impact variables (e.g. output losses, consumption growth changes, exchange market pressure index, etc.) on a battery of pre-crisis policy variables, including foreign reserves. Blanchard et al. (2010) and Rose and Spiegel (2009) find that the pre-crisis level of foreign reserves does not play a central role in protecting countries from the global financial crisis. In contrast, Frankel and Saravelos (2012) find that the foreign reserve level (scaled by GDP, external debt and imports) in 2007, along with exchange rate movements, is a significant leading indicator of the cross-country incidence of the crisis: the higher the foreign reserve ratios, the less likely an economy would be hit by the global financial crisis. In the same vein, Llaudes et al. (2010) find a positive and statistically significant role of reserves scaled by short-term debt on output growth during the crisis. They further argue that this relationship is non-linear; namely, reserves had a more significant impact on output in countries with low levels of reserves but much less in countries with high levels of reserves. Our paper incorporates several novel aspects. The above cited papers are all broad studies examining many different aspects of the crisis impact using a number of different policy variables. In contrast, our paper focuses on the relationship between pre-crisis reserve accumulation and real economic growth during the crisis. One key important contribution of our paper is to assess the impact of reserves alongside capital controls. We provide intuition and empirical evidence on the complementarity between reserves and capital controls in terms of managing the impact of the global financial crisis. Moreover, we go beyond a mere documentation of the correlation between reserves and growth by using instrumental variables. In addition, the results from these early papers lead to diverging conclusions as different authors used different reserve metrics and different country samples. The samples used are much smaller than in our study. For instance, Blanchard et al. (2010) run a regression using 29 countries and Llaudes et al. (2010) have a mixed sample of emerging economies and developing countries with 40 observations. For our paper, we construct a large dataset of

more than 100 emerging and developing countries and we follow a rigorous econometric procedure to establish the relationship between reserves and economic growth.

Finally, our study is also related to several papers that examine the use of reserves during the GFC. Aizenman and Sun (2009), Aizenman and Hutchison (2012), Dominguez (2012) and Dominguez et al. (2012) have all addressed the following question: if international reserves are held to cope with potential external shocks, were they used during the GFC? While Aizenman and Hutchison (2012) highlight the 'fear of losing reserves', Dominguez (2012) and Dominguez et al. (2012) find that countries whose pre-crisis reserves exceeded optimal levels predicted by standard models of reserve accumulation were the most likely to use their reserves during the crisis. Compared to this strand of literature on the use of reserves, we defend the thesis that the pre-crisis level of reserves still matters. For us, international reserves should be viewed as being akin to 'nuclear weapon' having a deterrent effect, rather than to true 'gunpowder', to be used in intervention. In other words, having a large stock of reserves prior to any external shocks will deter speculators from attacking. This is of course consistent with the literature of the second generation crisis model (e.g. Obstfeld, 1986) that demonstrates that the occurrence of a speculative attack on a country's currency is conditional on this country's foreign reserve holdings. A sufficient level of reserves will hence obviate the need for a country to intervene massively as the risk of crises is minimized.

The rest of the paper is organized as follows. Section 2 describes the data and the methodology used. Section 3 presents our main econometric analysis of the role of international reserves on economic growth during the GFC. Section 4 concludes.

2 Data and specification

2.1 Data and key variables

Our primary data source for annual international reserves is the database *International Financial Statistics* (IFS) of the International Monetary Fund (IMF). The macroeconomic data are also retrieved from the *IFS* and complemented with the *World Development*

Indicators (WDI) issued by the World Bank (WB). For selected countries that are absent from the IMF and WB databases (e.g. Taiwan), national sources are used.

To preserve the homogeneity of our sample in terms of reserve accumulation and capital account policy, we decided to focus only on non-advanced countries. Our database includes 161 countries, divided into two sub-samples: 32 EMEs and 129 LDCs. EMEs are defined according to a combined criteria of the IMF and the economic magazine *the Economist*. For 49 countries, we did not have enough observations for the key independent variables including control variables; therefore, 112 countries are effectively used in our main regressions. The details about our country coverage can be found in Online Appendix B.

2.1.1 International reserves

Several important features of the reserve data we use in this paper need to be highlighted.

Which assets are included in reserves? International reserves can be defined as the immediately available external assets denominated in foreign currencies that a country's government or monetary authority effectively holds. According to the *IFS*, total international reserves comprise foreign exchange reserves[5], reserve position in the Fund, the U.S. dollar value of SDR holdings and gold holdings[6]. Except gold holdings, all the other assets are included in the reserve data we use in the scope of this paper. The reason to exclude gold holdings is that the gold share is very small in non-advanced countries and gold holdings are less liquid than other reserve assets. As foreign reserves constitute the major component of international reserves (reserve position in the Fund and SDR holdings are also very small), we will interchangeably use the terms international reserves and foreign reserves in this paper.

Similarly, external assets held by sovereign wealth funds are not included in our reserve data. Foreign assets held by a sovereign wealth fund and that under control of a central

[5]This includes 'official claims on nonresidents in the form of foreign banknotes, bank deposits, treasury bills, short- and long-term government securities and other claims usable in the event of balance of payments need' (IFS Yearbook 2012).

[6]Gold holdings are expressed in millions of fine troy ounces and valued in U.S. dollar by each country.

bank are indeed managed under very different principles. While higher returns and strategic value are the objective of reserve management in a sovereign wealth fund, the liquidity and security of foreign assets are the guidelines for reserve management in a central bank. As we focus on the insurance role of foreign reserves, we only consider those foreign assets managed under the liquidity and security motives.

Moreover, the IMF credit facilities (e.g. Precautionary and liquidity line, Flexible credit line, Stand-by facility, etc.) and bilateral swap lines between countries are not included in foreign reserves defined by the *IFS* and used in this paper[7]. There are fundamental differences between the self-owned stock of foreign reserves and *ad hoc* contingent facility instruments which are short-term in nature. A few papers examine the substitutability between swap lines and foreign reserves (See Aizenman et al., 2011, Obstfeld et al., 2009). Although the role of these alternative forms of financing is out of the scope of this paper, we do control the existence of IMF credit lines and swap lines with US Federal Reserves as additional robustness checks to our baseline results.

How to incorporate reserve data into our analysis? In this paper, we will use reserve adequacy ratios (in log[8]) instead of the absolute level of reserves. The reasons are two-fold. First, a reserve adequacy ratio facilitates cross-country comparison; the heterogeneity in the stock of reserves is tremendous, for example between China, which holds more than a third of the world foreign reserves, and small African countries. Second, the absolute level of reserves does not provide useful information about the robustness and resilience of a country facing shocks; at most it shows the country has enough financial resources to purchase reserve assets. On the contrary, reserve adequacy ratios do provide information about how reserves can be deployed to cope with some underlying target variables. Based

[7]However, we used a dummy variable for the Fed swap lines. This only concerns Korea and Mexico in our non-advanced country sample. The introduction of this dummy does not change our results. Details are available upon request.

[8]We use the log ratio in our regressions for several reasons. First, it is commonly used in the existing literature regarding the role of foreign reserves during crises in emerging market economies. Second, the evolution of international reserves, especially in non-advanced countries, is non-linear, displaying an exponential pattern. Third, based on our analysis, the effect of *ex ante* holding of reserves on economic growth is non-linear; it exhibits positive and concave patterns, meaning that the marginal contribution of the reserve adequacy ratio on growth is diminishing. The effect is more pronounced for countries with low values of reserves to short-term debt ratio. Llaudes et al. (2010) provide a more detailed account on the non-linearity of this effect.

on an extensive literature, we use the following four indicators:

- GDP-based indicator : $log(\frac{\text{Reserves}}{\text{GDP}} \times 100)$ (rsv_gdp)
- Trade-based indicator: $log(\frac{\text{Reserves}}{\text{Imports}} \times 12)$ $(rsv\_imports)$
- Debt-based indicator: $log(\frac{\text{Reserves}}{\text{Short-term debt}} \times 100)$ (rsv_std)
- Money-based indicator: $log(\frac{\text{Reserves}}{M_2} \times 100)$ (rsv_m2)

The GDP-based indicator is a way to control for country size, no further information can be inferred from it. 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 months of imports. The debt-based indicator has developed with the financial integration of emerging market economies 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 repayment of all foreign-currency denominated short-term debt. The money-based indicator has gained popularity with Obstfeld et al. (2010) who emphasize the role of foreign reserves on stabilizing domestic financial markets. A country needs to hold enough foreign reserves to offset capital flight triggered by a weak confidence in that economy on financial markets. 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 covered by foreign reserves.

2.1.2 Capital controls

An important control variable for our analysis regards the controls on capital flows. There are a number of measures of capital controls in the literature, either *de jure* or *de facto*[9]. Our measure of capital controls is based on the *de jure* measure of capital

[9]For *de jure* measures see Chinn and Ito (2006), Kose et al. (2009), etc.; for *de facto* measures see Lane and Milesi-Ferretti (2007)

openness constructed by Chinn and Ito (2006). This is not only a widely used index of the financial openness, it also well captures regulatory restrictions on capital account transactions, which is essential as we focus on policy variables.

For ease of interpretation, we invert the Chinn-Ito index such that the higher our capital control index, the more stringent the constraints on both capital inflows and outflows. Table 1 summarizes the basic statistic descriptions of our measure.

Table 1: Capital controls: Descriptive Statistics (2007)

	Non-advanced countries			Advanced countries
	EME	LDC	Total	
mean	-0.69	-0.04	-0.18	-2.20
median	-0.12	1.14	0.29	-2.50
s.d.	1.53	1.58	1.59	0.61
min	-2.50	-2.50	-2.50	-2.50
max	1.14	1.86	1.86	-0.12
obs	31	117	148	30

2.2 Specification

The analysis of this paper is based on cross-section econometrics; this allows us to make cross-country comparisons and to homogenize the shock of the recent crisis. Our benchmark specification is described below:

$$y_{i,09} = \beta_0 + \beta_1 rsv_{i,07} + \boldsymbol{\beta X_{i,07}} + \epsilon_{i,09} \tag{1}$$

$rsv_{i,07}$ stands for one of the four reserve adequacy ratios mentioned above. $\boldsymbol{X_{i,07}}$ is a vector of additional control variables. Note that all the independent variables (except for dummies) are lagged two periods[10]. Taking lagged independent variables allows us to have a snapshot of the situation of the country before the start of the crisis, and to use this picture to explain its performance during the crisis. Using later values for reserves and other controls would be problematic, since countries may already have changed their

[10]As a robustness test, we have also used independent variables lagged three periods. The results remain very similar to that presented in the paper. Details can be provided upon request.

reserve holdings by the end of 2008 due to the start of the crisis. Yet, this does not solve endogeneity issues, which we will tackle in Section 3.4.

To assess the role of foreign reserves in mitigating the crisis impact on real economic growth in 2009, we need to construct appropriate measures of the GFC impact, namely our independent variable $y_{i,09}$. Based on the above-cited literature on this issue, we use two measures that aim at capturing the gap between the actual real economic growth rate and a counterfactual growth rate should the crisis have not occurred.

The first method calculates the difference between the realized real economic growth rate and a linear prediction from a historical mean. We call this dependent variable 'purged real GDP growth', and denote it $rgdp\_residual$ in our equations and tables. It is obtained as follows:

$$rgdp\_residual_{i,09} = \Delta ry_{i,09} - \widehat{\Delta ry}_{i,09} \tag{2}$$
$$\text{where} \quad \widehat{\Delta ry}_{i,09} = \hat{\alpha}_0 + \hat{\alpha}_1 \overline{\Delta ry}_{i,03-08}$$

The coefficients $\hat{\alpha}_0$ and $\hat{\alpha}_1$ are estimated using a preliminary regression:

$$\Delta ry_{i,09} = \alpha_0 + \alpha_1 \overline{\Delta ry}_{i,03-08} + \epsilon_{i,09} \tag{3}$$

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

Our alternative dependent variable follows Blanchard et al. (2010) and Berkmen et al. (2012) and captures the change between the actual real GDP growth in 2009 and the IMF World Economic Outlook (WEO) forecast in the first quarter of 2008 (before the Lehman collapse in September of the same year). This variable measures the real output losses due to the unexpected magnitude of the financial crisis. We call it 'unexpected real GDP growth' and denote it $rgdp\_fe$. One caveat about this variable is that there might be estimation errors associated with the forecast model that the IMF adopts. We assume

that these errors are not time-varying and consistent over time.

We have also tried another potential dependent variable: the difference between actual real GDP growth and a historical mean, over 2003-2008. We find consistent results using this different dependent variable[11].

In Appendix A, a list of the main variables used in our econometric analysis is available. In addition, Figures 5a and 5b illustrate the ranking of a few big emerging market economies (belonging to the G20) in terms of our two dependent variables $rgdp\_residual$ or $rgdp\_fe$.

3 The role of pre-crisis reserves during the GFC

3.1 Reserve adequacy ratios: 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 metrics.

We find that the reserves to short-term debt ratio is the most useful indicator to explain the real output growth during the crisis. The stock of foreign reserves scaled by the level of short-term debt two years prior to the crisis is positively and significantly correlated with the real GDP growth deviation from the trend. We illustrate this result using the full sample and the 'purged real GDP growth' as dependent variable in Table 2 (the different numbers of observations are due to the data availability of the scaling variables).

This simple bivariate result suggests that the underlying macroeconomic target of foreign reserve accumulation could be short-term debt, which is a destabilizing factor for economic growth in times of crisis (e.g. non-payment of foreign debt, or default, may lead to more stringent borrowing conditions). The central bank needs to have sufficient

[11]The results using this third variable as dependent variable are available upon request due to the limited length of the paper.

foreign-currency assets to pay the country's foreign creditors in an immediate future to sustain production. This results is in line with a large literature on short-term debt and crisis vulnerability, such as Reinhart and Rogoff (2011), Dobrescu et al. (2011) and Berkmen et al. (2012).

Table 2: Results with different reserve adequacy ratios

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
L2.log rsv/gdp	-0.359			
	(0.607)			
L2.log rsv/imports		0.704		
		(0.627)		
L2.log rsv/m2			-0.0378	
			(0.564)	
L2.log rsv/std				0.624**
				(0.257)
Constant	1.522	-0.590	0.491	-3.165**
	(1.814)	(1.058)	(2.097)	(1.588)
Observations	143	134	138	138
R^2	0.002	0.009	0.000	0.042
Adjusted R^2	-0.005	0.002	-0.007	0.035

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

This result is robust even if we switch the dependent variable to the 'unexpected real GDP growth' (Table 9 in Online Appendix C). The coefficient associated with the reserves to short-term debt ratio is significant. We have also checked the robustness of this result by removing outliers[12] and small countries [13] from the sample. As can be seen in Tables 10 and 11 in Online Appendix C, the main conclusions remain unchanged. Given that China has a very specific behavior in terms of reserve accumulation, we also removed this country from the sample, and obtained largely unchanged results.

[12]The outliers removed are countries whose reserve adequacy ratio or dependent variable fall below the 1st percentile or above the 99th percentile. They correspond to Armenia, Bahamas, Botswana, Latvia, Lebanon, Liberia, Libya.

[13]We use the World Bank classification to define small countries.

There is, however, a natural question that arises at this point: although the coefficient of the reserves to short-term debt ratio is significant, does the statistical significance come from the numerator or the denominator of this ratio? Although legitimate, this is a complex question, which is tackled in Online Appendix D. Evidence is mixed, but these additional results seem to indicate that short-term debt plays an important role, and therefore the significance of our results is not only due to reserves.

3.2 Adding control variables

In order to better understand the influence of reserve holdings on output growth, we add control variables and estimate the full specification of our regression equation (1). The vector of control variables $\boldsymbol{X_{i,07}}$ includes capital controls, trade openness, an exchange rate regime dummy[14] and an oil exporter dummy[15].

After controlling for further specific characteristics of different countries, we still find that the accumulation of foreign reserves prior to the crisis positively and significantly contributes to the real GDP growth during the crisis. The significance and magnitude of the coefficient associated with the reserve adequacy ratio remain similar when adding controls, for both our dependent variables (columns (1) and (2) in Table 3).

We further test the robustness of our results by estimating the same regressions using trimmed samples. Online Appendix E provides the results obtained after outliers[16] or/and small countries are ruled out. The coefficients have the same signs as in Table 3 but have larger magnitude and stronger significance. One additional control variable, trade openness, becomes significant and has a negative sign as expected when *rgdp_residual* is used as dependent variable. The goodness of fit, in terms of R^2 and adjusted R^2, also becomes

[14]Our exchange rate regime dummy is constructed based on the classification by Reinhart and Rogoff (2004). It takes the value 1 when a country has a 'crawling peg' or more controlled exchange rate regime; it takes the value 0 when a country has a 'managed floating' or 'free floating' regime.

[15]The countries classified as oil exporters/producers are the following: Algeria, Angola, Bahrain, Cameroon, Chad, Congo, Ecuador, Equatorial Guinea, Gabon, Iran, Iraq, Kazakhstan, Kuwait, Libya, Mexico, Nigeria, Oman, Qatar, Russia, Saudi Arabia, Sudan, Timor-Leste, Trinidad and Tobago, Turkmenistan, United Arab Emirates, Uzbekistan, Venezuela, Yemen.

[16]Defined in the same line as in footnote 12, namely all observations which fall below the 1st percentile or above the 99th percentile of any continuous variables (i.e. dependent variable, reserve ratio and trade openness). This criterion will apply in the subsequent sections when outliers are eliminated. As a result we further drop Brazil, Hong Kong, Rwanda and Singapore from the sample (no financial centers in this case).

Table 3: Full specification

	(1) rgdp_fe	(2) rgdp_residual
L2.log rsv/std	0.615**	0.729**
	(0.291)	(0.317)
L2.capital controls	0.498*	0.689**
	(0.282)	(0.307)
L2.exchange regime index	-1.282	-0.652
	(1.335)	(1.457)
L2.trade openness	-0.0194*	-0.0184
	(0.0117)	(0.0128)
oil dummy	-2.612**	-1.561
	(1.292)	(1.410)
financial center	5.374	5.284
	(4.941)	(5.395)
Constant	-5.527**	-1.400
	(2.358)	(2.575)
Observations	112	112
R^2	0.154	0.155
Adjusted R^2	0.106	0.107

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

larger. Hence, our results can be regarded as robust and do not depend on outliers and small countries. For robustness, we also tested our results with additional control variables (i.e. net foreign assets and current account balance); the results are qualitatively similar. More restrictively trimmed samples have also been used throughout the paper[17]; the estimates of interest (reserves to short-term debt ratio and capital controls) become even larger and more significant. These results are available upon request.

3.3 Controlling for the interaction between reserves and capital controls

The introduction of an interacted term between foreign reserves and capital controls as a further control variable can help us check the robustness of our results, and shed light on the complementarity between foreign reserves and capital controls. We show how the role of foreign reserves on economic growth may depend on other relevant policies, in particular capital account management, and then present the specification we adopt to estimate the interacted term.

3.3.1 Intuition

Our empirical results suggest that foreign reserves and capital controls are complements with regard to their impact on economic growth during the GFC. We provide here some intuitions that support this particular relationship. In fact, foreign reserves can be seen as ammunitions of liquidity that can be deployed when a country is cut off from external financial markets and a closed capital account can be interpreted as a protected playing field for the impact of reserves to be effective. Indeed, capital controls insure that public capital outflows (foreign reserve purchasing) are not completely offset by private capital inflows (accumulation of private foreign liabilities). As a matter of fact, foreign reserves can be used to provide an aggregate insurance to the economy, but the moral hazard associated with foreign reserve accumulation might incite the private sector, firms and

[17]In these regressions, we have removed the top and bottom 5% observations of any continuous variables, or countries whose reserves to short-term debt ratio exceeds 1000 (75th percentile) in 2007.

banks, to take extra risks given that the government will provide foreign currency liquidity when it is necessary. Therefore, the insurance provided by foreign reserves can be offset by private capital inflows should the capital account be completely open. There are a few recent theoretical works which support our intuition and empirical finding. For example, Benigno and Fornaro (2012), Bacchetta et al. (2013) and Cheng (2013) all argue that the imperfect substitutability between public and private capital flows is crucial for foreign reserves to play a role. According to this strand of literature, foreign reserve accumulation and a closed capital account are complements rather than substitutes. In fact, foreign reserves allow the central bank to finance domestic bond issuance while capital controls enable it to control domestic interest rates to accommodate savers or borrowers depending on the tightness of the domestic financial frictions.

3.3.2 Specification

There are several ways to introduce an interactive term. To facilitate interpretation, we use a demeaned interacted term: $(rsv\_std_i - \overline{rsv\_std_i}) \times (cc_i - \overline{cc}_i)$ as stated in equation (4).

$$y_{i,09} = \beta_0 + \beta_1 rsv\_std_{i,07} + \beta_2 cc_{i,07} + \beta_3 \underbrace{(rsv\_std_{i,07} - \overline{rsv\_std}_{07}) \times (cc_{i,07} - \overline{cc}_{07})}_{\text{interaction}} + \boldsymbol{\beta x_{i,07}} + \epsilon_{i,09} \tag{4}$$

The marginal effect of foreign reserves is calculated as follows:

$$\frac{\partial y_{i,09}}{\partial rsv\_std_{i,07}} = \beta_1 + \beta_3 \times (cc_{i,07} - \overline{cc}_{07}) \tag{5}$$

Using this setting, the coefficient before rsv_std_i (respectively cc_i) refers to the marginal effect of that variable when cc_i (respectively rsv_std_i) is valued at its mean. Note that $\boldsymbol{x_{i,07}}$ refers to the set of control variables we used in Section 3.2 except capital controls.

To fully validate the introduction of an interacted term, we need to make sure that a statistically significant coefficient before the interacted term does not come from a bivariate relationship between the two variables incorporated in the interacted term, namely rsv_std_i and cc_i in this paper[18].

[18]To avoid spurious regressions, we have controlled for the quadratic forms of rsv_std_i and cc_i re-

3.3.3 Results

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

In Table 4, columns (1) and (2), we see that foreign reserves and capital controls both contribute to reduce a country's real GDP losses during the recent financial crisis (they both have a positive and significant coefficient). The coefficient associated with the interacted term is also significant and positive, reinforcing the marginal effects of the reserve adequacy ratio and of capital controls. One can look at the joint F-test (test scores reported at the bottom of Table 4) between reserves and the interaction term in order to infer the significance of the impact of foreign reserves on growth. These estimates are indeed jointly highly significant (at the 98% significance level).

Taking into account the interactive term, we can calculate the marginal effects of foreign reserves on economic growth as a function of capital controls using the estimates reported in Table 4 column (2):

$$\frac{\partial y_{i,09}}{\partial rsv\_std_{i,07}} = 0.623 + 0.333 \times (cc_{i,07} - \overline{cc}_{07}) \tag{6}$$

The marginal effect of reserves on $rgdp\_residual$ is equal to 0.623 for a country that has an average level of capital controls. The more stringent a country's capital account (higher value of cc), the more pronounced the marginal effect of the *ex ante* foreign reserve adequacy ratio on economic growth during the GFC. Figure 3a gives an illustrative overview of the evolution of the marginal effects of reserves as a function of the tightness of capital controls. The marginal effects of reserves is increasing and becomes positive slightly before capital controls reach their 3rd decile ($cc > -1.18$); it becomes significantly different from zero when capital controls are beyond their 5th decile ($cc > -1.12$). Moreover, Figure 3b shows how the predicted real detrended economic growth improves with a higher reserves to short-term debt ratio when all other variables (including capital

spectively. We have also orthogonalized these two key variables using the Frisch-Waugh theorem before constructing the interacted term. The details of these results are available upon request.

controls) are valued at their mean value.

Table 4: Foreign reserve accumulation and capital controls

	(1) rgdp_fe	(2) rgdp_residual	(3) rgdp_fe	(4) rgdp_residual
L2.log rsv/std	0.506*	0.623*	0.911***	0.866***
	(0.291)	(0.319)	(0.305)	(0.329)
L2.capital controls	0.586**	0.774**	0.0713	0.281
	(0.281)	(0.308)	(0.274)	(0.292)
L2.log rsv/std × capital controls	0.345**	0.333*	0.0965	0.170
	(0.170)	(0.187)	(0.199)	(0.216)
L2.exchange regime index	-1.344	-0.711	-0.934	-0.260
	(1.316)	(1.443)	(1.234)	(1.316)
L2.trade openness	-0.0191*	-0.0181	-0.0233**	-0.0283**
	(0.0115)	(0.0126)	(0.0105)	(0.0113)
oil dummy	-2.642**	-1.590	-3.124***	-1.962
	(1.273)	(1.396)	(1.137)	(1.214)
financial center	4.718	4.649		
	(4.881)	(5.352)		
Constant	-4.981**	-0.872	-6.921***	-1.477
	(2.340)	(2.566)	(2.305)	(2.477)
Observations	112	112	104	102
R^2	0.186	0.180	0.215	0.206
Adjusted R^2	0.131	0.125	0.166	0.156
testccF	3.656	4.155	0.127	0.615
testccP	0.0292	0.0184	0.881	0.543
testresF	4.350	4.287	5.359	4.685
testresP	0.0153	0.0163	0.00620	0.0115

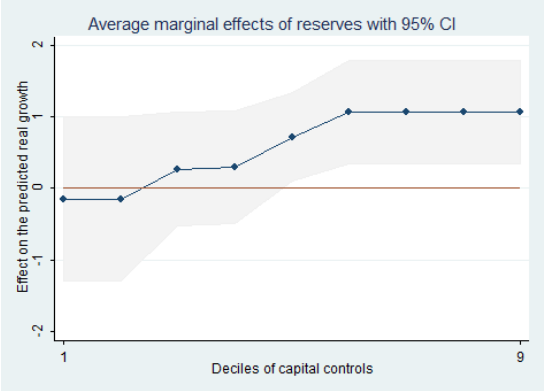
Standard errors in parentheses

Homoscedasticity not rejected according to the White test

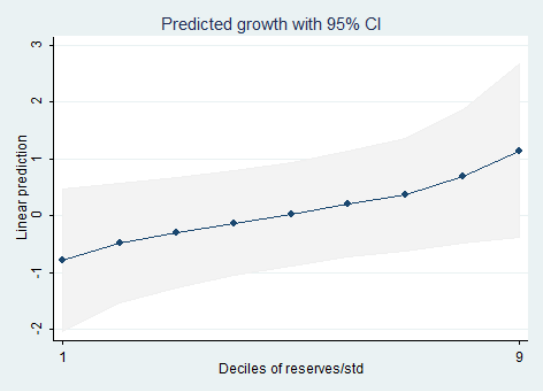
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Here again, we check for robustness by dropping outliers[19]. Whereas the previous results (without the interaction term between reserves and capital controls) were fairly robust to this change of sample, here both the coefficients of capital controls and of the interaction term lose significance when we control for outliers, as one can see in columns

[19]Results are similar when excluding both small countries and outliers. They are presented in Online Appendix F Table 16. Results using more restrictively trimmed samples are available upon request.



(a) Marginal effects of reserves



(b) Predicted real economic growth

Figure 3: Marginal effects and predictions

(3) and (4) of Table 4[20]. However, the coefficient associated with the reserves to short-term debt ratio is highly significant and increases in magnitude. From this, we can conclude that the impact of the reserve adequacy ratio itself is still fairly robust, even after we drop outliers from our sample. Finally, as regards the magnitude of the coefficient associated with the reserve adequacy ratio, it seems that the estimate we obtained in our benchmark regression (Table 3) is rather a minimal value, since the associated coefficient tends to increase when excluding outliers.

3.4 Accounting for endogeneity

As mentioned above, using foreign reserves as an explanatory variable to explain real economic growth can cause endogeneity issues. Foreign reserves might be held by a central bank as in anticipation of a future negative shock to the national economy; foreign reserves and higher GDP growth might also both be by-products of a mercantilist exchange rate policy. So far, we have been using lagged metrics of foreign reserves as our main explanatory variable without controlling for endogeneity; this is also the method adopted by most existing empirical papers on foreign reserves. This may induce a bias in our coefficient estimates, the direction of which is however ambiguous. On the one hand, if we consider that fragile countries accumulate more reserves for precautionary reasons,

[20]Note that by dropping outliers (top and bottom 1% of observations of each continuous variable), we drop all financial centers from our sample, which explains the absence of the financial center dummy in columns (3) and (4) of Table 4.

and are more likely to be affected in a crisis (because of the idiosyncratic fragility), we can argue that the OLS coefficient associated to reserves may be biased downwards. On the other hand, reserve accumulation can be a buy-product of an undervalued domestic currency, which stimulates economic growth through strong exports. This mechanism implies an upward bias of our OLS coefficient. It is therefore difficult to predict the direction of the bias altogether. We go one step further to account for endogeneity and reverse causality by choosing appropriate instrumental variables for foreign reserve metrics.

3.4.1 Construction of instrumental variables

Finding an instrumental variable for reserves is not an easy task. An appropriate instrumental variable needs to fulfill two conditions: first, it needs to be correlated with the instrumented variable; second, it must be uncorrelated with the error term in the original OLS regression (equation (1)). After carefully examining various candidates, we conclude that the regional peer pressure is the best suited instrumental variable with respect to our analysis.

Regional peer pressure for reserve accumulation captures the idea of 'keeping up with the Joneses', namely a country might be motivated to hold foreign reserves as its neighbors do so. In many empirical papers[21], this idea of regional peer pressure is introduced to study the demand function of foreign reserves. Therefore, it should be highly correlated with foreign reserve accumulation *per se*. Furthermore, these instrumental variables allow us to focus on reserves accumulated for 'neighborhood' motives, and disregard those related to precautionary or mercantilist motives, which are related to the economic performance of a country and therefore endogenous.

As for our instrumental variables, we propose two proxies to measure the regional peer pressure:

- $\boldsymbol{IDW06_i}$: An inverse distance weighted mean for country i measures the average of the reserves to GDP ratio of all other countries in the world ($j \neq i$) weighted by the inverse distance between country i and country j (so that country i's neighbors

[21] See Bastourre et al. (2009), Cheung and Sengupta (2011), etc.

matter more than remoter countries). We assume that country i can only observe the decision made by other countries in terms of reserve accumulation in the previous year. As a result, we use the inverse distance weighted mean in 2006 as the instrument for the reserves to short-term debt ratio in 2007. This instrument has the advantage of being more broadly defined and comprising much more information than regional dummies. The construction of $IDW06_i$ is detailed below and the data on geographical distance is retrieved from Mayer and Zignago (2011). Note that country i's own reserve ratio is not included in its distance weighted mean.

$$IDW06_i = \sum_{j \neq i} w_i^j \frac{Reserves_j}{GDP_j} \tag{7}$$

$$w_i^j = \frac{(dist_{ij})^{-2}}{\sum_{k \neq i}(dist_{ik}^{-2})} \tag{8}$$

- ***Joneses$_i$***: The Joneses index defined by Cheung and Sengupta (2011) is calculated by the sum of the reserves to GDP ratio of country i's neighboring countries $j \neq i$ in a given geographical region[22]. Here again, country i's own reserve ratio is excluded from this sum.

$$Joneses_i = \sum_{j \neq i} \frac{Reserves_j}{GDP_j} \tag{9}$$

Given the regional patterns we observe in terms of reserves accumulation (Asian countries for instance accumulate much more reserves than others), we expect a positive correlation between our instrumental variable and our reserve adequacy ratio. Moreover, we need to insure that our instrumental variables are 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 compared to non-crisis times, 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). The importance of reserve holdings of a country i's neighbors in 2006

[22]We define 8 regions: East Asia & Pacific, South Asia, Eastern Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, Sub-Saharan Africa, European Union (27) and North America. Advanced countries being dropped out, the latter two regions, European Union (27) and North America do not have observations.

should not be directly related to the impact of the 2009 financial crisis on economic growth in country i. Hence, the reserve accumulation behavior of neighbor countries before the crisis has no clear relationship with residuals of our OLS regression (which correspond to the crisis impact that is not explained by reserves, capital controls, trade openness, exchange rate regime, and financial centers)[23].

We provide the results of the first-stage regressions using our candidate instrumental variables, in Table 17 in Appendix G. Column (1) shows the results using the distance-weighted index, column (2) uses the Joneses index, while column (3) uses both variables as joint instruments. In all three cases we find a significant correlation with the instrumented variable, reserves to short-term debt ratio, and obtain signs consistent with our expectation, namely the stronger regional pressure, the higher reserve adequacy ratio. The R^2 is also reasonably large, around 14% in all three cases. These findings confirm our choice of instrumental variables. The sign and goodness of fit of the distance-weighted index remain stable when we drop outliers; that of the Joneses index is slightly weaker (see Table 18 in Online Appendix G).

3.4.2 Two-stage least square regressions

We present in Table 5 the results of the second stage regression when the reserve adequacy ratio is instrumented. To facilitate interpretation, we repeat our OLS results in column (1). Columns (2), (3) and (4) respectively show the final results of the two-stage least square procedure (2SLS) using the distance-weighted index, the Joneses index and both.

Using instrumental variables, the coefficients of interest in our regressions are not significant any more. This result is not very surprising, since we know that the 2SLS procedure usually yields larger standard errors, driving down the significance of the 2SLS estimates. For this reason, it is hard to conclude anything in terms of bias correction

[23]One caveat: one may argue that countries in a given region have similar trade and financial flows, therefore the pattern of their reserve accumulation may have a common component related to common growth expectations in the region. This would weaken the exogeneity of our instruments, especially the "Joneses" index. However, we do not think that the regions defined face very similar trade shocks. For instance, in the "East Asia & Pacific" region, countries like Singapore and Hong Kong may have similarities, but those are probably not shared with Cambodia or Myanmar, that are part of the same region.

Table 5: 2SLS: Second stage

	(1) OLS	(2) distance weighted index	(3) Joneses	(4) both
L2.log rsv/std	0.729**	2.088	0.944	1.413
	(0.317)	(1.888)	(1.485)	(1.213)
L2.capital controls	0.689**	0.506	0.660*	0.597*
	(0.307)	(0.408)	(0.356)	(0.343)
L2.exchange regime index	-0.652	-1.330	-0.759	-0.993
	(1.457)	(1.789)	(1.589)	(1.556)
L2.trade openness	-0.0184	-0.00567	-0.0164	-0.0120
	(0.0128)	(0.0220)	(0.0184)	(0.0167)
oil dummy	-1.561	-2.131	-1.651	-1.848
	(1.410)	(1.673)	(1.498)	(1.479)
financial center	5.284	1.700	4.718	3.479
	(5.395)	(7.488)	(6.488)	(6.169)
Constant	-1.400	-9.972	-2.754	-5.716
	(2.575)	(12.03)	(9.502)	(7.821)
Observations	112	112	112	112
R^2	0.155	0.007	0.151	0.117
Adjusted R^2	0.107	-0.049	0.103	0.067
Hausman $p-value$	.	0.442	0.886	0.563

Standard errors in parentheses

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

and magnitude. The signs of the 2SLS estimates are consistent with the OLS estimates, although the magnitude of the 2SLS estimates are higher, but none of the coefficients estimated through 2SLS are significantly different from zero[24].

For robustness checks, Table 19 in Online Appendix G presents similar results when dropping outliers from the sample. We also instrumented the reserve adequacy ratio when adding the interaction term between reserves and capital controls in the regression; results are fairly similar to that presented above and are available upon request.

3.5 Foreign reserves: gunpowder or nuclear weapons?

We have so far seen that foreign reserve adequacy (relative to short-term debt) contributes, on its own or jointly with capital controls, to real output growth during the recent global financial crisis. Other papers (e.g. Aizenman and Sun, 2009 and Dominguez et al., 2012) rather focus on reserve depletion (i.e. use of reserves) and its impact on economic growth in the same period. These different views reflect an interesting question behind: are foreign reserves 'gunpowder', meaning that they have to be deployed during a war (crisis), or are they akin to 'nuclear weapons' - the mere existence of reserves suffices to act as a protection?

On the one hand, considered as "gunpowder", foreign reserves can be deployed in times of crisis to settle imports or to pay foreign creditors if market financing is cut off. Central banks can also use them to intervene on the foreign exchange market whenever the domestic currency is under depreciation pressure. Reserves can, on the other hand, be a deterrent force as "nuclear power". That is, the mere existence of sufficient reserves enhances investors' confidence on a country's expected exchange rate or its capacity to repay foreign liabilities; monetary authorities do not need to actually deplete reserves but only to keep them visible and credible in crisis time. In fact, as explained in Krugman (1999), a downward expectation on a country's currency would normally lead to an expected deterioration of firms or banks' balance sheet due to currency mismatch, which would ultimately results in lower aggregate investment. Cheng (2014) further proves,

[24]Considering that the corresponding Hausman test fails to reject the null hypothesis of exogenous right-hand-side variables, we feel more confident on relying on our OLS estimates.

using a theoretical model à la Krugman (1999), that this situation would not materialize if the central bank holds sufficient reserves and is committed to rescue the private sector. In this case, foreign reserves serve as a contingent insurance depending on the expected value of the domestic currency and do not necessarily need to be deployed.

We try to bring some empirical evidence to this question here. First, we want to know whether countries that had a larger pre-crisis level of reserves compared to short-term debt depleted more reserves during the GFC. The scatter plot in Figure 4 does not show a clear relationship between pre-crisis reserve adequacy and reserve depletion during the GFC[25]. This feature remains true even if we exclude outliers. It seems like only countries whose pre-crisis reserves to short-term debt ratio fits in the middle range depleted reserve assets during the GFC; countries that had either a very high or very low reserve adequacy ratio did not use much their reserves. Notice that in order to cover a broader range of non-advanced countries, we use the change in the *total* reserve stock as our proxy for reserve depletion during the GFC (different from Dominguez et al., 2012 who use SDDS data).

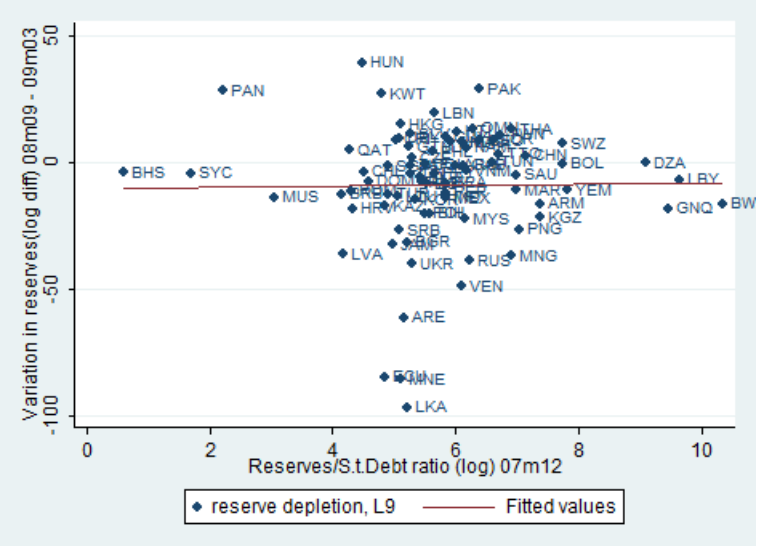


Figure 4: Depletion vs. Pre-crisis adequacy

Next, we include a control variable of reserve depletion in our main specification, equation (1), so that we can see whether this control variable has an effect on the co-

[25]We also tested this relationship empirically using an OLS regression. Results can be provided upon request.

efficients we estimated above. In particular, we are interested to see whether including reserve depletion changes the coefficient of pre-crisis reserve adequacy ratio.

For this exercise, we construct a dummy variable as a proxy of reserve depletion. It takes the value 1 if the growth rate of reserves is zero or negative between 2008 and 2009 and the value 0 otherwise. We find that the pre-crisis reserve adequacy ratio remains statistically significant when the variable of reserve depletion is added (reserve depletion itself is not significant, see Table 6). This result should be interpreted with caution, the depletion of reserves during the crisis being highly endogenous.

Table 6: Reserve depletion as a control variable

	(1)	(2)
	rgdp_residual	rgdp_residual
L2.log rsv/std	0.729**	0.752**
	(0.317)	(0.321)
L2.capital controls	0.689**	0.719**
	(0.307)	(0.313)
L2.exchange regime index	-0.652	-0.681
	(1.457)	(1.469)
L2.trade openness	-0.0184	-0.0169
	(0.0128)	(0.0130)
oil dummy	-1.561	-1.179
	(1.410)	(1.563)
financial center	5.284	4.844
	(5.395)	(5.458)
reserve depletion dummy		-0.758
		(1.422)
Constant	-1.400	-1.594
	(2.575)	(2.603)
Observations	112	111
R^2	0.155	0.157
Adjusted R^2	0.107	0.100

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

4 Conclusion

In the late 1990s and early 2000s, a consensus developed that reserves were useful in averting, or at least mitigating, the occurrence of crises in emerging market and developing countries. Policy makers from these countries have apparently absorbed the lessons from this literature, as the level of international reserves dramatically increased in the 2000s (even accepting that other motives have played a role). The results presented in this paper suggest that the Great Financial Crisis has further demonstrated the usefulness of reserves: empirically, the countries that held more reserves as a percentage of short-term debt have been less negatively impacted than others, ceteris paribus. The results also suggest that to some extent this effect is especially strong when the capital account is less open.

Given that reserves seem to have played a role in offsetting the effect of the crisis, it is not surprising that the countries that depleted reserves to a greater extent are also the ones that rebuilt them more quickly in the direct aftermath of the crisis. The IMF confirms, in fact 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 (IEO, 2012).' The behavior of post-crisis foreign reserve accumulation certainly deserves future research.

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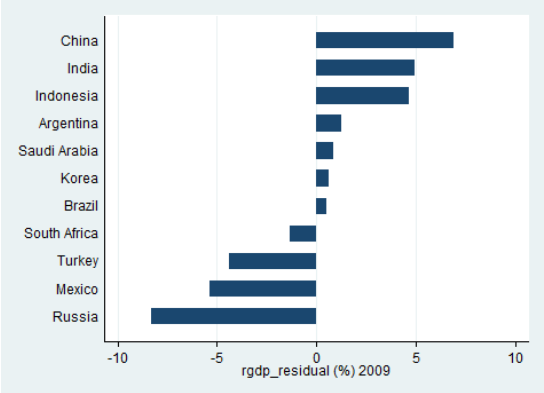
Appendix

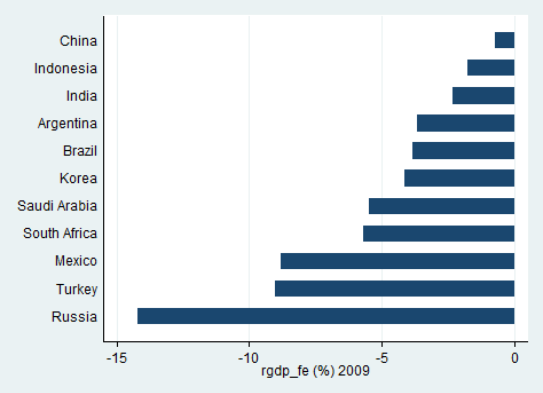
A Variables used for econometric analysis

Table 7: Key variable description

Variable	Description	Source
rgdp_residual	real GDP 09 - linear prediction from a mean 03-08	IMF IFS (2012)
rgdp_fe	real GDP 09 - IMF forecast in 2008Q1	IMF WEO (2008), IFS (2012)
rsv	reserve adequacy ratios detailed in p.9	IMF IFS (2012)
rsv_std	$log\frac{reserves}{s.t.debt} \times 100$	IMF IFS (2012)
capital controls (*cc*)	$-kaopen$	Chinn and Ito (2006)
trade openness	$\frac{X+M}{GDP} \times 100$	IMF IFS (2012)
exchange regime index	De facto exchange rate classification	Reinhart and Rogoff (2004)
oil dummy	Oil producer/exporter index	IMF (2012)
financial center	Financial center index	IMF (2012)



(a) Crisis impact using *rgdp_residual*



(b) Crisis impact using *rgdp_fe*

Figure 5: Marginal effects and predictions

B Country sample

For Eastern European countries, we decided to classify countries at the periphery of Europe and not in the Eurozone as emerging market economies, whereas countries that belong to the Eurozone are considered as advanced economies and not included in our sample.

Table 8: Country list

country	cncode	region	regioncode	country group
Afghanistan	AFG	South Asia	1	LDC
Albania	ALB	Europe & Central Asia	8	LDC
Algeria	DZA	Middle East & North Africa	4	LDC
Angola	AGO	Sub-Saharan Africa	7	LDC
Antigua and Barbuda	ATG	Latin America & Caribbean	3	LDC
Argentina	ARG	Latin America & Caribbean	3	EME
Armenia	ARM	Europe & Central Asia	8	LDC
Aruba	ABW	Latin America & Caribbean	3	LDC
Azerbaijan	AZE	Europe & Central Asia	8	LDC
Bahamas	BHS	Latin America & Caribbean	3	LDC
Bahrain	BHR	Middle East & North Africa	4	LDC
Bangladesh	BGD	South Asia	1	LDC
Barbados	BRB	Latin America & Caribbean	3	LDC
Belarus	BLR	Europe & Central Asia	8	LDC
Belize	BLZ	Latin America & Caribbean	3	LDC
Benin	BEN	Sub-Saharan Africa	7	LDC
Bhutan	BTN	South Asia	1	LDC
Bolivia	BOL	Latin America & Caribbean	3	LDC
Bosnia and Herzegovina	BIH	Europe & Central Asia	8	LDC
Botswana	BWA	Sub-Saharan Africa	7	LDC
Brazil	BRA	Latin America & Caribbean	3	EME
Brunei Darussalam	BRN	East Asia & Pacific	6	LDC
Bulgaria	BGR	Europe & Central Asia	8	EME
Burkina Faso	BFA	Sub-Saharan Africa	7	LDC
Burundi	BDI	Sub-Saharan Africa	7	LDC
Cambodia	KHM	East Asia & Pacific	6	LDC
Cameroon	CMR	Sub-Saharan Africa	7	LDC
Cape Verde	CPV	Sub-Saharan Africa	7	LDC
Central African Republic	CAF	Sub-Saharan Africa	7	LDC
Chad	TCD	Sub-Saharan Africa	7	LDC
Chile	CHL	Latin America & Caribbean	3	EME
China	CHN	East Asia & Pacific	6	EME
Colombia	COL	Latin America & Caribbean	3	EME
Comoros	COM	Sub-Saharan Africa	7	LDC
Congo	COG	Sub-Saharan Africa	7	LDC
Congo (Dem)	ZAR	Sub-Saharan Africa	7	LDC
Costa Rica	CRI	Latin America & Caribbean	3	LDC
Cote d'Ivoire	CIV	Sub-Saharan Africa	7	LDC
Croatia	HRV	Europe & Central Asia	8	LDC
Czech Republic	CZE	Europe & Central Asia	8	EME
Djibouti	DJI	Middle East & North Africa	4	LDC
Dominica	DMA	Latin America & Caribbean	3	LDC
Dominican Republic	DOM	Latin America & Caribbean	3	LDC
Ecuador	ECU	Latin America & Caribbean	3	LDC
Egypt	EGY	Middle East & North Africa	4	EME

El Salvador	SLV	Latin America & Caribbean	3	LDC
Equatorial Guinea	GNQ	Middle East & North Africa	4	LDC
Eritrea	ERI	Sub-Saharan Africa	7	LDC
Ethiopia	ETH	Sub-Saharan Africa	7	LDC
Fiji	FJI	East Asia & Pacific	6	LDC
Gabon	GAB	Sub-Saharan Africa	7	LDC
Gambia	GMB	Sub-Saharan Africa	7	LDC
Georgia	GEO	Europe & Central Asia	8	LDC
Ghana	GHA	Sub-Saharan Africa	7	LDC
Grenada	GRD	Latin America & Caribbean	3	LDC
Guatemala	GTM	Latin America & Caribbean	3	LDC
Guinea	GIN	Sub-Saharan Africa	7	LDC
Guinea-Bissau	GNB	Sub-Saharan Africa	7	LDC
Guyana	GUY	Latin America & Caribbean	3	LDC
Haiti	HTI	Latin America & Caribbean	3	LDC
Honduras	HND	Latin America & Caribbean	3	LDC
Hong Kong	HKG	East Asia & Pacific	6	EME
Hungary	HUN	Europe & Central Asia	8	EME
India	IND	South Asia	1	EME
Indonesia	IDN	East Asia & Pacific	6	EME
Iran	IRN	Middle East & North Africa	4	LDC
Iraq	IRQ	Middle East & North Africa	4	LDC
Jamaica	JAM	Latin America & Caribbean	3	LDC
Jordan	JOR	Middle East & North Africa	4	LDC
Kazakhstan	KAZ	Europe & Central Asia	8	LDC
Kenya	KEN	Sub-Saharan Africa	7	LDC
Kiribati	KIR	East Asia & Pacific	6	LDC
Korea	KOR	East Asia & Pacific	6	EME
Kosovo	KSV	Europe & Central Asia	8	LDC
Kuwait	KWT	Middle East & North Africa	4	LDC
Kyrgyz Republic	KGZ	Europe & Central Asia	8	LDC
Lao	LAO	East Asia & Pacific	6	LDC
Latvia	LVA	Europe & Central Asia	8	EME
Lebanon	LBN	Middle East & North Africa	4	LDC
Lesotho	LSO	Sub-Saharan Africa	7	LDC
Liberia	LBR	Sub-Saharan Africa	7	LDC
Libya	LBY	Middle East & North Africa	4	LDC
Lithuania	LTU	Europe & Central Asia	8	EME
Macao	MAC	East Asia & Pacific	6	LDC
Macedonia	MKD	Europe & Central Asia	8	LDC
Madagascar	MDG	Sub-Saharan Africa	7	LDC
Malawi	MWI	Sub-Saharan Africa	7	LDC
Malaysia	MYS	East Asia & Pacific	6	EME
Maldives	MDV	South Asia	1	LDC
Mali	MLI	Sub-Saharan Africa	7	LDC
Marshall Islands	MHL	East Asia & Pacific	6	LDC
Mauritania	MRT	Sub-Saharan Africa	7	LDC
Mauritius	MUS	Sub-Saharan Africa	7	EME
Mexico	MEX	Latin America & Caribbean	3	LDC
Micronesia	FSM	East Asia & Pacific	6	LDC
Moldova	MDA	Europe & Central Asia	8	LDC
Mongolia	MNG	East Asia & Pacific	6	LDC
Montenegro	MNE	Europe & Central Asia	8	LDC
Montserrat	MSR	Latin America & Caribbean	3	LDC
Morocco	MAR	Middle East & North Africa	4	EME
Mozambique	MOZ	Sub-Saharan Africa	7	LDC
Myanmar	MMR	East Asia & Pacific	6	LDC
Namibia	NAM	Sub-Saharan Africa	7	LDC
Nepal	NPL	South Asia	1	LDC

Nicaragua	NIC	Latin America & Caribbean	3	LDC
Niger	NER	Sub-Saharan Africa	7	LDC
Nigeria	NGA	Sub-Saharan Africa	7	LDC
Oman	OMN	Middle East & North Africa	4	LDC
Pakistan	PAK	South Asia	1	EME
Panama	PAN	Latin America & Caribbean	3	LDC
Papua New Guinea	PNG	East Asia & Pacific	6	LDC
Paraguay	PRY	Latin America & Caribbean	3	LDC
Peru	PER	Latin America & Caribbean	3	EME
Philippines	PHL	East Asia & Pacific	6	EME
Poland	POL	Europe & Central Asia	8	EME
Qatar	QAT	Middle East & North Africa	4	LDC
Romania	ROM	Europe & Central Asia	8	EME
Russia	RUS	Europe & Central Asia	8	EME
Rwanda	RWA	Sub-Saharan Africa	7	LDC
Samoa	WSM	East Asia & Pacific	6	LDC
Sao Tome and Principe	STP	Sub-Saharan Africa	7	LDC
Saudi Arabia	SAU	Middle East & North Africa	4	EME
Senegal	SEN	Sub-Saharan Africa	7	LDC
Serbia	SRB	Europe & Central Asia	8	LDC
Seychelles	SYC	Sub-Saharan Africa	7	LDC
Sierra Leone	SLE	Sub-Saharan Africa	7	LDC
Singapore	SGP	East Asia & Pacific	6	EME
Solomon Islands	SLB	East Asia & Pacific	6	LDC
Somalia	SOM	Sub-Saharan Africa	7	LDC
South Africa	ZAF	Sub-Saharan Africa	7	EME
Sri Lanka	LKA	South Asia	1	LDC
St. Kitts and Nevis	KNA	Latin America & Caribbean	3	LDC
St. Lucia	LCA	Latin America & Caribbean	3	LDC
St. Vincent and the Grenadines	VCT	Latin America & Caribbean	3	LDC
Sudan	SDN	Sub-Saharan Africa	7	LDC
Suriname	SUR	Latin America & Caribbean	3	LDC
Swaziland	SWZ	Sub-Saharan Africa	7	LDC
Syrian Arab Republic	SYR	Middle East & North Africa	4	LDC
Taiwan	TWN	East Asia & Pacific	6	EME
Tajikistan	TJK	Europe & Central Asia	8	LDC
Tanzania	TZA	Sub-Saharan Africa	7	LDC
Thailand	THA	East Asia & Pacific	6	EME
Timor-Leste	TMP	East Asia & Pacific	6	LDC
Togo	TGO	Sub-Saharan Africa	7	LDC
Tonga	TON	East Asia & Pacific	6	LDC
Trinidad and Tobago	TTO	Latin America & Caribbean	3	LDC
Tunisia	TUN	Middle East & North Africa	4	LDC
Turkey	TUR	Europe & Central Asia	8	EME
Turkmenistan	TKM	Europe & Central Asia	8	LDC
Tuvalu	TUV	East Asia & Pacific	6	LDC
Uganda	UGA	Sub-Saharan Africa	7	LDC
Ukraine	UKR	Europe & Central Asia	8	EME
United Arab Emirates	ARE	Middle East & North Africa	4	LDC
Uruguay	URY	Latin America & Caribbean	3	LDC
Uzbekistan	UZB	Europe & Central Asia	8	LDC
Vanuatu	VUT	East Asia & Pacific	6	LDC
Venezuela	VEN	Latin America & Caribbean	3	EME
Vietnam	VNM	East Asia & Pacific	6	LDC
Yemen	YEM	Middle East & North Africa	4	LDC
Zambia	ZMB	Sub-Saharan Africa	7	LDC
Zimbabwe	ZWE	Sub-Saharan Africa	7	LDC

C Complementary results for Section 3.1

Table 9: Results with different reserve adequacy ratios, with $rgdp\_fe$ as dependent variable

	(1) rgdp_fe	(2) rgdp_fe	(3) rgdp_fe	(4) rgdp_fe
L2.log rsv/gdp	-0.0670			
	(0.566)			
L2.log rsv/imports		0.810		
		(0.574)		
L2.log rsv/m2			-0.0315	
			(0.524)	
L2.log rsv/std				0.671***
				(0.238)
Constant	-4.956***	-6.455***	-5.131***	-9.090***
	(1.691)	(0.970)	(1.948)	(1.473)
Observations	142	133	138	138
R^2	0.000	0.015	0.000	0.055
Adjusted R^2	-0.007	0.007	-0.007	0.048

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

Table 10: Results with different reserve adequacy ratios, without outliers

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
L2.log rsv/gdp	-0.135			
	(0.630)			
L2.log rsv/imports		0.649		
		(0.677)		
L2.log rsv/m2			0.468	
			(0.595)	
L2.log rsv/std				0.857***
				(0.253)
Constant	0.966	-0.350	-1.200	-4.406***
	(1.876)	(1.116)	(2.202)	(1.561)
Observations	135	126	130	131
R^2	0.000	0.007	0.005	0.082
Adjusted R^2	-0.007	-0.001	-0.003	0.075

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

D Respective contribution of reserves and short-term debt

This appendix presents our arguments in favor of the use of the reserves to short-term debt ratio.

Evaluating the impact of international reserves *per se* makes sense only if we consider the amount of reserve holdings within an adequacy ratio. Indeed, what matters is not the absolute level of reserves holdings, but their level compared to the size of the domestic economy, or to some critical variables like imports, short-term debt or a monetary aggregate, which international reserves are expected to cover in case of financial crisis. It is therefore necessary to scale the reserves by one of these variables. We examine various possibilities and reach the conclusion that the ratio of reserves to short-term debt seems better suited. Disentangling the role of this ratio's two components by separating them in the regressions is difficult, as we have to scale each of them by a third variable, which may raise collinearity issues. We tested below several auxiliary regressions to identify the respective contribution of reserves and short-term debt to our dependent variable.

Table 11: Results with different reserve adequacy ratios, without outliers and small countries

	(1) rgdp_residual	(2) rgdp_residual	(3) rgdp_residual	(4) rgdp_residual
L2.log rsv/gdp	-0.723			
	(0.729)			
L2.log rsv/imports		0.213		
		(0.816)		
L2.log rsv/m2			-0.431	
			(0.775)	
L2.log rsv/std				0.957***
				(0.355)
Constant	3.006	0.611	2.336	-4.971**
	(2.160)	(1.391)	(2.898)	(2.216)
Observations	100	95	97	101
R^2	0.010	0.001	0.003	0.068
Adjusted R^2	-0.000	-0.010	-0.007	0.059

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

A first test consists in regressing the dependent variables on $\log(reserves/gdp)$ and $\log(std/gdp)$; results are shown in Table 12. Only the short-term debt over GDP ratio is significant. However, the non-significance of the term $\log(reserves/gdp)$ in this regression is not surprising, since it is not significant alone either, as can be seen in Table 2 of this paper. We further tested the restriction that both coefficients are equal (with opposite signs) and we reject the null at the conventional 10% level of significance. This means that, statistically speaking, regressing our dependent variable on $\log(reserves/gdp)$ and $\log(std/gdp)$ is different from regressing it on $\log(reserves/std)$.

A second test we tried is to regress the dependent variables on $\log(reserves/std)$ and $\log(std/gdp)$. Results in Table 13 show that both $\log(reserves/std)$ and $\log(std/gdp)$ both lost significance (except for $\log(std/gdp)$ when $rgdp\_residual$ is used as dependent variable). There might be, however, some identification issues associated with this regression, since the short-term debt appears both in the denominator of the reserves ratio and in the numerator of the second ratio.

Finally, some other papers also find that reserves do matter even when controlling for short-term debt. Using $\log(reserves/gdp)$ and $\log(std/gdp)$ as two separate regressors, Llaudes et al. (2010) find that the ratio of reserves to GDP is significant for countries holding less reserves while the ratio of short-term debt to GDP is significant for countries with high reserves.

Table 12: Robustness check: log($reserves/gdp$) and log(std/gdp)

	(1) rgdp_fe	(2) rgdp_residual
L2.log rsv/gdp	-0.0345	-0.338
	(0.554)	(0.594)
L2.log std/gdp	-0.815***	-0.821***
	(0.258)	(0.277)
Constant	26.31***	33.07***
	(10.00)	(10.74)
Observations	138	138
R^2	0.069	0.064
Adjusted R^2	0.055	0.050

Standard errors in parentheses

Hypothesis of equality of coefficients rejected at 90%

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

Table 13: Robustness check: log($reserves/std$) and log(std/gdp)

	(1) rgdp_residual	(2) rgdp_fe
L2.log rsv/std	-0.338	-0.0345
	(0.594)	(0.554)
L2.log std/gdp	-1.159*	-0.850
	(0.647)	(0.603)
Constant	47.09*	27.74
	(28.09)	(26.16)
Observations	138	138
R^2	0.064	0.069
Adjusted R^2	0.050	0.055

Standard errors in parentheses

Hypothesis of equality of coefficients rejected at 99%

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

E Complementary results for Section 3.2

Table 14: Full specification without outliers

	(1) rgdp_fe	(2) rgdp_residual
L2.log rsv/std	0.951***	0.937***
	(0.292)	(0.316)
L2.capital controls	0.0352	0.220
	(0.263)	(0.281)
L2.exchange regime index	-0.892	-0.196
	(1.226)	(1.311)
L2.trade openness	-0.0235**	-0.0286**
	(0.0104)	(0.0113)
oil dummy	-3.142***	-1.987
	(1.132)	(1.211)
Constant	-7.111***	-1.830
	(2.263)	(2.431)
Observations	104	102
R^2	0.213	0.201
Adjusted R^2	0.173	0.159

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

Table 15: Full specification without outliers and small countries

	(1) rgdp_fe	(2) rgdp_residual
L2.log rsv/std	1.355***	1.292**
	(0.472)	(0.516)
L2.capital controls	-0.00486	0.347
	(0.354)	(0.375)
L2.log rsv/std × capital controls	0.248	0.277
	(0.273)	(0.299)
L2.exchange regime index	-1.342	-0.540
	(1.342)	(1.428)
L2.trade openness	-0.0269**	-0.0300**
	(0.0128)	(0.0139)
oil dummy	-2.953**	-1.900
	(1.261)	(1.346)
Constant	-9.293***	-3.791
	(3.136)	(3.384)
Observations	82	80
R^2	0.214	0.207
Adjusted R^2	0.151	0.141
F-test capital controls	0.417	0.786
P-value	0.660	0.459
F-test reserves	4.309	3.345
P-value	0.0169	0.0407

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

F Complementary results for Section 3.3

Table 16: Foreign reserve accumulation and capital controls, without outliers and small countries

	(1) rgdp_fe	(2) rgdp_residual
L2.log rsv/std	1.355***	1.292**
	(0.472)	(0.516)
L2.capital controls	-0.00486	0.347
	(0.354)	(0.375)
L2.log rsv/std × capital controls	0.248	0.277
	(0.273)	(0.299)
L2.exchange regime index	-1.342	-0.540
	(1.342)	(1.428)
L2.trade openness	-0.0269**	-0.0300**
	(0.0128)	(0.0139)
oil dummy	-2.953**	-1.900
	(1.261)	(1.346)
Constant	-9.293***	-3.791
	(3.136)	(3.384)
Observations	82	80
R^2	0.214	0.207
Adjusted R^2	0.151	0.141
F-test capital controls	0.417	0.786
P-value	0.660	0.459
F-test reserves	4.309	3.345
P-value	0.0169	0.0407

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

G Complementary results for Section 3.4

G.1 Results of the 1st-stage regressions

Table 17: First stage regression for 2SLS

	(1) L2.log rsv/std	(2) L2.log rsv/std	(3) L2.log rsv/std
L2.capital controls	0.107	0.101	0.0800
	(0.111)	(0.108)	(0.112)
L2.exchange regime index	0.591**	0.576**	0.650**
	(0.297)	(0.268)	(0.299)
L2.trade openness	-0.0109**	-0.0106**	-0.0119**
	(0.00447)	(0.00440)	(0.00467)
oil dummy	0.517	0.364	0.455
	(0.394)	(0.359)	(0.395)
financial center	3.095**	2.803*	3.194**
	(1.440)	(1.419)	(1.475)
L2.distance weighted index	0.0325**		0.0287*
	(0.0150)		(0.0149)
L2.Joneses		0.00228**	0.00209*
		(0.00111)	(0.00106)
Constant	5.749***	5.037***	4.646***
	(0.375)	(0.679)	(0.646)
Observations	112	112	112
R^2	0.132	0.143	0.164
Adjusted R^2	0.082	0.094	0.108

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

Table 18: First stage regression, without outliers

	(1)	(2)	(3)
	L2.log rsv/std	L2.log rsv/std	L2.log rsv/std
L2.capital controls	0.199**	0.196**	0.177*
	(0.0909)	(0.0871)	(0.0918)
L2.exchange regime index	0.423	0.470*	0.491*
	(0.286)	(0.269)	(0.292)
L2.trade openness	-0.00735	-0.00744*	-0.00815*
	(0.00445)	(0.00447)	(0.00461)
oil dummy	0.537	0.421	0.491
	(0.369)	(0.342)	(0.372)
L2.distance weighted index	0.0255*		0.0227
	(0.0149)		(0.0151)
L2.Joneses		0.00157	0.00144
		(0.000989)	(0.000967)
Constant	5.683***	5.230***	4.921***
	(0.408)	(0.659)	(0.617)
Observations	102	102	102
R^2	0.149	0.154	0.169
Adjusted R^2	0.105	0.110	0.116

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

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

G.2 Results of the 2nd-stage regressions

Table 19: Second stage regression, without outliers

	(1) OLS	(2) distance weighted index	(3) Joneses	(4) both
L2.log rsv/std	0.937***	1.116	1.541	1.353
	(0.316)	(2.070)	(1.896)	(1.467)
L2.capital controls	0.220	0.180	0.0852	0.127
	(0.281)	(0.531)	(0.501)	(0.421)
L2.exchange regime index	-0.196	-0.266	-0.434	-0.360
	(1.311)	(1.507)	(1.490)	(1.402)
L2.trade openness	-0.0286**	-0.0274	-0.0247	-0.0259*
	(0.0113)	(0.0172)	(0.0164)	(0.0144)
oil dummy	-1.987	-2.070	-2.267	-2.180
	(1.211)	(1.510)	(1.476)	(1.358)
Constant	-1.830	-2.923	-5.524	-4.375
	(2.431)	(12.74)	(11.68)	(9.086)
Observations	102	102	102	102
R^2	0.201	0.198	0.170	0.186
Adjusted R^2	0.159	0.156	0.127	0.144
Hausman $p-value$	.	0.932	0.750	0.776

Standard errors in parentheses

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

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