International Reserves and the Financial Crisis: Monetary Policy Matters

Devizové rezervy a finanční krize: úloha měnové politiky

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Abstract

The global financial crisis in 2008 and 2009 renewed interest for the role of international reserves in preventing and mitigating currency crises. The findings usually support the view that higher (or excess) reserves provided insurance against currency instability, which is considered as a good measure for evaluation how successful countries were in international comparison. Large depreciation of the currency is even explained as a fear of losing international reserves. But in case of inflation targeting countries (IT), which during the crisis witnessed sharp depreciations, this may be of a limited value. This paper enlighten the importance of monetary policy regime in estimating the level of international reserves and extends the current literature with the discussion on central bank credibility.

Keywords

foreign exchange reserves, inflation targeting, crisis

JEL Codes

F31, F33

Introduction

The currency crises in late 1990's in several Asian countries gave rise to investigation which measures are appropriate to minimize costs and prevent future attacks. One important finding, not only, from the literature is that reserves may serve as a form of protection against currency crisis and improvement of external vulnerability. The global financial crisis in 2008 and 2009 gave a chance to critically review this stance, i.e. if countries with larger reserves coped better with crisis. Several papers suggest so, but the results strongly depend on how the eventual success is measured.

This paper expands the current literature at least in two ways. First, it brings back a discussion on the role of monetary policy for international reserves determination and presents the estimated impact on the level. More, it extends the trilemma framework not only with the international reserves but the central bank credibility. Based on new findings, it revises

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the current understanding of the role of reserves in global financial crisis and proposes alternative solutions to external vulnerability.

The international reserves belong to standard monetary policy instruments, despite their limited inclusion in monetary policy framework. All instruments are interlinked and any changes to goals and the overall settings impacts substantially the role of reserves. So if the role of reserves should be changed, other monetary policy instruments should gain importance.

The global financial crisis showed that countries are well able to create ad hoc instruments to improve international liquidity (e.g. swap lines) to substitute standard monetary policy instruments but their use is rather limited in time and between countries. Of course, this stream may be developed further on international level.

On country level, the possibilities are rather limited. The experience of the inflation targeting countries suggests that central bank credibility can become also a monetary policy instrument. The empirical evidence supports this view, but of course, appropriate model is necessary. This task is beyond the scope of this paper.

The remainder of the paper is structured as follows. Section 2 summarizes main findings from the literature. Section 3 presents the main working framework, the data and estimation results.

Section 4 offers an alternative view on external vulnerability with an empirical assessment. Finally, section 5 concludes the paper.

1 Literature Review

The literature on determination of international reserves has long tradition dating back 1960s and 1970s. The first studies, which are often called ***buffer stock,*** comprise work of Heller (1966) and Olivera (1969). According to these papers the optimal reserve level should be determined by balance-of-payments disequilibria, propensity to import and opportunity cost. In this notion, the reserves serve as a buffer stock to fluctuations in external transaction and so positively effected by the variance of these fluctuations.

With the collapse of Bretton Woods system in 1973 the discussion on international reserves changed substantially. Capital mobility together with floating exchange rate brought a new trilemma with no explicit solution for reserves, especially for advanced countries. Free floating regimes do not require by definition reserves, while liberalized financial account would minimize the need for reserves to absorb a given set of balance-of-payments shocks. But free capital movements can generate more instability and certainly monetary authorities are not indifferent to exchange rate movements.

In fact, currency crisis in developing countries like Mexico (1973-1982) and Argentina (1978-1981) gave a rise to ***currency crisis literature***. So called *first generation models*[2] show that expansive domestic policies together with fixed exchange rate regime lead to

2 For literature review see Flood and Marion (1998).

currency crises. Higher reserve level can postpone the crisis until the reserves are depleted and the fixed exchange rate regime abandoned. *Second generation models* stressed a self-fulfilling aspect of currency crisis (Obstfeld, 1986, 1996; Morris and Shin, 1998). Here the reserves can be understood as reflecting fundamentals or commitment to defend the peg (as in Obstfeld, 1996). If the reserves are not high enough (or commitment is weak) so the speculators may be able to break the peg, the speculative attack seems a rational response. In this view, the level of the reserves has a self-fulfilling nature.

As a response to currency crisis in late 1990's, the economic research turned back attention to the role of reserves in crisis prevention and mitigation. Asian countries were extremely vulnerable to what Calvo (1998) defines as the sudden stop syndrome: a massive reversal of capital inflows. A large stream of literature appeared suggesting how to indicate vulnerable countries and what measures are appropriate to minimize current costs and future attacks.

The first attempt to propose adequate indicators in International monetary fund (IMF, 1998) suggests that the overvaluation of the real exchange rate, M2-to-reserves ratio and the growth of domestic credit tended to signal a currency crisis quite well. Based on more profound research, IMF prepared a set of indicators (reserve adequacy, debt-related) which are currently used in Staff Reports for the Article IV Consultation. So called External Vulnerability Indicators play an important role in vulnerability assessment relative to more detailed country-specific analyses and based on them statistical models to predict future currency crisis are built. Later work of Berg and others (1999) improved the technical background and had more success in predicting the crises out of sample.

The ratio of short term debt to reserves is a key indicator of early warning systems and the level of reserves is required at least to cover the short term debt. The ratio proved to be important in many studies, e.g. Bussiere and Mulder (1999)[3]. Similarly, Chang and Velasco (1999) find that the short term debt should be taken into account when trying to measure potential illiquidity of the country. They are rather critical to the involvement of IMF in crisis, as it insists on fiscal austerity as a precondition for lending.

On other hand, Mr. Guidotti argued that reserves should cover scheduled external amortization for one year. Further, according to Mr. Greenspan, country's external liquidity position should be calculated over wide range of possible outcomes, taking into account full set of external assets and liabilities („liquidity at risk"). The adequate level should reflect probability that external liquidity will be sufficient to avoid new borrowing for one year.

The lesson learned from Asian crisis is straightforward. If the economic fundamentals are weak and the risk of contagion is high, the policy response can contain built-up of reserves and/or extension of liquidity by an international body or lender of the last resort.

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3 This study also implies that a benchmark of one for the ratio of reserves to short-term debt is broadly appropriate. To avoid any impact of contagion, reserves should be such that the reserves to short-term debt ratio is one plus 5 percent for every percentage point of GDP current account deficit, and an additional 1 percent for every percent the real effective exchange rate has appreciated in the previous 4 years. In this sense, the reserves can offset weak fundamentals and prevent crisis spreading.

But are there any alternatives? Garcia and Soto (2004) tested the importance of accumulation of reserves in crisis prevention compared to measures like the quality of political institutions and the soundness of the financial system. In this view, the reserve accumulation is rather costly approach; the countries should improve their political and financial systems.

Despite these findings, the policy makers now see the reserve management as a strong instrument in crisis mitigation and prevention. In fact, the rise in reserve levels became a global phenomenon and its impact is substantial. Recently, Mendoza (2010) found that policy makers in developing countries are now more responsive by holding reserves than in pre-Asian crisis period. The elasticity of the reserves to several indicators (external debt and liabilities) increased indicating that the level of reserves became one of the true measures with regard to crisis prevention.

So last ten years were marked by an increase in international reserves worldwide by far larger than what "crisis prevention" literature would imply. New theories like "mercantilist motives" (Aizenman and Lee, 2007) or "financial globalization motives" (Obstfeld et al., 2008) appeared to explain recent developments.

Finally, the global financial crisis in 2008 and 2009 renewed interest in the role of reserves, i.e. if countries with higher reserves coped better with crisis. Obstfeld et al. (2009) showed that countries holding more reserves relative to M2 (relative to a measure of predicted reserves based on financial motives) have tended to appreciate in the crisis. Aizenman a Sun (2010) studied how emerging markets reacted on liquidity stress and they found that countries sensitive to trade shocks used their reserves up to no more than one third of their level, to mitigate currency movements. In case of countries, where financial factors play important role in determining the level of reserves, the depletion of reserves was limited. As they conclude, "the adjustment of EMs was constrained more by their fear of losing IR [international reserves] than by their fear of floating".

If we take a closer look on actual data, it becomes evident that Aizenman and Sun (2010), in their evaluation of the global financial crisis impact, underestimated the role of monetary policy setting. In fact, as Table 1 in Appendix shows 17 countries were hit by large currency depreciation (more than 35% between March 2008 and 2009, with limited impact on reserves), out of which 13 were inflation targeting. Inflation targeting countries do not use FX interventions as a standard instrument, although temporary interventions may occur to reduce volatility. These findings suggest that monetary policy settings may drive the actual development of the reserves and so called fear of losing reserves may be of a limited relevance. Therefore, I will continue the discussion on the role of the reserves in global financial crisis with regard to monetary policy.

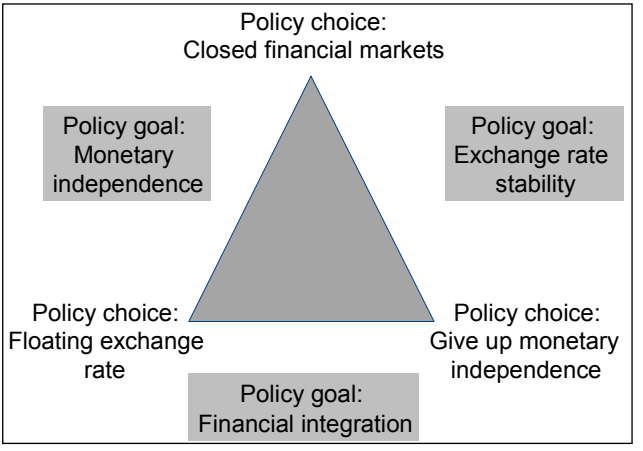
2 International Reserves and the Role of Monetary Policy

This chapter will present the link between monetary policy and international reserves, including empirical analysis and critical reviews.

2.1 Trilemma, Quadrilemma and the Role of Monetary Policy Regimes

In order to understand the link between monetary policy and international reserves we can start with simple Mundell-Flemming model of impossible trinity. This framework (see fig. 1) shows that in any point of time the country may choose two but not three of policy goals: monetary independence, exchange rate stability and financial integration. For example, to gain exchange rate stability and financial integration euro area countries had to give up monetary independence.

Figure 1: Mundell-Flemming's Trilemma framework



Aizenman, Chinn and Ito (2008) investigated empirically this issue. Their testing showed that higher flexibility of the exchange rates in recent decades was accompanied by reserve accumulation, which is in contrary to what the simple Mundell-Flemming model shows. So they suggested an extension of this classical framework with financial stability issues and international reserves. Globalization and financial integration worldwide may force developing countries to improve their financial stability by accumulation of the reserves, as their exposure to capital flights and deleveraging crises increased. So, the financial integration was followed by accumulation of the reserves as a self protection against financial turbulences. In this sense, the new dimension of the triangle includes financial stability, which proved to be highly topical in recent years.

Therefore the first step in my analysis comprises the evaluation of the relationship between reserves and different monetary policy settings after 1999[4]. I will use the hints from the trilemma, e.g. countries with desire to keep exchange rate stable and financial markets integrated will improve their position in the triangle using accumulation of the reserves. The accumulation of the reserves worldwide may than well reflect only changing structure of the moentary policy settings.

4 *Most of the studies use the data from 1990's.*

2.2 Model and Data

In empirical estimation I followed Obstfeld et al. (2008) with the traditional and financial stability model estimated on large panel of countries during 1990's. Here the dependent variable is the (natural) log of the reserves to GDP ratio.

The panel dataset covers 123 countries during 1999 and 2009 and the summary (as well as sources) is in Table 1. The basic explanatory variables are population, trade openness (exports and imports to GDP), GDP per capita (in current prices, USD), all expressed in log. The inclusion of trade and capital account openness is motivated by findings from the literature; these indicators are used to capture external vulnerability of the country[5]. GDP per capita should measure the relative wealth so richer countries can afford to keep larger reserves. As an alternative, I included a dummy for advanced countries as they are defined by IMF.

More, it contains the share of the country on the world net exports as these countries may prefer to hold larger international reserves to ensure stable oil revenues in domestic currency and even transfer part of the revenues to reserves.

Table 1: Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Reserves on GDP	1353	0.189	0.189	0.001	1.583
Population (mil)	1353	46.329	157.117	0.250	1345.750
GDP per capita	1353	11.606	15.916	0.086	117.955
Trade openess	1353	0.933	0.564	0.190	4.381
Capital account openess	1353	0.864	1.577	-1.844	2.478
Oil exports	1353	0.673	2.266	0.000	19.030
HIM	1305	0.764	0.109	0.000	0.954
M2 to GDP	1353	0.788	0.818	0.067	6.639
Banking crisis	1353	0.061	0.239	0.000	1.000

Source: author's calculation from World Development Indicators (Worldbank), IFS IMF (April 2011), Economic Intelligence Unit (for several data missing), Heritage Foundation website and Laeven and Valencia (2010) database.

Newly I added a set of variables representing the angles of the trilemma triangle. To capture ***financial market integration*** I used a measure of financial openness - Chinn-Ito capital market openness index which measures a country's degree of capital account openness, namely restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER)[6].

5 As literature shows, one of the most important indicators of external vulnerability is the ratio of short term debt to GDP. Due to limited data availability it is not included in this study.

6 See http://web.pdx.edu/~ito/Chinn-Ito_website.htm.

Monetary independence, or how successful countries were in monetary policy conduct, will be represented by Heritage monetary freedom index[7] (HMFI), defined as follows:

$$HI\_M_i = 100 - \alpha\sqrt{\theta_1\pi_{it} + \theta_2\pi_{it-1} + \theta_3\pi_{it-2}} - PC_i,$$

where π is inflation, PC is an adjustment for price controls, i stands for country and t time. Eventually, it is a weighted average of the inflation over last three years adjusted for price controls. Higher value of the index indicates monetary independence, as it shows that the financial authority was successful in achieving and maintaining price stability. As an alternative I included a dummy variable from monetary policy arrangement according to IMF (data available after 2001). We may expect that countries with no monetary independence (like currency unions) will have lower reserves. This classification has 5 categories, but I added one more for countries with monetary union. These are: Inflation targeting (1), Monetary aggregate targeting (2), Fund-supported or other monetary program (3), Exchange rate anchor (4), Other[8] (5), Monetary union (6).

Newly I added variables capturing differences in ***exchange rate arrangements***[9]. A dummy variable for exchange rate regime is according two classifications:

- IMF classification of exchange rate arrangements, de facto after 1997[10], available from AREAER annually. It has 7 categories from "no separate legal tender" to "independently floating", as shows Table 2.
- de facto classification according to Reinhart and Rogoff (2004), which used historical chronologies and data on market-determined parallel exchange rates. There are two kinds of classification schemes – one consists of 14 types of arrangements and the other with aggregated 5 categories (so called coarse grid). It allows form much finer grid and newly it adds a category of "freely falling" with inflation over 40 %. While the coarse grid in Table 3, the fine one you can find in the appendix (Table 2).

7 *It is rather a rough measure of independente. Data are possible to download from HI website: http://www.heritage.org/index/monetary-freedom*

8 *The country has no explicitly stated nominal anchor, but rather monitors various indicators in conducting monetary policy.*

9 *The impact of exchange rate regimes on international reserves was estimated also by Choi, Ch. and Baek, S. (2004): Exchange rate regimes and the international reserves, unpublished, but this study used a different specification with large potential bias and Reinhart and Rogoff (2004) classification only.*

10 *Before 1997 IMF used classification based on official Exchange rate arrangement, which was in several cases quite different from de facto development. Therefore the revision brought a new methodology and the studies showed that differences between the classification schemes now became much lower than in 1990's.*

Table 2: Exchange rate system classified by IMF

1	Exchange arrangement with no separate legal tender
2	Currency board arrangement
3	Conventional pegged arrangement
4	Pegged exchange rate within horizontal bands
5	Crawling peg
6	Crawling band
7	Managed floating with no predetermined path
8	Independently floating

Source: IMF.

Table 3: Exchange rate system classified by Reinhart and Rogoff (2004) – coarse grid

1	No separate legal tender; Pre announced peg or currency board arrangement; Pre announced horizontal band that is narrower than or equal to +/-2%; De facto peg
2	crawling peg and band that is narrower than or equal to +/-2%
3	Pre announced crawling band that is wider than or equal to +/-2%; De facto crawling band that is narrower than or equal to +/-5%; Moving band that is narrower than or equal to +/-2%; Managed
4	Freely floating
5	Freely falling
6	Dual market in which parallel market data is missing.

Source: Reinhart and Rogoff (2004).

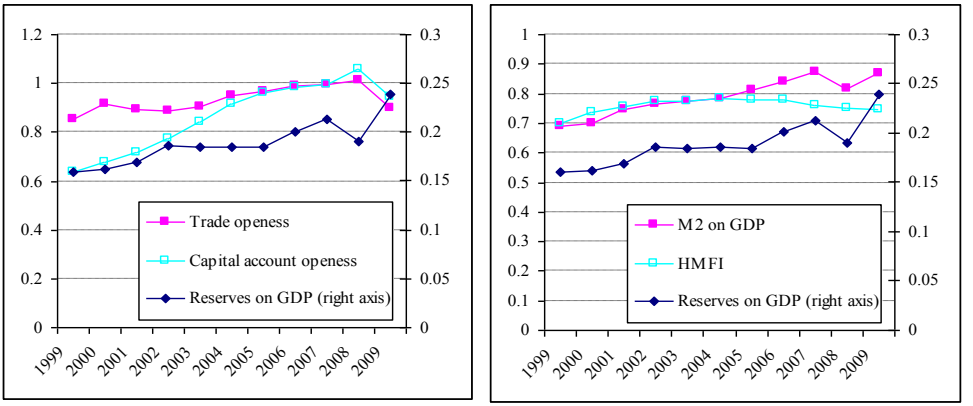
Finally, ***financial stability*** dimension will be represented by the ratio of M2 to GDP, which represents a potential domestic capital flight. It can be originated from internal reasons as banking sector crisis (so called internal vulnerability). More generally, it can represent liquidity conditions in the country. As literature showed, the level can differ between countries due to their local conditions, but any shock to liquidity like the global financial crisis will be reflected in the indicator. As a novelty I tested directly if the realization of the banking crisis has impact on the level of reserves. The banking crisis dummy used in this paper come from Laeven and Valencia (2010) database[11].

2.3 Trends in Reserve Accumulation after 1999

Before presenting the estimation results, I will describe shortly the overall development of the variables, as most of the studies cover only 1990's. The overall trend in increase of reserves (scaled by GDP) after 2000 continued, mainly in case of emerging countries. It was accompanied both by increase in trade and capital account openness. The global financial crisis brought a sharp interruption due to liquidity slump, which is particularly evident in case of M2 on GDP. The reserves lowered as well because many countries were hit by depreciation in 2008 or even used reserves to provide foreign liquidity temporarily. Monetary freedom index grew until 2004, while the global rise of prices (e.g. for commodities) lowered the indicator in the following years.

11 The data can be downloaded from author's website: http://www.luclaeven.com/Data.htm

Figure 2: Trends in explanatory variables (average over cross-section)



Source: author's calculation.

As for the exchange rate systems, we cannot see a trend of growing flexibility as described in literature for 1990's. Both classification schemes indicate a return to more fixed arrangement in recent years; for example the share of countries with fixed or pegged regime (categories 1-3 according to IMF) increased from 37 % in 2000 to 48 % in 2008 (see Figure 1 in appendix). This evidence is supported also by data Reinhart and Rogoff (2004) and also the share of countries with exchange rate anchor increased (Figure 2 in appendix).

Also looking at monetary policy arrangements, again there is no clear trend towards more flexibility. The number of countries in monetary union increased, due to enlargement of the euro area, as well as the number of countries with exchange rate anchor. Inflation targeting as a monetary arrangement has gained a lot of attention in recent years and the number of countries in my sample increased from 16 to 26 between 2001 and 2008.

2.4 Estimation Results

Using pooled data I estimated an equation using OLS (ordinary least squares) and with fixed effects, although scaling reserves by GDP make the time series stationary. More, the standard errors are clustered by country to allow for heteroscedasticity across countries. The first estimate gives us more details on cross-country aspects, so it is a preferred choice also in the literature. Still, the fixed effects (capturing more time dimension) are significant and not to be omitted. The correlation matrix is in Table 3 of the appendix.

In line with previous findings I estimated first a ***standard model*** including all basic macroeconomic variables and the results are shown in Table 4.

As expected, countries more open to external transactions have higher reserves as a buffer to fluctuations and this effect is still large. Similarly, oil exporters tend to have larger reserves. On the other hand, GDP per capita has negative sign, while previous studies found positive or insignificant coefficient. This may be due to inverted-U relationship with reserve holdings. Middle income countries tend to have larger reserve than high- and low-income, and as a number of countries with high income grows, the overall effect

becomes negative. So I included a dummy for advanced countries directly (equation II) and its impact is substantial.

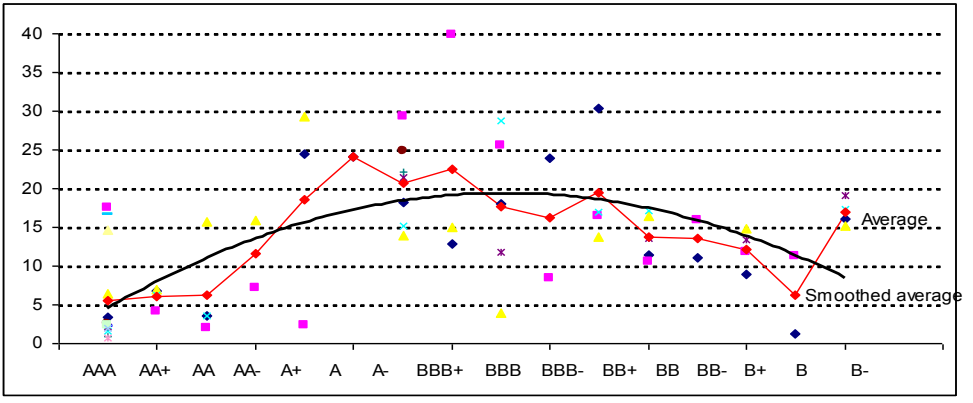
Table 4: Estimation results - baseline

	I		II		III	
	Traditional model		With advanced country		With interaction term	
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects
Population	-0.067	0.475				
	0.049	*0.441*				
GDP per capita	-0.195***	0.074				
	0.052	*0.084*				
Trade openess	0.579**	0.614***	0.575***	0.702***	0.604***	0.731***
	0.224	*0.151*	*0.204*	*0.145*	*0.198*	*0.144*
Capital account openess	-0.071	-0.075	-0.019	0.004		
	0.045	*0.055*	*0.044*	*0.051*		
Net oil export	0.083***	0.19***	0.041**	0.194***	0.048***	0.19***
	0.020	*0.056*	*0.016*	*0.062*	*0.017*	*0.063*
Advanced country dummy			-1.154***	-1.696***	-0.858***	-1.457**
			0.240	*0.565*	*0.242*	*0.601*
Interaction term					-0.049**	-0.048*
					0.024	*0.026*
Constant	-1.555***	-3.184***	-1.725***	-1.696***	-1.688***	-1.621***
	0.128	*0.922*	*0.088*	*0.130*	*0.085*	*0.136*
R-sq (overall/within)	0.218	0.076	0.315	0.144	0.329	0.159
Obs	1353	1353	1353	1353	1353	1353

*Note: author's calculations. Robust standard errors in italics, ***, **, * denote statistical significance at 1%, 5% a 10% levels, respectively.*

This variable was intended to proxy the creditworthiness and ability to issue debt (and access swap lines in case of liquidity crisis). Country's long-term credit rating is another indicator and plotting it against reserves brings forward that again countries with middle rating feel more vulnerable and accumulate reserves.

Figure 3: Long-term rating (Fitch) and reserves on GDP in 2003



Note: author's calculations.

This is closely related to a topic of capital account openness (see equation III). Its sign is negative and insignificant, so I tried an interaction term between GDP per capita and KAOPEN. In fact, a small country with fully open capital account may feel much vulnerable to external shocks than a big country. Opening capital account was a very dynamic process in 1990's, while after 2000 it slowed down and/or the indicator is less suitable for this analysis.

Table 5: Estimation results – exchange rate arrangements

	I		II		III	
	IMF classification		**Intermediate regimes**		**Reinhart and Rogoff coarse classification**	
	Pooled OLS	**Fixed effects**	**Pooled OLS**	**Fixed effects**	**Pooled OLS**	**Fixed effects**
Trade openess	0.504***	0.874***	0.509***	0.878***	0.696***	0.826***
	0.163	*0.156*	*0.162*	*0.155*	*0.187*	*0.154*
CO interaction term	-0.048*	-0.066***	-0.046*	-0.063***	-0.127***	-0.096***
	0.024	*0.020*	*0.023*	*0.020*	*0.025*	*0.028*
Net oil export	0.028*	0.212***	0.027*	0.213***	0.061***	0.183***
	0.015	*0.062*	*0.015*	*0.060*	*0.018*	*0.060*
Regime 1	-1.39***	-1.405**	-1.401***	-1.485**	0.059	-0.242
	0.301	*0.554*	*0.298*	*0.587*	*0.395*	*0.248*
Regime 2	0.475**	0.327*	0.471**	0.322	0.331	0.008
	0.219	*0.196*	*0.216*	*0.198*	*0.358*	*0.180*
Regime 3	0.493***	0.043	0.495***	0.065	0.511	-0.114
	0.157	*0.136*	*0.157*	*0.128*	*0.378*	*0.171*
Regime 4	0.402**	0.275				
	0.163	*0.218*				
Regime 5	0.192	-0.143			-0.938**	-0.485**
	0.214	*0.180*	0.2*	0.054	*0.370*	*0.196*
Regime 6	0.071	0.022	*0.113*	*0.068*	0.492	-0.029
	0.235	*0.121*			*0.500*	*0.256*
Regime 7	0.183	0.052				
	0.123	*0.070*				
Constant	-1.999***	-1.824***	-2.002***	-1.829***	-1.967***	-1.755***
	0.116	*0.121*	*0.116*	*0.121*	*0.349*	*0.184*
R-sq (overall/within)	0.472	0.191	0.470	0.185	0.352	0.150
Obs	1230	1230	1230	1230	1137	1137

*Note: Author's calculations. Robust standard errors in italics, ***, **, * denote statistical significance at 1%, 5% a 10% levels, respectively.*

The next step will be the results for equation with ***exchange rate arrangements*** (Table 5). As a benchmark I chose freely floating regimes, as two classifications differ in categories (but broadly they are from fix to float). Of course, the results for OLS estimations yield more information as dummy variables are usually time variant to a limited extend. It can be summarized, that compared to freely floating regimes, countries in monetary union or no separate legal tender hold less reserves. Most reserves are held by de facto pegs. In appendix (Table 4), there are also results for fine grid and they support the results for IMF

de facto classification[12]. This inverted-U relationship may indicate that growing number of countries with pegged regimes gave rise to enormous accumulation of the reserves while regional monetary union can be a way to reach more exchange rate stability. The reason, why managed floating regimes hold the same amount of reserves as free floaters, can be that the latter may claim not to intervene on the markets but they eventually do. Finally, freely falling regimes have lower reserves, as their economies are transition or developing with large fiscal deficits, external indebtedness and political instability.

With regard to ***financial stability,*** as Table 6 shows the results are not as convincing as in Obstfeld et alt. (2008). The coefficient for M2 to GDP is statistically significant only with fixed effects, in OLS estimation it is positive but insignificant. More, it is sensitive to inclusion of other variables in the equation. On the other hand, dummy for banking crisis has expected negative sign. Countries, which suffer from banking crisis, have to face pressure on currency and the use of reserves is obvious.

Finally, with regard to ***monetary independence,*** low inflation countries have higher reserves so HMFI reflects more the general development of the country rather than monetary independence. Also a dummy for different monetary policy arrangements does not yield any convincing answer (see Table 5 in the appendix). The results are broadly similar to exchange rate regimes. The lowest levels of reserves have countries with monetary union. Inflation targeting countries have lower reserves than countries, that follow several indicators ("other"). Countries with exchange rate anchor hold more reserves, but the coefficient is not statistically significant. Generally, the differences are rather small. It is rather difficult to capture the monetary independence and for that reason the last part of this paper will give a first glimpse on the relationship between central bank independence, which is connected with monetary independence, and reserve holdings.

12 The basic classification by IMF performs now well compared to other classification schemes. This is due to change to de facto classification in 1997 and lower number of "free falling" regimes in last decade compared to previous years. This certainly simplifies the use of classification in future research.

Table 6: Estimation results – financial stability and monetary independence

	I		II	
	Financial stability		**With monetary independence**	
	Pooled OLS	**Fixed effects**	**Pooled OLS**	**Fixed effects**
Trade openess	0.464***	0.787***	0.506***	0.803***
	0.158	*0.165*	*0.160*	*0.173*
CO interaction term	-0.061***	-0.074***	-0.069***	-0.074***
	0.023	*0.020*	*0.023*	*0.020*
Net oil export	0.035**	0.216***	0.04**	0.193***
	0.016	*0.054*	*0.018*	*0.057*
M2 on GDP	0.225**	0.35**	0.136	0.276*
	0.101	*0.143*	*0.108*	*0.157*
Banking crisis	-0.336***	-0.359***	-0.29**	-0.336***
	0.116	*0.072*	*0.119*	*0.073*
Regime 1	-1.528***	-1.457**	-1.47***	-1.455**
	0.333	*0.569*	*0.325*	*0.574*
Regime 2	0.47**	0.179	0.436**	0.183
	0.202	*0.155*	*0.216*	*0.142*
Regime 3	0.446***	0.026	0.401**	0.000
	0.154	*0.120*	*0.159*	*0.129*
Regime 4-7	0.245**	0.027	0.295**	0.043
	0.116	*0.071*	*0.119*	*0.074*
HMFI			1.206**	0.495*
			0.492	*0.270*
Constant	-1.823***	-1.575***	-2.787***	-1.988***
	0.143	*0.139*	*0.431*	*0.278*
R-sq (overall/within)	0.492	0.235	0.509	0.238
Obs	1230	1230	1182	1182

*Note: Author's calculations. Robust standard errors in italics, ***, **, * denote statistical significance at 1%, 5% a 10% levels, respectively.*

3 Monetary and Central Bank Independence

The previous analysis showed that accumulation of reserves in recent years was to a large extent driven by external and internal vulnerability. Openness to trade as well as financial globalization certainly puts a pressure on central banks to increase barriers to shocks, especially if they decide for any fixed form of exchange rate regime. But are there any alternatives? As shown in previous chapters, a monetary union brings exchange rate stability with full open financial markets and the need for reserves is limited. This step has disadvantages, as recent experience with euro debt crisis showed. Therefore, a search for another approach is highly topical.

In previous analysis the attempt to measure monetary independence by HMFI did not give the expected result. It was due to the assumption that more independent central bank is more successful in achieving and maintaining low inflation levels. But it possible to employ directly central bank independence index (CBI), as it is in Crowe and Meade (2008). The data are available only for 2003 and smaller sample of countries; the estimation result is in Table 7. The sign of CBI indicates that more independent central bank can afford to have lower reserves, which is in line with the discussion. The evidence is rather weak, though. The central banks do not follow any optimal path for the level of reserves, as one generally expected model is missing. Generally more credible central banks may stop accumulating reserves, as this is a costly approach and their external vulnerability decreases. Of course, appropriate model is necessary but this task is beyond the scope of this paper.

Table 7: Estimation results – Central bank independence (CBI)

Number of obs = 81						
R-squared = 0.253						
Number of clusters (code) = 81						
	Coeficient	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
Trade openess	0.538	0.258	2.08	0.041	0.024	1.052
Capital account openess	-0.269	0.073	-3.71	0.000	-0.414	-0.125
Net oil export	0.033	0.029	1.12	0.268	-0.026	0.091
HMFI	0.020	0.010	1.95	0.055	0.000	0.040
CBI	-0.769	0.462	-1.67	0.100	-1.688	0.150
Constant	1.782	0.892	2	0.049	0.008	3.556

Note: author's calculations. Cross-section for 2003.

Conclusions

This paper extended the current literature on international reserves with the discussion on the link with monetary policy. It showed the position of the country within a trilemma triangle influences the level of reserves and monetary policy decisions are all interlinked, though the relationship is not always linear. To summarize main results, the countries more open to external transactions have higher reserves as a buffer to fluctuations and this effect is still large. The overall wealth effect is also important. As for monetary policy settings, the exchange rate regimes are key determinants; inverted-U relationship may indicate that growing number of countries with pegged regimes gave rise to enormous accumulation of the reserves while regional monetary union can be a way to reach more exchange rate stability. Also financial stability issues are reflected in the level of reserves, any banking crisis has substantial effect on the current level of reserves. Finally, improving central bank independence may be an alternative to accumulation of reserves.

Finally, this framework offers an explanation for mixed results for inflation targeting countries. Although these countries do not hold lower level of reserves, they prefer the side of triangle associated with monetary independence and floating regime. Here the relevance of the reserves is limited and building up of central bank credibility is a crucial task. This is also an inspiration for countries looking for an alternative to current approach in international reserves accumulation.

References

AIZENMAN, J. (2011). *The Impossible Trinity – from the Policy Trilemma to the Policy Quadrilemma, work in progress*.

AIZENMAN, J.; LEE, J. (2007). International reserves: precautionary versus mercantilist views, theory and evidence. *Open Economies Review*. Vol. 18 (2), pp. 191-214.

AIZENMAN, J.; SUN, Y. (2010). *The financial crisis and sizable international reserves depletion: From 'fear of floating' to the 'fear of losing international reserves'*?

BECK, R.; WEBER, S. (2010). *Should larger reserve holdings be more diversified*? ECB working paper 1193, May 2010.

BERG, A.; PATILLO, C. (1999). Predicting Currency Crises: The Indicators Approach and an Alternative. *Journal of International Money and Finance*. Vol. 18, Issue 4, pp. 561–86.

BUSSIERE, M.; MULDER, C. B. (1999). *External Vulnerability in Emerging Market Economies - How High Liquidity Can Offset Weak Fundamentals and the Effects of Contagion*. IMF Working Papers 99/88.

CALVO, G. (1998). Capital Flows and Capital-market Crises: The Simple Economics of Sudden Stops. *Journal of Applied Economics* 1. pp. 35–54.

CHANG, R.; VELASCO, A. (1999). *Liquidity Crises in Emerging Markets: Theory and Policy*. NBER Working Papers 7272. National Bureau of Economic Research.

CHINN, M. D.; ITO, H. (2008). A New Measure of Financial Openness. *Journal of Comparative Policy Analysis*. Vol. 10, Issue 3, pp. 309 - 322.

CROWE, CH.; MEADE, E. E. (2003). *Central Bank Independence and Transparency: Evolution and Effectiveness*. IMF Working Papers 08/119.

FLOOD, R. P.; MARION N. P. (2002). *Holding International Reserves in an Era of High Capital Mobility*. IMF Working Papers 02/62.

GARCÍA, P.; SOTO, C. (2004). *Large Hoardings of International Reserves: Are They Worth It*? Working Papers Central Bank of Chile 299. Central Bank of Chile.

HELLER, H.R. (1966). Optimal International Reserves. *Economic Journal*. Vol.76, pp. 296-311.

LAEVEN, L.; VALENCIA, F. (2010). *Resolution of Banking Crises: The Good, the Bad, and the Ugly*. IMF working paper 10/146.

MENDOZA, R. U. (2010). Was the Asian crisis a wake-up call?: Foreign reserves as self-protection. *Journal of Asian Economics*. Vol. 21 (1), pp. 1-19.

MORRIS, S.; SHIN, H. S. (1998). *A Theory of the Onset of Currency Attacks*. CEPR Discussion Papers 2025.

OBSTFELD, M. (1986). *Rational and Self-Fulfilling Balance-of-Payments Crises*. American Economic Review. Vol. 76 (1), pp. 72–81.

OBSTFELD, M. (1996). *Models of Currency Crises with Self-Fulfilling Features*. European Economic Review. Vol. 40 (3–5), pp. 1037–47.

OBSTFELD, M., SHAMBAUGH, J. C.; TAILOR, A. (2008). *Financial Stability, the Trilemma, and International Reserve*. NBER Working Paper. No. 14217.

OBSTFELD, M., SHAMBAUGH, J. C.; TAILOR, A. (2009). *Financial Instability, Reserves, and Central Bank Swap Lines in the Panic of 2008*. American Economic Review. Vol. 99 (2), pp. 480–486.

OLIVERA, JULIO H. G. (1969). A Note on the Optimal Rate of Growth of International Reserves. *The Journal of Political Economy*. Vol. LXXVII.

REINHART, C.M.; ROGOFF, K.S. (2002). *The Modern History of Exchange Rate Arrangements: A Reinterpretation*. NBER Working Papers 8963.

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Appendix

Table 1: Exchange rate movements (% change between March 2008 and 2009)

Depreciation				Appreciation
> 35 %	25 - 35 %	15 - 25 %	0 - 15 %	
Iceland	Mongolia	Kazakhstan	Costa Rica	Hong Kong
Poland	Belarus	Jamaica	Thailand	Trinidad and Tobago
Ukraine	Norway	Kenya	Paraguay	Japan
Zambia	South Africa	Uganda	Peru	Laos
New Zealand	Swaziland	Croatia	Madagascar	China
South Korea	Pakistan	Botswana	Algeria	Azerbaijan
Russian Federation	Gambia, The	Latvia	Georgia	Bolivia
United Kingdom	Canada	Macedonia	Tanzania	
Sweden	Indonesia	Guinea-Bissau	Libya	
Colombia	Czech Republic	Cape Verde	Singapore	
Hungary	Mauritius	Bosnia & Herzegovina	Kuwait	
Australia	Bhutan	Bulgaria	Sri Lanka	
Turkey	India	Estonia	Haiti	
Mexico	Nigeria	Denmark	Guatemala	
Chile	Albania	Lithuania	Dominican Republic	
Romania		Armenia	Nicaragua	
Brazil		Israel	Burundi	
		Philippines	Sierra Leone	
		Ethiopia	Rwanda	
		Uruguay	Egypt	
		Argentina	Angola	
		Switzerland	Bangladesh	
		Morocco		
		Kyrgyz Republic		
		Malaysia		

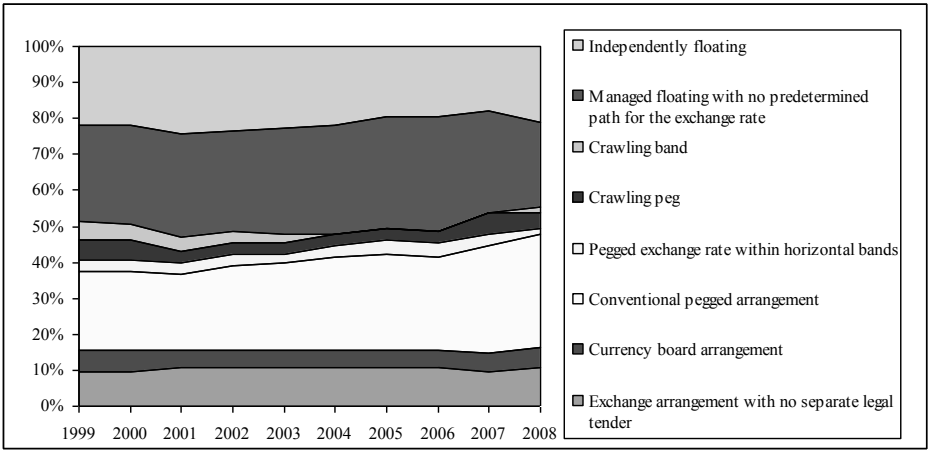
Note: inflation targeting countries are highlighted; the table covers only countries included in this study.

Table 2: The fine classification according to Reinhart and Rogoff (2004)

1	No separate legal tender
2	Pre announced peg or currency board arrangement
3	Pre announced horizontal band that is narrower than or equal to +/-2%
4	De facto peg
5	Pre announced crawling peg
6	Pre announced crawling band that is narrower than or equal to +/-2%
7	De factor crawling peg
8	De facto crawling band that is narrower than or equal to +/-2%
9	Pre announced crawling band that is wider than or equal to +/-2%
10	De facto crawling band that is narrower than or equal to +/-5%
11	Moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time)
12	Managed floating
13	Freely floating
14	Freely falling
15	Dual market in which parallel market data is missing.

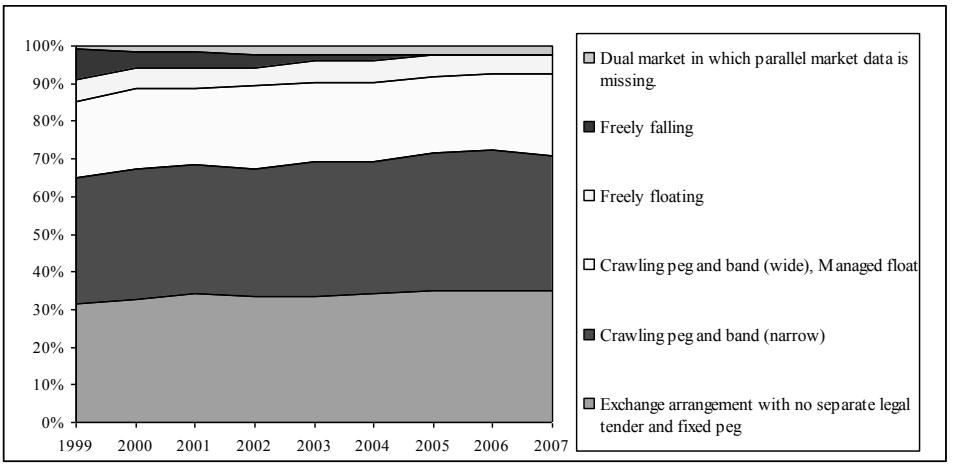
Source: Reinhart and Rogoff (2004).

Figure 1: Exchange rate system classified by IMF in 1999-2008



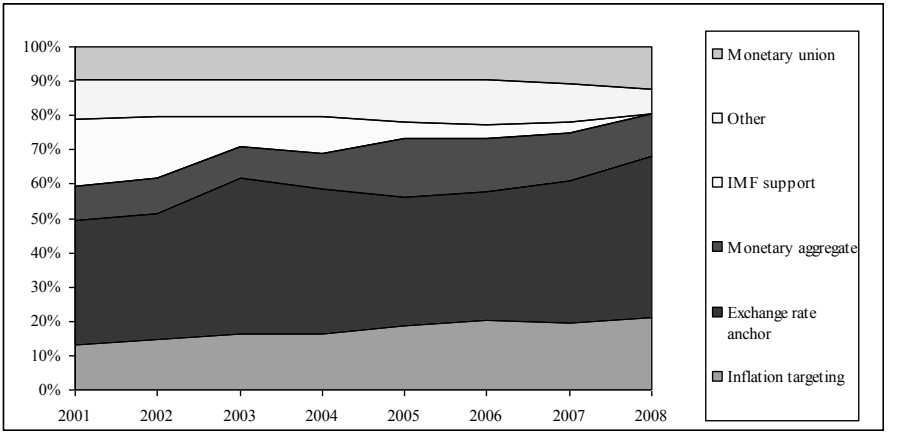
Note: author's calculations based on data from IMF.

Figure 2: Exchange rate system classified by Reinhart and Rogoff (2003) in 1999-2008



Note: author's calculations based on data from Reinhart and Rogoff (2003).

Figure 3: Monetary policy arrangements by IMF in 1999-2008



Note: author's calculations based on data from IMF.

Table 3: Correlation matrix

	log(reserves/ GDP)	log(population)	log(gdp per capita)	log(trade openess)	log(m2 to gdp)	Interaction term	Advanced countries	Banking crisis dummy
log(reserves/GDP)	1							
log(population)	-0.173	1						
log(gdp per capita)	-0.263	-0.137	1					
log(trade openess)	0.261	-0.556	0.219	1				
log(m2 to gdp)	-0.142	-0.033	0.623	0.231	1			
Interaction term	-0.399	-0.030	0.702	0.133	0.489	1		
Advanced countries	-0.482	0.058	0.688	0.044	0.574	0.734	1	
Banking crisis dummy	-0.163	0.066	0.146	-0.009	0.119	0.113	0.128	1
HMFI	-0.037	-0.113	0.460	0.075	0.506	0.407	0.425	-0.017

Note: author's calculations.

Table 4: Estimation results – fine grid from RR

Number of obs = 1128						
R-squared =	0.5562					
Number of clusters (code) = 122						
	Coeficient	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
Trade openess	0.518	0.150	3.46	0.001	0.221	0.815
CO interaction term	-0.045	0.023	-1.94	0.055	-0.090	0.001
Net oil export	0.018	0.013	1.41	0.161	-0.007	0.043
Regime 1	-1.134	0.450	-2.52	0.013	-2.026	-0.243
Regime 2	0.837	0.369	2.27	0.025	0.106	1.568
Regime 3	1.418	0.307	4.62	0.000	0.811	2.024
Regime 4	0.884	0.350	2.53	0.013	0.191	1.577
Regime 6	0.459	0.353	1.3	0.196	-0.240	1.158
Regime 7	0.547	0.344	1.59	0.114	-0.134	1.227
Regime 8	0.714	0.339	2.11	0.037	0.043	1.386
Regime 9	0.614	0.368	1.67	0.098	-0.115	1.342
Regime 10	0.870	0.417	2.08	0.039	0.044	1.695
Regime 11	0.666	0.549	1.21	0.227	-0.421	1.753
Regime 12	0.439	0.364	1.2	0.231	-0.283	1.160
Regime 14	-0.473	0.333	-1.42	0.159	-1.133	0.187
Regime 15	1.008	0.559	1.8	0.074	-0.100	2.115
Constant	-2.386	0.319	-7.48	0.000	-3.017	-1.755

*Note: author's calculations. Robust standard errors in italics, ***, **, * denote statistical significance at 1%, 5% a 10% levels, respectively.*

Table 5: Estimation results – monetary policy arrangements (2001-2008)

Compared to inflation targeting		**Compared to other**	
Trade openess	0.573***	Trade openess	0.573***
	0.166		*0.166*
CO interaction term	-0.043*	CO interaction term	-0.043*
	0.024		*0.024*
Net oil export	0.034**	Net oil export	0.034**
	0.014		*0.014*
Monetary aggregate ta	0.126	Inflation targeting	-0.321**
	0.148		*0.156*
Fund-supported or oth	-0.023	Monetary aggregate tar	-0.195
	0.152		*0.133*
Exchange rate anchor	0.035	Fund-supported or othe	-0.345**
	0.288		*0.141*
Other	0.321**	Exchange rate anchor	-0.286
	0.156		*0.245*
Monetary union	-1.824***	Monetary union	-2.145***
	0.250		*0.259*
Constant	-1.861***		-1.54***
R-sq (overall/within)	0.535		0.535
Obs	984		984

*Note: author's calculations. Robust standard errors in italics, ***, **, * denote statistical significance at 1%, 5% a 10% levels, respectively.*