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**Accumulation of Foreign Exchange
Reserves: Asian Case**

Bachelor's thesis

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Abstrakt

Bakalářské práce pojednává o vývoji akumulace devizových rezerv u vybraných asijských zemí. V první části jsou popsány různé důvody pro držení devizových rezerv. Kromě standardních operativních důvodů, se dají u asijských zemí najít důvody zajišťovací a novo-merkantilistický. Dále je porovnána výše rezerv s několika mírami adekvátnosti její úrovně. Během devadesátých let se všechny zkoumané země dostaly nad tato kritéria, ale během první dekády 21. Století ve většině případů nedošlo k dalšímu nárůstu vzhledem k použitím referencím. V ekonometrické části byl sestaven model s použitím fixních efektů a panelových dat. Z analýzy vyplynulo, že po asijské krizi došlo ke zrychlení v akumulaci devizových rezerv ve zkoumaných zemích. Dále byl použit model k predikci vývoje rezerv po finanční krizi v roce 2008. Před rokem 2008 akumulace rezerv ve studovaných státech měla společný trend, nicméně po roce 2008 se vývoj rezerv ve zkoumaných zemích rozdělil.

Abstract

Bachelor's thesis deals with development of accumulation of foreign exchange reserves in selected Asian countries. In the first chapter various reasons for holding reserves are described. Apart from standard operational purposes, signs of neo-mercantilist and self-insurance motives can be identified in the case of Asian countries. Subsequently, reserve holdings are compared with measures of adequacy. During the 1990's all countries in the sample exceeded criteria suggested but during the first decade of the twenty-first century the growth of foreign exchange reserves slowed down in relative terms. In the econometric part a fixed effect model was designed. Policy analysis proved the presence of structural break after the Asian crisis in 1997. The model was used for prediction of reserves after financial crisis in 2008. Before 2008 accumulation in of reserves in examined states had common trend, however after 2008 trends in sample countries diverged.

Klíčová slova

Devizové rezervy, Predikce rezerv, Asijské ekonomiky, Asijská krize, Finanční krize

Keywords

Foreign exchange reserves, Reserves prediction, Asian economies, Asian crisis, Financial crisis

Thesis length: 61 583 characters

Declaration of originality

1. I declare that I am a sole author of the submitted thesis and that I used only sources mentioned in Bibliography.
2. I declare that the submitted thesis was not used in order to obtain another academic degree.
3. I agree with making the submitted thesis available for academic and research purposes.

In Prague 17 May 2013

Ladislav Tůma

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Preliminary scope of work

V této práci budu studovat hromadění devizových rezerv asijskými zeměmi (Čínou, Jižní Koreou, Malajsií atd.).
V úvodu je mým záměrem popsat vývoj úrovně rezerv v asijských zemích posledních letech a porovnávat ho se světovými trendy.
V další části se pokusím aktuální úroveň rezerv porovnat s různými koncepty, které se snaží určit úroveň optimálních rezerv (např. Edison 2003). Dále se pokusím zanalyzovat výhody a nevýhody, které plynou z masivního hromadění devizových rezerv.
Mým přínosem bude použití aktuálních data a zaměření se posun mezi asijskou krizí v roce 1997 a světovou finanční krizí na konci první dekády 21. století.

Preliminary scope of work in English

In this thesis I will study the accumulation of foreign exchange reserves in Asian countries (China, South Korea, Malaysia e.g.).
In the beginning my aim is to describe recent development of the level of holdings and to compare it with trends worldwide.
In next section I will strive to compare the current level of holdings with different concepts, which try to estimate the optimal level of holdings (Edison 2003 e.g.). Moreover I will analyze advantages and disadvantages of large foreign exchange holding.
My contribution to the field will be the usage of current data and focus on the shift between Asian crisis in 1997 and World financial crisis in late-2000s

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Introduction

During the nineteen-nineties and the beginning of the new millennium East Asian countries began to accumulate unprecedentedly high levels of foreign exchange reserves. The patterns for accumulation and levels of holding differ from former guidelines that can be applied to developed countries in the Western World. Whereas the patterns did not change in occidental countries, East Asian countries changed their behavior and started hoarding foreign exchange reserves. Ratio of Foreign reserves to GDP was 3,6 % in case of industrialized countries and 8 % in case of East Asian countries in 1990, whereas in 2011 these two figures differed a lot. The ratio was 39 % in the Asian case and 2,6 % in the case of industrialized countries.

Some studies such as Polterovich & Popov (2003) suggest that countries use their reservoirs of foreign currencies as the support for their export-oriented strategy. Study proposes that states, notably China intervene in the foreign exchange markets to gain advantage for their export-oriented strategy. This activity is called by Aizenman & Lee (2006) monetary mercantilism. Even if the long-term current account surpluses are one of the factors allowing accumulation of reserves and signs of possible undervaluation of the domestic currency and application of export-oriented policy of the domestic government, the pace of accumulation cannot be attribute solely to this motive.

Other observers suggest that reserves are held because of precautionary motives. Self-insurance is the main purpose. Some countries felt the need for self-protection was necessary after the experience with the Asian crisis in 1997, where states hit by the crisis had to rely on the help of the International Monetary Fund. The appropriateness of the solution for East Asian countries after the Asian crisis is doubted by several authors [(Allen & Hong, 2011), (Aizenman & Marion, 2002)], who among other reasons emphasize lack of Asian influence in the governing boards of IMF those days. Absence of Asian voice in the IMF should have resulted in the badly tailored solution.

In the first chapter, we will describe idea of adequate and excess reserves. Concurrently, last development in the reserves accumulation will be described. The trade-off between benefits gained from holding and costs incurred is a key factor for assessing foreign reserves adequacy and so several standard rule-of-thumb measures for evaluation of FX reserves adequacy will be employed.

Second chapter will involve econometric analysis of drivers for holding reserves. The part will be based on previous econometric papers dealing with the issue [(Edison, 2003), (Aizenman & Marion, 2002), (Gosselin & Parent, 2005) and (Park & Estrada, 2009)]. The aim of the econometric part is to design fixed effects regression to, which explains accumulation of reserves.

Main goal of this thesis is to examine whether there were a change in patterns for accumulation after recent financial crisis. Notably, research is focused on the issue whether the pace of hoarding changed and whether states also focused their efforts on mitigation of liability-aspects of holding.

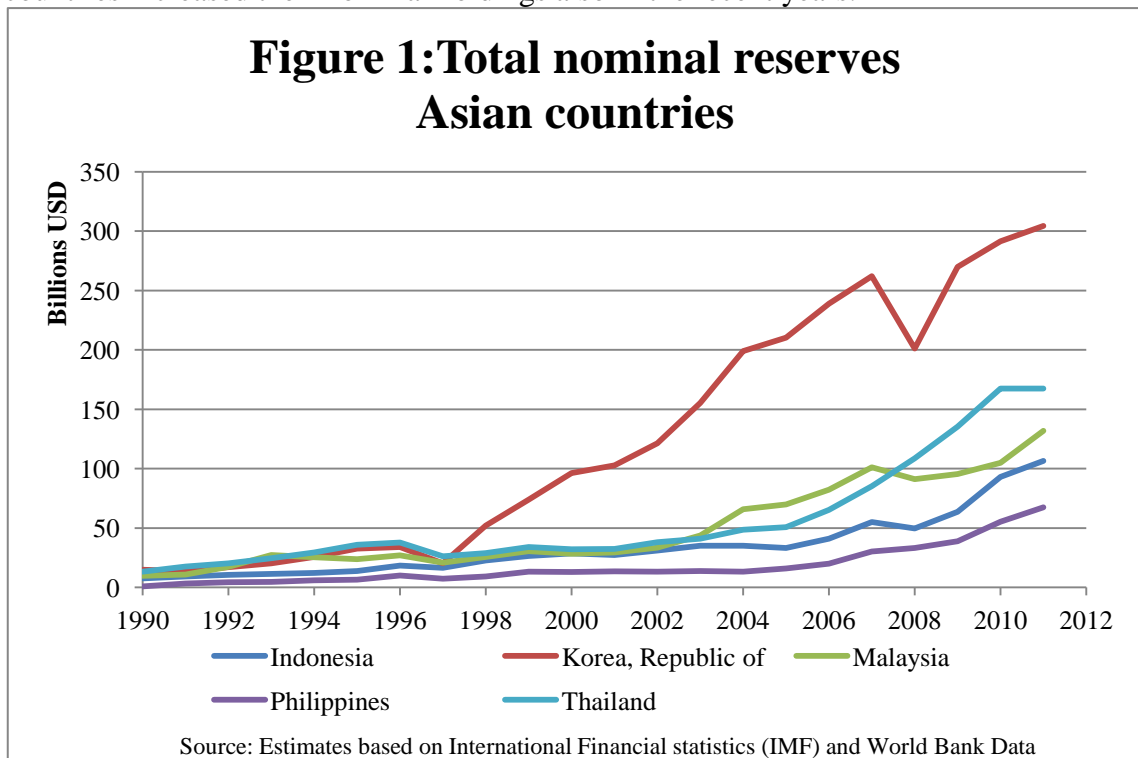
1. Chapter 1 – Stylized facts and informal examination

1.1. Stylized facts about accumulation

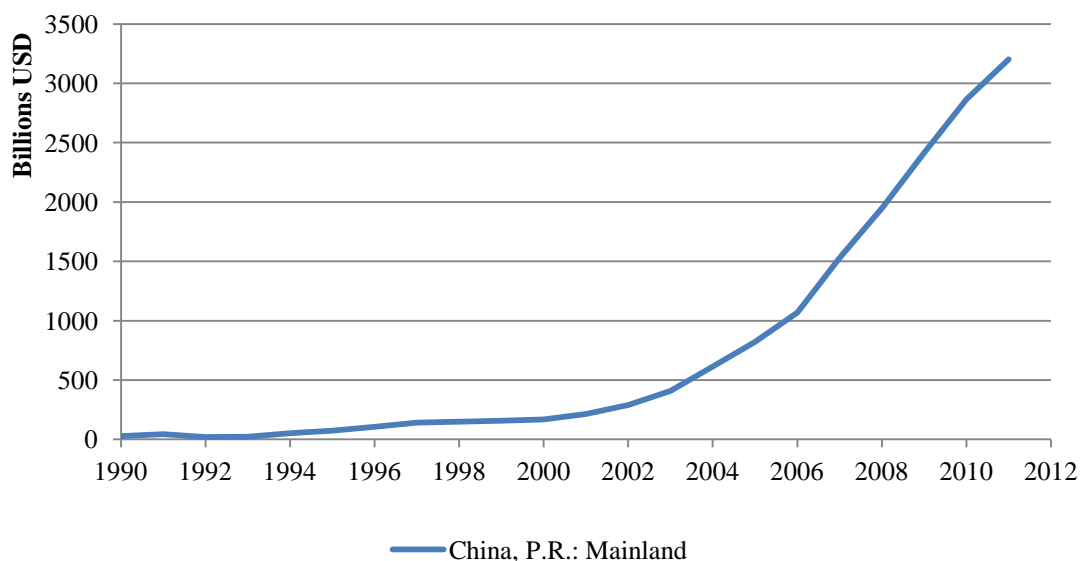
In the last two decades, we witnessed large accumulation of foreign exchange reserves in East Asia. China, the world largest reserves holder, is not only one in the region that pursues strategy of hoarding international foreign reserves. If we examine the patterns of holding reserves and their development, we come to same conclusions about increasing levels of foreign liquidity with or without China.

Figures 1 and 2 describe the development of reserves holdings of six selected East Asian countries. Five countries (Indonesia, South Korea, Malaysia, Philippines and Thailand) included in the examined sample, were affected by the Asian crisis in 1997 and had to rely on the assistance of the International monetary fund. The Asian crisis resulted in devaluation of currencies of these states vis-à-vis US dollar [Indonesia – 83 %, South Korea – 34 %, Malaysia – 39 %, Philippines – 37 %, Thailand – 40 % (Cheetham, 1998)]. On top of that, China as the largest holder is included among six countries that will be examined.

In nominal terms the level of reserves increased at least 12 times for each country between 1990 and 2011. The pace of reserves growth was almost never below 10% except crisis years 1997 and 2008. Yearly growth rates of reserve holdings are displayed in Figure 3. The speed of reserves accumulation had positive sign and countries increased their nominal holdings also in the recent years.

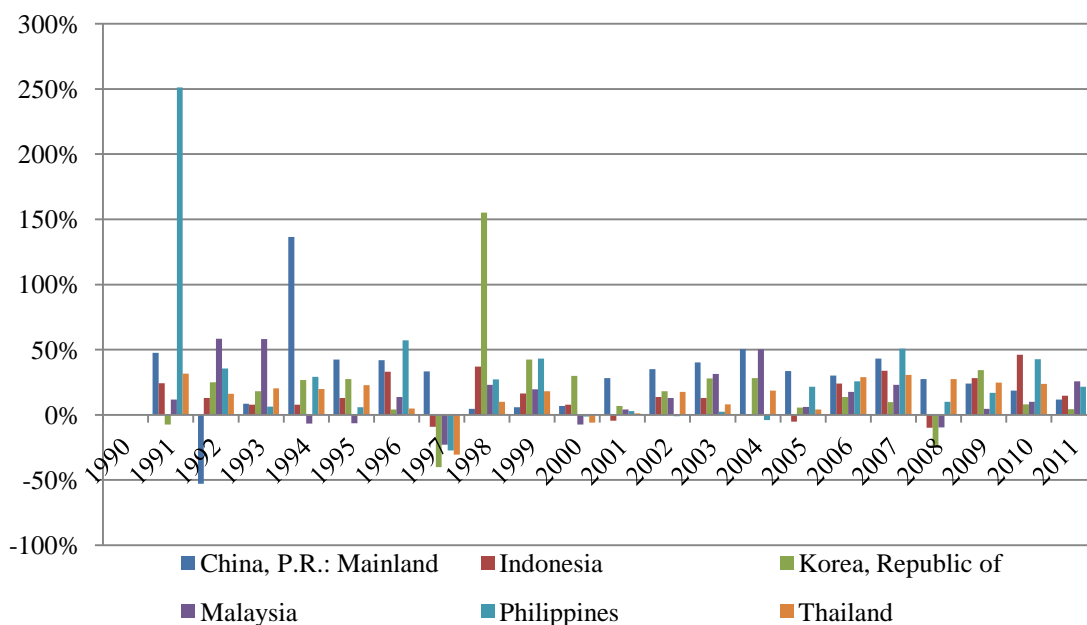


**Figure 2: Total nominal reserves
China, P.R.: Mainland**



Title: Estimates based on International Financial statistics (IMF) and World Bank Data

Figure 3: Yearly nominal reserves growth



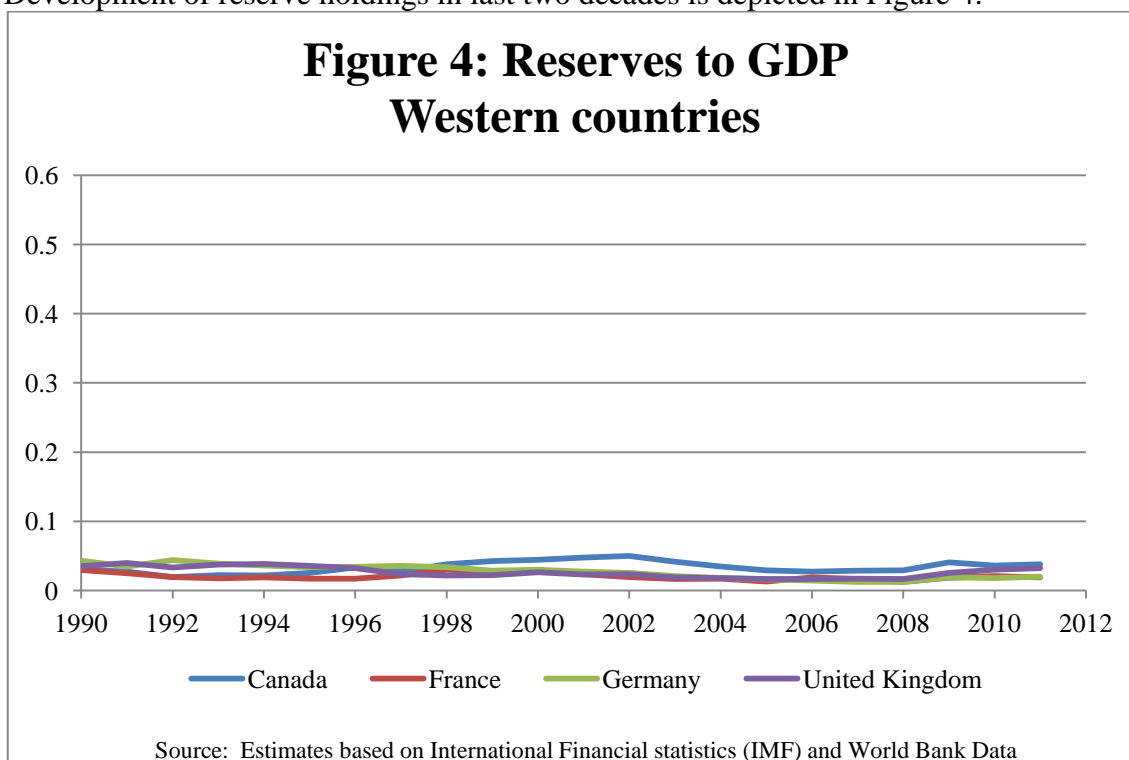
Source: Estimates based on International Financial statistics (IMF) and World Bank Data

Chinese reserves were accumulated most steeply. Average annual increase of their holdings was 29 %. The speed of hoarding reserves even accelerated after 2000. Between 2000 and 2010 Chinese reserves increased by 1603 %, whereas in previous decade (1990-2000) the assets grew by 469 %. Changes in reserve holdings are described in Table 1.

Table 1: Reserves growth (total increment over period)						
	China, P.R.: Mainland	Indonesia	Korea, Republic of	Malaysia	Philippines	Thailand
1990-2000	469%	282%	550%	190%	1316%	141%
2000-2010	1603%	226%	203%	270%	323%	423%
1990-2011	10725%	1328%	1957%	1251%	7180%	1158%

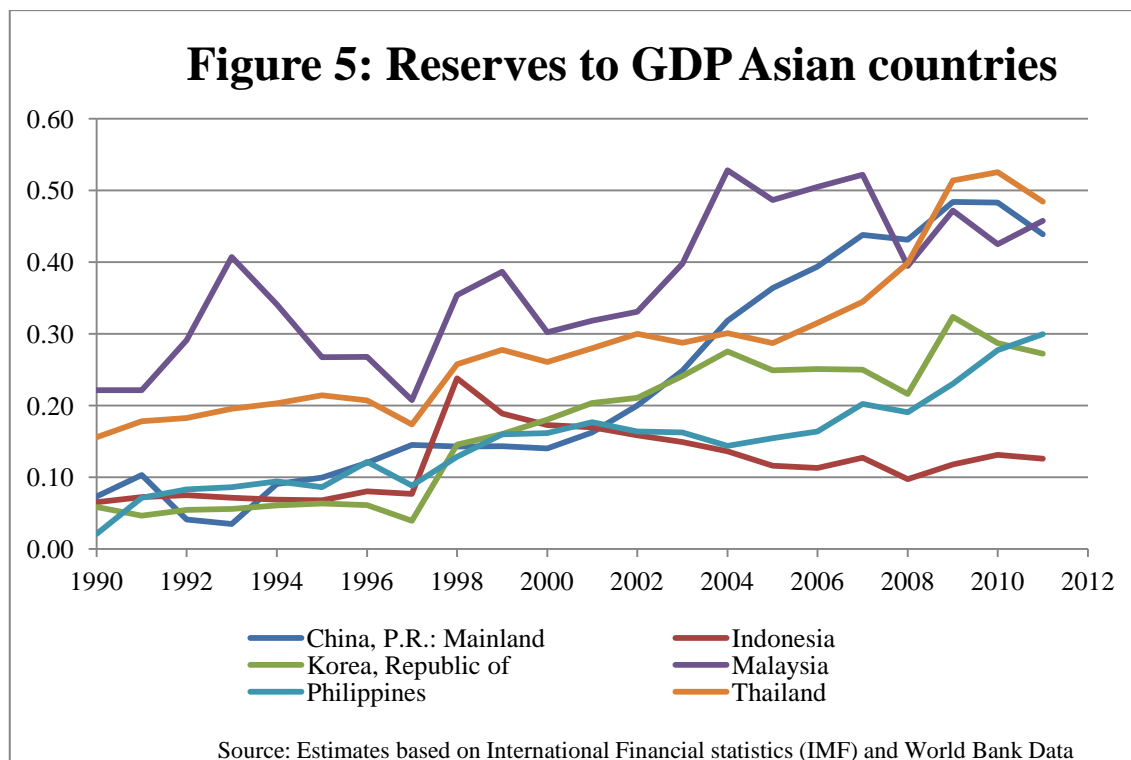
Source: Estimates based on International Financial statistics (IMF) and World Bank Data

Since the collapse of Bretton-Woods system, western developed countries held reserves amounting approximately to 3% of their GDP. The ratio reserves to GDP is not a measure of adequacy. However it provides comparison as to the size of economy. In the beginning of the 1990s western countries' holdings did not exceed 5% of GDP. Neither deeper European integration nor the common European currency¹ nor further globalization nor any crisis affected the accumulation patterns for western countries. Development of reserve holdings in last two decades is depicted in Figure 4.



In the earlier 1990s holding of East Asian countries were higher in terms of reserves to GDP but not significantly, except for Thailand and Malaysia because of their exchange rate regimes. The change for all countries in our sample occurred after Asian crisis in 1997, when the amount of reserves in terms of GDP started to grow and the growth has continued up till now. China's reserves to GDP ratio increased the most. In 2011 it was 37 percentage points higher than in 1990. The smallest growth occurred in case of Indonesia, where reserves to GDP ratio rose from 7 % in 1990 to 13 % in 2011. Still 13 % is four times higher figure than in case of western countries.

¹ The European Central Bank held in December 2012 possessed official reserve assets of 0,6 % Eurozone's GDP.



1.2. Reasons for holding foreign exchange reserves

There are six reasons for holding international foreign reserves mentioned by Nugée (2000). The most traditional use of reserves is formal backing of the domestic currency. Historically, states possessed gold, which was exchangeable for domestic currency at a set rate. However, it is no longer a case today. Usage of foreign reserves to provide confidence in domestic currency is nowadays linked to currency boards. For example, Honk Kong operates its own currencies under the fixed exchange rate regime with US dollar and so they need to hold certain amount of reserves denominated in US dollars to formally back their domestic currencies.

Foreign exchange reserves are most commonly used as a tool of monetary and exchange rate policy. Notably countries that have fixed exchange regimes has to posses foreign exchange reserves to be able to intervene in the market against undesirable pressure on domestic currency. Countries using managed floating regime act alike. Even states whose currencies float freely hold reserves for optional intervention or for a case of change in policy.

Thirdly, countries opt for holding because of servicing foreign liabilities and debt obligations. States could acquire foreign currency just before the repayment but this approach bears a lot of risk, e.g., exchange rate fluctuations or market distortion when large amount of foreign exchange reserves would be acquired.

Reserves can be also possessed as a source of funds for financing expenditures abroad. In particular countries, who are able to predict their imports or whose expenditures overseas follow well-known seasonal pattern, may use reserves for smoothing payment schedules.

Not to mention that reserves can serve as a reservoir of funds in case of sudden and serious disasters and emergencies. As far as natural disasters are concerned, they

may harm country's export-leading sector and holdings of FX reserves serve as warranty and raise confidence in eyes of potential lenders. Reserves serve as a tool of self-insurance for economic turmoil as well. Countries with high reserves can deal with adverse impacts on domestic economy relying on their accumulated pool of foreign exchange reserves. Allen & Hong (2011) propose that South Korea was able to navigate through 2008 crisis thanks to big buffer of foreign exchange reserves without relying on any foreign creditor. They compare the situation with Asian crisis in 1997, when the liquidity denominated in foreign currency was drained out of the country and South Korea was left to take a loan from the International Monetary Fund. Serving as a lender of last resort, the IMF conditioned the loan with restrictions, which may not have been well-tailored for Asian case. We will discuss IMF's role later in more detail.

Last reason mentioned by Nugée (2000) is holding reserves as investment funds. This is not reason for most of countries but recently we saw the emergence of sovereign wealth funds. Sovereign Wealth Fund Institute (2013) presents the list of largest sovereign wealth funds. Governments operating wealth funds come from East Asian countries and from countries exporting oil and natural gas. Decision to establish a sovereign wealth fund arises when country holds enough liquidity and seeks higher return than is yielded by traditional assets held as foreign exchange reserves for above-mentioned purposes.

As far as East Asian countries are concerned the level of their holdings exceeds traditional measures of adequacy. The size of the reserves is attributed to the export-led policy and keeping the currency undervalued and perhaps the most significant explanation is precautionary insurance against economic distortions.

1.3.Reasons for holding – Asian countries

1.3.1. Self-insurance motives

Polterovich & Popov (2003) argue that Japan, Korea and Taiwan used to take advantage of their undervalued currencies to support their export-oriented economies. They add that these countries abandoned this strategy but it was suggested that China pursues such policy and the policy of keeping yuan undervalued was achieved through the accumulation of foreign exchange reserves.

Nevertheless other works stress the importance of self-insurance motives as the key driver of foreign exchange reserves accumulation [(Aizenman & Marion, 2002), (Aizenman & Lee, 2006), (Edison, 2003) and (Allen & Hong, 2011)]. Aizenman & Marion (2002) list two reasons for holding reserves – the need to smooth consumption and distortions intertemporally when a country has conditional access to the credit market and increase in the volatility of economic shocks and risk aversion after 1997.

Smoothing consumption intertemporally comes from the buffer stock model that balances costs that would be incurred in the absence of holding foreign exchange reserves and the opportunity costs of holding reserves. In the case of reserves absence and the adverse economic development country faces production shock and is able to gather only smaller tax collections, whereas government expenditures are generally inelastic. Moreover other funds may be needed to substitute shortfall in tax collections. Resources may be obtained through credit market, where country in unfavorable conditions may issue new credit with high interest rate because of smaller confidence in the performance of its economy. Even more, depressed country may be forced to ask a

lender of last resort, the International Monetary Fund, for new credit, which may be conditioned by reforms or specific policies that must be installed in the domestic economy.

Self-insurance motive hypothesis is supported by (Allen & Hong, 2011), who compare two then so-called Asian tigers – South Korea and Taiwan. In 1996, Korea's Reserves to GDP ratio was 5,9 % while Taiwan's was 30,7 %. After the crash of Hong Kong stock exchange in 1997 and the transmission of the crisis. Korea was exposed to domestic non-performing debts. Korea banks, which provided credit for domestic highly-leveraged and low-profitable conglomerates, were not able to meet their short-term liabilities and applied to the Bank of Korea for assistance. The Bank of Korea injected \$20 billion in the domestic credit market but almost ran out of foreign exchange reserves. Thus it was forced to make an arrangement with the International Monetary Fund. The IMF offered help in form a \$21 loan.

However, the contract was conditioned by immediate policy actions. South Korea had to increase interest rates, which put highly-indebted Korean chabeloas under more pressure. This led to three times higher number of insolvencies in 1998 than in 1997. Moreover, the Korea government was not allowed to use a fiscal spending as a stimulus for economy despite low indebtedness. The Korean debt amounted to 11 % of GDP in 1997.

Asian crisis and the IMF measures resulted in drop of GDP growth to -6,8 % in 1998 from 4,6% in 1997, whereas Taiwan's GDP growth decreased only by 2,1 % from 6,6 % in 1997 to 4,5 % in 1998. Allen & Hong (2011) attribute this difference to the unlike level of holding foreign exchange reserves.

Authors of the study then compare Korean case in 1997 and 2008 and draw a striking conclusion. Even if the roots of both crises were different South Korea had to deal with similar issue. Once again Korean Central Bank faced lack of foreign liquidity among domestic banks. Foreign investors held 40 % of Korean capital prior to 2008 and the crisis made investors pull out most of their investments from the country and thus large amounts of foreign liquidity was demanded from Korean banks.

Though, South Korea possessed higher amount of foreign exchange reserves this time. The exposure to short term debt was lower than in 1997. In 1997 Korean holdings of foreign exchange reserves were smaller than its external short debt. In 2007, a year before massive pull out of foreign investors from Korean market, foreign exchange reserves exceeded external short term debt by 63 %. When banks started losing liquidity in 2008, Korean central bank was able to supply liquidity to domestic banks and make desirable interventions in foreign exchange market without resorting to rely on an external lender.

Allen & Hong (2011) suggest that Korean experience with and without reserves, when the country navigated through crisis by relying on its own reserves and thus corroborate the self-precautionary motive for holding reserves.

Feldstein (2002) also supports above-stated hypothesis of precautionary motives for holding reserves. It is claimed that emerging market economies behave like risk-averse agents. It means that countries put more emphasis on prevention of consumption

decrease rather than on the possibility of increase. Gains from self-insurance by holding a lot of reserves is balanced with opportunity costs from not diversifying the portfolio and not investing into riskier assets. However, (Feldstein, 2002) does not assess whether these two costs are balanced, it is even stressed that countries are biased in accumulating foreign exchange reserves and they do not pay attention to liability side of the issue properly.

Empirical examination of the issue was conducted by Edison (2003). The results of econometric analysis showed that both groups of variables, self-insurance motives and the monetary mercantilism, were statistically significant but only precautionary holding reasons had economical significance. The exchange rate volatility, explanatory variable associated with the monetary mercantilism, was predictably negatively correlated with the amount of reserves but its economic significance was negligible. The variables associated with potential vulnerability of current account, export volatility and imports to GDP ratio, were both statistically and economically significant.

Aizenman & Lee (2006) argue that the alleged undervaluation of yuan, the prime suspect for being driver of the hoarding in East Asia, was not supported with enough evidence and cannot be the sole driver of the accumulation. They illustrate the case with the counterparts of Japan and South Korea that rejects the hypothesis that the accumulation serves only for export-oriented strategy by keeping the exchange rate undervalued. The authors suggest that Japan and Korea started to hoard reserves when they were going through economically adverse situation. The growth of the reserves stockpile started in 1992, when Japanese economy began to stagnate. In case of South Korean the accumulation began after the Asian crisis in 1997. It is indicated that countries suffered from negative impacts of financial mercantilism² in the form of non-performing loans and decided to create a buffer, which would serve as fund during crisis.

This policy change mitigated the possible transmission of banking crisis to currency crisis. The policy of accumulating foreign exchange reserves was later adopted by China after Asian crisis without going through an unfavorable economic event.

Moreover, Aizenman & Lee (2006) stress that the strategy of accumulating is pursued by almost all countries in the East Asian region. The monetary mercantilism to be effective requires that this policy is not applied by other countries, which certainly is not a case in East Asia. Competitive hoarding of reserves by more countries can result in a game with negative outcome, where costs of holding large reserve may outweigh gains from undervalued currency.

To conclude, researches that were conducted propose two drivers of the accumulation. The first one is the precautionary motive, which provides insurance to countries when they undergo economic crisis. This hypothesis is supported by Korean experience with and without reserves and with econometric examinations mentioned earlier in the text. Apart of them, Dominguez, Hashimoto, & Ito (2011) showed that countries with higher Reserves to GDP ratio had higher post-2008 financial crisis GDP growth rate. In their econometric model, every additional percentage point in Reserves

² Financial mercantilism is defined by (Aizenman & Lee, 2006) as the policy approach, where domestic banks are encouraged to support domestic growth and domestic economy via favorable loan conditions to domestic companies.

to GDP ratio meant extra 0,2 percentage points in GDP growth rate. Economic significance was even higher, when the sample of countries was narrowed to the emerging ones. The second one is the neo-mercantilist approach to keep currency undervalued and thus run long-term current account surpluses, even in the time of GDP growth. According to theory current account surpluses, should lead to the real appreciation of the domestic currency and this process should result in higher imports and lower exports. Alleged undervaluation of East Asian currencies will be examined in the next subchapter.

1.3.2. Neo-mercantilist motive

The second motivation suggested for accumulating foreign exchange reserves is the support of export-oriented economy. As far as total reserves of each country are concerned, distinguishing functionality of layers is almost impossible, thus we examine characteristics, whose presence suggests the presence of successful neo-mercantilist strategy. These features are current account surplus and the undervaluation of the domestic currency.

1.3.2.1. The IMF position

IMF (2012) identifies that various East Asian currencies are undervalued, explicitly mentioning China, Korea, Malaysia and Thailand. The report states that current exchange rates are not in line with medium term fundamentals and that balances would be different with the set of more desirable policies. On top of that the study claims that inflation pressures are under control and thus will not force currencies to appreciate in real terms. On top of that, IMF (2012) suggests that current account balances are not likely to turn negative in following years.

1.3.2.2. Undervaluation of RMB yuan

Exchange rate of RMB and US dollar, eventually RMB yuan and euro, has been a source of heated discussions between Chinese, American and European authorities. The most hyped phase of the discussions started in 2005 when China decided to leave their previous exchange rate regime against dollar, which was in fact a dollar peg and installed the heavily managed floating against a basket of currencies. Condoleezza Rice, the former US Secretary of State, publicly claimed in 2006 that exchange regime of RMB yuan is damaging trade between China and the rest of the World and it needs revision.

In this part, we will focus mainly on exchange rate between dollar and RMB yuan with minor focus on euro. The situation of euro is similar to Dollar in the political perspective. The European Union also pushes China to scale down the level of undervaluation since EU believes that undervalued currency has adverse impact on European trade balances but since yuan was almost pegged to dollar between 1997 and 2005 the movements of yuan vis-à-vis Euro were different to the ones of dollar. Until 2002 US dollar continuously appreciated and so did RMB yuan however after 2002 when the dollar started to depreciate RMB yuan went along but euro appreciated vis-à-vis yuan which amplified the Chinese exporting advantage.

The first obvious sign of the undervaluation are long-lasting big current account's surpluses and a hoarded mass of foreign exchange reserves China possesses. This state according to self-balancing mechanism of international trade should lead to the appreciation of the Chinese currency and then to the balanced current account.

However, RMB yuan appreciated against dollar in nominal terms from 2005 to 2010 by 24 % and by 50% in real terms (The Economist, 2011). The real appreciation

was induced by the growing labor costs, which rose by 25% in the aforementioned period. Despite ostensibly fast appreciation the Chinese exports rose by 50% (US-China Business Council stats), which is exactly opposite the economic theory suggests – appreciation of a domestic currency should reduce exports and provoke larger imports from other countries. So is the current account surplus and Chinese pivotal role in international trade caused only by RMB yuan and the way the Bank of People's Republic of China manages it?

This would be elegant but very simplifying answer. Das (2009) explains that a China as the second biggest recipient of the foreign direct investments in past decade, where most of it was used for building industrial plants of multinational companies, whose production was dedicated to be exported. Also catching-up Chinese industry contributed to the augmenting Chinese exports.

Previous paragraph shows that the export potential of China was not depleted yet and still incoming foreign direct investments to export industries are a sign of general opinion that China is still suitable destination for an export base, to who undervalued RMB yuan contributes as well.

On the contrary, Das (2008) notes that even if undervalued RMB yuan has a boosting effect on export, it must be realized that there is large import content in the Chinese economy so undervalued currency means harm from this perspectives. Das (2008) also points that there exist some studies which argue that current Chinese exchange rate policy results in more costs than benefits but it is not a prevailing opinion in the field.

To look on the issue from a different perspective, we can use real exchange rate analysis base on purchasing power parity-theory of one price. Das (2009) reports about publicly well-known popular indices the Big Mac index and Starbucks tall-latte. According to the former one RMB yuan was undervalued by 54% but according to the latter it was also undervalued but only by one percent. Nevertheless, such approach based only on one product can lead to misleading results. Tyers, Bain, & Bu (2009) used three-good general equilibrium model and indicated that undervaluation of RMB yuan was present but they suggests that it should not be more than 10%. We must note, however, this methodology have a major flaw because the components of Chinese and American GDP differ significantly, private consumption represents slightly over 30% in the Chinese case whereas in the USA it is more than seventy percent so using consumer price indices can be misleading.

Frankel (2006) proposed measuring undervaluation using Ballassa-Samuellson hypothesis, which dealt with the differences of the structure of tradable non-tradable sectors. However, his methodology does not correspond with empirical evidence because he predicted that RMB yuan should have appreciated 24,4% in real terms from 2000 to 2010 but in fact it was approximately 50%. He also suggested that gradual inflation in China will keep appreciating RMB yuan. It was claimed if Chinese inflation is 2,24 percentage points above American for next decade RMB yuan will no longer be undervalued. Given the facts about recent data about Chinese inflation and still omnipresent view that Chinese currency is undervalued this was also inexact prediction.

Finally, Cheung, Chinn, Fujii (2007) used econometric model based on absolute purchasing power stated that employing basic inference findings corresponds to conventional wisdom that RMB yuan is undervalued but after applying uncertainty in inference and controlling for serial correlation they were unable to prove substantial undervaluation.

To conclude the issue, economists, who studied the RMB yuan undervaluation almost unanimously showed that RMB yuan is undervalued. However they significantly differ in projection of the magnitude of the undervaluation. Dunaway & Li (2005), who published resume of various research papers on the topic, concluded that based on various scientific researches the undervaluation of RMB yuan ranged between 0% and 50% in 2005. Such a huge variation in results gives us absolutely no clue about how much we the Chinese currency really undervalued in the last decade. The most recent publications have not rendered much light on the issue since their conclusions are contradictory [(Mallaby & Wethington, 2012), (Hanke, 2012)].

Therefore, based on the literature review, the hypothesis of the undervalued cannot be rejected, even if the outcomes of researches are not alike. Outcomes are negatively biased. Authors suggest either fair pricing or undervaluation. On top of that, during the review we did not come across a research suggesting the overvaluation of yuan so the suspicion of undervaluation in the case of RMB yuan is legitimate.

1.3.2.3. Current account balance

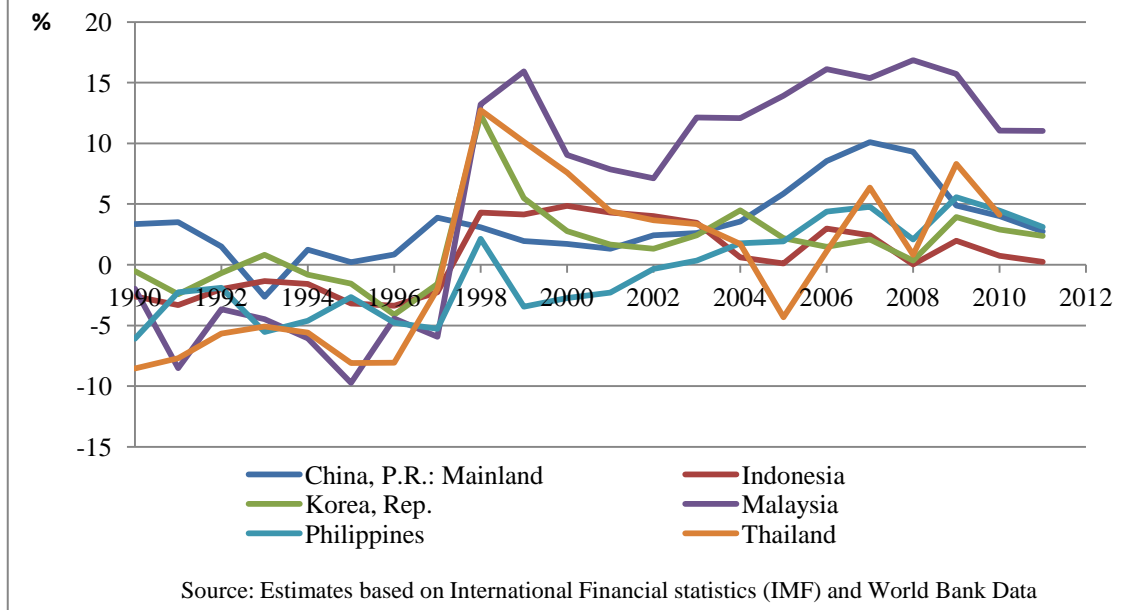
Figure 6 illustrates the substantial change in current account balances in East Asian countries. Prior to 1997 all countries in the sample except China ran current account deficits. In 1997 currencies depreciated and the absolutely opposite situation occurred in 1998, when all examined countries reported current account surpluses. This situation persisted until now. All countries have shown current account surpluses since 2002, except for Thailand in 2005. Even the magnitude of change is worth noticing. Malaysia, Philippines and Thailand had high³ current account deficits prior to 1997, but most notably Malaysia benefited from high prices of exported resources and kept very high current account surplus during the last decade. Turning into net exporters of goods and services is not a surprise after proceeding to devaluation of domestic currency by at least 35 % but the persistence of current account surplus for a decade is intriguing.

McCauley & Ma (2008) suggest that so persistent current account surpluses are an uncanny circumstance and are sign of the policy supporting exports. Even if, the presence of current account surpluses and its time pattern is not a proof of causal connection between growth of foreign exchange reserves and the success of Asian exporters but we view it as a sign of neo-mercantilist strategy. McCauley & Ma (2008) identify three main determinants of current account balances. These are business cycle, fiscal policy and real exchange rate, all three variables appeared both statistically and economically significant in the econometric model created by authors.

Significance of real exchange rate variable and previously discussed undervaluation of currencies, together with persistent current account surpluses and growing stacks of foreign exchange reserves suggest the application of neo-mercantilist strategy by East Asian countries. Nonetheless, foreign exchange reserves cannot be presented as the only driver of export-oriented strategies. Other determinants for further research are capital controls, domestic financial regulation and FDI policy.

³ (McCauley & Ma, 2008) identify 3% current account surplus or deficit as high.

Figure 6: Current account balance as of GDP



1.4. Costs of holding reserves

Holding of foreign exchange reserves cannot be viewed as an asset only, foreign exchange reserves bear a liability side as well. Green & Torgerson (2007) argue that marginal benefit of accumulating more reserves declines at some point and they note that we should compare marginal returns with marginal costs. Even, if authors suggest that accumulation of foreign exchange reserves is costly, they add that quantification of costs is often obscure. Green & Torgerson (2007) pinpoint among others sterilization and opportunity costs of holding reserves.

1.4.1. Sterilization costs

Accumulation of foreign exchange reserves can have an inflationary impact on domestic economy because of increased money supply. To prevent an inflationary impact on domestic market, central bank can offset increase in money supply by sterilizing it. The most common mean of sterilization is issuing domestic debt. Green & Torgerson (2007) indicate two features of sterilization fiscal costs and systematic costs.

Systematic costs represent costs that are incurred by preventing current account from its natural adjustment. Sterilized interventions are ineffective in case of emerged economies because domestic and foreign bonds and treasuries are equivalent. Lavigne (2008) suggests that the equivalence does not hold for emerging markets and thus substantiate possibility that foreign exchange reserves can be used as tool for neo-mercantilist motives.

Fiscal costs incorporate the difference between the yield of reserves and interest paid on domestic debt that was issued to offset inflationary pressure. In rare cases, when

interest paid on domestic debt is lower than gain from foreign exchange reserves, fiscal costs may be even negative. As far as Asian countries are concerned, Lavigne (2008) finds that they resorted to sterilizations without any additional inflationary pressure but exact level of sterilizations is hard to be disentangled because growing economies are naturally increasing its money supply.

Rodrik (2006) argues that fiscal costs are tantamount to spread between interest rate earned and paid on domestic debt. The Author estimates the spread to be 5 % and calculate that emerging countries' costs associated with reserves are 1 % of their GDP.

1.4.2. Opportunity costs

Other costs, worth considering when managing foreign exchange reserves, are opportunity costs. Basic notion of opportunity costs is that they should equal to the second most beneficial opportunity to invest in but Green & Torgerson (2007) suggest that Asian countries are not managing foreign exchange reserves judiciously from this point of view. Authors argue that alleged excessive reserves could be invested in the domestic development project.

Summers (2006) estimates the real return foregone by accumulating reserves and not investing in domestic health, educational and infrastructure projects to be 6 % p.a.

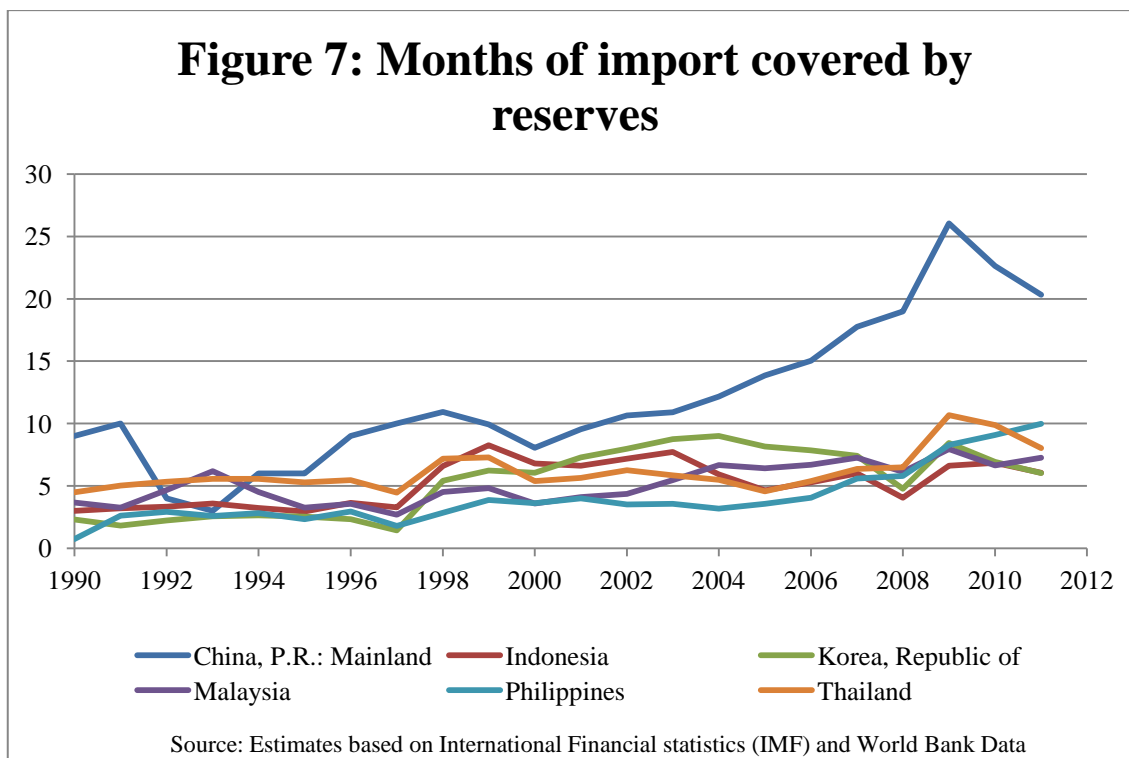
1.5. Measures of adequacy

As reserves embody both costs and benefits, there must be equilibrium for optimal holdings. In this part three informal measures of adequacy will be described. Even if there are some rule of thumb levels of three following measures, we will not pay much patience to absolute levels of these measures because Moghadam, Ostry, & Sheehy (2011) suggest that adequate level of foreign exchange reserves is a subject to country specifics. We will rather focus on development of these scales.

1.5.1. Months of Import

Prior to globalization foreign exchange reserves were mainly used for managing current account payments. Thus months of import are used to demonstrate how long a country would be able to defray its import expenses if suddenly it lost any access to foreign liquidity from abroad.

The common rule of thumb of adequacy is three months of import. Figure 7 shows that in the beginning of 1990's not all sample countries exceeded this level but later trend of months of import grew steadily that it covered more than five months in 2011, thus all countries in our sample are more insured for covering current account expenses.

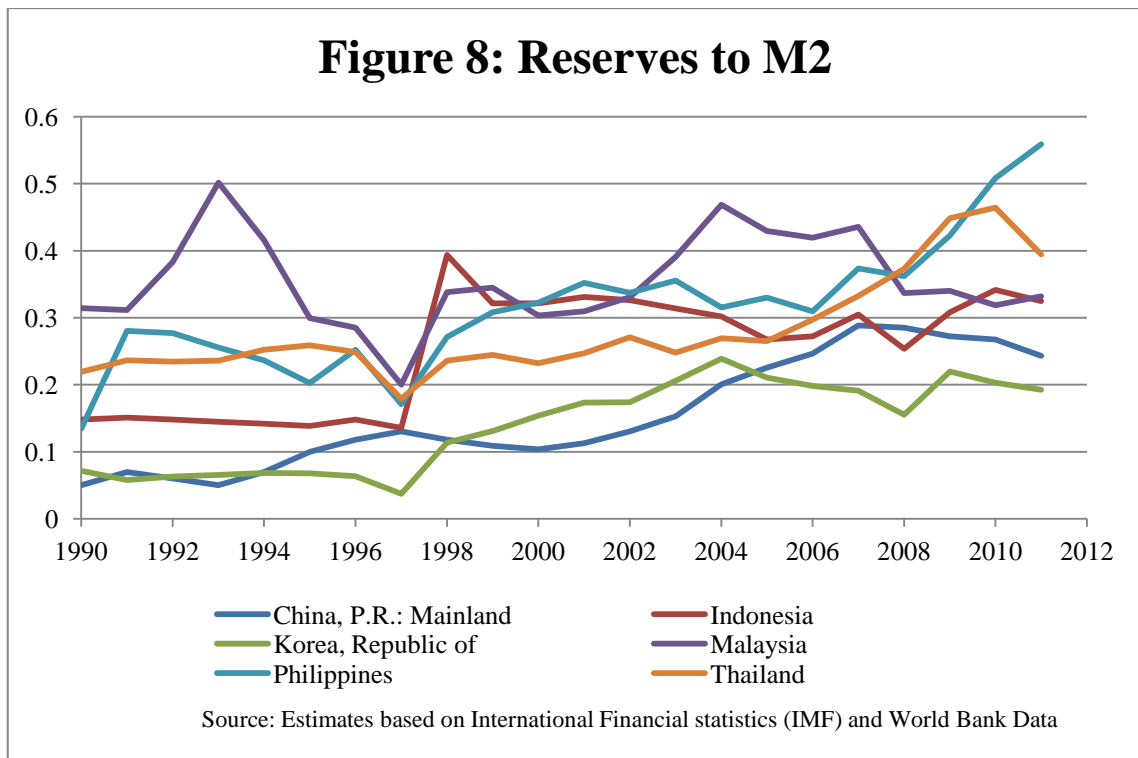


1.5.2. Reserves to M2

Green & Torgerson (2007) identify usefulness of this metric for countries that are endangered by possible capital flights, which we assume Asian countries are as foreign investors pulled out their capital from Asian markets during Asian crisis in 1997.

Level of adequacy for this measure ranges from 5 % to 20 % based on exchange rate regime. Green & Torgerson (2007) indicate that the larger the ratio the larger confidence in domestic currency by external parties. Figure 8 depicts the development of this measure over 22 years. All countries increased their reserves to broad money compared with 1990 except for Malaysia, whose ratio was already high in 1990.

Breaking point in this case is year 1997. After Asian crisis other five countries increased their reserves with respect to broad money. In 1997 confidence in their currencies was shaken and they were forced to devalue them. Based on the development of this metric, accumulation of foreign exchange reserves can be partly explained as an aim to regain confidence in domestic currencies.



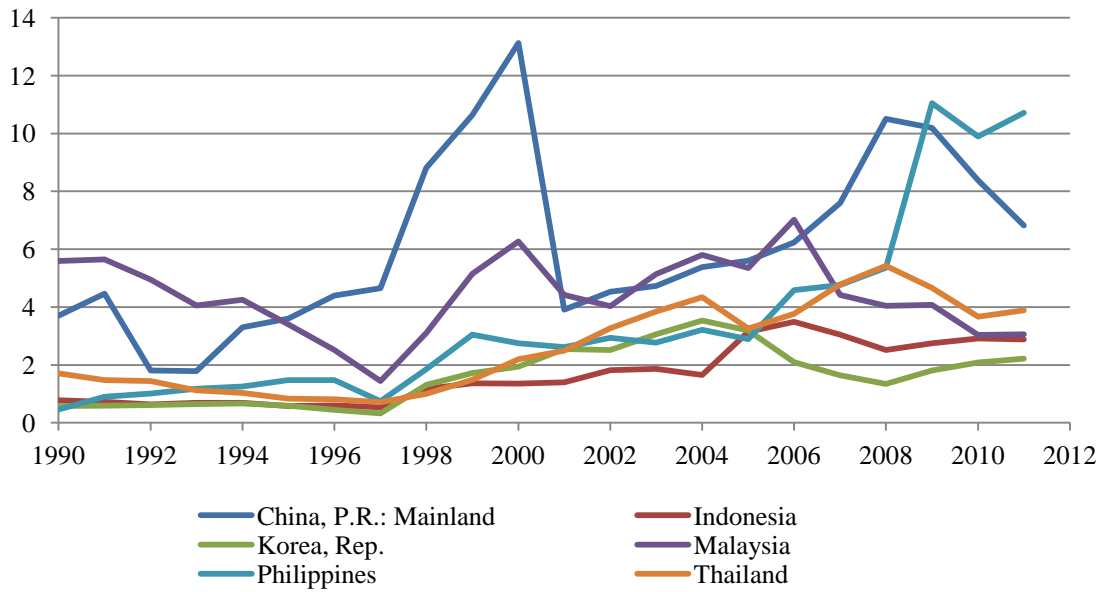
1.5.3. Reserves to short-term debt

Last informal measure presented is reserves to short-term debt. This metric describe how a country is able to meet its current liabilities in case of conditional access to foreign exchange markets.

Figure 9 illustrates that Korea, the Philippines and Indonesia had this measure less or slightly above one prior to Asian crisis. During Asian crisis countries not having reserves higher than short-term debt were forced to ask the IMF for assistance. Subsequently, Feldstein (1999) stated that emerging countries cannot rely on IMF and should be able to cover current liabilities on their own. Informal rule for this setting also known as Guidotti–Greenspan rule says that reserves should exceed short-term debt.

According to this measure reserve holdings increased as well and prior to 2008 crisis all countries fulfilled Guidotti–Greenspan rule. The role of exposure to short-term debt during recent financial crisis will be discussed later.

Figure 9: Reserves to short-term debt



Source: Estimates based on International Financial statistics (IMF) and World Bank Data

2. Chapter 2 – Econometric examination

In this part the econometric examination of the accumulation of the foreign exchange reserves will be presented. The core of the econometric research comes from Edison (2003), who designed a model predicting real exchange reserves. The dataset comprised of 122 emerging economies. Apart from East Asian countries the dataset included oil exporters, South American states, emerging East European economies and others. The model used by Edison (2003) was formally initially defined by Aizenman & Marion (2002). Coefficients of the model are computed through linear regression with panel data using fixed effects with errors corrected for autocorrelation and heteroscedasticity.

Edison (2003) used data from 1980 to 1996 and then compared predicted data in the following years with the real reserves holdings. Research resulted in proclamation that holdings were in line with previous years until 2000 but after the beginning of the new millennium, the model failed to predict holdings and underestimated actual level of foreign exchange reserves. As a consequence of this findings (Edison, 2003) suggested that level of reserves does not correspond to the economic fundamentals and that the rapid accumulation of reserves would stop. However, deceleration of accumulation did not occur as shown in the previous chapter.

Park & Estrada (2009) replicated the research with the sample of 130 emerging economies from 1980 to 2004. Their results were analogous to the ones of Edison (2003), their predictions also underestimated the future development of the reserves holdings. However Gosselin & Parent (2005) identify that a lot of econometric researchers studying panel data models does not take into account unit roots and ignore possible spurious regression.

The research goal of this econometric examination is to do alike procedure in computing coefficients and then evaluating the accuracy of predictions. Nevertheless this research will include few changes. Notably, dataset will be narrowed to East Asian countries and dummy variables for controlling of policy analysis and structural change will be incorporated.

2.1. Model specification

The starting model is specified equivalently as in Edison (2003) and Park & Estrada (2009).

$$\begin{aligned} \log(\text{real reserves}_{it}) &= \beta_0 + \beta_1 \log(\text{population}_{it}) + \beta_2 \log(\text{real gdp pc}_{it}) \\ &+ \beta_3 \log(\text{export volatility}_{it}) + \beta_4 \log(\text{imports to gdp}_{it}) \\ &+ \beta_5 \log(\text{volatility of neer}_{it}) + a_i + e_{it} \end{aligned} \quad (1)$$

The model explains real reserves holdings with five independent variables. Population and real gross domestic product per capita represent size of the country and its domestic output per capita. Export volatility and imports to GDP are variables linked to risk exposure of current account and thus their coefficients can be analyzed with respect to self-insurance motives of holding reserves, whereas volatility of the nominal effective exchange rate is associated to neo-mercantilist motives of holding reserves. Penultimate item on the right side of the equation is country's unobserved effect and the last item is and idiosyncratic error. Variables are in logarithmic forms because of

scaling. For example imports to GDP ratio larger than ten is far-fetched whereas population of a country amounts to hundreds of millions in several cases. Logarithmic forms are also according to Wooldridge (2002) appropriate for measuring sensitivities, which is congruous to economic analysis.

2.2. Dataset

Aforementioned econometric analyses were conducted with large data samples containing over one hundred emerging economies, even if the goal of the research was to examine accumulation of the foreign exchange reserves in East Asia. Fixed effect models allow for different intercepts among countries but they assume the same slope across dataset. This assumption is at least questionable because dynamics of the accumulation of foreign exchange reserves were different in East Asia, Latin America and East Europe (Edison, 2003).

Therefore, we will limit our dataset to only six countries informally analyzed in previous chapter: PRC, Indonesia, South Korea, Malaysia, Philippines and Thailand. To main consistency with Edison (2003) and Park & Estrada (2009) our sample starts in 1980. The last year in our sample is 2011. Table 2 describes all variables used during econometric research.

Table 2: Lists of variables		
	Description	Source
lres	Natural logarithm of real reserves excluding gold in US dollars. Nominal	IMF
lpop	Natural logarithm of population.	WB data
lrgdpc	Natural logarithm of real GDP per capita in US dollars. Nominal values are deflated by US GDP Deflator (2005=100).	IMF
lexv	Volatility of real export receipts, natural logarithm. Volatility is calculated using annual data and is the standard error of a regression of trend real exports.	IMF
limpg	Natural logarithm of imports to GDP.	WB data
lrimp	Natural logarithm of real imports of goods and services in US dollars.	IMF
lvolneer	Volatility of the nominal effective exchange rate, natural logarithm. Annual volatility is calculated using the previous 24 months of data and is the standard deviation of the innovation of the percentage change in the nominal effective exchange rate.	IMF
lm2g	Natural logarithm of M2 to GDP.	WB data

2.3. Unit roots

Gosselin & Parent (2005) argued that econometric panel data examination of foreign reserves holdings ignored possible presence unit roots and The study of unit roots and cointegration is a common practice in case of time-series but in last fifteen years several tests for unit roots [(Levin, Lin, & Chu, 2002), (Im, Pesaran, & Shin, 2003)] and cointegration [(Pedroni, 2002) and (Westerlund, 2007)] were developed. Regressing variables, which are integrated of order one may lead according to Wooldridge (2002) a spurious regression. This is an event, when unrelated variables show statistically significant dependence without any causal dependence. Regression of I(1) variables is causally valid if variables have the cointegration property i.e., their linear combination is stationary.

Baltagi (2008) concludes that (LLC, 2002) is more restrictive test for unit roots than (IPS, 2003) because its null hypothesis is that panels contain unit roots against alternative of stationarity of panels, whereas (IPS, 2003)'s null hypothesis is that all panels contain unit root with alternative hypothesis that some panels are stationary. However the limitation of (LLC, 2002) is a fact that it strongly depends upon cross-independence. With panels correlated across sections, the test is not applicable.

For assessing the dependence of panels we use Pesaran's test of cross sectional independence (Pesaran, 2004)⁴. After conducting the test, we fail to reject the hypothesis of cross sectional independence at 5 % level of significance⁵, so we may employ both aforementioned tests for unit roots in panel data.

Table 3: Unit root tests (p-values)				
	LLC 2002	LLC 2002 trend	IPS 2003	IPS 2003 trend
lres	0,64	0,02	1,00	0,00
lpop	0,00	0,00	0,00	0,00
lrgdpc	0,99	0,14	1,00	0,49
lexv	0,00	0,00	0,00	0,00
limpg	0,43	0,37	0,74	0,20
lrimp	0,87	0,03	1,00	0,06
lvolneer	0,00	0,00	0,00	0,00
Source: Author's estimates				

Table 3 contains results of unit root tests. In case of logged imports to GDP we fail to reject hypothesis of unit roots for all four tests conducted, so it will be omitted from our model. Still, imports seem to be a good fit for an explanatory variable because one of main purposes of reserves is defray imports and on top of that months of imports are one of common rule-of-thumb measures of adequacy. Therefore, logged real imports are introduced as a new variable. After testing it for a unit root, we conclude that this variable is non-stationary but it is stationary around its trend.

Another questionable variable is logged real GDP per capita, which only appears trend-stationary at 15 % level of significance when using (LLC, 2002). However, it will be kept in the model to maintain consistency with Edison (2003).

As far as other variables are concerned, there is the ample evidence that all of them are trend-stationary. Since the dependent variable is not stationary, we do not look for cointegration space. Trend is added to the equation to make it valid (Wooldridge, 2002).

2.4.Heteroscedasticity and serial correlation

Neither heteroscedasticity nor autocorrelation nor the presence of both does cause estimates to be inconsistent or biased but their presence makes classical statistical inference unreliable (Wooldridge, 2002). In order to be able to assess statistical significance of a variable or a set of variables, the presence of heteroscedasticity and

⁴ xtcsd command in Stata

⁵ standard errors were corrected for heteroscedasticity and serial correlation

serial correlation shall be tested and corrected if identified. The tests will be conducted on the updated model.

$$\begin{aligned} \log(\text{real reserves}_{it}) &= \beta_0 + \alpha t + \beta_1 \log(\text{population}_{it}) + \beta_2 \log(\text{real gdp pc}_{it}) \\ &+ \beta_3 \log(\text{export volatility}_{it}) + \beta_4 \log(\text{real imports}_{it}) \\ &+ \beta_5 \log(\text{volatility of neer}_{it}) + a_i + e_{it} \end{aligned} \quad (2)$$

2.4.1. Serial correlation

For testing serial correlation we use a test described by Wooldridge (2010)⁶. The null hypothesis of no first-order autocorrelation is rejected at 1 % level of significance, so standard errors will have to be corrected.

2.4.2. Heteroscedasticity

In order to test for the presence of heteroscedasticity we use likelihood ratio test described by Wiggins & Poi (2001). Likelihood ratio test compares two models and asserts under which data are more likely. Exact methodology including Stata commands can be found in Wiggins & Poi (2001).

The test bluntly rejects null hypothesis of homoscedasticity at 1 % level of significance and thus the model is more likely to explain variance with for heteroscedasticity-corrected standard errors, so we will have to correct for heteroscedasticity as well.

2.4.3. Correcting standard errors

To gain statistically reliable results we have to correct disturbances for both concerns. Wooldridge (2011) suggests using cluster errors⁷, which are robust to the presence of heteroscedasticity or autocorrelation or both. Six clusters are used and each represents one country.

2.4.4. Multicollinearity and Exogeneity

Multicollinearity is tested⁸ and rejected so regression results will not suffer from inflated variance. In the case of exogeneity, which guarantees consistency of the estimator, we rely on assumptions made by Edison (2003) that explanatory variables are exogenous.

2.5. Regression results

Running the regression described by equation (2) yielded results depicted in Table 4. Coefficients of logged export volatility and logged real imports have expected signs. Both corroborate idea that country, whose current account exposure is larger, should hold larger reserves and as a regression results show, it is a real practice.

Volatility of nominal effective exchange rate has opposite sign than expected which does not substantiate theory of neo-mercantilism. Nevertheless, the null hypothesis of the slope being zero cannot be rejected at any reasonable level of significance. The reason, why volatility of nominal effective exchange rate cannot explain the variance in real reserve holdings, is hidden in exchange rate regimes countries in our sample pursued. Malaysia and China abandoned peg in 2005. Korean won and Thai baht were also pegged until 1997 and Indonesia heavily managed its

⁶ xtserial command in Stata

⁷ xtreg ,fe cluster(countrycode) command in Stata

⁸ _rmcoll command in Stata

currencies exchange rate. Only one country in our sample, Philippines, has had freely floating currency for a long period.

Logged real GDP per capita has an expected sign. Logged population has an opposite sign than it would be seem plausible but the coefficient is statistically insignificant.

Overall issue with the regression is that only one explanatory variable is significant at 5 % level. Testing for joint-significance of four individually insignificant variables does not substantiate current model specification either. We fail to reject null hypothesis of joint insignificance for at 5 % level of significance. Such results are a clear impetus for the model re-specification.

Table 4: Regression results (2)		
	Coefficient	P> t
lres	Dependent variable	
constant	-110,91	0,05
trend	0,07	0,08
lpop	-1,43	0,31
lrgdpc	0,46	0,18
lexv	0,04	0,14
lrimp	0,61	0,04
lvolneer	0,01	0,90
P>F	0,00	
R-sq	0,93	
Obs.	192	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

2.6. Model re-specification

There are several ways how the model could be re-specified. The first one is changing functional form of some variables but maintaining logarithmic forms is crucial for scaling variables and measuring elasticity. Another possible solution is adding new variables. Broad money is a suitable candidate for our model. Gosselin & Parent (2005) used M2 in their research on explaining reserve holdings in Asia and on top of that it is one of measures of adequacy introduced in the first chapter. However, logged real imports and logged M2 are almost perfectly correlated, which violates assumptions of fixed effects regression. Thus we will incorporate broad money in the proportional form to GDP, which is not perfectly correlated with logged real imports. New regression equation is defined as follows.

$$\begin{aligned} \log(\text{real reserves}_{it}) &= \beta_0 + \alpha t + \beta_1 \log(\text{real imports}_{it}) + \beta_2 \log(M2/GDP_{it}) + a_i \\ &+ e_{it} \end{aligned} \quad (3)$$

Logged M2/GDP is trend-stationary variable and the errors in the regression were corrected for heteroscedasticity and autocorrelation. Regression results can be found in Table 5. Now both variables are statistically and economically significant and their coefficients have expected positive signs.

Main drawback of newly specified regression is unavailability of data of broad money for sample countries till 1980, so we were forced to shorten time span to 1990 – 2011. Therefore, in this phase of research we abandoned the initial goal of comparing the results with Edison (2003) and Park & Estrada (2009) because our original constructed dataset did not correspond with condition for econometric analysis with stationary panel data with fixed effects.

Table 5: Regression results (3)		
	Coefficient	P> t
lres	Dependent variable	
constant	-89,81	0,05
trend	0,05	0,07
lrimp	0,87	0,02
lm2g	0,78	0,01
P>F	0,00	
R-sq	0,90	
Obs.	132	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

2.6.1. Exogeneity and multicollinearity

Wooldridge (2002) mentions exogeneity and multicollinearity as key assumptions for fixed effects regression. Notably violation of assumption of exogeneity leads to inconsistent estimator. We consider our variables exogenous with respect to real reserve as imports are determined by domestic demands for foreign goods and services regardless of foreign exchange reserves domestic central bank possess.

Our model relies on assumption on supply of broad money to be exogenous. We assert that money supply is managed in the first place and foreign exchange reserves secondly and not vice versa.

Multicollinearity was not detected in our sample⁹.

2.7. Policy analysis

In this part the ostensible structural break in foreign exchange reserves accumulation patterns will be examined. Policy shift and faster pace of accumulation after 1997 seem obvious from figures in the preceding chapter but the current subject of examination is whether there is an econometric proof that substantiate the hypothesis.

Wooldridge (2002) proposes two ways of testing for the structural break. The first one is the Chow test, where sum of squared residuals of the unrestricted mode is compared with total of sum of squared residuals of two submodels. The simple F-statistics is computed and the null hypothesis of the test is that there is no structural break. This test yields unequivocal result of structural break's presence but for analyzing change in slopes or intercepts Wooldridge (2002) argues that using dummy variables and product terms in the regression is an appropriate solution.

⁹ _rmcoll Stata command

In order to be able to do the policy analysis, a dummy variable and product terms will be added to the equation (3). D98 is a new variable whose value is one for years after 1998, year 1998 included, and zero for years before 1998. Regression (4) is designed to test for difference in slope and in intercept after 1997.

$$\begin{aligned} \log(\text{real reserves}_{it}) &= \beta_0 + d98 + \alpha t + \beta_1 \log(\text{real imports}_{it}) + \beta_2 \log(M2_{it}) \\ &+ \beta_3 \log(\text{real imports}_{it}) * d98 + \beta_4 \log(M2/GDP_{it}) * d98 + a_i \\ &+ e_{it} \end{aligned} \quad (4)$$

Table 6: Regression results (4)		
	Coefficient	P> t
lres	Dependent variable	
constant	-52,95	0,23
trend	0,04	0,17
lrimp	0,28	0,46
lm2g	1,26	0,00
d98	-18,31	0,02
lrimp*d98	0,73	0,02
lm2g*d98	-0,81	0,02
P>F	0,00	
R-sq	0,93	
Obs.	132	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

Table 6 identifies that variables controlling for difference in slopes and in the intercept are both economically and statistically significant, which could be viewed as an ample evidence of the structural break. Still, there is one issue worth noticing. Variable *lrimp* became suddenly statistically insignificant, according to Wooldridge (2002) this can be a sign of multicollinearity among explanatory variables. When correlation is tested¹⁰, almost perfect positive correlation between *lrimp*d98* and *d98* is found. Multicollinearity does cause estimator to be inconsistent but inflates standard errors of estimates.

However, Allison (2012) proposes that multicollinearity can be ignored when it is caused by adding powers or products of variables or dummy variables representing a group. This is exactly this case. What is more, he also notes product terms should be tested together with original variables and product terms and original variables should be viewed as one piece. Thus joint F test for *lrimp*d98*, *d98* and *lrimp* rejects null hypothesis of joint insignificance. This could be concluded as a clear proof of structural break after 1997.

2.7.1. Position of structural break

Even if it was shown in the previous part that there is the evidence for the structural after the Asian crisis, we believe it is worth considering point of the structural break also after year 1997. Years from 1997 to 2001 were tested for possible structural

¹⁰ correlate command in Stata

break in the same manner, which was applied before. In all years differences in slopes and intercepts were statistically significant.

From the whole interval of years, the year 2001 shows the most significant results. Variables associated with policy analysis are most significant of all regressions and the variance of the original variables is least inflated. Variable $d01$ is defined as if year ≥ 2001 then $d01=1$ and $d01=0$ for remaining cases. Results of the regression can be found in Table 8.

$$\begin{aligned} \log(\text{real reserves}_{it}) &= \beta_0 + d01 + at + \beta_1 \log(\text{real imports}_{it}) + \beta_2 \log(M2_{it}) \\ &+ \beta_3 \log(\text{real imports}_{it}) * d01 + \beta_4 \log(M2/GDP_{it}) * d01 + a_i + e_{it} \end{aligned} \quad (5)$$

Table 7: Regression results (5)		
	Coefficient	P> t
lres	Dependent variable	
constant	-83,19	0,06
trend	0,05	0,05
lrimp	0,33	0,29
lm2g	1,14	0,00
d01	-15,94	0,02
lrimp*d01	0,63	0,00
lm2g*d01	-0,68	0,01
P>F	0,00	
R-sq	0,92	
Obs.	132	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

2.8. Forecasting

In this subchapter, we will examine the development of the reserves holdings in the last year. We will examine, whether there was a change in accumulating reserves in respect to fundamentals. The assessment will be done analogously to Edison (2003), Gosselin & Parent (2005) and Park & Estrada (2009). The regression (5) will be re-estimated but observations for 2008, 2009, 2010 and 2011 will be excluded. Then, we will use the coefficients of the regression to predict out of sample values. Results of the regression from restricted dataset are very similar to the one from unrestricted.

Table 8: Regression results (5), year<2008		
	Coefficient	P> t
lres	Dependent variable	
constant	-96,81	0,16
trend	0,06	0,13
lrimp	0,28	0,35
lm2g	1,01	0,00
d01	-18,19	0,00
lrimp*d01	0,71	0,00
lm2g*d01	-0,72	0,01
P>F	0,00	
R-sq	0,89	
Obs.	108	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

2.8.1. Using bigger sample for forecasting

In addition to doing the forecast from sample of six Asian countries, that were examined thoroughly also informally, another forecast based on 53 emerging markets will be conducted. Dataset comprises states from Asia, Central and South America, Africa and Eastern Europe. Six countries from the smaller sample are included as well.

The regression is will be run as equation (5) states, the dataset traces from 1990 to 2008 to ensure consistency with previous forecast. Still, it is required that variables and possible structural changes are tested if they are statistically significantly. Due to the possible issues of multicollinearity and variance inflation, changes in slopes and intercepts will be tested separately.

After conducting the tests, we are able to conclude that neither changes in slopes nor change in intercepts is statistically significant. Hence, we exclude these terms from equation (5). Another arising issue is apparent insignificance of *lm2g*, the variable is kept in the model to maintain consistency with forecast on smaller sample. Not excluding the variable can be also justified because of its lesser economic significance compared to *lrimp*. For the forecasting on the bigger sample, we resort to using the initial model defined by equation (3).

Table 9: Regression results (3), 53 Emerging markets, year<2008		
	Coefficient	P> t
lres	Dependent variable	
constant	-127,85	0,00
trend	0,07	0,00
lrimp	0,67	0,00
lm2g	0,18	0,43
P>F	0,00	
R-sq	0,55	
Obs.	954	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

2.9. Empirical results

Conducting linear regression with panel data structure using fixed effect we came to interesting results. At first we tested structural break in patterns for holding reserves after Asian crisis. We found expected statistical evidence for structural break in intercept and slopes for all years between 1997 and 2001. Statistically the most significant structural break was found in 2001.

When we expanded our original dataset of six countries to 53 emerging markets, presence of structural break was rejected. On this ground, it can be concluded that change in behavior with respect to reserve accumulation was Asia specific and was not common for other emerging markets.

Outcomes of the forecast are indecisive with respect to common conclusion concerning countries in smaller dataset. Until 2007 the actual holdings coincide with predicted ones independent of method used in quantity and the trend of accumulation but after 2007 countries' trends diverge and do not have a common path.

We can separate our sample into three groups based on the comparison of actual and predicted reserves after 2007. The first group contains South Korea, Indonesia and Malaysia, whose predictions exceeds actual reserve holdings. The second group comprises of China and the Philippines, where the model underpredicts levels of holdings. The last group includes Thailand, whose actual reserves correspond approximately to the predicted ones.

This result opposes to the findings of Edison (2003), Gosselin & Parent (2005) and Park & Estrada (2009), whose econometric forecasts jointly underpredicted future reserves holdings in case of Asian countries. Still, we used different explanatory variables and did forecast for different period. On top of that, our conclusions are independent of dataset used for forecast.

Chinese reserve holdings are underpredicted by both datasets. Still, using narrow dataset is more exact in this case and holdings in 2011 are equal to those predicted by a narrow sample. Using sample of 53 emerging countries underpredicts Chinese holdings

more substantially, which confirms that Chinese amount of reserves is not in line with economical fundamentals in other countries.

Although in –sample predictions exceeded actual Thai holdings prior to 2008, after 2008 actual holdings were in line with the predictions, so we conclude that the model has strong predictive power in case of Thailand.

Another interesting case in our sample is the Philippines, whose pace of reserve accumulation even accelerated after 2007 and actual and predicted (6 countries) differed by 100 % in 2011. The clear impetus for faster accumulation is not apparent because as Yap, Reyes, & Cuenca (2009) point out the Philippines were affected by the financial crisis but overall impacts were among the least in the region.

In case of Korea, Indonesia and Malaysia, we can spot interesting development in 2007 predicted and actual reserves almost corresponded but after 2008 the holding stopped being in accordance with predicted levels. Aizenman & Sun (2009) list these three countries among those whose reserves depleted during recent financial crisis. Authors impute this to higher liability exposure of these. This conclusion is corroborated by Figure 9, where Malaysia, Indonesia and South Korea had the lowest ratio of reserves to short-term debt in 2007.

Aizenman & Sun (2009) argue that depleting own reserves is better solution for financial distress than asking a lender of last resort and expect that these three countries will start accumulating reserves again after they recover. This expectation was true as we can see in Figure A3. None of these three countries depleted their real reserves after 2008 but accumulated them again. Aizenman & Sun (2009) describe this return to accumulation as fear of losing foreign exchange reserves and preparation for another adverse situation. We perceive it as the prove of beneficiality of holding reserves because of self-insurance motives.

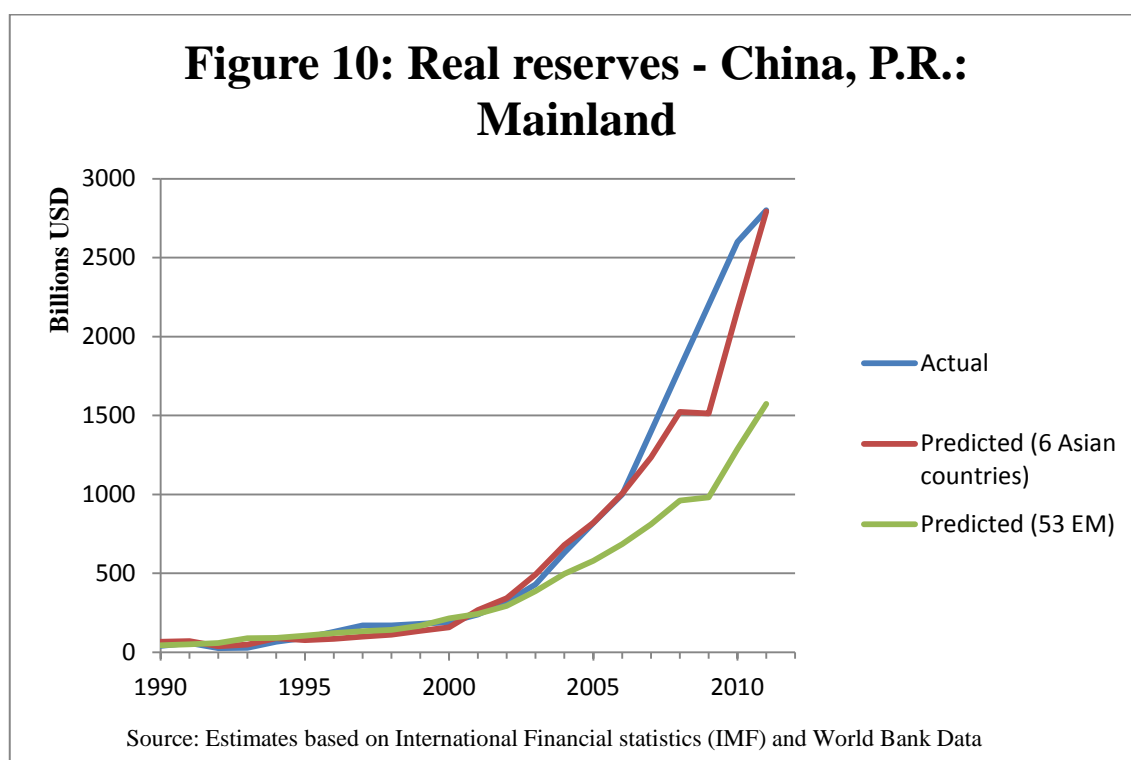
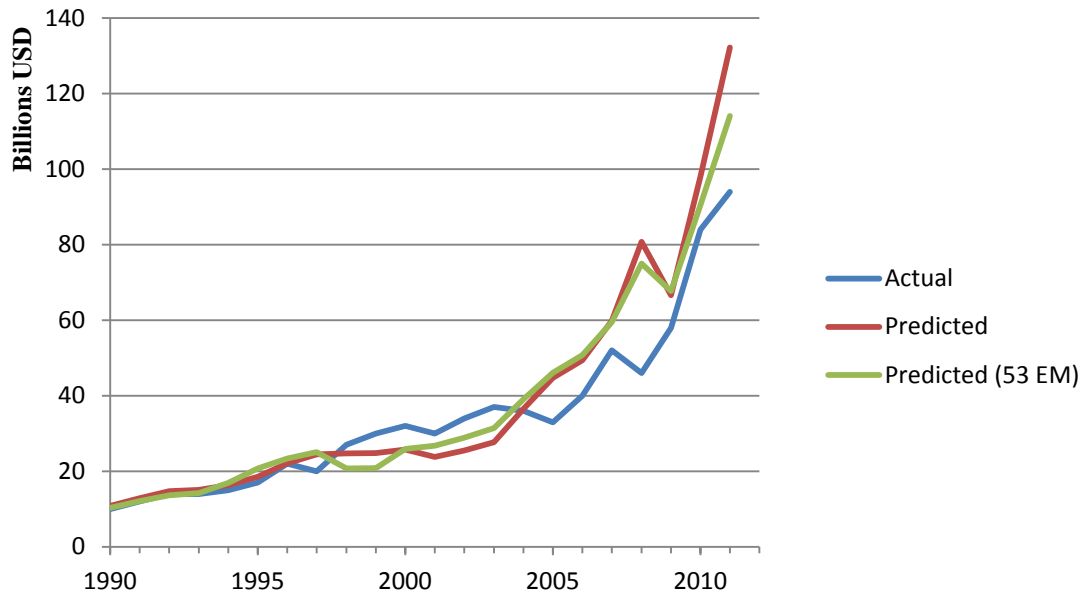
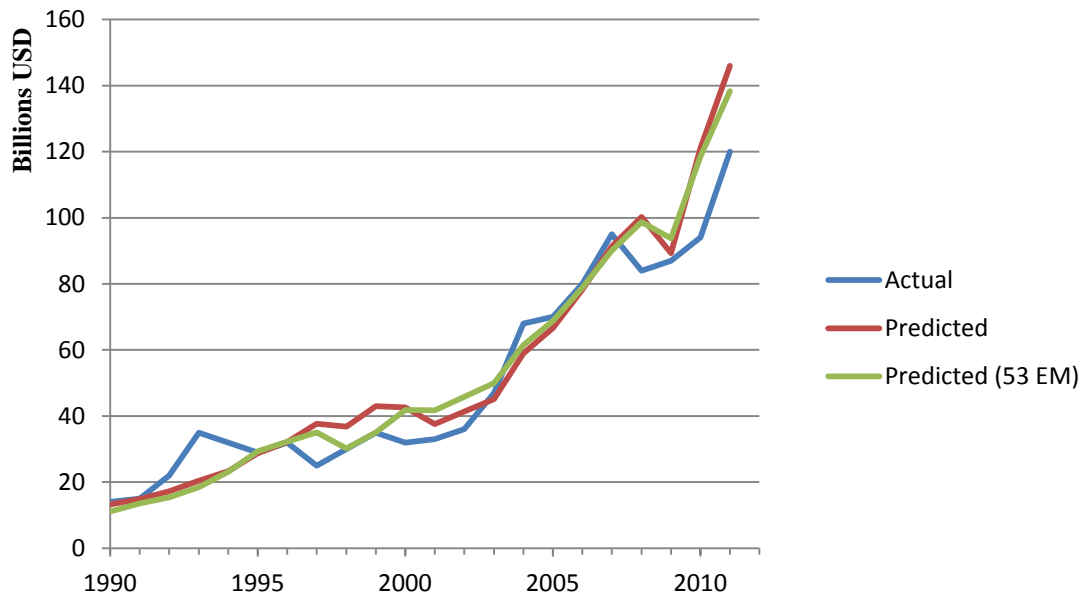


Figure 11: Real reserves - Indonesia



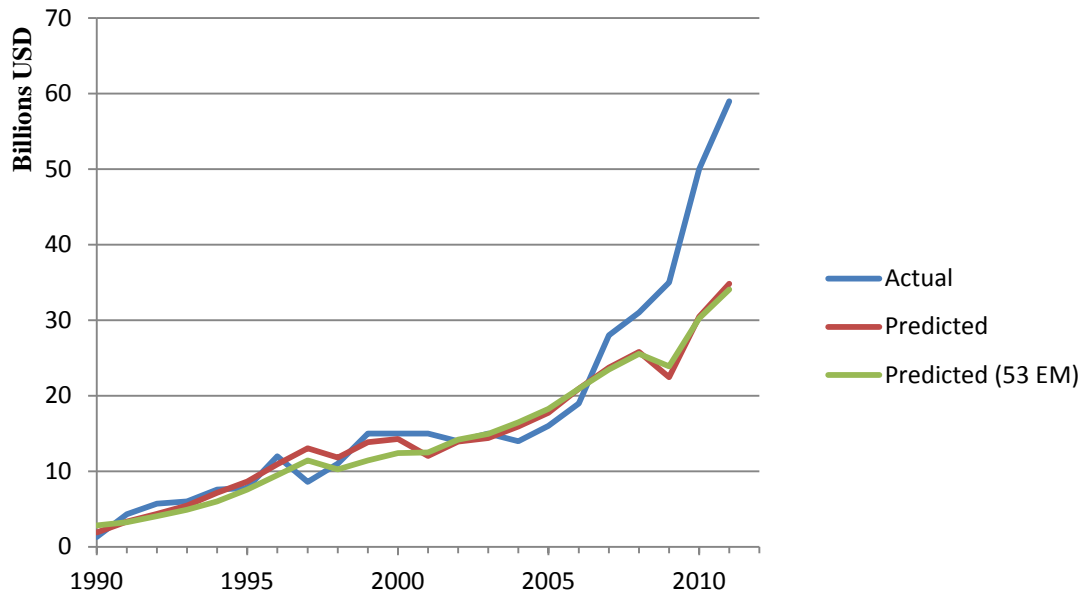
Source: Estimates based on International Financial statistics (IMF) and World Bank Data

Figure 12: Real reserves - Malaysia



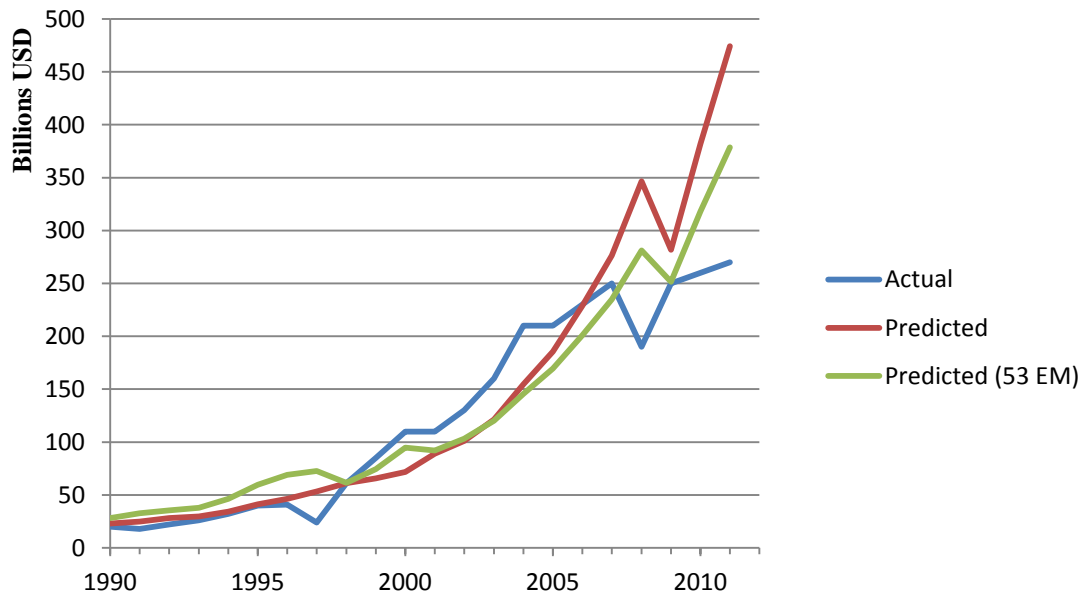
Source: Estimates based on International Financial statistics (IMF) and World Bank Data

Figure 13: Real reserves - Philippines



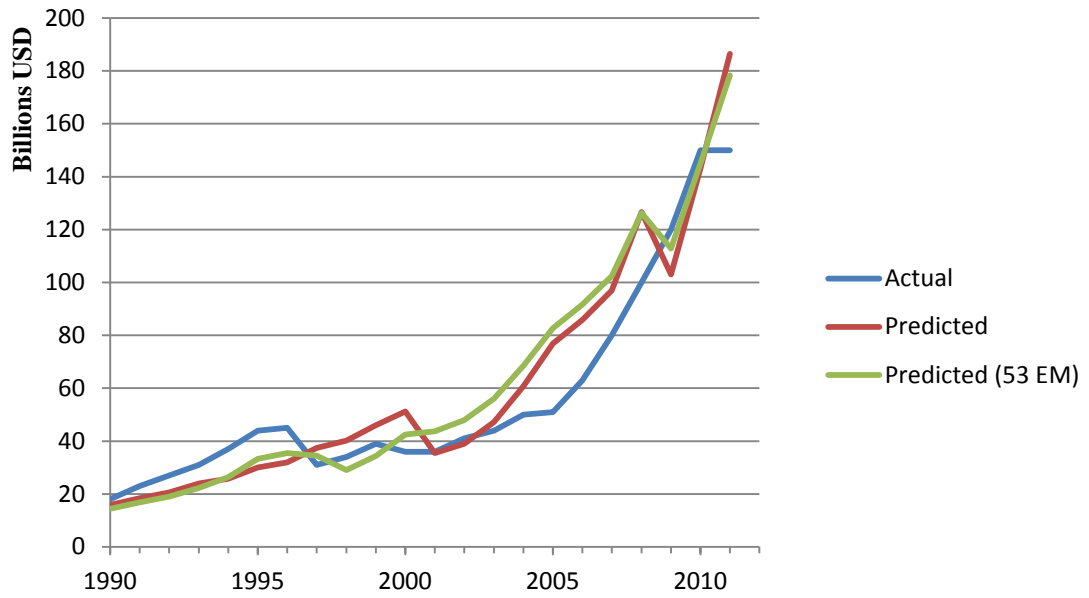
Source: Estimates based on International Financial statistics (IMF) and World Bank Data

Figure 14: Real reserves - South Korea



Source: Estimates based on International Financial statistics (IMF) and World Bank Data

Figure 15: Real reserves - Thailand



Source: Estimates based on International Financial statistics (IMF) and World Bank Data

Concluding Remarks

This thesis focused on research of foreign exchange reserves holdings in China, Indonesia, Malaysia, South Korea, Thailand and the Philippines. Firstly motives for holdings foreign exchange reserves were described and signs of both self-insurance neo-mercantilist reasons were indicated. Presence of self-insurance motive is substantiated by comparing countries' experience during crisis Asian and recent financial crisis.

During both crises some countries were forced to supply foreign liquidity to banks or intervene in foreign exchange market. As far as the recent financial crisis is concerned, states did not have to rely on external lenders and could use their internal reservoirs of foreign liquidity.

Neo-mercantilist use of foreign exchange reserves is corroborated by the literature review, which suggests undervaluation of East Asian currencies. The second feature supporting neo-mercantilist theory is a decade-persistent current account surplus in East Asian countries.

Three informal measures of reserves adequacy (M2, short-term debt and months of import) were used to assess levels of foreign exchange reserves. According to all measures reserves were higher in 2001 than in 1990 and in case of all countries reserve holdings exceeded common rules of thumb. Development of exceeding these measures after 2001 is different subjected to country examined and measure used. However, we conclude that there is not common increment in excesses since 2001 and ratios of reserves and references stagnated in more case than increased because variables used as measures of adequacy grew as well parallel to foreign exchange reserves.

Not increasing level of holdings compared to informal measures is a sign of not increasing costs of holding foreign exchange reserves by sample countries in relative terms.

In the econometric part, we digressed from initial aim to replicate fixed effects model designed by Aizenman & Marion (2002) because our dataset violated assumptions of consistent and inspurious regression. Instead, the model featuring two informal measures of adequacy was defined.

The policy analysis confirmed the presence of structural break after the Asian crisis. Surprisingly, the most significant shift was found in 2001 and not right after the crisis. This conclusion was drawn using dataset of six examined countries. Employing dataset of 53 emerging countries, no evidence of structural break was found, which indicates that change in pattern of accumulation was the Asian specificum.

The regression was circumscribed until 2007 and out-of-sample forecast till 2011 was made. Although in-sample predictions were similar to actual reserves for all countries, out-of-sample forecasts differed among countries. Notably, Korean, Indonesian and Malay holdings are under those that would correspond to pre-crisis levels. Aizenman & Sun (2009) came to the similar conclusion about these countries with different methodology.

Still, we do not present our findings as an unequivocal proof of divergence in accumulation of foreign exchange reserves among East Asian countries. Our findings are subject to specific model used. Nevertheless, the same conclusions were drawn on the basis of two different data samples. Change in holding patterns after financial crisis is a topic for further research. Notably examination of structural break after 2008 is worth investigating in few years.

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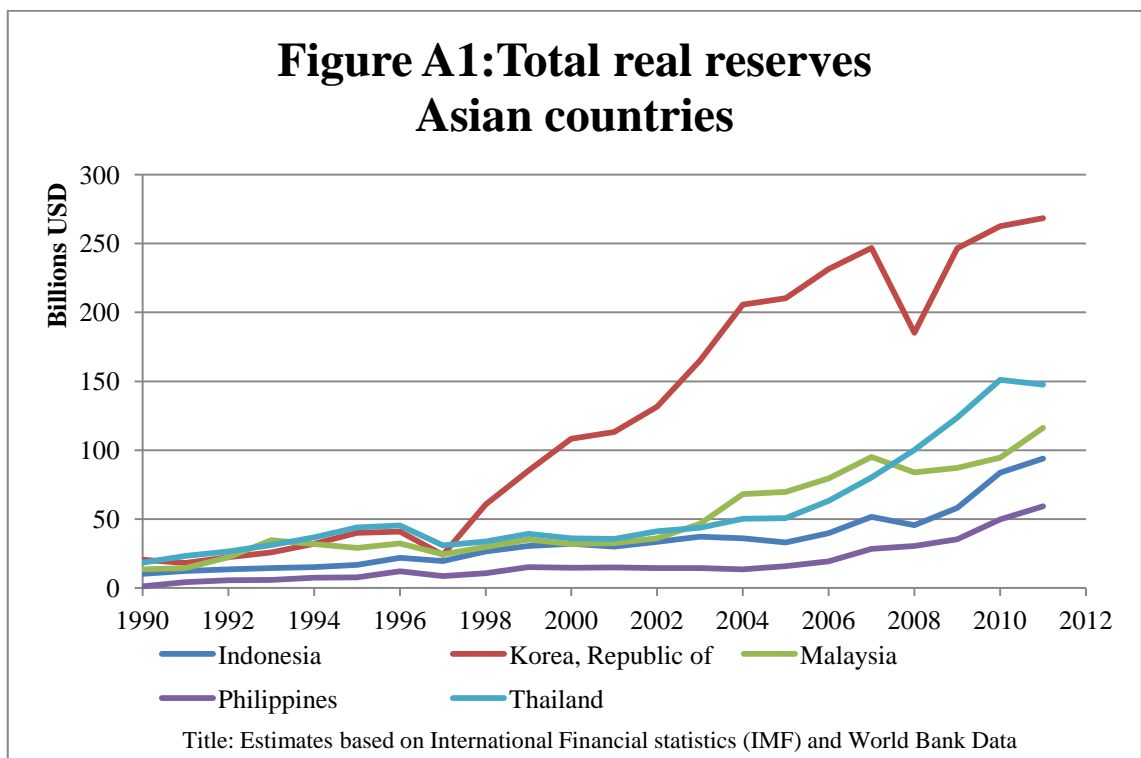
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Appendix

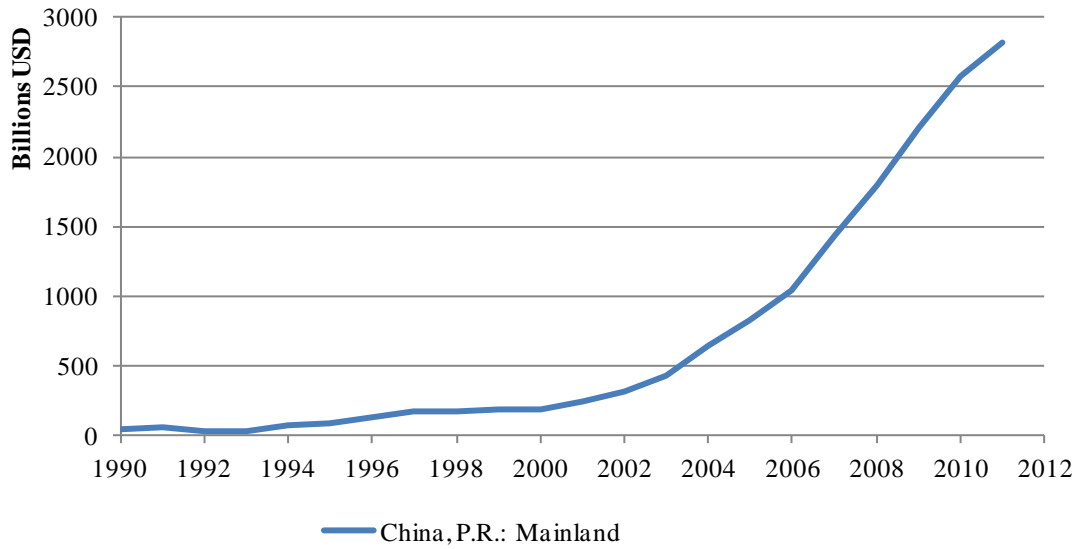
Table A1 and Figures A1, A2 and A3 are analogous to those in the first chapter with difference that here real reserves are portrayed instead of nominal ones.

Table A1: Real reserves gr. (total increment over period)						
	China, P.R.: Mainland	Indonesia	Korea, Republic of	Malaysia	Philippines	Thailand
1990-2000	363%	211%	429%	136%	1052%	96%
2000-2010	1261%	161%	142%	196%	238%	318%
1990-2011	6795%	810%	1210%	760%	4537%	701%

Source: Estimates based on International Financial statistics (IMF) and World Bank Data

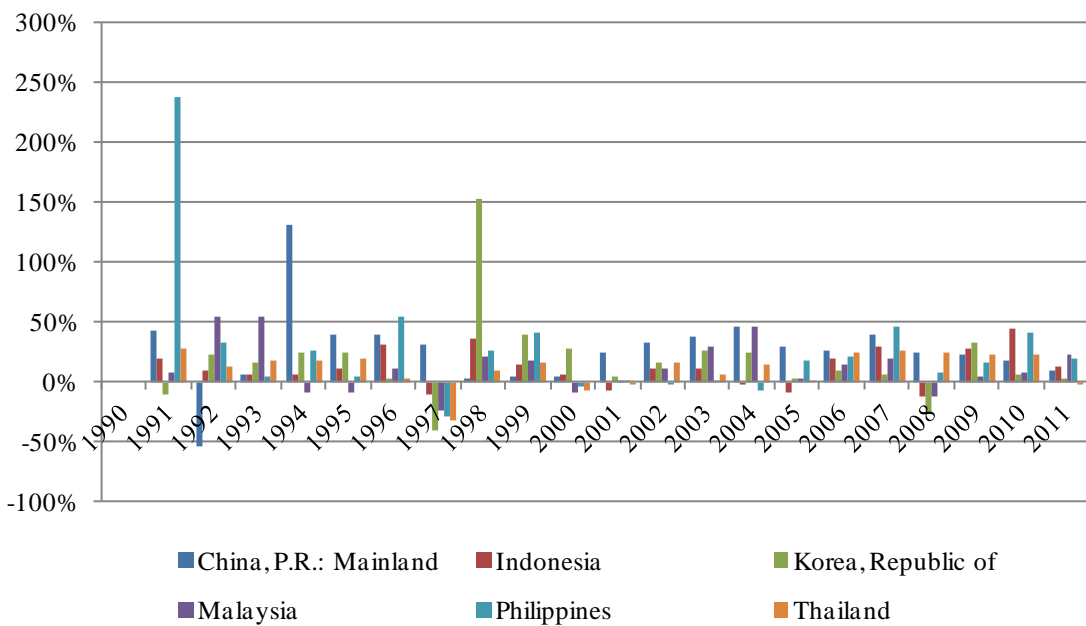


**Figure A2: Total real reserves
China, P.R.: Mainland**



Title: Estimates based on International Financial statistics (IMF) and World Bank Data

Figure A3: Yearly real reserves growth



Title: Estimates based on International Financial statistics (IMF) and World Bank Data

Tables A2, A3 and A4 contain regression results from testing position of structural break Regression is identical to equation (4), only dummy variable is changed.

Table A2: Regression results (4) d97		
	Coefficient	P> t
lres	Dependent variable	
constant	-93,64	0,04
trend	0,06	0,04
lrimp	0,20	0,56
lm2g	1,33	0,00
d97	-17,86	0,00
lrimp*d97	0,70	0,00
lm2g*d97	-0,72	0,05
P>F	0,00	
R-sq	0,92	
Obs.	132	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

Table A3: Regression results (4) d99		
	Coefficient	P> t
lres	Dependent variable	
constant	-59,77	0,14
trend	0,06	0,09
lrimp	0,32	0,36
lm2g	1,24	0,00
d99	-17,41	0,01
lrimp*d99	0,69	0,01
lm2g*d99	-0,79	0,01
P>F	0,00	
R-sq	0,92	
Obs.	132	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

Table A4: Regression results (4) d00		
	Coefficient	P> t
lres	Dependent variable	
constant	-78,01	0,06
trend	0,05	0,04
lrimp	0,30	0,36
lm2g	1,19	0,00
d00	-17,37	0,01
lrimp*d00	0,68	0,01
lm2g*d00	-0,77	0,01
P>F	0,00	
R-sq	0,92	
Obs.	132	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

Tables A5, A6 and A7 contain regression results of testing structural shifts with data sample including 53 emerging countries.

Table A5: Regression results (3), 53 Emerging markets, year<2008		
	Coefficient	P> t
lres	Dependent variable	
constant	-144,78	0,00
trend	0,07	0,00
lrimp	0,66	0,00
lm2g	0,18	0,43
d01	-0,11	0,19
P>F	0,00	
R-sq	0,55	
Obs.	954	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

Table A6: Regression results (3), 53 Emerging markets, year<2008		
	Coefficient	P> t
lres	Dependent variable	
constant	-140,28	0,00
trend	0,07	0,00
lrimp	0,66	0,00
lm2g	0,19	0,40
lrimp*d01	-0,00	0,34
P>F	0,00	
R-sq	0,55	
Obs.	954	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

Table A7: Regression results (3), 53 Emerging markets, year<2008		
	Coefficient	P> t
lres	Dependent variable	
constant	-135,89	0,00
trend	0,07	0,00
lrimp	0,66	0,00
lm2g	0,17	0,45
lm2g*d01	0,06	0,43
P>F	0,00	
R-sq	0,55	
Obs.	954	
Source: Author's estimates. Errors corrected for autocorrelation and heteroscedasticity.		

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