
Munich Personal RePEc Archive

Does financial development reduce the motivation to hoard foreign reserves?

Heng, Dyna

Australian National University

2011

Online at https://mpra.ub.uni-muenchen.de/48555/
MPRA Paper No. 48555, posted 24 Jul 2013 23:43 UTC

Does financial development reduce the motivation to hoard foreign reserves?

Heng Dyna[1]

Australian National University

This version: May 2012

Abstract: Managing capital flows and liquidity demand have been central issues for emerging market countries. This paper analyzes the effects of financial development and capital flows on foreign reserve accumulation in East Asian economies. Using annual data from 12 Asian economies between 1980 and 2009, the empirical results suggest that financial development can reduce a central bank's motivation to hoard foreign reserves by reducing the impact of capital flows on foreign reserve demand. Based on the empirical observations, this study then constructed a simple model of foreign reserve accumulation in which the optimal level of foreign reserves depends on the level of financial development. With an asymmetric preference in exchange rate, the actual level of foreign reserves held by a central bank is usually higher than the optimal level of foreign reserves needed for liquidity supply.

Keywords: foreign reserves, capital flows, financial development, liquidity demand.
JEL Classification: E52, F21, F36, F41, F62.

1. Introduction

'…Following the Asian crisis of the late 1990s, it was likely that countries might choose to build up large foreign exchange reserves in order to be able to act as "do it yourself" lender of last resort in US dollars.'

Mervyn King, Governor of the Bank of England (2006, p.5)

As emerging market economies are engaged in trade and often seek external finance to boost domestic capital accumulation, capital inflows into these economies are inevitable. With the growing global financial integration, the rapid growth of foreign reserves in emerging market economies over the past two decades has posed important questions for scholars and policy makers. What has driven such rapid foreign reserve accumulation? Are current levels of foreign reserves justified by economic fundamentals? What are the impacts of such rapid foreign reserve accumulation on global patterns of exchange rates, capital flows, and interest rates?

[1] Author's email. dynaheng@anu.edu.au. Tel: 855-78-708-628. This paper is based on a chapter of the author's PhD dissertation on "Macroeconomic Impacts of Capital Flows and Policy Responses", the Australian National University, Canberra, Australia. Heng, D (2013).

Emerging market economies have been observed to hoard foreign reserves to unprecedented levels. Since the early 1990s, while the average ratio of reserves to GDP in developed economies has remained steady at around 4 percent, the average reserve ratio in Asian and some other emerging market economies has risen from 4 percent to over 20 percent of GDP (Jeanne 2010). East Asian economies, for instance, have accumulated a large amount of foreign reserves, which were only USD 0.7 trillion before the Asian crisis in 1997, but rose nine-fold to around USD 6 trillion in 2010[2]. This amount is more than half the total global foreign reserves.

Against this backdrop, three major motives behind the rapid foreign reserve buildup are; precautionary self-insurance against a crisis (Aizenman & Lee 2008), mercantilism to stimulate growth (Dooley et al. 2004), and managing exchange rate volatility (Levy-Yeyati & Sturzenegger 2006). The precautionary motive is to build a 'war chest' to buffer against both current and capital account shocks (e.g. Jeanne & Ranciere 2006; Caballero & Panageas 2008) as well as to serve as 'do it yourself' lender of last resort after the 1997-1998 Asian crisis (King 2006). The mercantilist motive is to keep a currency undervalued in order to promote export competitiveness, No single explanation, however, can account for the behavior of all countries at all times. In addition, the importance of each rationale may change over time (Ghosh et al. 2012).

Despite a huge literature on foreign reserves, few studies have considered the role of an underdeveloped financial system in motivating foreign reserve accumulation among emerging market economies. Holmström and Tirole (1997; 2011) and Caballero and Krishnamurthy (2001; 2004) highlight the role of government in providing liquidity in financially underdeveloped economies. These studies suggest that governments in emerging market economies may address a shortage in the domestic supply of low-risk and liquid assets by accumulating foreign reserves. Similarly, Mendoza et al. (2007) make a theoretical argument that the global imbalance can be the outcome of financial integration, when countries differ in financial markets depth, implying the role of financial underdevelopment in motivating foreign reserve accumulation. None of these studies, nonetheless, provide direct evidence on the dynamics among capital flows, financial development and foreign reserve accumulation. In addition, many theoretical studies (e.g. Aizenmen 2008; Aizenman & Lee 2008) on foreign reserve accumulation, although addressing each aspect individually, do not take into account other aspects such as 'fear of appreciation', often noticed among emerging market economies.

This paper attempts to fill this gap by examining the effects of financial development and capital flows on foreign reserve accumulation. Applying simple pooled regressions with annual data from 12 East Asian economies in the period 1980-2009, this study first examines the relationship between capital flows, financial development, and foreign reserve accumulation. A fixed-effect method and alternative measures of financial development are also employed to check the robustness of the estimations. The results consistently suggest that financial sector development reduces the precautionary motivation to hoard reserves. Second, based on the empirical results, this study constructs a theoretical model of foreign reserve accumulation, in which a central bank holds foreign reserves to supply liquidity in a financially underdeveloped economy. The theoretical model argues that with a low capacity

[2]These economies are China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand and Vietnam.

of the private sector to mobilize resources for the liquidity supply due to an underdeveloped financial market, the monetary authority plays a key role in supplying additional liquidity. This theoretical model shows that development of the financial system reduces a monetary authority's motivation to hoard foreign reserves for liquidity provision. The theoretical model used in this study also shows that with an asymmetric preference in exchange rate, the actual level of foreign reserves held by a central bank is usually higher than the optimal level of foreign reserves needed for liquidity supply.

This paper contributes to the literature in three ways. First, the analysis concentrates on East Asian economies which attract a large share of global capital flows. Cross-region studies usually overlook the characteristics of each region. Thus, focusing on Asia could provide an in-depth analysis of the region, which takes into account its special characteristics, such as export-orientation and 'fear of appreciation'.

Second, the study formally takes into account the level of financial development in discussing foreign reserve demand and capital flows. This is an important departure from the existing literature on foreign reserve accumulation, which largely does not address how financial development could influence central bank's foreign reserve accumulation. This study provides empirical evidence that financial development matters to liquidity management and a central bank's behaviour in foreign reserve accumulation.

Third, the theoretical model incorporates a monetary reaction with an asymmetric preference in the exchange rate and the concept of private and public liquidity provision. Although there are several motives for foreign reserve accumulation, most theoretical studies address only one of the three motives. At the same time, the empirical literature shows that foreign reserve accumulation is driven by a combination of the three motives. This study constructs a theoretical model that puts together the three motives, helping reconcile the gap between the theoretical models and empirical evidence in the literature. In addition, most of the theoretical studies focus on optimal level foreign reserves but are still puzzled by why countries hold more foreign reserves than the optimal levels, often suggested in the literature. This study incorporates 'fear of appreciation' into the model, explaining why the actual level of foreign reserves in emerging market economies is usually higher than the optimal levels suggested by the literature.

The next section describes recent trends in foreign reserve accumulation among Asian emerging market economies. Section 3 reviews the literature on foreign reserve accumulation and its nexus with capital flows and financial development. Section 4 shifts focus to the empirical investigation while Section 5 discusses the results. Section 6 presents a model explaining the motives for foreign reserve accumulation and the role of the private sector in liquidity provision. Section 7 concludes and discusses some directions for further research.

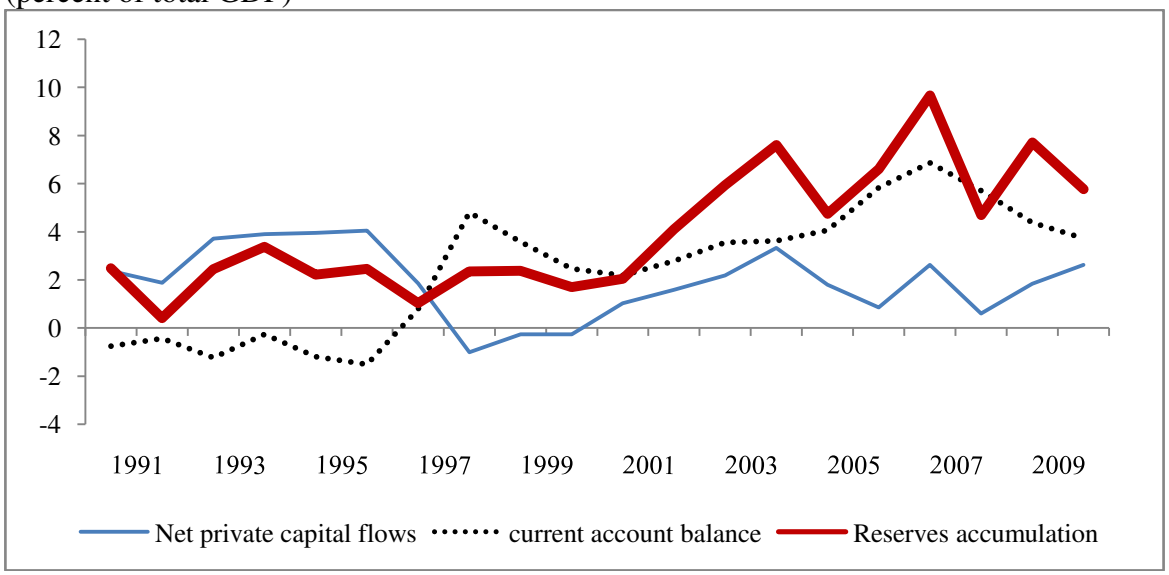
2. Recent trends in foreign reserve accumulation and capital flows in Asia

Any observation of the pattern on capital flows and foreign reserve accumulation in East Asia is not complete without considering the 1997-1998 Asian crisis. As can be seen in Figure3.1, net private capital inflows have rebounded from the sharp capital reversal during the 1997-1998 Asian crisis. Furthermore, the current account balance had been consistently

negative before the financial crisis but became positive after the crisis. Accompanied by a surge in capital flows into the region, the current account surplus has provided an even larger source of foreign exchange for the massive foreign reserve accumulation.

The rapid accumulation of foreign reserves in Asia began in the mid-1990s and has accelerated in recent years. Foreign reserve accumulation grew rapidly in the period 2002-2007, at a pace three times more than that in the period 1999-2001. The accumulation rate of foreign reserves in the Asian region was only 2 percent of GDP in the period 1999-2001, but rose quickly to around 7 percent in the period 2005-2007. Central banks in East Asia, particularly China's central bank, accounted for the bulk of the build-up. Among foreign reserve accumulators, Asian economies are among the ten largest reserves holders: China, Japan, Taiwan, Korea, India, Hong Kong, Singapore, and Malaysia. The share of global foreign reserves held by Asian economies increased from 45 percent in 1995 to 66 percent in 2010. In addition, only a few monetary authorities hold an increasingly larger share of the reserve holding. China and Japan account for more than half the total world reserve accumulation. In terms of share of GDP (Figure 3), Hong Kong has accumulated the highest percentage of reserves to GDP (121 percent) followed by Singapore (106 percent), Taiwan (94 percent), Malaysia (50 percent), and China (49 percent).

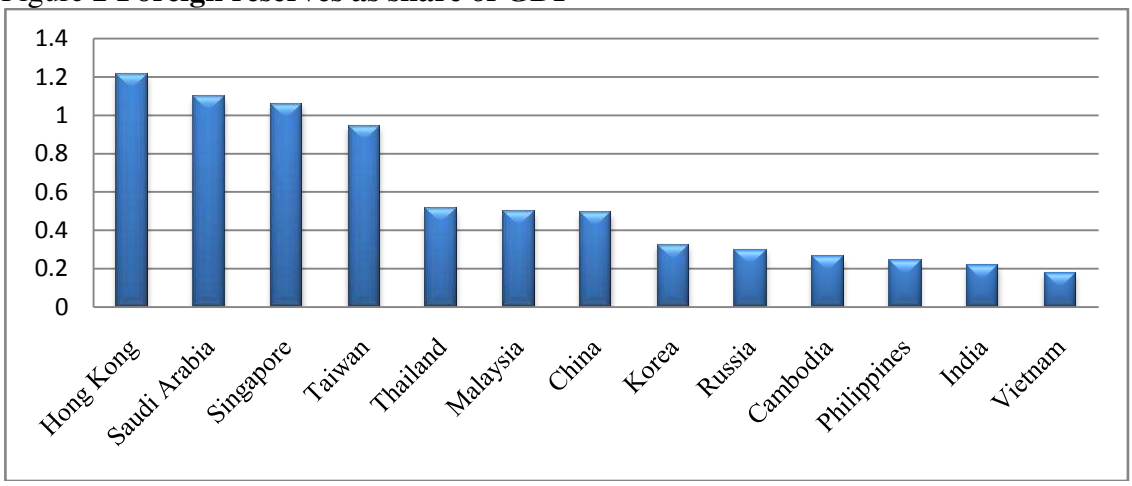
Figure 1 **Current account balance, capital flows, and reserve accumulation in Asia** (percent of total GDP)



Note: Countries are all in Asia.
Source: Author's calculation based on Balance of Payments Statistics, IMF(December 2010).

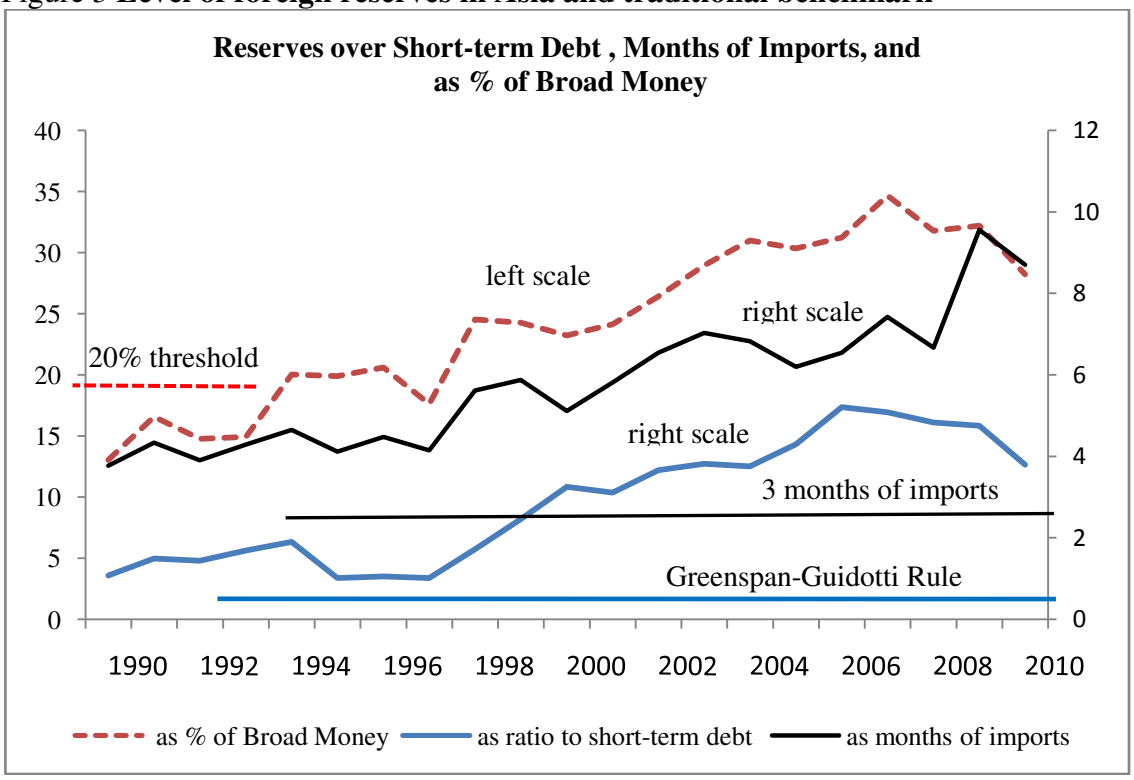
In practice, there have been a number of 'rules of thumb' for a country's appropriate level of foreign reserves. These rules include maintaining reserves of: (1) three to four months of imports to offset current account shocks; (2) 5-20 percent of broad money (M2) to be able to maintain confidence in the value of the domestic currency against capital flight (Calvo 1996; Wijnholds et al. 2001); (3) the total amount of short-term external debt, known as the Greenspan-Guidotti rule (Rodrik & Velasco 1999; Garcia &Soto 2004).

Figure 2 **Foreign reserves as share of GDP**



Source: International Financial Statistics, IMF (December 2010). Central Bank of the Republic of China (Taiwan) (December 2010).

Figure 3 **Level of foreign reserves in Asia and traditional benchmark**



Note: These Asian economies are China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand and Vietnam.
Source: Author's calculation based on International Financial Statistics, IMF (December 2010).

The Asian region as a whole seemed to follow these rules until the Asian crisis in 1997-1998. As shown in Figure3.3, the level of foreign reserves, for example, was around five months of imports, just above the three-month rule. Similarly, the ratio of reserves to short-

term external debt was just above one month as suggested by the Greenspan-Guidotti rule. Foreign reserves as a percent of broad money were within the 5-20 percent range.

The pattern of foreign reserves, however, changed after the 1997-1998 Asian crisis. Based on the three traditional indicators, the current level of foreign reserves in emerging Asian economies may be substantially in excess. In the period 2009-2010, East Asian economies held around nine months of imports, three times higher than the three-month rule. The level of foreign reserves as a ratio to short-term external debt in the period 2008-2010 was around five, far above the level suggested by the Greenspan-Guidotti rule. In addition, the level of foreign reserves as a percent of broad money in the period 2008-2010 was around 33 percent, which is above the 5-20 percent range suggested by the literature.

This unprecedented reserve accumulation in several key Asian economies indicates that factors other than purely precautionary motives might be driving the rapid buildup of international reserves (Aizenman & Lee 2008). The evidence also suggests that limiting vulnerability has probably not been the primary motive for the recent foreign reserve buildup in these economies. Wijnholds and Kapteyn (2001) argue that the old rule of thumb that reserves should be equivalent to three months of imports is obsolete and a different benchmark that takes into account capital flows is needed. The authors argue that the benchmark should consist of the sum of short-term debt (external drain) and an allowance for possible capital flight by domestic residents (internal drain), taking into account differences in country risks and exchange rate regime. An internal drain refers to a run from bank deposits to currencies while an external drain refers to a flight from the domestic currency to foreign currencies or banks (see Kaminsky & Reinhart 1999). The argument put forward by Winjholds and Kapteyne (2001) suggests the important role of financial integration and financial development, which is the central issue of this study.

Nonetheless, determining the optimal level of foreign reserves is not straightforward as it is subjective to uncertainty and institutional factors such as degree of capital mobility, financial liberalization, or weaknesses in the domestic banking system. With financial globalization, the high volatility of capital flows complicates the conduct of monetary policy and exchange rate policy, and has impacts on an economy's ability, particularly an economy with an underdeveloped financial market, to deal with sudden capital inflows and outflows. Thus, this environment indeed influences the level of foreign reserves.

3. Literature review

Three major explanations stand out in the literature on foreign reserve demand: precautionary motives, mercantilist motives, and financial stability motives. In the precautionary view, countries accumulate foreign reserves as self-insurance to avoid costly liquidation of long-term projects (Aizenman & Lee 2008), and to smooth domestic absorption as a cushion against sudden stops in capital inflows (Jeanne & Rancière 2006). In addition, countries can use international reserves to smooth the impact of capital flow volatility, to manage an adjustable-peg or managed-floating exchange rate regime (Frankel&Jovanovic 1981; Edwards 1984), and to stabilize output (Ben-Bassat & Gottlieb 1992; Aizenman & Marion 2004; Garcia & Soto 2004; Jeanne & Ranciere 2006). Similarly, foreign reserves can be used to stabilize fiscal expenditure in countries with limited taxing

capacity and sovereign risks, and limited access to global capital markets (Aizenman & Marion 2004).

In the mercantilist view, reserve accumulation is a result of a growth strategy which keeps exchange rates undervalued to stimulate export growth and competitiveness (Dooley et al. 2004). Countries hold foreign reserves as 'collateral' to encourage FDI. Similarly, foreign reserve accumulation can occur in the aftermath of a growth strategy that combines export promotion and credit subsidization, known as 'financial mercantilism' (Aizenman & Lee 2008). The development experience of East Asia suggests the prevalence of export promotion by preferential financing, which effectively subsidizes investment in targeted sectors (Aizenman & Lee 2008). This promotion has been achieved in several ways: including through direct subsidies funded by state banks; or financial repression where favored sectors have enjoyed preferential access to cheaper external debt; or through 'moral suasion' where private banks were encouraged to provide favorable financing.

In the financial stability view, a major motivation of central banks to hold foreign reserves is to support the overall banking system and to insure against financial instability (Obstfeld et al. 2010). In this view, a financial shock is not simply a 'sudden stop' in which case a country would need to hold foreign reserves only in proportion to its short-term external debt (Greenspan-Guidotti rule). With a vulnerability to portfolio shifts by domestic residents (internal and external drain), the monetary authority needs to hold reserves proportional to the size of its banking system.

However, the importance of each motive may change over time. Ghosh et al. (2012) find that self-insurance against current account shocks was relatively important in the 1980s. They suggest that the motive to insure against capital account shocks becomes more important when emerging market economies become more financially integrated. In East Asia which relies more on export sectors, the mercantilist motive may have become more important over time while the precautionary motive was reinforced by the 1997-1998 Asian crisis.

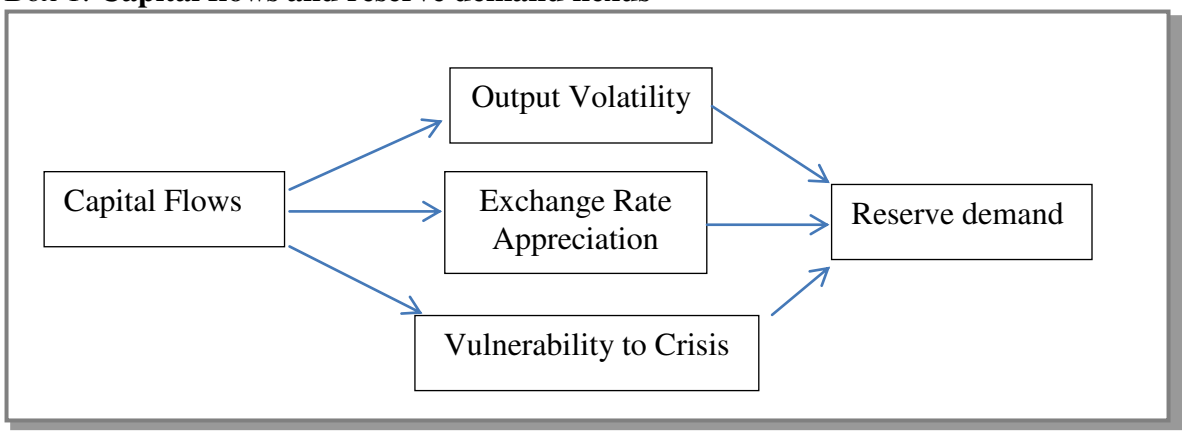
Apart from these three motives, other features of the domestic financial systems in emerging market economies may have played a role in Asia's reserve hoarding. The relatively underdeveloped local financial systems, for instance, create difficulties both in channeling domestic savings to investment and in diversifying capital resources to their most productive uses. In addition, the interaction between underdeveloped capital markets and an excess of domestic savings, driven either by a 'saving glut' or low investment, gives an intermediary role to the central bank in accumulating 'safe' assets (Mendoza et al.2007; William et al.2011).In other words, financial development should help channel domestic saving, which is often high in Asian emerging market economies, to domestic investment, and thereby reduce capital outflows.

Capital flows, financial development and reserve accumulation

The reserve accumulation by many emerging market economies seems to be an outcome of the integration of these economies into the global market. Most Asian economies have been major players in international trade but still have relatively underdeveloped financial systems. This asymmetry appears to be one of the reasons why emerging market economies hold a large share of world foreign reserves whereas mature economies, with complete and

deep financial markets, hold a relatively constant amount of foreign reserves (Pineau et al. 2006).

Box 1: **Capital flows and reserve demand nexus**



This section connects the links between capital flows, reserve accumulation, and financial development. In one strand of the literature, capital flows can have an impact on economic performance and macroeconomic stability (Gruben & MacLeod 1998; Bosworth & Collins 1999; Mody & Murshid 2005; Mileva 2008), which affects foreign reserve demand through at least three channels as can be seen in Box 1.

First, capital flows affect foreign reserve demand due to concerns about increased output volatility associated with volatile capital flows. As experience of capital inflows in many countries shows, capital inflows are more often pro-cyclical than counter-cyclical (Kaminsky et al. 2004; Reinhart & Reinhart 2008; Mendoza & Terrones 2008). For instance, sudden changes in the direction of capital flows tend to induce or exacerbate boom-bust cycles in economies that lack a deep and well-functioning financial sector (Aghion et al. 2005; Caballero & Krishnamurthy 2001). In other words, increased capital flows tend to increase output volatility, which motivates more precautionary demand for foreign reserves to insure against output volatility.

Second, capital inflows influence reserve demand through their appreciation impact on the real exchange rate and negative effects on the external competiveness of recipient economies (Corden 1993; Athukorala & Rajapatirana 2003). As Asian economies have a fear of appreciation (Pontines & Yongqiang 2010), central banks are induced to intervene in the foreign exchange market, often known as 'leaning against the wind', accumulating foreign reserves when there is upward pressure on the exchange rate. One reason behind such an intervention could be that a fixed or relatively rigid exchange rate can provide benefits in terms of macroeconomic stability, particularly to a developing country, where financial development is limited and the capital market is closed. Rogoff et al. (2003) show that for countries at a relatively early stage of financial development, fixed or relatively stable exchange rate regimes appear to offer some anti-inflation credibility gains without compromising growth objectives. Rogoff et al. (2003) also suggest that because of institutional weaknesses and limited financial development, emerging market economies should only consider adopting more flexible exchange rate regimes if they develop economically and institutionally. On the other hand, based on a systematic panel data analysis of 83 countries for the period 1960-2000, Aghion et al. (2009) show that real

exchange rate volatility consistently reduces growth in countries with a relatively thin financial market. Part of the explanation for this is that financial stocks tend to be greatly amplified in financially underdeveloped economies. Therefore, foreign reserve accumulation is a result of intervening in foreign exchange markets or stabilizing the real exchange rate in the presence of volatile terms of trade shocks and potentially destabilizing capital flows.

Third, capital inflows motivate foreign reserve demand as a result of an increased vulnerability to crises induced by capital inflows. As experience of the impact of capital inflows in emerging market economies shows, capital inflows drive up equity and asset prices (Grenville 2008; Schadler 2008), reduce the quality of assets, and can adversely affect the maturity and currency composition of the balance sheets of the private sector. In addition, real estate booms and asset price bubbles can amplify financial fragility and crisis risk, making the economy particularly vulnerable to financial shocks and crises (Reinhart & Rogoff 2009). Reinhart and Rogoff (2009) provide comprehensive historical evidence of capital flows, financial vulnerability, defaults, and crises. In many instances, borrowing countries may find it difficult to resist the temptation to take what is offered during good times and are typically of the 'This time is different' syndrome (Reinhart & Rogoff 2009). Similarly, Kaminsky and Reinhart (1999) show that, following a prolonged period of economic boom fuelled by capital inflows, crises often occur when an economy enters a recession. In this regard, foreign reserve buildup can also be associated with growing fragility of the banking system of a country, because concerns about financial stability lead countries to hoard foreign reserves for liquidity provision during shocks.

In another strand of the literature, the financial sector is a crucial factor in the link between capital flows and their impact on reserve demand. In particular, the financial sector plays a central role in macroeconomic performance by reducing the impacts of capital flows on output volatility, real exchange rate appreciation, and financial vulnerability, all of which can motivate foreign reserve accumulation. Easterly et al. (2000) and Beck and Levine (2004) show that a more developed financial system is associated with lower output volatility across countries. Moreover, a deep and active financial sector can provide broad investment opportunities, direct capital inflows towards their most productive uses, mitigate investment demand constraints (Ötker-Robe et al. 2007), and thus reduce real exchange rate appreciation (Saborowski 2009). Finally, financial development has a large causal effect in the reduction of macroeconomic volatility as a result of liquidity provision by the financial sector (Raddatz 2006), which then requires less liquidity provision by the government (Caballero & Krishnamurthy 2001). Analyzing data on 70 manufacturing industries in 48 countries during the period 1981-1998, Raddatz (2006) shows that financial underdevelopment can significantly increase the relative volatility of sectors that typically need a large amount of liquid funds for their operation. In other words, financial development reduces volatility because it can help firms facing temporary cash flow (liquidity) or net worth problems (solvency) to obtain the necessary working capital.

These two strands of the literature indicate that the three channels of transmission (i.e. output volatility, real exchange rate and financial fragility), through which capital flows affect foreign reserve demand, can be weakened by development of the financial sector.

On the other hand, underdeveloped financial markets and their interaction with large capital flows are shown to be more likely to contribute to financial stability risk (Bank of England 2011). In particular, as countries with underdeveloped financial markets enter the early stages of financial liberalization, their economies can be vulnerable to a 'sudden stop' in capital inflows. This vulnerability can be exacerbated if their domestic financial markets are underdeveloped but closely integrated with global financial networks (Durdu et al. 2009). This concern will increase the demand for low-risk and liquid financial assets in order to insure as well as to mitigate output loss in the case of shocks (Mendoza et al. 2007). In other words, the demand for low-risk and liquid assets increases because economic agents in financially underdeveloped economies have limited access to such assets and instruments that allow them to hedge risks. As often pointed out in the literature on 'liquidity versus solvency', an economic agent's ability to withstand shocks cannot be supported by net wealth (solvency) alone, but by liquidity management also. With a shortage in the domestic supply of 'safe' assets, emerging market economies turn to accumulating 'safe' assets (foreign reserves) from advanced economies to address the shortage in the domestic supply of safe assets (Gourinchas et al. 2008). The relationship between a central bank's foreign reserves (safe assets) and capital flows is reinforced by the fact that many financially underdeveloped economies directly or indirectly impose restrictions on private capital outflows. In this case, foreign reserve accumulation is partly a reflection of the intermediary role played by the government to supply 'safe' assets (Bank of England 2011).

To summarize, capital inflows influence reserve demand with their volatility, potential destabilizing effects and the risk of sudden stops and reversals (Frankel 2010; Jeanne 2010; Kaminsky et al. 2004). In other words, capital inflows can have potentially adverse impacts on recipient economies, which motivates foreign reserve buildup. At the same time, given the important role of financial markets in mobilizing and allocating resources efficiently, financial development can help reduce the impact of capital flows on real exchange rate appreciation (Saborowski 2009), and lower output and macroeconomic volatility (Raddatz 2006). These relations shape this study's hypothesis that the impact of capital flows on reserve demand could be reduced by development of deep financial markets and institutions.

4. Empirical investigation

This section turns to an empirical investigation of capital flows, financial development, and foreign reserve accumulation. Except for the interaction term, the specification here closely follows the specifications in the literature (e.g. Obstfeld et al. 2010; Aizenman & Lee 2008). To ensure that the interaction term does not proxy for capital inflows or the level of financial development, the latter variables are included in the regression independently. The reduced form for the empirical study can be simplified as:

$$Reserves_{it} = \alpha_1 + \alpha_2 Capflows_{it} + \alpha_3 Findev_{it} + \alpha_4 CapFin_{it} + \alpha_5 X_{it} + \eta_i + \varepsilon_{it}$$

where $Reserves_{it}$ is the log value of foreign reserves over GDP in country *i* at time *t*, *Capflows* is the log value of capital inflows over GDP, *Findev* is financial development, and *CapFin* is the interaction term between capital flows and financial development. X_{it} is a

vector of control variables including GDP per capita, broad money, openness to international trade, exchange rate stability and financial openness. These are standard control variables in the literature. η is the country fixed-effects. The study also includes a dummy for the post Asian crisis period in order to capture potential differences in the foreign reserve accumulation patterns across countries between the pre- and post-Asian crisis period.

The parameters of main interest are α_3 and α_4, which capture the effects of financial development and the interaction of capital flows and financial development on foreign reserve accumulation, respectively. If financial development can reduce the impact of capital flows on foreign reserve accumulation, then α_4 should be negative and statistically significant. The coefficient of capital flows α_2 is expected to be positive and that of financial development α_3 is expected to be negative.

4.1 Explanatory variables

In the literature, foreign reserve accumulation is explained by a number of motives including the self-insurance motive, mercantilism, the financial stability motive, and exchange rate management. The explanatory variables included in this study to capture these motives, except financial development and the interaction term, follow those in Obstfeld et al. (2010). The study uses annual data from 12 Asian economies during the period 1980-2009. The definitions and sources of the data are in the Appendix.

Financial development (Findev)
Financial development is a broad economic concept and there are various measures of financial development (see also, Beck et al. 2000). Each measure has its own strengths and limitations. Among all measures, the sum of domestic credit to the private sector and market capitalization is often used as an indicator of a country's level of financial development in terms of both size and depth. In this study, this standard measure is be used in the main regression and analysis.

Also close to the concepts of financial development and a country's access to international finance, total external equity liability and debt liability as a share of GDP can be used as a proxy for financial development (Lane & Milesi-Ferretti 2003). The measure of financial market development, as the extent of external liabilities, is based on the assumption that countries with less developed domestic financial markets also have fewer external liabilities. One limitation of this measure, however, is that it might not be closely related to the capacity of the financial sector in risk management and information processing (King & Levin 1993). Alternatively, the total stock value traded and stock market capitalization is also often used as a measure of the financial market in terms of liquidity and size of the market respectively. Thus, these three alternative measures are used for robustness check of the results.

Capital flows (Capflows)
For capital flows, this study follows Mendoza (2010) by using a sum of the current account and net FDI inflows, scaled by GDP. This measure captures more the short-term

components of capital flows (hot money), considered to be volatile and potentially destabilizing. A negative value indicates the level of short-term flows needed to finance a current account deficit. A positive value might reflect a current account surplus and positive net FDI inflows. This indicator could be interpreted as a possible inducement for appreciation pressure on the currency, in which there would be a positive link to foreign reserve accumulation.

GDP per capita (GDPPC)
Foreign reserve holdings should increase with international transactions and the standard of living (Aizemen & Marion 2003). As GDP per capita is often used to reflect the standard of living, this study includes GDP per capita in the regressions. GDPPC is expected to be positively correlated to the foreign reserve accumulation.

Broad money (M2/GDP)
Broad money often indicates a country's exposure to the withdrawal of assets or resident-based capital flight from the domestic currency. Following Wijnholds and Kapteyn (2001), the Early Warning System literature, and the financial stability model presented by Obstfeld et al. (2010), this study uses broad money as a proxy for the financial stability motive for foreign reserve accumulation. Obstfeld et al. (2010) argue that broad money supply is the most appropriate measure to serve as an indicator of the potential need for foreign reserves, given the potential run out of domestic currency deposits and potential capital flight. It is also a measure of the potential need for bank support in or after a crisis, given a central bank's role of lender of last resort. In this regard, broad money is expected to be positively linked to reserve accumulation.

Trade (trade/GDP)
International trade requires foreign reserves for transactions. A conventional rule of thumb by practitioners is that a country should hold a level of foreign reserves that is enough to finance three to four months of imports, without income flows. For this reason, a country may hold foreign reserves because of a precautionary motive for foreign reserve demand and for self-insurance. Therefore, the ratio of imports over GDP is expected to be positively linked to foreign reserve accumulation.

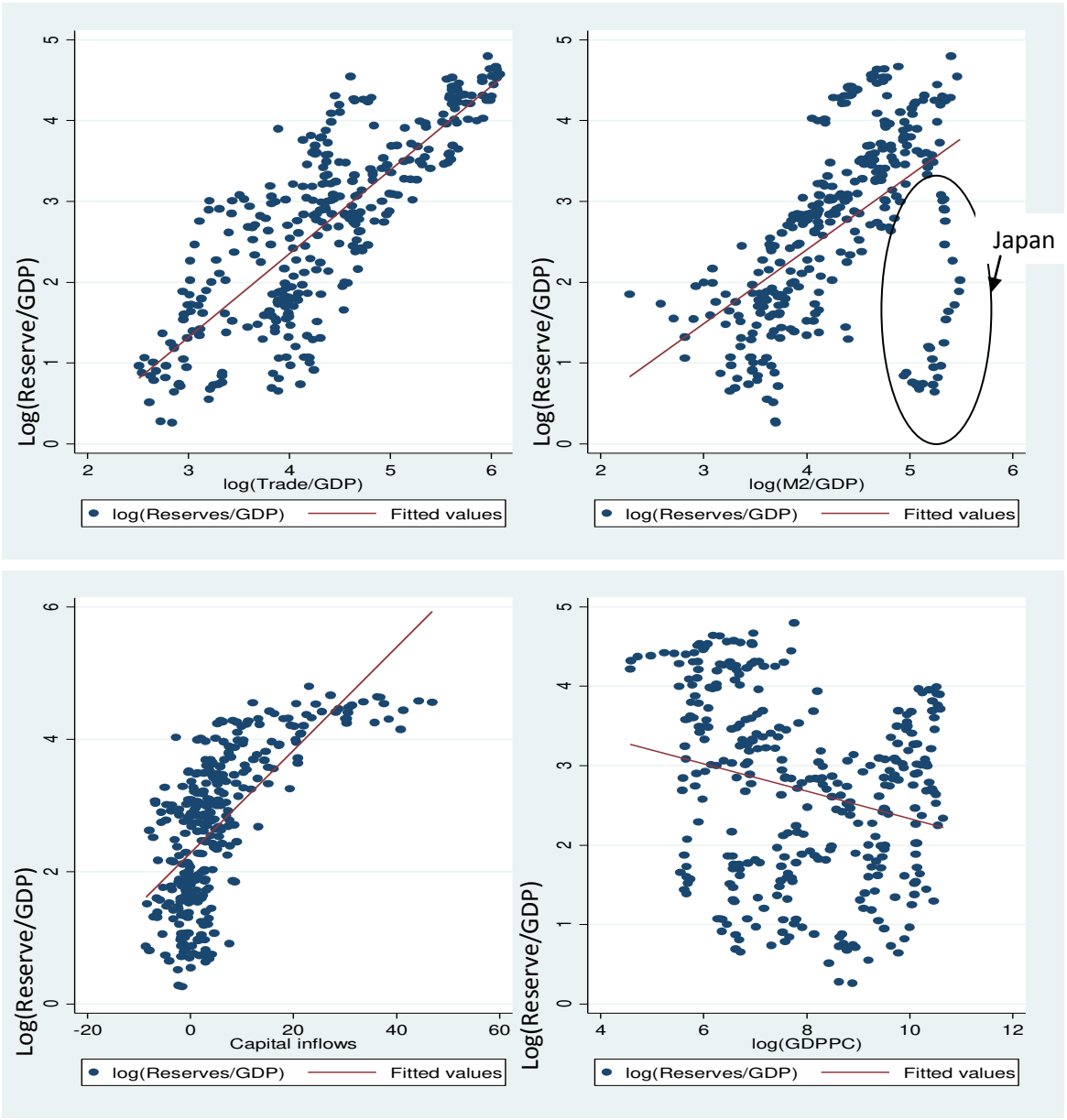
Financial Openness
Greater financial openness suggests vulnerability to external financial shocks, and is expected to increase the precautionary demand for reserves. Among the many measures of financial openness, this study uses the Chinn-Ito Index. A higher value signals a higher degree of openness to financial transactions.

Exchange Rate Volatility
Greater exchange rate flexibility should reduce the demand for foreign reserves as a central bank no longer needs a large foreign reserve stockpile to manage a fixed exchange rate (see, for example, Aizenman & Marion 2003). In other words, exchange rate fluctuations within a certain range would result in less government intervention in the foreign exchange market, and thus less foreign reserve buildup. However, greater real exchange rate volatility is empirically shown to have a link to lower growth and financial instability, particularly in financially underdeveloped countries (Rogoff et al. 2003; Hviding et al. 2004). Thus, this variable is expected to be positively linked to foreign reserve holding.

4.2 Concern on outliers

Given the nature of foreign reserves across the Asian region, one might have a concern that China and Japan could be the outliers in the sample and thus could affect the results. To address this potential concern, the study first examines the sample with scatter plots. As shown in Figure 3.4, the data for Japan are far from the fitted values in the scatter plot between foreign reserves (Reserves/GDP) and broad money (M2/GDP). However, the variables foreign reserves, trade, capital inflows, and GDP per capita do not produce any serious outliers. China seems not be an outlier in this study. Thus, Japan will be dropped from the sample size to check the robustness of the results.

Figure 3.4 **Scatter plots of foreign reserves, trade, M2, Capital inflows, and GDPPC**



5. Regression results and analysis

Table 3.1 reports the results of the regressions with a log of reserve accumulation over GDP as the dependent variable. Column 1 shows the result of the simple pooled regressions while columns 2, 3, and 4 report the results of the robustness checks with country-fixed effects, year fixed effects, and country and year fixed effects, respectively.

In the simple pooled OLS (column 1), no fixed effects are allowed and the standard errors allow for clustering within countries. An unstructured serial correlation is allowed in the error term within countries. Column 1 is a between-group panel estimation, so serial correlation in no way affects the results or generates spurious-regression effects. In this estimation, most variables, except for financial openness and financial development, have the expected sign and are statistically significant. The coefficient on financial development is negative as expected but is not significant. At the same time, the coefficient on the interaction term is negative and statistically significant, as expected.

Column 2 introduces the country-fixed effects, in which all cross-sectional means are removed. In this regard, there is only 'within' identification, not 'between' identification. Thus, the coefficients in column 2 are estimates of all the variables from the time-series variation within the country units. R^2 improves in the country-fixed effect estimation and the coefficients of trade and capital flows become slightly weaker. The interaction term remains negative and statistically significant.

Column 3 introduces year-only fixed effects and produces similar results to that of the pooled OLS in column 1. The fit is only slightly improved. The coefficients of the interaction remain negative and significant and do not change by a large or statistically significant amount.

Column 4 includes both year and country fixed effects. In this specification, capital flows and the interaction term remain negative and statistically significant. The coefficients of financial development still have the expected sign but are statistically insignificant. At the same time, financial development is positive as in the country-fixed effect estimation and is statistically significant.

In the four regressions, the coefficients on trade, capital inflows, and the interaction term between capital flows and financial development have the expected sign and are statistically significant. These results confirm the hypothesis that financial development can reduce foreign reserve accumulation by reducing the impact of capital flows on foreign reserve demand, induced by macroeconomic effects. The implication here is that although capital inflows could motivate foreign reserve accumulation, a well-functioning financial system could help reduce the impact of capital flows on foreign reserves hoarding. In other words, the magnitude of the impact of capital flows on foreign reserve demand decreases with a higher level of financial development due to efficient absorption of the capital inflows.

Table 1 **Regression results** (reserves/GDP in log as dependent variable)

	(1) OLS	(2) FE	(3) FE	(4) FE
LogGDPPC	-0.094	-0.182	-0.114	-0.566
	(0.032)**	(0.104)	(0.036)***	(0.125)***
Log(M2/GDP)	0.653	0.425	0.633	-0.116
	(0. 221)**	(0.358)	(0. 238)**	(0.462)
Log(trade/GDP)	0.715	1.301	0.683	1.339
	(0.078)***	(0. 283)***	(0.084)***	(0.541)**
Exchange rate volatility	-3.919	-2.544	-4.506	-1.888
	(1.627)**	(1. 297)*	(2.328)*	(1.691)
Post Crisis	0.468	0. 258		
	(0.155)**	(0. 202)		
Financial Openness	-0.015	0.076	0.000	0.115
	(0.04)	(0.089)	(0.038)	(0.086)
Capital Inflows	2.856	4.321	2.523	2.654
	(0.591)***	(1.992)*	(0.692)***	(1.389)*
Findev1	-0.035	0.321	-0.051	0. 205
	(0.081)	(0.097)***	(0.094)	(0.098)*
Interaction Terms (CapFin1)	-0.651	-1.187	-0.59	-0.775
	(0. 204)***	(0.336)***	(0. 214)**	(0. 266)**
Constant	-2.539	-4.143	-1.855	-0.839
	(0.670)***	(1.773)**	(0.924)*	(2.595)
Country fixed effect	No	Yes	No	Yes
Year fixed effect	No	No	Yes	Yes
Observations	242	242	242	242
R-squared	0.85	0.91	0.883	0.93

Note: Robust standard errors clustered by country are in parentheses. The symbols ***, ** and, * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Financial Development 1 (FinDev1) is the sum of domestic credit and market capitalization over GDP.

The coefficients of financial development deserve further discussion. The coefficients of financial development in columns 1 and 3 have a negative sign as expected but are not statistically significant. On the contrary, the coefficients of financial development in columns 2 and 4 have a positive sign and are statistically significant. An explanation for these contrasting results lies in the measurement of financial development. As financial development (Findev1) is the sum of domestic credit and market capitalization over GDP, it measures size and depth and does not perfectly proxy for the capacity of resource mobilization, which is the focus of this study. Given this limitation and that this measure partly reflects the size of the market, it is not surprising that the coefficient can be positive. In addition, these positive and statistically significant coefficients of financial development on foreign reserve demand confirm the financial stability motive by which countries hoard

foreign reserves accordingly to the size of their financial market. As Obstfeld et al. (2010) argue, countries hoard foreign reserves partly to support the overall financial system and also to insure against financial instability.

On the other hand, the findings on trade, capital flows, and the interaction term appear to be quantitatively important. In a country and year fixed-effect estimation (column 4), for example, when the ratio of trade over GDP rises by 10 percent, the ratio of foreign reserves over GDP would increase by 13 percent (between 7-13 percent in all regressions). Based on the estimates, a 10 percent point increase in the capital flow ratio would lead to around a 26 percent increase in the ratio of foreign reserves to GDP. This effect is reasonably high, and can be observed in some Asian economies. In the sample in this study, the average capital inflow is 4 percent while the average increase in the foreign reserves-to-GDP ratio is 14 percent.

To estimate how important financial development is in reducing the impact of capital flows on foreign reserve demand, one can ask the hypothetical question of how much reserve demand is reduced by a unit increase in financial development. Based on the results in column 4 of Table 3.1, one can determine the threshold level of financial development around which the effects of capital flows on foreign reserve accumulation could be neutralized. To do this, one can differentiate the model with respect to capital flows and set the first order condition to zero:

$$\frac{\partial Reserves}{\partial CapFlows} = 2.65 - 0.775 * FinDev$$

The threshold level of financial development is around 3.42, which is equivalent to 342 percent of GDP in terms of domestic credit and market capitalization. This is indeed a high level of financial development. In this study, only Hong Kong and Japan have such a level of financial size and depth. Nonetheless, the threshold itself is not important. Rather, a significant implication is that high level financial sector development reduces the impact of capital flows on foreign reserve accumulation.

One also observes that exchange rate fluctuation has a negative sign in all the regressions, but is significant only in the first three regressions. This result seems to support the argument that exchange rate fluctuations within a certain range (flexibility) could cushion against capital inflows (Combes et al. 2011), which leads to less government intervention in the foreign exchange market, and thus less reserve buildup.

Robustness check

To conduct robustness checks, the study first drops Japan from the sample due to the suspicion of outliers, as discussed in Section 3.4.2. The results reported in Table 3.2 show that the estimations, using the sample without Japan, are not substantially different from the earlier findings. The coefficients of the interaction term have a negative sign and remain statistically significant. Similarly, the coefficients of broad money, trade, capital flows, and post-crisis dummy do not substantially change and remain statistically significant. Therefore, the results in this study do not suffer from outliers or influential observations.

In addition, this study uses access to international financial resources (FinDev2), domestic market liquidity (FinDev3), and market size (FinDev4) as alternative proxies of financial development and resource mobilization by the private sector. Access to international financial resources is measured by external equity liability and debt liability as a share of GDP. Market liquidity is captured by the total stock value traded over GDP. Market size is measured by the market capitalization of listed companies over GDP.

The results are reported in Tables 2, 3, and 4. In these tables, all the interaction terms between capital flows and financial development have a negative sign and remain statistically significant. The results confirm the hypothesis that financial development reduces the impact of capital flows on foreign reserve accumulation. Based on the results, a 10 percent increase in financial development would reduce the impact of capital flows on reserve accumulation by between 7 and 11 percent. It should be noted that when financial development is measured as the ability to have access to international finance, the coefficients of financial development, as shown in Table 3, are all negative although they are not statistically significant.

Table 2 **Robustness check (excluding Japan)**

VARIABLES	(1) OLS	(2) FE	(3) FE	(4) FE
LogGDPPC	-0.059	-0.179	-0.081	-0.515
	(0.021)**	(0.089)*	(0.016)***	(0.149)***
Log(M2/GDP)	0.703	0.794	0.698	0.319
	(0.083)***	(0.317)**	(0.065)***	(0.522)
Log(trade/GDP)	0.423	1.242	0.423	1.321
	(0.055)***	(0.362)***	(0.054)***	(0.634)*
Exchange rate	-1.490	-2.580	-1.547	-1.885
volatility	(1.109)	(1.412)*	(2.113)	(2.101)
Post Crisis	0.388	0.112		
	(0.140)**	(0.186)		
Financial Openness	0.055	0.046	0.056	0.074
	(0.019)**	(0.088)	(0.021)**	(0.092)
Capital Inflows	4.075	4.174	3.823	2.754
	(0.771)***	(1.686)**	(0.677)***	(1.353)*
Findev1	0.103	0.201	0.076	0.115
	(0.069)	(0.065)**	(0.066)	(0.090)
Interaction Terms (CapFin1)	-0.964	-1.027	-0.905	-0.702
	(0.262)***	(0.270)***	(0.228)***	(0.270)**
Constant	-2.003	-5.218	-1.544	-2.674
	(0.496)***	(1.901)**	(0.327)***	(2.466)
Country fixed effect	No	Yes	No	Yes
Year fixed effect	No	No	Yes	Yes
Observations	221	221	221	221
R-squared	0.884	0.908	0.910	0.930

Note: Robust standard errors clustered by country are in parentheses. The symbols ***, ** and, * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Financial Development 1 (FinDev1) is the sum of domestic credit and market capitalization over GDP. The sample excludes Japan.

Table 3 **Robustness check with access to international market**

	(1) OLS	(2) FE	(3) FE	(4) FE
LogGDPPC	-0.066	0.175	-0.1	-0.123
	(0.04)	(0.1)	(0.042)**	(0.161)
Log(M2/GDP)	0.471	0.528	0.427	0.198
	(0.131)***	(0. 210)**	(0.126)***	(0. 251)
Log(trade/GDP)	0.814	0.683	0.774	0.701
	(0.110)***	(0. 217)***	(0.128)***	(0. 267)**
Exchange rate volatility	-3.598	-1.446	-3.979	-0.65
	(1.867)*	(1.137)	(2. 288)	(1.08)
Post Crisis	0.522	0.471		
	(0.172)**	(0. 217)*		
Financial Openness	0.022	0.19	0.04	0. 204
	(0.051)	(0.081)**	(0.052)	(0.066)**
Capital Inflows	2.888	2.057	2.721	1. 245
	(0.858)***	(1.091)*	(1.009)**	(1.467)
Fin. Development2	-0.052	-0.009	-0.08	-0.063
	(0.045)	(0.064)	(0.06)	(0.082)
Interaction term(CapFin2)	-1.058	-1.094	-1.044	-0.987
	(0. 275)***	(0.361)**	(0. 298)***	(0.412)**
Constant	-2.557	-4. 264	-1.683	-0.364
	(0.604)***	(0.674)***	(0.761)**	(2.058)
Country fixed effect	No	Yes	No	Yes
Year fixed effect	No	No	Yes	Yes
Observations	322	322	322	322
R-squared	0.85	0.91	0.871	0.93

Note: Robust standard errors clustered by country are in parentheses The symbols ***, ** and, * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Financial Development 2 is the sum of total equity liability and total debt liability over GDP.

Table 4 **Robustness check with market liquidity**(stock value traded over GDP)

	(1) OLS	(2) FE	(3) FE	(4) FE
LogGDPPC	-0.113	-0.116	-0.138	-0.548
	(0.036)***	(0.109)	(0.038)***	(0.120)***
Log(M2/GDP)	0.517	0.635	0.484	-0.044
	(0.157)***	(0.318)*	(0.159)**	(0.487)
Log(trade/GDP)	0.65	1. 264	0.607	1.366
	(0.099)***	(0. 281)***	(0.095)***	(0.476)**
Exchange rate volatility	-3.858	-2.576	-4.477	-2.005
	(1.636)**	(1. 296)*	(2. 230)*	(1.658)
Post Crisis	0.484	0. 285		
	(0.150)***	(0. 235)		
Financial Openness	-0.03	0.063	-0.022	0.104
	(0.045)	(0.096)	(0.044)	(0.094)
Capital Inflows	3	2.508	2.906	1.473
	(0.757)***	(1.88)	(0.773)***	(1. 261)
Fin. Development4	0.133	0. 245	0.137	0.139
	(0.114)	(0.078)***	(0.117)	(0.092)
Interaction Terms (CapFin4)	-1.108	-1.091	-1.115	-0.686
	(0.387)**	(0.404)**	(0.368)**	(0.363)*
Constant	-1.685	-4.98	-0.881	-1. 24
	(0.524)***	(1.506)***	(0.661)	(2.312)
Country fixed effect	No	Yes	No	Yes
Year fixed effec	No	No	Yes	Yes
Observations	246	246	246	246
R-squared	0.85	0.902	0.881	0.93

Note: Robust standard errors clustered by country are in parentheses The symbols ***, ** and, * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Financial Development 4 is the ratio of market capitalization over GDP.

Table 5 **Robustness check with market size** (market capitalization over GDP)

	(1) OLS	(2) FE	(3) FE	(4) FE
LogGDPPC	-0.107	-0.11	-0.126	-0.514
	(0.047)**	(0.106)	(0.048)**	(0.100)***
Log(M2/GDP)	0.52	0.626	0.505	-0.104
	(0.175)**	(0.343)*	(0.172)**	(0.433)
Log(trade/GDP)	0.658	1.189	0.636	1.348
	(0.095)***	(0.302)***	(0.091)***	(0.472)**
Exchange rate volatility	-3.534	-2.407	-4.089	-1.646
	(1.735)*	(1. 200)*	(2.339)	(1.644)
Post Crisis	0.43	0. 275		
	(0.145)**	(0. 237)		
Financial Openness	-0.027	0.052	-0.02	0.093
	(0.051)	(0.102)	(0.049)	(0.096)
Capital Inflows	1.985	1.5	1.79	0.787
	(0.557)***	(1.353)	(0.668)**	(0.896)
Fin.Developmentt3	0. 245	0. 291	0.186	0. 217
	(0.085)**	(0.060)***	(0.100)*	(0.059)***
Interaction Terms (CapFin3)	-1.091	-1.029	-0.989	-0.684
	(0.316)***	(0. 278)***	(0.331)**	(0. 261)**
Constant	-1.772	-4.587	-1.18	-1. 22
	(0.554)***	(1.751)**	(0.634)*	(2. 252)
Country fixed effect	No	Yes	No	Yes
Year fixed effect	No	No	Yes	Yes
Observations	247	247	247	247
R-squared	0.847	0.903	0.877	0.93

Note: Robust standard errors clustered by country are in parentheses. The symbols ***, ** and, * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Financial Development 3 is the ratio of total stock value traded over GDP.

6. A simple model of reserve accumulation

Based on the empirical observations in Section 3.5 and their implications, this section constructs a simple model of international reserve accumulation in a financially underdeveloped economy. Three works from different strands of the literature serve as a starting point for the theoretical argument in this study. Obstfeld et al. (2010) provide an excellent starting point for discussion on liquidity demand and foreign reserve accumulation, arguing that central banks would hold an optimal amount of foreign reserves equivalent to a potential liquidity demand, largely based on the size of the banking system. Obstfeld et al. (2010), however, do not consider the role of the financial sector in supply liquidity.

In another strand of the literature, Holmström and Tirole (1998; 2011) and Caballero and Krishnamurthy (2001; 2009) provide insightful analyses of the public and private supply of

liquidity in imperfect financial markets. These studies make a powerful argument that financial development and governments are both important for the supply of liquidity. With aggregate uncertainty, the private sector is not self-sufficient to provide liquidity. In this regard, the government can intervene actively to supply additional liquidity. One of the implications from Caballero and Krishnamurthy (2001; 2009) is that a higher level of financial sector development, or a reduction in collateral constraints, could help the economic agents smooth a sudden stop or liquidity shocks among the economic agents in the private sector.

On the other hand, Srinivasan et al. (2009) observe central banks' asymetric preference in exchange rate and the corresponding patterns of foreign reserve accumulation. They argue that part of foreign reserve accumulation in emerging market economies is explained by a central banks' preference for exchange rate stability or depreciation rather than 'appreciation'. This view is consistent with the argument onemerging market economies' fear of floating put forward by Calvo and Reinhart (2002). Levy-Yeyati and Sturzenegger (2007) show that exchange rate policies have evolved towards an apparent 'fear of floating in reverse' or 'fear of appreciation' whereby interventions have been aimed at limiting appreciation rather than depreciation. The study by Pontines and Rajan (2011) also confirms the existence of asymmetry in the central bank's foreign exchange intervention,in response to currency appreciation versus depreciation, in India, Korea, the Philippines, Singapore, Thailand and Indonesia.

Each of these studies addresses different aspects of foreign reserve accumulation: financial development, and liquidity demand and supply. However, none of these studies fully explain the behavior of foreign reserve accumulation observed in many emerging economies. Therefore, based on these three works, the theoretical model in this study attempts to provide a more complete framework to analyze the relationship between the level of financial development, foreign reserve demand and liquidity concerns induced by capital flows. This theoretical model is also the first to incorporate a monetary reaction with asymmetric preference in the exchange rate and the dynamics of private and public liquidity provision to explain the behavior of foreign reserve accumulation.

Following Holmström and Tirole (1998; 2011) and Caballero and Krishnamurthy (2001), the model takes into account the concept of private and public liquidity supply into an analysis of a financially underdeveloped economy for two main reasons. First, 'liquidity' is linked to capital flows (capital account shocks) as in the case of a 'sudden stop', capital flight, or capital outflows. An economy with an underdeveloped financial market may be vulnerable to a 'sudden stop' in capital flow, which leads the monetary authority to hold more 'safe' assets as a 'war chest' to insure against immediate liquidity shocks. Second, 'liquidity', as opposed to 'solvency' plays an essential role in the literature of financial crises (e.g. Diamond & Dybvig 1983; Diamond & Rajan 2005). An economy's or economic agent's ability to withstand shocks cannot be supported by net wealth alone. A country can still face major economic shocks if it faces immediate liquidity issues. In addition, as Mulder and Bussière (1999) show, higher liquidity can significantly decrease a countries' vulnerability to external shocks in the face of weak domestic fundamentals. Similarly, Krishnamurthy (2010) shows in a model of the amplification mechanism of financial shocks that liquidity provision by the central bank can alleviate a crisis.

In the case of liquidity demand shocks, domestic residents or firms can meet liquidity by issuing claims on their productive assets or by using a credit line (Holmström & Tirole 1998). When financial markets are not well developed enough to provide these options, however, the government may need to step in to supply additional liquidity. The underdeveloped financial market can be caused by collateral constraints (Caballero & Panageas 2005). Therefore, the buildup of foreign reserves is motivated by the government's role in supplying additional liquidity to domestic economic agents during a liquidity shock, i.e. a sudden stop or capital outflow, with the presence of an underdeveloped capital market which fails to fully meet a liquidity demand. This relation indicates that development of a deep and active financial market could bring at least three benefits. First, it can promote resource mobilization for more private liquidity provision. Second, as discussed in Section 3.3.2, financial development can reduce the impact of capital flows on macroeconomic and exchange rate volatility, and on vulnerability to financial crises. Third, by providing more international access to global low-risk and liquid assets, financial development can help reduce a central bank's intermediary role in securing such assets. These three benefits, therefore, can reduce a state's motivation to hoard foreign reserves.

The model begins with liquidity demand in the domestic economy as in Obstfeld et al. (2010). A shock or pessimistic view by some domestic agents on the economy drives the private sector's liquidity demand for a foreign currency[3]. However, unlike Obstfeld et al. (2010) who do not consider the role of the private sector in liquidity supply, the private sector, including banks in this model, coordinates among themselves to supply liquidity (self-provision of liquidity) given their access to international financial markets and capacity for resource re-allocation[4]. Given the underdeveloped capital markets, however, the private sector's liquidity supply cannot fully offset the liquidity demand, which puts pressure on the exchange rate. The low level of financial sector development can be reflected through limited capacity to borrow from each other and limited capacity to borrow from foreign investors[5]. In addition, different from Obstfeld et al. (2010) in which the central bank sells foreign reserves passively to supply liquidity in response to liquidity demand, the central bank in this model intervenes to supply liquidity, based on a monetary reaction function with asymmetric preference in the exchange rate. This is an important departure from Obstfeld et al. (2010) as many emerging economies have a preference for exchange rate undervaluation or stability (e.g. Calvo & Reinhart 2002; Levy-Yeyati & Sturzenegger 2007).

6.1 The private sector and liquidity demand

The economy in the model consists of two typical periods, t and $t+1$. The exchange rate on date $t+1$ is expressed as:

[3]This liquidity demand for foreign exchange can arise in the form of buying foreign assets or foreign investment by domestic investors in the normal case, or in the form of capital flow reversal or currency attack in a bad scenario.

[4]Holmström and Tirole (2011) call private liquidity supply 'inside liquidity', and government supply of liquidity 'outside liquidity'.

[5] In the liquidity literature, this limited capacity is caused by domestic and international constraints (Caballero & Krishnamurthy 2001) or by the non-pledgeable part of income or assets. In other words, some proportion of agents' income stream or assets cannot be promised or pledged to investors/lenders.

$$e_{t+1} = e(\theta) = \alpha\theta, \tag{1}$$

where e is the foreign currency price of the domestic currency[6]. θ reflects the future state of the economy. Higher values of θ indicate a more favorable state of the economy. Economic agents in the domestic economy have divergent views on the economic fundamentals that will materialize in period $t+1$. For a given θ, agent i expects that the fundamental will be $\theta+\varepsilon$, where noise ε_i is uniformly distributed over the interval $[-\bar{\varepsilon}, \bar{\varepsilon}]$ and $\theta - \varepsilon_i > 0$. Domestic agents are all risk neutral and are indexed by $i \in [0\ 1]$.

The model assumes that, in period t, there is a liquidity shock, i.e. a sudden stop or capital flow reversal, which increases the demand for foreign currency. For simplicity, foreign investors are assumed to be not willing to hold the home currency at any price. In this case, the exchange rate is determined by the exchange market, involving only the domestic private sector and home monetary authority. The model also assumes that domestic interest rates can be prevented, by the monetary authority, from fully offsetting any expected exchange-rate changes, or that an increase in interest rate *per se* is so damaging to financial stability that home residents discount them. Transaction costs and gains from interest that could be potentially earned from a currency position are also ignored here for simplicity. In such circumstances, people fundamentally care about the exchange rate in period $t+1$, compared to the exchange rate in period t. If θ is very low, then the average market forecast is for continuing home currency weakness. However, domestic agents hold divergent views on how weak a currency will be.

In this economy, domestic agents hold domestic perfectly liquid assets (i.e bank deposits), the size of which is proportional to total liquid assets l_t in period t. Bank assets, in contrast, are illiquid[7]. Thus, if domestic agents liquidate their liquid assets, financial institutions can repay domestic residents, only if loans can be called in or financial resources have to be mobilized domestically or internationally to fully meet liquidity demand. Otherwise, the domestic monetary authority intervenes to supply the additional liquidity.

Based on these assumptions, a domestic agent i would trade the home currency for a foreign currency if the home currency is expected to fall from its current level, or:

$$E\{e_{t+1} / (\theta + \varepsilon_i)\} = \alpha(\theta + \varepsilon_i) \le e_t. \tag{2}$$

For a given date t, exchange rate e_t, the measure of agents such that $\alpha(\theta+\varepsilon_i) \le e_t$, or $\varepsilon_i \le (e_t / \alpha) - \theta$, is:

$$\frac{1}{2\bar{\varepsilon}} \int_{-\bar{\varepsilon}}^{(\frac{e_t}{\alpha})-\theta} dx = \frac{1}{2\bar{\varepsilon}} (\bar{\varepsilon} + \frac{e_t}{\alpha} - \theta) \tag{3}$$

Therefore, at date t, the liquidity demand for foreign exchange in terms of the home currency is:

---

[6]A fall in e means depreciation of the home currency.

[7]This asymmetry in asset liquidity is known in the literature as the bank business of providing 'liquidity-transforming service'.

$$l_t^d = \frac{l_t}{2\bar{\varepsilon}}(\bar{\varepsilon} + \frac{e_t}{\alpha} - \theta), \tag{4}$$

where l_t^d is the total demand for foreign exchange liquidity.

6.2 The private supply of liquidity

From here, the model departs from Obstfeld et al. (2010) by introducing private liquidity supply. Domestic financial institutions will coordinate to supply liquidity, whose amount depends on the capacity of the financial sector to mobilize resources domestically or internationally to meet the liquidity demand. As in Caballero and Krishnamurthy (2001), liquidity supply of foreign exchange by the private sector is possible because an optimistic or 'intact' agent can provide liquidity domestically or even borrow more from international investors, given their international collateral. In this regard, net aggregate liquidity demand is:

$$l_t^d - l_t^s, \tag{5}$$

where l_t^s is aggregate liquidity supply, coordinated by all private financial institutions.

However, liquidity supply by the private sector cannot fully offset liquidity demand ($l_t^s < l_t^d$) for a number of reasons. First, as in Caballero and Krishnamurthy (2001) and Holmström and Tirole (1998; 2011), the private sector faces two constraints: limited borrowing capacity with respect to each other, and limited borrowing capacity from international investors. These constraints are due to the underdeveloped capital markets, in which there are information asymmetry and collateral constraints between firms, banks, or international investors. In other words, because income/assets cannot serve as collateral at their full values (i.e. loan to collateral ratio is less than one), the private sector's self-provided supply of liquidity or 'inside liquidity' is limited. Caballero and Krishnamurthy (2001) show that in the case of capital flight of foreign exchange (e.g. during panics), a fire sale of domestic assets would lead to a fall in asset prices, leading to tightened domestic and international collateral. This interaction would further reduce the private sector's capacity to supply liquidity of foreign exchange. A shortage of liquidity supply is worse when no agents or institutions are willing to supply liquidity during a panic.

Let λ_t, $0 < \lambda_t < 1,$ capture the level of the financial sector's capacity to coordinate the liquidity supply of foreign exchange. It also represents the degree of development of the domestic financial markets and access to international markets. Thus, $l_t^s = \lambda_t l_t^d$. Eq.5 can be rewritten as:

$$l_t^d - l_t^s = (1 - \lambda_t)\frac{l_t}{2\bar{\varepsilon}}(\bar{\varepsilon} + \frac{e_t}{\alpha} - \theta) \geq 0 \tag{6}$$

It should be noted that $\left(\bar{\varepsilon} + \frac{e_t}{\alpha} - \theta\right) \geq 0$ because $\alpha(\theta + \varepsilon_i) \leq e_t$ and ε_i is uniformly distributed over the interval $[-\bar{\varepsilon}, \bar{\varepsilon}]$. Eq.6 implies that level of financial development partly determines net liquidity demand. A higher capacity of financial markets to coordinate resources for liquidity supply would help offset liquidity demand. As in Caballero and

Krishnamurthy (2001) and Holmström and Tirole (1998; 2011), domestic and international constraints and a wedge of project/collateral valuations between borrowers and lenders often lead to a shortage of aggregate liquidity supply by the private sector.

6.3 The public supply of liquidity and central bank's reaction function

With a shortage of privately provided liquidity supply, some sources of public liquidity are necessary. Put simply, insufficient liquidity provision by the private sector provides a role for government intervention to make up for the liquidity shortage. Bacchetta et al. (2012) further argue that in an economy where the private sector does not have complete access to external liquidity, it is optimal for the central bank to provide the additional liquidity.

Following these arguments, the central bank is assumed to intervene in the foreign exchange market to minimize the following inter-temporal criterion:

$$\min_{R_{t+1}} E_t\{L_t + \delta L_{t+1}\},$$

where δ is the discount factor and L_t is the loss function at period t. In specifying the function, the model follows Srinivasan et al. (2008) whose function captures asymmetric preference on exchange rate. Many studies show that emerging market economies have a fear of appreciation (Calvo & Reinhart 2002; Levy-Yayati & Surzenegger 2007). Pontines and Rajan (2011) provide evidence of asymmetric preference on exchange rate depreciation as opposed to appreciation, in India, Korea, the Philippines, Singapore, Thailand and Indonesia. In this regard, the monetary reaction function is:

$$L_{t+1} = \frac{1}{2}(R_{t+1} - R^*)^2 + \frac{\beta}{2}\left\{(e_{t+1} - e^*)^2 + \frac{\gamma}{3}(e_{t+1} - e^*)^3\right\}, \quad (7)$$

where $\beta > 0$ is the relative weight and γ is the asymmetric preference parameter on exchange rate depreciation. Here, R^* and e^* are the optimal level of foreign reserves and target exchange rate, respectively. The reaction function is expressed in period *t+1* because we later assume that exchange rate at period *t* is the central bank's target rate. The loss function departs from the standard quadratic form in that policy makers are allowed to treat differently the rate of appreciating and depreciating pressure. It should be noted that if γ=0, the loss function becomes symmetric. If γ>0, eq.13 implies that the rate of appreciation is weighted more heavily than the rate of depreciation in the loss function. In other words, if $\frac{\partial L_{t+1}}{\partial e_{t+1}} = \beta\left[(e_{t+1} - e^*) + \frac{\gamma}{2}(e_{t+1} - e^*)^2\right] > 0$, then exchange rate appreciation would increase the policymaker's loss.

Basically, a central bank provides liquidity by selling its foreign reserves. Since this study takes into account a central bank's motives for foreign exchange market intervention, it is assumed that exchange rate depreciation/appreciation can be reduced by the central bank's intervention. That is,

$$e_{t+1} - e^* = a_0 + a_1 R_{t+1} + \epsilon_{t+1}, \quad (8)$$

where $a_1 > 0$ and ϵ_{t+1} is the error term with a zero mean and a variance σ_ϵ^2. Eq.8 implies that pressure on exchange rate depreciation would deplete foreign reserves, whereas appreciation would result in more foreign reserve accumulation because of central bank intervention. Indeed, for emerging economies with a thin domestic bond market and a shallow financial system, there may be no practical short-run means of managing the exchange rate other than through reserves sales.

Minimizing eq.7 subject to eq.8 leads to the following intervention reaction function of the central bank:

$$R_{t+1} = R^* + \frac{\beta}{2} E_t\{2a_1(e_{t+1} - e^*) + \gamma a_1(e_{t+1} - e^*)^2\}. \quad (9)$$

Suppose that a central bank's optimal level of reserves is equal to the net liquidity demand in period *t* as expressed in eq.6. In other words, given the economic fundamentals and with an underdeveloped financial market, the central bank would hold the necessary precautionary reserves to supply additional liquidity by selling *R* in foreign reserves, which is measured in foreign currency. The optimal level of reserves for the economy's central bank in period *t* is then given by:

$$\frac{R^*}{e_t} = (1 - \lambda_t)\frac{l}{2\bar{\varepsilon}}(\bar{\varepsilon} + \frac{e_t}{\alpha} - \theta). \quad (10)$$

Also, we assume that exchange rate in period t is the target exchange rate aimed by the central bank, i.e. $e_t = e^*$. Thus, eq. 9 can be transformed as:

$$R_{t+1} = (1 - \lambda_t)\frac{l_t}{2\bar{\epsilon}} e_t \left(\bar{\epsilon} + \frac{e_t}{\alpha} - \theta\right) + \frac{\beta}{2} E_t\{2a_1(\Delta e_t) + \gamma a_1(\Delta e_t)^2\}. \quad (11)$$

Eq.11 indicates that reserve accumulation is influenced by the expected liquidity demand, the fundamentals of the economies, the central bank's target exchange rate, its preference on exchange rate fluctuations, and the level of financial development.

6.4 Financial development and foreign reserve accumulation

Eq.10 and eq.11 provide an interesting framework to understand the behavior of foreign reserve accumulation in emerging market economies. First, eq. 10 suggests that if a country has a perfect financial market to coordinate full private supply of liquidity ($\lambda_t = 1$), the optimal foreign reserves would be 0. On the contrary, if the domestic financial market is at a very low level ($\lambda_t = 0$), then the central bank needs to hold a full optimal level of foreign reserves, $\frac{R^*}{e_t} = \frac{l}{2\epsilon}(\bar{\epsilon} + \frac{e_t}{\alpha} - \emptyset)$, which is equivalent to the optimal level of foreign reserves in Obstfeld et al. (2010). However, the level of financial development in emerging market economies is usually neither perfect nor zero, i.e. $0 < \lambda_t < 1$. In short, if the capacity of the financial market is high (high value of λ), then pressure on the currency would be smaller (small net liquidity demand), which requires less government intervention.

Eq.11 is the *actual* level of foreign reserves and consists of two terms. The first term is the *optimal* level of foreign reserves while the second term is the central bank's expectation of exchange rate deviation from its target rate. Eq.11 partly explains why actual foreign

reserve levels in emerging countries with a preference for exchange rate depreciation or stability is higher than the *optimal* level of foreign reserves, often discussed in the literature.

Overall, eq.11 implies that domestic financial sector development would help reduce a central bank's necessity to accumulate foreign reserves for liquidity supply. This argument is supported by taking first derivatives of (11) with respect to λ and *l*, which yields:

$$\frac{\partial R_{t+1}}{\partial \lambda_t} = -\frac{l_t}{2\bar{\epsilon}} e_t \left(\bar{\epsilon} + \frac{e_t}{\alpha} - \theta\right) \leq 0 \qquad (12)$$

$$\frac{\partial R_{t+1}}{\partial l_t} = (1-\lambda_t)\frac{e_t}{2\bar{\epsilon}} \left(\bar{\epsilon} + \frac{e_t}{\alpha} - \theta\right) \geq 0 \qquad (13)$$

$$\frac{\partial R_{t+1}}{\partial (\lambda_t l_t)} = -\frac{1}{2\bar{\epsilon}} e_t \left(\bar{\epsilon} + \frac{e_t}{\alpha} - \theta\right) \leq 0 \qquad (14)$$

Eq.12 implies that a high level of financial sector development would correspond to a lower actual level of foreign reserve accumulation. Similarly, eq. 13 implies that an increase in potential liquidity demand would lead to an increase in foreign reserves, to forestall output loss caused by liquidity shocks. The size of the change in foreign reserves, however, depends on the ability of the financial sector to coordinate the private supply of liquidity.

Suppose there is a bad realization of θ which causes a liquidity shock, and therefore pressure on the home currency as people liquidate their asset to speculate in foreign exchange. With an underdeveloped financial market which cannot fully coordinate to meet full liquidity demand, the monetary authority will then exercise its lender of last resort role by using its reserves to moderate the exchange rate fall. This is motivated by a central bank's desire to limit exchange rate volatility and avoid a currency crisis. Nevertheless, with a huge liquidity demand shock, pressure on the exchange rate will be greater and require a bigger intervention if the economy's financial development is low.

Similarly, if there is upward pressure on the exchange rate as a result of capital inflows, the monetary authority with a preference for exchange rate stability would intervene by buying foreign currency and end up with foreign reserve accumulation. If the financial sector is developed enough to efficiently allocate resources to productive investments rather than to consumption, or to efficiently intermediate capital outflows to offset inflows, then intervention in the foreign exchange market by the central bank becomes less necessary. Less intervention should partly reduce a central bank's motivation to hoard reserves.

The model provides implications, not only for a central bank's liquidity provision, but also for active management of liquidity by a central bank that values macroeconomic and financial stability. Simply, the role of states in easing illiquidity and providing liquidity, increases when financial markets are underdeveloped and cannot fully guarantee liquidity during shocks. In other words, an open economy with less developed financial markets is expected to accumulate more reserves to ensure liquidity, while limiting the exchange rate and macroeconomic volatility. This implies that motivation to hoard reserves could be mitigated partly by developing a deep financial sector.

7. Conclusion

This study empirically examined the relationship between capital flows, level of foreign reserves and financial development. Applying fixed-effect and simple pooled regressions with annual data from 12 East Asian economies between 1980 and 2009, the empirical results suggest that financial development can reduce a central bank's motivation to hoard foreign reserves by reducing the impact of capital flows on foreign reserve demand. This study also used alternative measures of financial development to check the robustness of the estimations. The results consistently suggest that financial sector development reduces a central bank's motivation to hoard reserves.

Motivated by the empirical results, this study constructed a model in which a state with asymmetric preference on exchange rate holds reserves to supply foreign exchange liquidity in underdeveloped capital markets. The theoretical argument is that with a low capacity of the private sector to meet liquidity demand due to underdeveloped financial markets, the state plays a role in supplying additional liquidity. Therefore, in this model, development of the financial system would reduce the monetary authority's motivation to hoard reserves for liquidity provision. In addition, asymmetric preference in the exchange rate partly explains why the actual level of foreign reserves held by a central bank is usually higher than the necessary optimal level of foreign reserves needed for liquidity supply.

The paper has discussed the motives and examined the role of underdeveloped capital markets in foreign reserve accumulation in emerging market economies. Serious assessment of the adequacy of reserve holding in emerging market economies is left to future research. In addition, further research could focus on the role of financial development at the regional level, including bond market development and regional monetary cooperation, which would reduce the need for unilateral reserve hoarding.

Reference

Aghion, P., P. Bacchetta, R. Ranciere, and K. Rogoff, 2009. Exchange rate volatility and productivity growth: the role of financial development, *Journal of Monetary Economics* 56, 494-513.

Aizenman, J., 2008. Large hoarding of international reserves and the emerging global economic architecture, *The Manchester School* 76, 487-503.

Aizenman, J., and J. Lee, 2008. Financial versus monetary mercantilism: long-run view of large international reserves hoarding, *World Economy* 31, 593-611.

___& Marion, N 2004, 'International reserve holdings with sovereign risk and costly tax collection', *The Economic Journal*, vol.114, no.497, pp.569-591.

Athukorala, P., and S. Rajapatirana, 2003. Capital inflows and the real exchange rate: a comparative study of Asia and Latin America, *The World Economy* 26, 613-637.

Bank of England 2011*,* 'The future of international capital flows', Financial Stability Paper, no.12, December, London.

Barnichon, R., 2008. *International reserves and self-insurance against external shocks*(International Monetary Fund, Policy Development and Review Dept.).

Beck, T., and R. Levine, 2004. Stock markets, banks, and growth: Panel evidence, *Journal of Banking & Finance* 28, 423-442.

Beck, T., R. Levine, and N. Loayza, 1999. Finance and the Sources of Growth, *World Development.*

___& Levine, R 2004, 'Stock markets, banks, and growth: panel evidence', *Journal of Banking & Finance,* vol.28, no.3, pp.423-442.

Ben-Bassat, A & Gottlieb, D 1992,'Optimal international reserves and sovereign risk', *Journal of International Economics*, vol.33, no.3, pp.345-362.

Bertrand, M., E. Duflo, and S. Mullainathan, 2004. How Much Should We Trust Differences-in-Differences Estimates?*, *Quarterly Journal of Economics* 119, 249-275.

Bosworth, B, Collins, S & Reinhart, C 1999, 'Capital flows to developing economies: implications for saving and investment', *Brookings Papers on Economic Activity*, vol.1999, no.1, pp.143-180.

Caballero, R., and S. Panageas, 2005. *Insurance and Reserves Management in a Model of Sudden Stops*.

___ & Krishnamurthy, A 2001, 'International and domestic collateral constraints in a model of emerging market crises', *Journal of Monetary Economics*, vol.48, no.3, pp.513-548.

___& Krishnamurthy, A 2003,'Excessive dollar debt: financial development and underinsurance', *The Journal of Finance,* vol.58, no.2, pp.867-894.

Calvo Guillermo, A., and C. M. Reinhart, 2002. Fear of Floating, *The Quarterly Journal of Economics*, 379-408.

Chinn, M., and H. Ito, 2008. A new measure of financial openness, *Journal of Comparative Policy Analysis: Research and Practice* 10, 309-322.

Corden, W. M., 1993. *Economic policy, exchange rates, and the international system*(Oxford university press).

Dooley, M., D. Folkerts-Landau, and P. Garber, 2004. The revived Bretton Woods system: the effects of periphery intervention and reserve management on interest rates & exchange rates in center countries, *NBER Working Paper*.

Durdu, C, Mendoza, E & Terrones, M 2009, 'Precautionary demand for foreign assets in Sudden Stop economies: an assessment of the New Mercantilism', *Journal of Development Economics*, vol.89, no.2, pp.194-209.

Easterly, W, Islam, R & Stiglitz, J 2000, *Shaken and stirred: explaining growth volatility,*The World Bank, Washington DC.

Edwards, S 1984, 'The demand for international reserves and monetary equilibrium: some evidence from developing countries', NBER Working Paper, no.1307, The National Bureau of Economic Research, Cambridge, Massachusetts.

Frankel, J., 2010. *Monetary Policy in Emerging Markets*(Elsevier).

Frankel, J& Jovanovic, B 1981, 'Optimal international reserves: a stochastic framework', *The Economic Journal*, vol.91, no.362, pp.507-514.

Garcia, P., and C. Soto, 2006. Large Hoarding of International Reserves: Are They Worth It?, *External Vulnerability and Preventive Policies*.

Ghosh, R, Ostry, D, & Tsangarides, G 2012, 'Shifting motives: explaining the build-up in official reserves in emerging markets since the 1980s' IMF Working Paper, no.34, International Monetary Fund, viewed 19 April 2012.

Gourinchas, P, Farhi, E& Caballero, R 2008,'An equilibrium model of" global imbalances" and low interest rates', *American Economic Review*, vol.98, no.1, pp.358-393.

Grenville, S., 2008. Central Banks and Capital Flows, *Asian Development Bank Institute Discussion Paper* 87.

Gruben, W & McLeod, D 1998, 'Capital flows, savings, and growth in the 1990s', *Quarterly Review of Economics and Finance*, vol.38, no.3, pp.287-301.

Heng, D 2013. 'Essays on macroeconomic impacts of capital flows and policy responses in emerging market economies', PhD dissertation, Australian National University, Canberra, Australia.

Holmström, B., and J. Tirole, 1998. Private and public supply of liquidity, *Journal of Political Economy* 106, 1-40.

___& Tirole, J 2011, *Inside and outside liquidity*, The MIT Press, Cambridge, Massachussets.

Hviding, K., M. Nowak, and A. Ricci, 2004. *Can higher reserves help reduce exchange rate volatility?*(International Monetary Fund).

Jeanne, O., 2010. Dealing with Volatile Capital Flows, *Peterson Institute for International Economics Policy Brief.*

___& Rancière, R 2006, 'The optimal level of international reserves for emerging market countries: formulas and applications', IMF Working Paper, no.229, International Monetary Fund, viewed 09 December 2010,

Kaminsky, G., and C. Reinhart, 1999. The twin crises: the causes of banking and balance-of-payments problems, *American Economic Review* 89, 473-500.

Kaminsky, G., C. Reinhart, and C. Végh, 2004. When it rains, it pours: procyclical capital flows and macroeconomic policies, *NBER Macroeconomics Annual* 19, 11-53.

King, R. G., and R. Levine, 1993. Finance and growth: Schumpeter might be right, *The Quarterly Journal of Economics* 108, 717.

Krishnamurthy, A., 2010. Amplification mechanisms in liquidity crises, *American Economic Journal: Macroeconomics* 2, 1-30.

Lane, P. R., and G. M. Milesi-Ferretti, 2007. The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970-2004, *Journal of International Economics* 73, 223-250.

Levy-Yeyati, E., and F. Sturzenegger, 2006. Fear of floating in reverse: exchange rate policy in the 2000s, *Harvard Kennedy School of Government*.

Mendoza, E. G., and M. Terrones, 2008. *An anatomy of credit booms: Evidence from macro aggregates and micro data*(National Bureau of Economic Research Cambridge, Mass., USA).

___, Quadrini, V& Rios-Rull, J 2007,'Financial integration, financial deepness and global imbalances', NBER Working Paper, no.12909, The National Bureau of Economic Research, Cambridge, Massachusetts.

Mileva, E 2008, 'The impact of capital flows on domestic investment in transition economies', ECB Working Paper, no.871, European Central Bank.

Mody, A & Murshid, A 2005, 'Growing up with capital flows', *Journal of International Economics*, vol.65, pp.249-266.

Mulder, C. B., and M. Bussière, 1999. External Vulnerability in Emerging Market Economies-How High Liquidity Can Offset Weak Fundamentals and the Effects of Contagion, *IMF Working Papers*.

Obstfeld, M., J. Shambaugh, and A. Taylor, 2010. Financial stability, the trilemma, and international reserves, *American Economic Journal: Macroeconomics* 2, 57-94.

Ötker-Robe, I., Z. Pola ski, B. Topf, and D. Vávra, 2007. *Coping with capital inflows: experiences of selected European countries*(Internat. Monetary Fund).

Pineau, G., E. Dorrucci, F. Comelli, and A. Lagerblom, 2006. The accumulation of foreign reserves, *Occasional Paper Series*.

Pontines, V., and R. S. Rajan, 2011. Foreign exchange market intervention and reserve accumulation in emerging Asia: Is there evidence of fear of appreciation?, *Economics Letters* 111, 252-255.

Pontines, V., and L. Yongqiang, 2010. Regime dependence, Mrs. Machlup's wardrobe and the accumulation of international reserves in Asia, *Economics Letters*.

Raddatz, C., 2006. Liquidity needs and vulnerability to financial underdevelopment, *Journal of Financial Economics* 80, 677-722.

Ramachandran, M., and N. Srinivasan, 2007. Asymmetric exchange rate intervention and international reserve accumulation in India, *Economics Letters* 94, 259-265.

Reinhart, C., and K. Rogoff, 2008. This time is different: a panoramic view of eight centuries of financial crises, *NBER Working Paper*.

Reinhart, C. M., and V. Reinhart, 2008. *Capital flow bonanzas: An encompassing view of the past and present*(National Bureau of Economic Research Cambridge, Mass., USA).

Rodrik, D., 2006. The social cost of foreign exchange reserves, *International Economic Journal* 20, 253-266.

___& Velasco, A 1999,'Short-term capital flow', NBER Working Paper, no.7364, The National Bureau of Economic Research, Cambridge, Massachusetts.

Rogoff, K, Husain, A M, Mody, A, Brooks, R & Oomes, N 2003, 'Evolution andperformance of exchange rate regimes',IMF Working Paper, no.243, International Monetary Fund.

Saborowski, C., 2009. *Capital Inflows and the Real Exchange Rate: Can Financial Development Cure the Dutch Disease*(International Monetary Fund).

Schadler, S., 2008. Managing Large Capital Inflows: Taking Stock of International Experiences, *Asian Development Bank Institute Discussion Paper* 97.

Surico, P., 2008. Measuring the time inconsistency of US monetary policy, *Economica* 75, 22-38.

Wijnholds, J. O. d. B., and Arend Kapteyn., 2001. *Reserve Adequacy in Emerging Market Economies*(IMF Working Paper WP/01/43 (September).
William S, Gregory T & Michelle, W 2011,' The future of international capital flows',Financial Stability Paper, no.12, Bank of England, viewed 16 March 2012. <www.bankofengland.co.uk/publications/fsr/fs_paper12.pdf>.

Appendix

Appendix A: List of economies in the sample

China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Singapore, the Philippines, Taiwan, Thailand, Vietnam.

Appendix B: List of variables, definition, and data sources

Variable	Definition	Source
Log(GDPPC)	GDP per capita	World Development Indicators (accessed January 2011)
Log(M2/GDP)	M2 over GDP	World Development Indicators (accessed January 2011)
Log(trade/GDP)	Exports plus imports over GDP	World Development Indicators (accessed January 2011)
Exchange Rate Fluctuation	Annual standard deviation of monthly change in exchange rate	Author's calculation based on exchange rate from IFS, IMF. (accessed January 2011)
Capital Inflows (Hot money)	The sum of current account and net FDI inflows over GDP.	Calculation based on data from IFS, IMF. (accessed January 2011)
Financial Development 1	Domestic Credit to private plus market capitalization over GDP	Calculation based on data from World Bank (accessed January 2011)
Financial Development 2	Total equity liability+ total debt liability over GDP	(Lane and Milesi-Ferretti 2007). Updated till 2009 (accessed January 2011)
Financial Development 3	Market capitalization over GDP	World Development Indicators (accessed on January 2011)
Financial Development 4	Total Stock Value traded over GDP	World Development Indicators (accessed January 2011)
Financial Openness	Chinn-Ito Index (2009)	*http://web.pdx.edu/~ito/Chinn-Ito_website.htm* (accessed February 2011)

Appendix C: summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Log(Reserves/GDP)	334	2.673	1.150	-0.724	4.799
logGDPPC	359	7.914	1.574	4.576	10.645
Log(M2/GDP)	339	4.302	0.670	2.065	5.490
Log(Trade/GDP)	353	4.336	0.882	2.514	6.082
FX Volatility	359	0.025	0.070	0.000	0.835
Financial Openness	355	0.691	1.605	-1.844	2.478
Capital Inflows	358	0.051	0.095	-0.086	0.469
Financial Openness	340	0.775	0.975	0.000	5. 299
Capitalization/GDP	251	0.917	0.941	0.003	6.170
Stock value traded/GDP	252	0.623	0.868	0.000	7.558
Financial Development	242	2.099	1.347	0. 290	7.416