Chapter 8

What Drives Some Countries to Hoard Foreign Reserves ?

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CHAPTER 8

What Drives Some Countries to Hoard Foreign Reserves?

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Managing capital flows and liquidity demand has been a central issue for emerging-market countries. In an era of global imbalances, rapid accumulation of foreign exchange reserves by surplus countries is also an issue for the interntional system. In a well-functioning international financial system there would be no advantage to holding large reserves so this raises the question of whether surplus countries have a deliberate strategy of building reserves and why they would do this. This paper examines the motives for foreign reserve accumulation and analyzes the effects of financial development and capital flows on reserve accumulation in East Asian economies. We present a model in which a state holds reserves to supply foreign exchange liquidity in underdeveloped financial markets. Using annual data for 12 Asian economies between 1980 and 2009, our empirical results confirm the precautionary motives and financial stability motives in the region. We also find that financial development attenuates central banks' motivation to hoard reserves by reducing the impacts of capital flows on foreign reserve demand. The policy implications are that improving financial market development within developing countries will reduce the incentive to build surpluses and accumulate reserves, while improving the international financial system to reduce volatility would also help.

Keywords: foreign reserves, capital flows, financial development

JEL Classifications: F31, F32, E44

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1. Introduction

> The lack of a clear benchmark for the appropriate level of precautionary reserves, and for the appropriate use of reserves, is a problem, both at the country level and at global level.
>
> — Olivier Jeanne[3]

Over the past two decades, East Asian economies have accumulated a large amount of foreign reserves. The reserves in the region were merely US$0.7 trillion before the Asian crisis in 1997, but rose nine fold to about US$6 trillion in 2010. This amount is more than half of total global foreign reserves.

Four major motivations behind the rapid reserve build-up, as often suggested, are precautionary self-insurance against crisis (Aizenman and Lee, 2008), mercantilism to stimulate growth (Dooley et al., 2004), supporting the overall banking system and insuring against financial instability (Obstfeld et al., 2010), and managing exchange rate volatility (Levy-Yeyati and Sturzenegger, 2006). These four rationales become even stronger amid increasing global capital flows, which are often volatile and potentially destabilizing. Capital flows, for instance, increase output volatility (Mendoza and Terrones, 2008), cause real exchange rate appreciation and thus loss of competitiveness (Corden, 1993), and drive asset bubbles (Grenville, 2008).

Reserve build-up, however, involves some types of domestic risks and costs (Pineau et al., 2006). The most significant ones include inflationary pressure, asset bubbles, misallocation of domestic bank lending, complications in the management of monetary policies, sterilization costs, and potentially sizeable capital losses on central banks' balance sheets. Conflict between reserve accumulation (that is, as a result of intervention in foreign exchange markets) and inappropriate increases in money supply, for instance, could cause inflation and asset price bubbles. Sterilization costs—as another example—can be a considerable drain on a country's budget when the reserves are excessive (Rodrik, 2006).[4]

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[3] Jeane (2010).

[4] Sterilization cost is the spread between interest paid on external borrowing and the returns from investment of reserves. For such costs, Rodrik (2006) provides an estimate of 1 percent of GDP when the reserve level is 30 percent of GDP.

To dampen macroeconomic effects associated with reserve accumulation and capital inflows, countries have applied various policies such as modest capital controls, sterilized foreign exchange intervention, and fiscal tightening. As these policies have generally not proved to be effective in many cases, a satisfactory way of managing capital flows and reserve build-up remains to be discovered.

In this paper, we hypothesize that the development of a deep and active financial sector attenuates the impact of capital flows on the demand for reserves. Capital inflows influence reserve demand via their volatility, potential destabilizing effects, and the risks of sudden stop and reversal (Frankel, 2010; Jeanne, 2010; Kaminsky et al., 2004). Financial development, meanwhile, reduces the impacts of capital flows on real exchange rate appreciation (Saborowski 2009), and lowers output and macroeconomic volatility (Raddatz, 2006). The main reason is that a well-functioning financial market enables efficient utilization of capital inflows, mobilizes resources, facilitates risk diversification, and provides access to global liquidity during shocks (Beck and Levine, 2004; Beck et al., 1999; King and Levine, 1993).

We present a model in which the state holds reserves in order to supply foreign exchange liquidity in underdeveloped financial markets. Our theoretical argument is that with the low capacity of the private sector to meet liquidity demand when financial markets are underdeveloped, the state plays a role in supplying additional liquidity. Thus, in our model, the development of the financial system reduces the monetary authority's motivation to hoard reserves for liquidity provision.

Using annual data for 12 East Asian economies between 1980 and 2009, we empirically examine the motives for foreign reserve accumulation and analyze the effects of capital flows and financial development on reserve demand. Fixed effects and alternative measures of financial development are also introduced to check the robustness of the estimations. We confirm the precautionary motives and financial stability motives for reserve demand in Asia. Our results also consistently suggest that financial sector development reduces the impacts of capital flows on the demand for reserves.

This paper contains three innovations. First, our analysis concentrates on East Asian economies that attract a large share of global capital flows. Second, we formally take into account the level of financial development in discussing foreign reserve

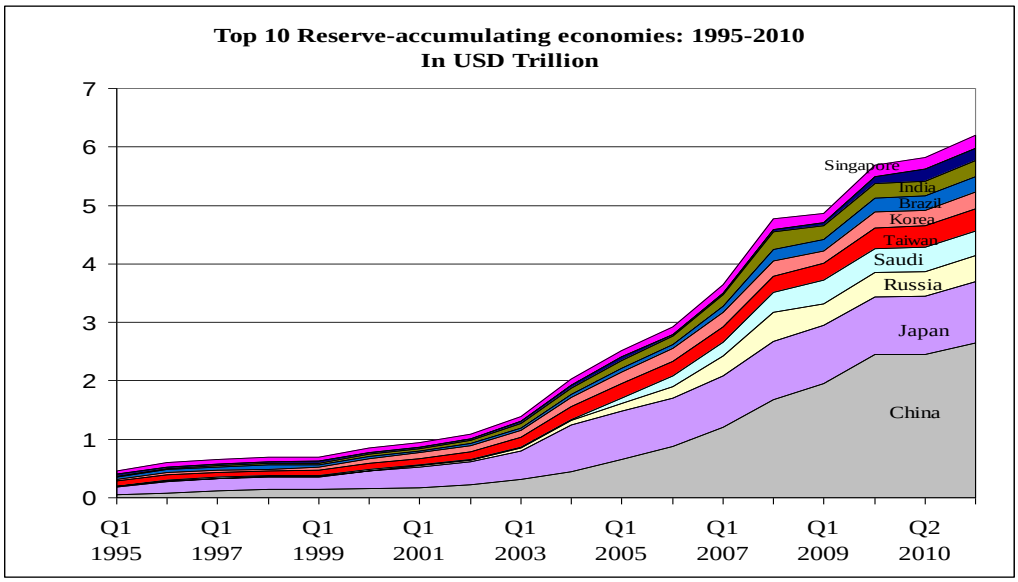
demand and capital flows. Third, we introduce a "rationalized" monetary policy reaction and the concept of private and public liquidity provision—first analyzed by Holmström and Tirole (1998)—into the framework set up by Obtsfeld et al. (2010).

The next section describes the recent trends in foreign reserve accumulation among Asian emerging-market economies. Section 3 provides a short review of the current state of understanding on foreign reserve accumulation and its nexus with capital flows and financial development. Section 4 introduces the theoretical underpinnings of the analysis. The formal model is presented in Appendix A. Section 5 presents the empirical investigation. Section 6 discusses the results. Section 7 concludes and sheds some light on policy implications in reserve accumulation. An appendix presents a model explaining the motives for reserve accumulation and the role of the private sector in liquidity provision.

2. Recent Trends in Foreign Reserve Accumulation Among Asian Economies

As can be seen in Figure 1, there are three features in the trend of reserve accumulation over the past two decades. First, reserves grew rapidly in 2002–07, at a pace three times more than that in 1999–2001. Second, central banks in East Asia, particularly China, accounted for the bulk of the build-up. Among the reserve accumulators, Asian economies are among the 10 largest reserve holders: China, Japan, Taiwan, Korea, India, Hong Kong, Singapore and Malaysia. The share of foreign reserves held by Asian economies increased from 45 percent in 1995 to 66 percent in 2010. Third, few monetary authorities held an increasingly larger share of the reserve holding. China and Japan accounted for more than half the total world reserve accumulation.

Figure 1. Top-10 Reserve-Accumulating Economies: 1995–2010 (in US$ trillion)

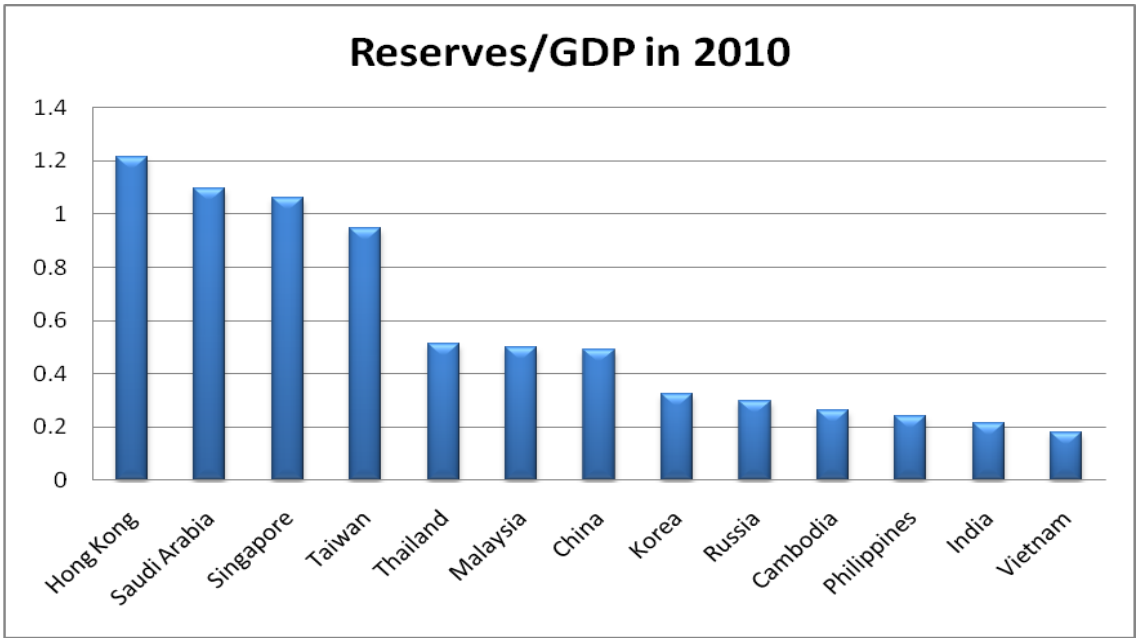


Source: Foreign exchange (series code:…1D.DZF), International Financial Statistics, IMF, (accessed 19 December 2010); Central Bank of the Republic of China (Taiwan).

As shown in Figure 2, Hong Kong accumulates the highest percentage of reserves to GDP (121 percent), followed by Singapore (106 percent), Taiwan (94 percent), Malaysia (50 percent), and China (49 percent).

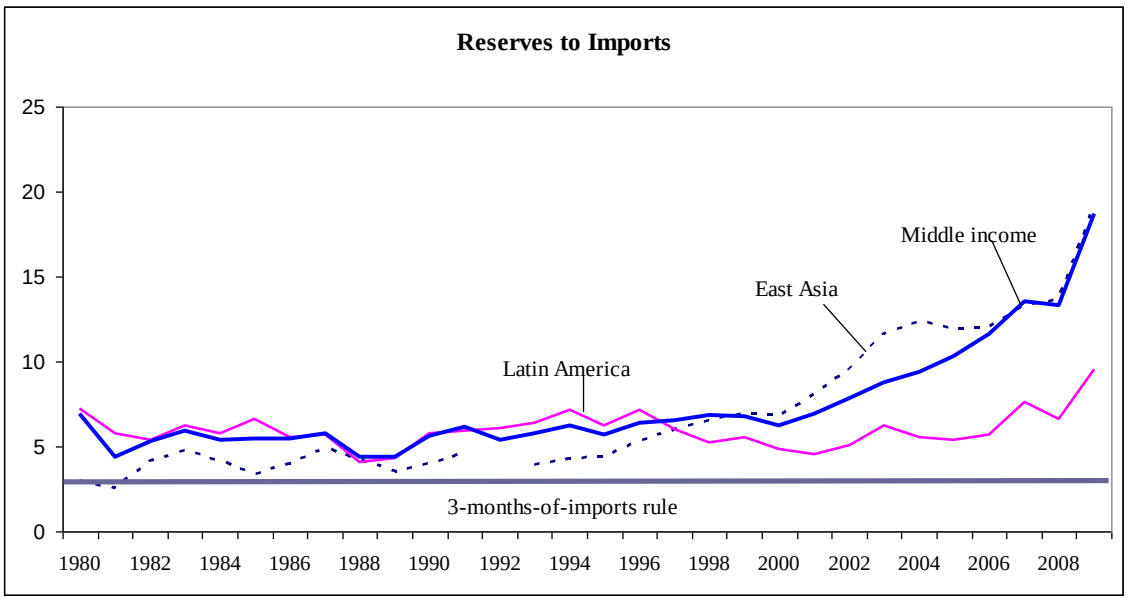
As shown in Figures 3, 4 and 5, ratios of reserves to imports for many Asian economies are far above the traditional rule of thumb, which is three to four months' coverage. Taiwan, for example, would be able to finance its imports for about two years with its reserves. Similarly, as can be seen in Figure 6, China's ratio of reserves to short-term external debt reaches a value of about 10, which is much higher than 1, suggested by the Greenspan–Guidotti rule. In addition, as shown in Figures 7 and 8, the reserves to broad money ratios in many Asian economies have increased significantly above the threshold values, which are suggested to be between 5 and 20 percent. In Singapore, for example, the ratio is about 90 percent.

Figure 2. Reserves/GDP in 2010



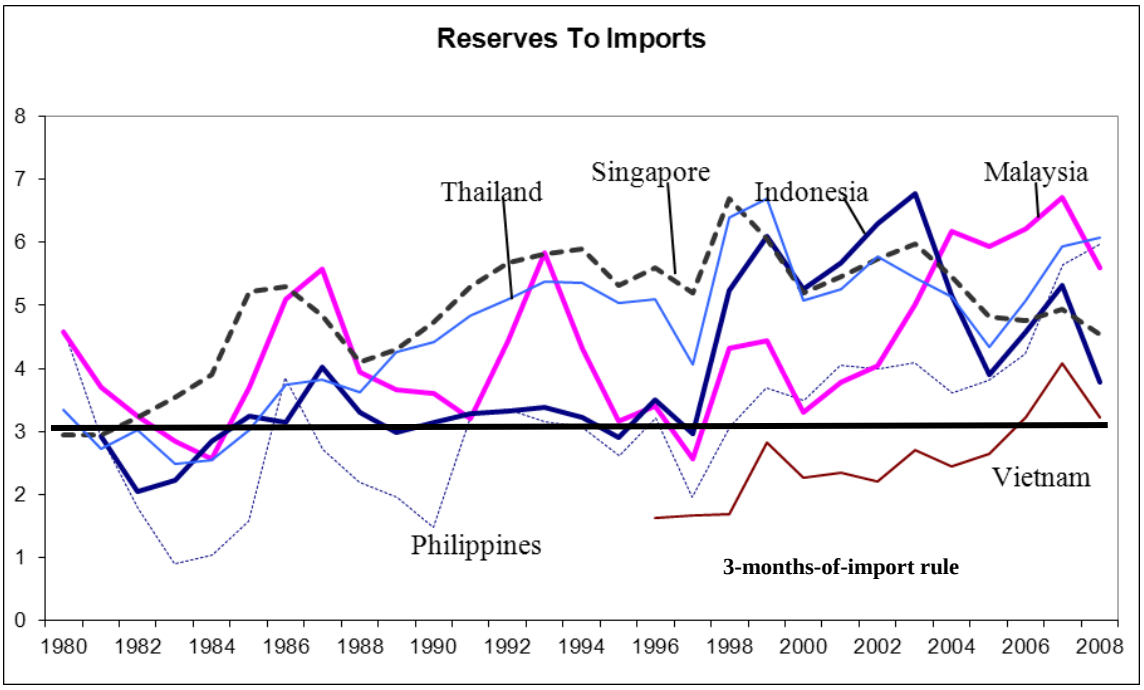
Source: International Financial Statistics, IMF. GDP from World Economic Outlook, IMF, (accessed 23 December 2010); Central Bank of the Republic of China (Taiwan).

Figure 3. Reserves to Imports



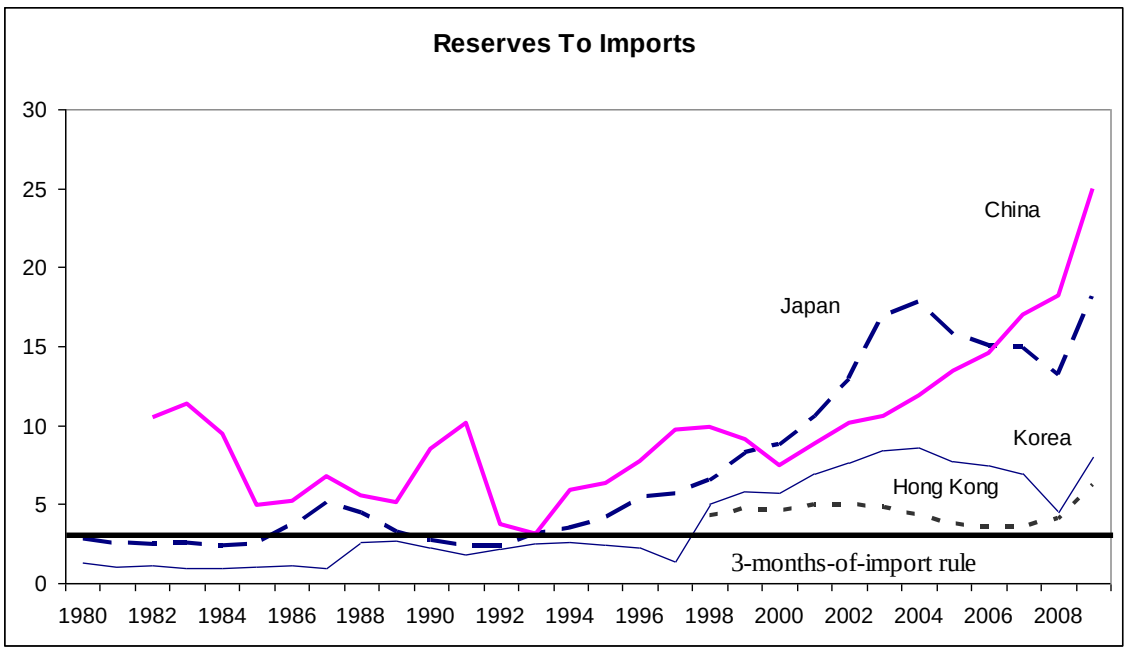
Source: World Development Indicators, World Bank (accessed 28 December 2010); Central Bank of the Republic of China (Taiwan).

Figure 4. Reserves to Imports



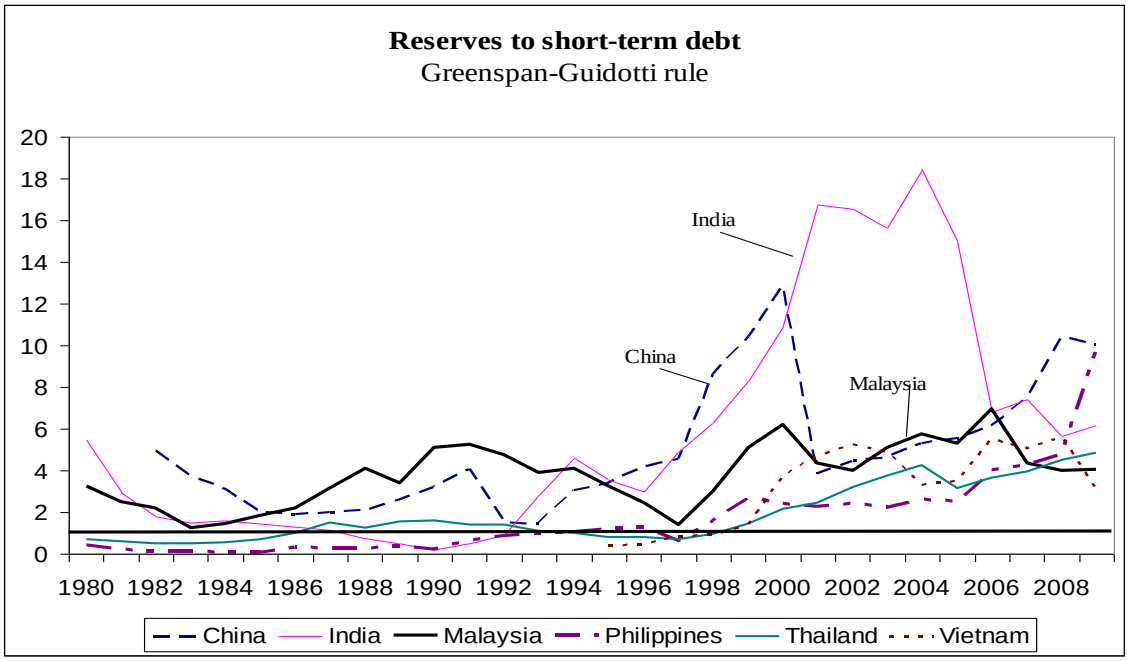
Source: World Development Indicators, World Bank (accessed 28 December 2010); Central Bank of the Republic of China (Taiwan).

Figure 5. Reserves to Imports



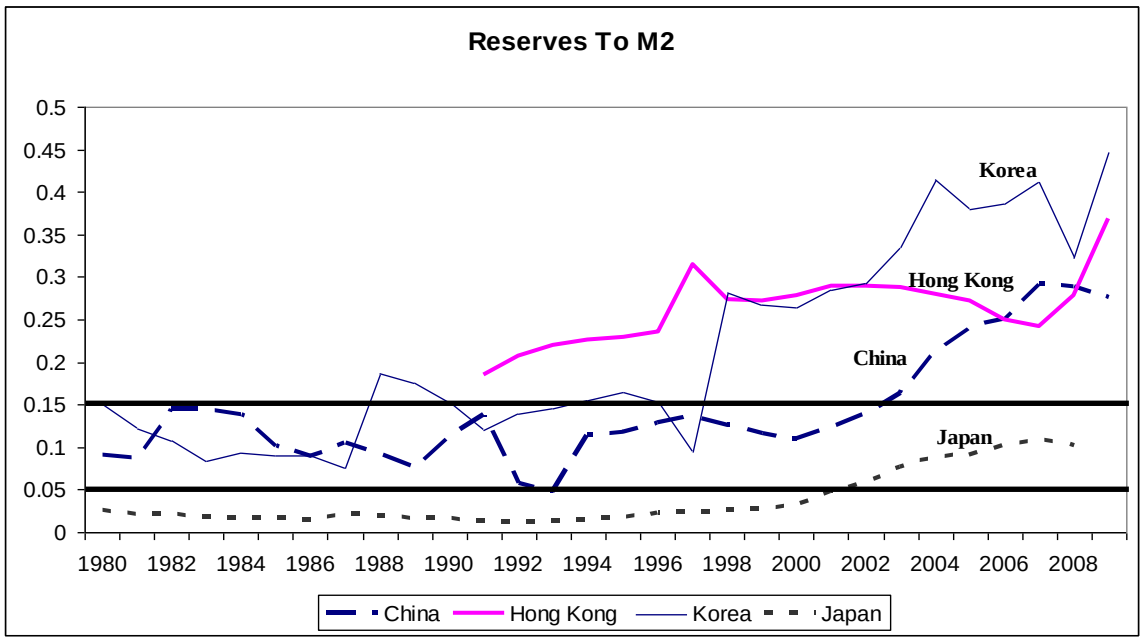
Source: World Development Indicators, World Bank (accessed 28 December 2010); Central Bank of the Republic of China (Taiwan).

Figure 6. Reserves to Short-Term Debt (Greenspan–Guidotti Rule)



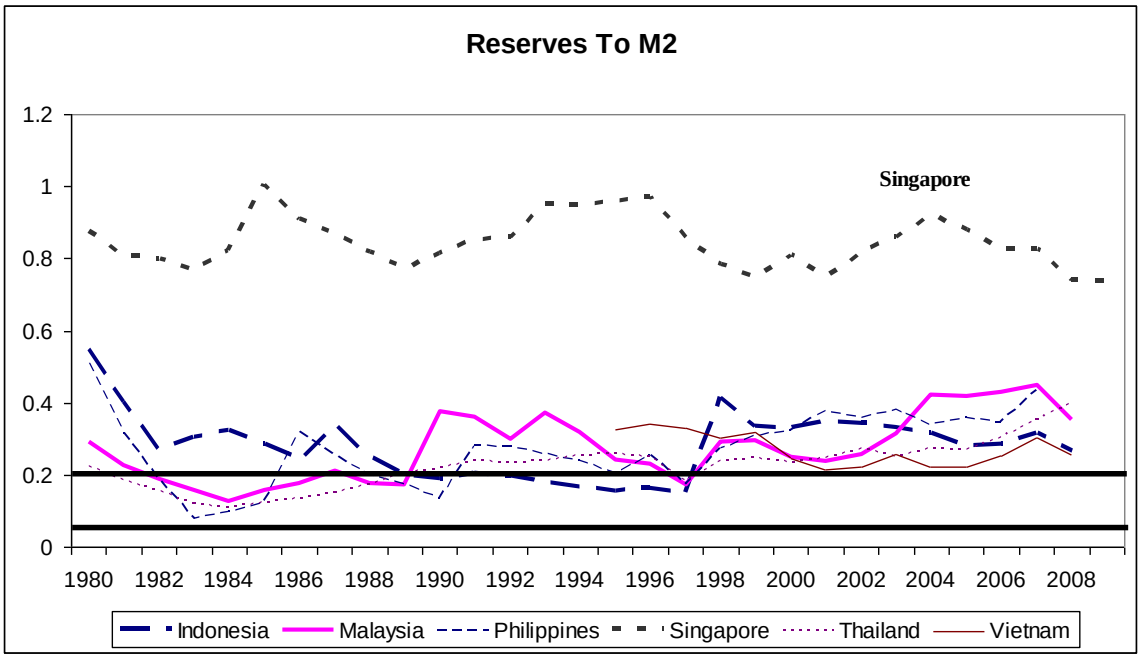
Source: Authors' calculation; World Development Indicators, World Bank (accessed 28 December 2010); Central Bank of the Republic of China (Taiwan).

Figure 7. Reserves to M2



Source: Authors' calculation; World Development Indicators, World Bank (accessed 28 December 2010); Central Bank of the Republic of China (Taiwan).

Figure 8. Reserves to M8



Source: Authors' calculation; World Development Indicators, World Bank (accessed 28 December 2010); Central Bank of the Republic of China (Taiwan).

Traditional indicators (see Box 1) for reserve adequacy suggest that in emerging Asian economies the stock of foreign reserves might be substantially in excess. The unprecedented accumulation in several key Asian economies indicates that factors other than purely precautionary motives might be driving the rapid build-up of international reserves (Aizenman and Lee, 2008). The evidence also suggests that limiting vulnerability has probably not been the primary motive for recent reserve build-ups in most economies. Nonetheless, determining the optimal level of foreign reserves is not straightforward as it is subject to uncertainty and institutional factors such as the degree of capital mobility, financial liberalization, or the weakness of the domestic banking system. Under 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 those with underdeveloped financial markets—to deal with sudden capital inflows and outflows. This environment indeed influences the desired stock of foreign reserves (see Box 2 for the case of South Korea during the 2008 crisis).

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 new benchmark that takes into account capital flows is needed. They argue that the new 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 risk and the exchange rate regime.

Box 1. Traditional Indicators for Reserve Adequacy

Ratio	Value	Notes
Reserves to imports	3 to 4	This ratio represents the number of months for which an economy could support its current level of imports if all other revenues were to stop. As a rule of thumb, countries should hold foreign reserves in order to cover their imports for three to four months.
Reserves to short-term external debt	1	This ratio, known as the Greenspan–Guidotti rule, reflects an economy's ability to service its existing short-term external debt (debt maturing within a year) in the case of a sharp deterioration in the external financing conditions. Typically, the country is prudent if the ratio is equal to 1 (Garcia and Soto, 2006; Rodrik and Velasco, 1999).
Reserves to broad money (M2)	0.05 to 0.2	This ratio reflects the potential for resident-based capital flight from the domestic currency because broad money indicates a country's exposure to the withdrawal of assets. If the ratio is close to zero, broad money largely exceeds foreign reserves. In the case of an exchange rate peg regime, the lower the ratio, the higher is the potential for capital flight in the event of negative money demand shocks. This ratio has indeed increased in most Asian economies since the 1997 Asian crisis (see Wijnholds and Kapteyn, 2001)

3. Literature Review

3.1. Reserve Demand

Three major theoretical explanations stand out in the literature on 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 and Lee, 2008), and to smooth domestic absorption as a cushion against sudden stops in capital inflows (Jeanne and Rancière, 2006) when the economy is susceptible to sudden stops. 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, 1983), and to stabilize output (Aizenman et al., 2004; Garcia and Soto, 2006; Jeanne and Ranciere, 2006). Similarly, foreign reserves can be used to stabilize fiscal expenditure in countries with limited taxation capacity and sovereign risk, and limited access to the global capital market (Aizenman and Marion, 2004).

In the mercantile view, reserve accumulation is the result of a growth strategy by keeping exchange rates undervalued to stimulate export growth and competitiveness (Dooley et al., 2004). Moreover, foreign reserves can serve as "collateral" for encouraging foreign direct investment (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 and 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 and Lee, 2008). The promotion was achieved in several ways, including through direct subsidies funded by state banks; by means of financial repression where favored sectors 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 for 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, financial shock is not simply a "sudden stop", in which case countries would need to hold reserves only in proportion to their

short-term external debt (Greenspan–Guidotti rule). Given such motivation and the desire for exchange rate stability and vulnerability to portfolio shifts by domestic residents, the monetary authority needs to hold reserves proportional to the size of its banking system.

3.2. Capital Flows, Reserve Accumulation and Financial Development

In this section, we connect the link among capital flows, reserve accumulation and financial development. Despite the benefits of capital flows on investment and growth (Bosworth and Collins, 1999; Mileva, 2008; Mody and Murshid, 2005), capital flows can have a direct impact on macroeconomic stability and then affect reserve demand through at least three channels, as can be seen in Box 3.

First, capital flows affect reserve demand through increased output volatility as they are more often pro-cyclical than countercyclical (Kaminsky et al., 2004; Mendoza and Terrones, 2008; Reinhart and Reinhart, 2008). Sudden changes in the direction of capital flows, for instance, tend to induce or exacerbate boom–bust cycles in economies that lack a deep and well-functioning financial sector (Aghion et al., 2005). This relation implies that increases in capital flows tend to increase output volatility, which motivates more precautionary demand for foreign reserves.

Second, capital inflows influence reserve demand through their appreciation impacts on the real exchange rate and thus have negative effects on the external competiveness of recipient economies (Athukorala and Rajapatirana, 2003; Corden, 1993). As Asian economies are fearful of appreciation (Pontines and Yongqiang, 2010), central banks are induced to intervene in foreign exchange markets by buying reserves to "lean against the wind" when there is upward pressure on exchange rates. The reasons for such intervention could be that a fixed or relatively rigid exchange rate can provide benefits in terms of macroeconomic stability, particularly to developing countries where financial development is limited and the capital market is closed (Aghion et al., 2009). On the contrary, real exchange rate volatility reduces growth in countries with relatively weak financial development (Aghion et al., 2009). In such cases, 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 reserve demand when they drive up equity and asset prices (Grenville, 2008; Schadler, 2008), reduce the quality of assets, and adversely affect the maturity and currency composition of the balance sheets of the private sector. This contributes to greater financial fragility, which increases the odds of a currency crisis (Kaminsky and Reinhart, 1999). Real estate booms and asset price bubbles can amplify financial fragility and crisis risks, thus making the economy particularly vulnerable to financial shocks and crises (Reinhart and Rogoff, 2008). In such cases, a reserve build-up can also be associated with growing fragility of a country's banking system because concerns about financial stability lead countries to hoard foreign reserves for liquidity provision to mitigate the possible transmission of a banking crisis to a currency crisis during shocks.

Analysis of the three transmission types implies that the development of the financial sector can attenuate the reserve demand by weakening the impacts of capital flows on output volatility, the real exchange rate and financial fragility. First, a more developed financial system is associated with lower output volatility across countries (Beck et al., 1999). Second, a deep and active financial sector can provide broad investment opportunities, direct capital inflows towards their most productive use, mitigate investment demand constraints (Ötker-Robe et al., 2007), and thus reduce real exchange rate appreciation (Saborowski, 2009). Third, 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.

Different strands of the literature discussed above underline: i) the motivation to accumulate reserves; ii) the potentially adverse impacts of capital inflows on the recipient economies and thus on the reserve build-up; and iii) the importance of the financial market in mobilizing and allocating resources efficiently to attenuate the impacts. These findings shape our hypothesis that the impacts of capital flows on reserve demand could be attenuated by the development of deep financial markets and institutions.

4. Theoretical Motivation Based on Liquidity View

The theoretical framework underpinning our analysis rests on three important strands of the literature: foreign reserve accumulation, liquidity provision and financial development. We take into account the concept of liquidity in the model as it plays an essential role in the literature of financial crisis. Higher liquidity can significantly decrease countries' vulnerability to external shock in the face of weak domestic fundamentals (Mulder and Bussière, 1999). Similarly, in the model of amplification mechanism of financial shock, liquidity provision by the central bank can alleviate the crisis (Krishnamurthy, 2010).

Drawing on the work of Holmström and Tirole (1998), we introduce the concept of private versus public supply of liquidity (domestic versus international liquidity) into the framework in Obstfeld et al. (2010). In the case of liquidity demand shock, domestic residents or firms can meet liquidity by issuing claims on their productive assets or by using a credit line (Holmström and Tirole, 1998). When financial markets are not developed well enough to provide these options, however, the government might need to step in to supply additional liquidity. The underdeveloped financial markets could be caused by collateral constraints (Caballero and Panageas, 2005). In these circumstances, the build-up of foreign reserves is motivated by the government's role in supplying additional liquidity to domestic economic agents during a liquidity shock—that is, a sudden stop or capital outflows, with the presence of an underdeveloped capital market that fails to fully meet liquidity demand. This relation implies that the development of a deep and active financial market could bring about two benefits. First, it could promote resource mobilization for more private liquidity provision. Second, it can reduce the impacts of capital flows on macroeconomic and exchange rate volatility, and vulnerability to financial crisis. These two benefits, therefore, can attenuate the state's motivation to hoard reserves.

The theoretical reasoning outlined above motivates our simple modeling of the relationship between the demand for liquidity, the level of financial sector development and an economy's international reserve accumulation. In the model outlined in the Appendix, we follow Obstfeld et al. (2010) in deriving the liquidity demand in a

domestic economy. Unlike the framework set out in Obtseld et al. (2010), however, in which the central bank sells foreign reserves passively, we introduce a monetary reaction function based on optimizing behavior to motivate its intervention. Furthermore, as noted earlier, our model also introduces concepts of private versus public liquidity provision and the level of capital market development.

5. Empirical Approach

We turn to an empirical investigation on the liquidity demand, financial development and reserve accumulation. Based on the theoretical motivation outlined in the previous section and Appendix A, the reduced form for our empirical study can be simplified as:

$$\text{Re}serves = \alpha_1 + \alpha_2 Capflows_{it} + \alpha_3 Findev_{it} + \alpha_4 CapFin_{it} + \alpha_5 X_{it} + \eta_{it} + \varepsilon_{it}, \qquad (12)$$

where *Reserves* is the amount of foreign reserves, *Capflows* is capital inflows, *Findev* is financial development, and *Capfin* is the interaction terms between capital flows and financial development. X_{it} is a vector of control variables including GDP per capita, broad money, trade, exchange rate stability, and financial openness, which are often included in the literature. η is the fixed effect and ε is the error term. We also include a dummy for the post–Asian crisis period, POST, in order to capture potential differences in reserve accumulation patterns across countries between the pre and post Asian crisis periods.

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 reserve accumulation, respectively. If financial development can attenuate the impact of capital flows on reserve accumulation then α_4 should be negative and statistically significant. Meanwhile, we expect the coefficient of capital flows, α_2, to be positive and that of financial development, α_3, to be negative.

For potential liquidity demand, we use broad money over GDP. Using broad money as a proxy for possible liquidity demand is motivated by (Wijnholds and Kapteyn, 2001), the Early Warning System literature, and the financial stability model presented by Obstfeld et al. (2010). Short-term external debt can also be a good proxy for liquidity demand. Given data availability, however, broad money (M2) is preferred in this analysis.

Financial development is a broad economic concept, within which there is a large literature on the measurement of financial development (see, for example, Beck et al., 1999). Among all measures, the sum of total external equity liability and debt liability is used as an indicator of a country's level of financial development in terms of access to external financial resources. 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. Thus, this measure will be used for our main regressions and analysis. Besides, the total stock value traded measures financial market liquidity while stock-market capitalization reflects the size and depth of the market. These alternative measures will be used for a robustness check in the next section.

For financial openness, the Chinn–Ito Index (2008) is used. This index is based on the binary dummy variables that codify the restriction on cross-border financial transactions reported in the International Monetary Fund's *Annual Report on Exchange Arrangements and Exchange Restriction* (*AREAER*). A higher value signals a higher degree of openness to financial transaction.

For capital flows, we follow Mendoza (2010) by using the sum of the current account and net FDI inflows scaled by GDP. This measure captures more of the short-term component of capital flows (hot money)—considered to be volatile and potentially destabilizing in the literature. 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 construed as a possible inducement for appreciation pressure on the currency, in which there would be a positive link to reserve accumulation.

Our annual data sample covers 30 years from 1980 to 2009 and includes 12 Asian economies.[5] (See Box 3 for an explanation of each variable and the Appendix for data sources.)

Box 3. List of Explanatory Variables for Reserve Build-Up

Variables	Sign	Notes
GDP per capita	+/–	GDP per capita can reflect the stage of economic development. It is expected to be positively/negatively linked to reserve accumulation according to the stage of the economy.
Capital flows (Hot money)	+	A potential indicator of hot money flows to a country is the sum of the current account and net FDI inflows scaled by GDP. 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 construed as a possible inducement for appreciation pressure on the currency, in which there would be a positive link to reserve accumulation.
Broad money	+	Broad money often indicates a country's exposure to the withdrawal of assets or resident-based capital flight from the domestic currency. Thus, it is used as a proxy for potential liquidity demand. Broad money is expected to be positively linked to reserve accumulation.
Trade	+	Trade openness might require foreign reserve demand for transaction. Also, a conventional rule of thumb suggests that a country should hold reserves enough to finance three or four months of imports without income flows. For this reason, as a precautionary demand, a country can hold more for self-insurance. Thus, imports/GDP is expected to be positively linked to reserve accumulation (*source*: WDI, the World Bank).
Financial development	–	A high level of financial sector development could mobilize resources more efficiently and would be less vulnerable to crises. Thus, it is expected to reduce demand for a reserve build-up. A country's total equity and debt liability is used as an indicator of capital market development and as a proxy for the country's access to the international financial market.
Interaction term (Capital flows* financial development)	–	The interaction term captures the marginal effect of capital flows on reserve demand. It is expected to take a negative sign given the hypothesis that increases in financial development could help attenuate the impact of capital flows on reserve demand.
Financial openness (Chinn–Ito)	+	We adopt the Chinn–Ito Index. Higher financial openness suggests vulnerability to external financial shocks, and is expected to increase precautionary demand for reserves.
Exchange rate fluctuation	+/–	On the one hand, exchange rate fluctuation within a certain range would result in less government intervention in the foreign exchange market, thus less reserve build-up. On the other hand, greater real exchange rate volatility is empirically linked to lower growth and financial instability—notably, in financially underdeveloped countries. Also, a higher level of reserves is empirically linked to reduced exchange rate volatility (Hviding et al., 2004). This variable is expected to be positively linked to reserve holding.

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

6. Regression Results and Analysis

Table 1 reports the results of regressions with a log of reserve accumulation over GDP as the dependent variable. Column 1 shows the result of regression with a country fixed effect while column 2 includes country and year fixed effect. In columns 3 and 4, we add capital flows, financial development and the interaction terms with country fixed effect and country and year fixed effect, respectively.

We observe that broad money and trade are positive and significant in all regressions while the post-crisis period is positive and significant in columns 1 and 3 (country fixed effect). These results confirm the precautionary motives and financial stability motives for reserve accumulation among Asian economies. Based on the results, a 10 percent increase in broad money over GDP leads to about a 5 percent increase in reserves over GDP. Similarly, when trade over GDP increases by 10 percent, the reserves over GDP ratio would increase by about 7 percent.

In columns 3 and 4, we find that the coefficient of capital flows is positive and significant. This finding implies that a 10 percentage point increase in the capital flows ratio would lead to about a 26 percent increase in the reserves-to-GDP ratio. This effect is fairly high, but is evidenced by some Asian economies' behavior. In our sample, an average capital inflow is 4 percent while the average increase in reserves-to-GDP ratio is 14 percentage points.

We also find that the interaction terms between capital flows and financial development have the expected sign and are significant. The results confirm our hypothesis that financial development attenuates the impacts of capital flows on reserve accumulation. The implication here is that although capital inflows could motivate reserve accumulation, a well-functioning financial system could help reduce the impacts of capital flows on reserve hoarding. In other words, the magnitude of the impacts of capital flows on reserve demand decreases with a higher level of financial development due to the efficient absorption of capital inflows.

More interestingly, if financial development increases by 10 percentage points, the impact of capital flows on reserve demand will be reduced by 11 percent. Based on the results of our empirical analysis, we can also determine the threshold level of financial

development around which the effects of capital flows on reserve accumulation are neutralized. To do this, we differentiate the model in equation 10 (in column 4) with respect to capital flows.

$$\frac{\Delta Reserves}{\Delta CapFlows} = 2.72 - 1.044 * FinDev$$

The threshold level of financial development is about 2.6, which is equivalent to 260 percent of GDP in terms of access to international financial resources. This is indeed a high level of financial development. In our data, only Hong Kong and Singapore have such financial size and depth. Nonetheless, the threshold itself is not important. Rather, an essential implication is that the high level of financial sector development attenuates the impacts of capital flows on reserve accumulation.

6.1. Robustness Check

To conduct a robustness check, we use domestic credit and market capitalization over GDP (DCMCAP) and domestic market liquidity (total stock value traded over GDP, SVT) as alternative proxies of financial development and resource mobilization for liquidity provision by the private sector. The results are presented in Table 2. We observe that the results are not quantitatively much different from our earlier findings. The coefficients of broad money, trade and the post–Asian crisis period dummy remain positive and significant. The interaction terms between capital flows and financial development are all negative and remain statistically significant. The results confirm our hypothesis that financial development attenuates the impact of capital flows on reserve accumulation. Based on the results, a 10 percent increase in financial development reduces the impacts of capital flows on reserve accumulation by between 6 and 10 percent.

7. Conclusion

This paper has examined the motives for foreign reserve accumulation and analyzed the effects of capital flows and financial development on reserve demand in the Asian region. We have presented a model in which a state holds reserves to supply foreign exchange liquidity in underdeveloped financial markets. Our theoretical argument is that with the low capacity of the private sector to meet liquidity demand due to underdeveloped financial markets, the state plays a role in supplying additional liquidity. Thus, in our model, the development of the financial system weakens the monetary authority's motivation to hoard reserves for liquidity provision.

Using annual data for 12 East Asian economies between 1980 and 2009, our results confirm the presence of a precautionary motive and a financial stability motive in hoarding reserves. By using various measures of financial development, we also consistently found that financial sector development reduces the impacts of capital flows on reserve demand.

Table 1. Regression Result with log(Foreign Reserves/GDP) as Dependent Variable

	(1)	(2)	(3)	(4)
logGDPPC	0.153	–0.099	0.175	–0.1
	(0.12)	(0.053)*	(0.10)	(0.042)**
logM2	0.542	0.485	0.528	0.427
	(0.242)**	(0.162)**	(0.210)**	(0.126)***
lnTrade	0.73	0.758	0.683	0.774
	(0.239)**	(0.110)***	(0.217)***	(0.128)***
Evol	–1.604	–3.631	–1.446	–3.979
	(1.03)	(2.21)	(1.14)	(2.29)
Kaopen	0.137	0.022	0.19	0.04
	(0.08)	(0.06)	(0.081)**	(0.05)
Post crisis	0.469		0.471	
	(0.237)*		(0.217)*	
Capital inflows			2.057	2.721
			(1.091)*	(1.009)**
Financial development			–0.009	–0.08
			(0.06)	(0.06)
Cap*Fin			–1.094	–1.044
			(0.361)**	(0.298)***
Observations	326	327	322	322
Country fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	No	Yes	No	Yes
R-squared	0.9	0.85	0.91	0.87

Note: Robust standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Financial Development 1 (Fin.Dev1) is the sum of total external equity liability and debt liability.

Table 2. Robustness Check with Access to International Market (External Access)

	(1)	(2)
logGDPPC	–0.114	–0.126
	(0.036)***	(0.048)**
logM2	0.633	0.505
	(0.238)**	(0.172)**
lnTrade	0.683	0.636
	(0.084)***	(0.091)***
Evol	–4.506	–4.089
	(2.328)*	(2.34)
Kaopen	0.00	–0.02
	(0.04)	(0.05)
Capital inflows	2.523	1.79
	(0.692)***	(0.668)**
DCMCAP	–0.051	
	(0.09)	
Cap*DCMCAP	–0.59	
	(0.214)**	
SVT		0.186
		(0.100)*
Cap*SVT		–0.989
		(0.331)**
Observations	242	247
Country fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
R-squared	0.88	0.87

Note: Robust standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

DCMCAP is domestic credit and market capitalization over GDP while SVT is total stock value trade over GDP.

It is widely believed that a deep financial sector helps allocate resources efficiently. In extending this concept to precautionary reserve holdings to provide liquidity provision against shock, an important implication is that financial development could help reduce reserve demand due to capital flows and their macroeconomic consequences. Our finding in this paper suggests that an important part of a long-term policy in dealing with capital flows is the development of a deep and active financial sector. Also, as capital flows can be volatile and potentially have destabilizing effects on macroeconomic management, the policy recommendation in favor of financial sector development becomes even stronger.

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Appendix A. The Analytical Model of Reserve Demand

A.1. The Private Sector

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

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

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

Assume that there is a liquidity shock—in other words, a sudden stop or capital flow reversal—which increases the demand for foreign currency and, for simplicity, that foreigners are not willing to hold the home currency at any price. In this case, the exchange rate will be determined by the exchange market involving only domestic residents, domestic financial institutions and the home monetary authority. We also assume that the monetary authority can prevent domestic interest rates from fully offsetting expected exchange rate changes, or that the increase in interest rate *per se* is so damaging to financial stability that home residents discount it. Transaction costs and interest gains that could potentially be earned from the currency position are ignored for simplicity here. In such circumstances, people fundamentally care about the exchange rate in period t+1, compared with the exchange rate in period t. If θ is very low and the economic consequence from a liquidity shock is expected to continue when the financial market cannot function to fully offset the liquidity demand then the average market forecast is for continuing home currency weakness. Domestic agents, however, hold divergent views on how weak the currency will be.

Assume that domestic agents hold a domestic liquid asset (that is, a bank deposit), the size of which is proportional to total liquid asset l_t at period t claimed by all domestic agents, and which can be sold for foreign exchange. Banks' asset, however,

are illiquid. Thus, if domestic agents liquidate their liquid asset, financial institutions can repay domestic residents only if they can mobilize resources domestically or internationally to fully meet liquidity demands or the domestic monetary authority intervenes to supply additional liquidity.

Given the assumptions, domestic agent i would trade the home currency for foreign exchange if the home currency is expected to fall from its current level, or

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

For a given date, t, and exchange rate, e_t, the measure of agents such that

$$\alpha(\theta+\varepsilon_i) \le e_t, \text{ or } \varepsilon_i \le (e_t/\alpha) - \theta, \text{ is } \frac{1}{2\bar{\varepsilon}} \int_{-\bar{\varepsilon}}^{(\frac{e_t}{\alpha})-\theta} dx = \frac{1}{2\bar{\varepsilon}}(\bar{\varepsilon} + \frac{e_t}{\alpha} - \theta) \tag{3}$$

.

Therefore, at date t, the demand for foreign exchange in terms of the home currency as a result of liquidity demand shock is

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

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

A.2. Private Liquidity Supply

From here, we depart from Obstfeld's framework by introducing private liquidity supply. The financial institutions will coordinate to supply liquidity, the amount of which depends on the capacity of the financial sector to mobilize resources domestically or internationally to meet the liquidity demand. In this regard, the net liquidity demand is

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

where l_t^s is the liquidity supply coordinated by all private financial institutions. If λ_t, for which $0 < \lambda < 1$ captures the level of the financial sector's ability to coordinate liquidity supply, $l_t^s = \lambda_t l_t^d$. Equation 5 can be rewritten as:

$$(1-\lambda_t)\frac{l_t}{2\bar{\varepsilon}}(\bar{\varepsilon}+\frac{e_t}{\alpha}-\theta). \quad (6)$$

Equation 6 implies that the level of financial development partly determines the net liquidity demand. Higher capacity to coordinate resources for liquidity supply would help offset the liquidity demand.

A.3. Public Liquidity Provision and Central Banks' Reaction Function

The central bank is assumed to intervene in the foreign exchange market to minimize the following intertemporal 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, we follow Surico (2008) and specifically Srinivasan et al. (2009) whose function captures the asymmetric preference on exchange rate stability. This is supported by the argument that emerging economies "fear floating" (see, for example, Calvo Guillermo and Reinhart, 2002). Levy-Yeyati and Sturzenegger (2006) conjectured that exchange rate policy has evolved towards an apparent "fear of floating in reverse" or "fear of appreciation" whereby interventions have been aimed at limiting appreciation rather than depreciations. Pontines and Rajan (2011) confirm the existence of the asymmetry in central bank foreign exchange intervention responses to currency appreciation versus depreciation 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 stability. Here, $\mathbf{R^*}$ and $\mathbf{e^*}$ are the optimal level of foreign reserves and the target exchange rate, respectively. We express the reaction function in period t+1 because we will later assume that the exchange rate at period *t* is the central bank's

target rate. The loss function departs from the standard quadratic form in that policymakers are allowed to treat differently the rate of appreciating and depreciating pressure. It should be noticed that if $\gamma = 0$, the loss function becomes symmetric. If $\gamma > 0$, equation 13 implies that the rate of appreciation is weighted more heavily than the rate of depreciation. In other words, if , the exchange rate appreciation would increase the policymaker's loss.

$$\frac{\partial L_{t+1}}{\partial e_{t+1}} = \beta\left[[(e]_{t+1} - e^*) + \left(\frac{\gamma}{2}\right)(e_{t+1} - e^*)^2\right] > 0$$

Furthermore, since we take into account the central bank's motives for foreign exchange market intervention, it is assumed that the exchange rate depreciation/appreciation can be reduced by the central bank's intervention. That is,

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

where $a_1 > 0$ and ϵ_{t+1} are the error terms with zero mean and variance σ_ϵ^2. Minimizing equation 7 subject to equation 8 leads to the following intervention reaction function of the central bank:

$$0 = R_{t+1} - R^* + \frac{\beta}{2} E_t\{2a_1(e_{t+1} - e^*) + \gamma a_1(e_{t+1} - e^*)^2\}. \tag{9}$$

Suppose that a central bank's optimal level of reserves is equal to the net liquidity demand in period *t* as expressed in equation 6. In other words, given the economic fundamentals and with the 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. Indeed, for emerging economies with a thin domestic bond market and shallow financial system, there might be no practical short-run means of managing the exchange rate other than reserve sales. The optimal level of reserves for the economy's central bank in period *t* is then given by

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

Also, we assume that exchange rate at period t is the target exchange rate aimed for by the central bank—that is, $e_t = e^*$. Thus, equation 15 can be transformed as the following:

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

Equation 11 indicates that the reserve accumulation is influenced by the expected liquidity demand, the fundamentals of the economy, the central bank's target exchange rate, its preference on exchange rate fluctuation, and the level of financial development. 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 intervention by the government. Equation 11 could also partly explain why reserve levels in countries with preference on exchange rate stability can be rather high.

Suppose there is a bad realization of θ, which causes a liquidity shock, and therefore pressure on the home currency as people liquidate their assets to speculate in foreign exchange. With the underdeveloped financial market, which cannot fully coordinate to meet the 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 the central bank's desire to limit exchange rate volatility and to avoid a currency crisis. Nevertheless, with a huge liquidity demand shock, the pressure on the exchange rate will be greater and will require a bigger intervention if the economy's financial development is low.

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

The model provides implications not only for the central bank's liquidity provision, but also for the active management of liquidity by the central bank that values

macroeconomic and financial stability. Put 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 exchange rate and macroeconomic volatility. This implies that the motivation to hoard reserves could be mitigated partly by developing a deep financial sector. This theoretical framework provides the basis for the following empirical investigation.

Appendix B

B.1. List of Economies in the Sample

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

Table B.1. List of Variables, Definition and Data Source

Variables	Definition	Source
Log(GDPPC)	GDP per capita	World Development Indicators
Log(M2/GDP)	M2 over GDP	World Development Indicators
Log(trade/GDP)	Export plus import over GDP	World Development Indicators
Exchange rate volatility	Annual standard deviation of monthly change in exchange rate	Authors' calculation based on exchange rates from IFS, IMF.
Capital inflows (Hot money)	The sum of current account and net FDI inflows over GDP	Calculation based on data from IFS, IMF.
Financial development	Total equity liability plus total debt liability over GDP	(Lane and Milesi-Ferretti, 2007). Updated until 2009
DCMCAP	Domestic credit and market capitalization over GDP	World Development Indicators
SVT	Total stock value traded over GDP	World Development Indicators
Financial openness	Chinn–Ito index (2008)	http://web.pdx.edu/~ito/Chinn-Ito_website.htm

Table B.2. 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 development	340	0.775	0.975	0.000	5.299
DCMCAP	242	2.099	1.346	0.289	7.416
SVT	252	0.623	0.868	0.000	7.558