Banking Systems, Central Banks and International Reserve Accumulation in East Asian Economies

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Abstract   This paper examines changes in the balance sheets of the banking system in five East Asian economies which were affected by the 1997 Asian Crisis. These countries have persistently accumulated foreign currency reserves since the crisis. This paper estimates the impact of reserve accumulation on some important balance sheet variables such as liquid assets, credits and deposits of the banking system by applying panel data techniques. Estimates using data from Thailand, South Korea, Malaysia, Philippines and Indonesia show that reserve accumulation has a positive impact on the liquid assets and deposits of the banking system, but not on credit flows, after controlling for the effect of other potential variables.

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1 Introduction

An analysis of the banking system has received a great interest in recent years, especially after the global financial crisis of 2007-08. Studies such as Kindleberger and Aliber (2005), Reinhart and Rogoff (2009) and Gorton (2010) have demonstrated, through historical evidence that the banking system rarely escapes any crisis[1]. In most cases, the banking system has usually aggravated and amplified the crisis, and finally suffered itself from it. A series of crises has proved that a balance sheet weakness of the banking system can ignite and propagate financial crises (Allen et al., 2002). Hence, a growing body of literature has now emphasized the importance of balance sheets of the banking system such as Adrian and Shin (2009), Brunnermeier (2009), Mittnik and Semmler (2011). It has been now recognized that the banking system, in fact, plays an important role to generate boom and bust cycle in the economy by expanding and contracting credit flows. More importantly, banks' balance sheets tend to be a mirror image of the economy especially when the balance sheets of the whole economy are not readily available (Villar, 2006).

The crises are usually manifested in the buildup of substantial balance sheet problems in the banking system as seen from the current global financial crisis and the 1997 Asian crisis. In the Asian crisis, currency and maturity mismatches in the balance sheet of the banking system had created a fragile financial situation (Shirai, 2001)[2] The accumulation of short-term external debts concentrated in the banking system, taking advantage of the financial liberalization and globalization, was one of the important factors behind the East Asian crisis of 1997. Banks made short-term borrowing from abroad for long-term lending domestically, mainly to the real estate sector. This practice of the banking system had created imbalances in the balance sheets of the banking system, which seemed to contribute to the outburst of the Asian crisis, starting from Thailand (Shirai, 2001). In fact, the banking system was the culprit as well as a victim of the 1997-1998 financial crisis in East Asian countries (Eichengreen, 2009; Frankel, 1998).

As a lesson learned from the painful financial crisis in 1997-1998, many East Asian economies, including some other emerging economies, have been building up substantial international reserves in the aftermath of the crisis, outpacing all sorts of benchmark levels (IMF, 2010). Such a persistent reserve accumulation has implications for the balance sheets of the central bank, the banking system and the economy as a whole (Mohanty and Turner, 2006; Banchs and Mollejas, 2010). Reserve accumulations seem to occur by running current account surpluses and intervening in the foreign exchange markets (Schularick, 2009). Foreign exchange interventions by the central banks inject the liquidity, i.e. flow of funds into the banking system unless it is sterilized. Even if it is sterilized, the size of the balance sheets of the banking system must change with reserve accumulation by changing

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[1] With growing financialization in the economy, economic crises have increasingly concentrated on the banking system (Cook, 2008).

[2] An overexposure of the US banking system in the housing sector, financed by the inflows of funds from abroad mainly contributed to the current global financial crisis.

the portfolio of the banking system. Indeed, the central bank's foreign reserves have counterpart liabilities in the form of bonds or currency because foreign exchange reserve buildup has to be financed either through government budget surpluses or by printing money or through accumulation of debt (Polterovich and Popov, 2003). With this reserve build-up, foreign currency assets play a much more important role in central banks' balance sheets and, consequently, in monetary policy operations (Higgins and Klitgaard, 2004; Banchs and Mollejas, 2010).

Yet the changing balance sheet structure of the banking system as a result of the accumulation of international reserves has not been examined. Despite some works on the Asian financial crisis, for example Delhaise (1998), Cook (2008) Carney (2009), Caprio et al. (2005), the literature has hardly covered the changing composition of banks' balance sheets in the post crisis period compared to the pre-crisis period. On the other hand, a number of studies has developed banking models to understand the banking behavior such as Baltensperger (1980), Stiglitz and Greenwald (2003), and Freixas and Rochet (2008). These models are mainly closed economy types and have ignored the important roles of foreign exchange markets for the banking system in an open economy. Only one study by Ho and McCauley (2009) has discussed some domestic implications of reserve accumulation in Asian countries. These authors found no strong link between reserve accumulation and domestic private credit growth, but did not examine the impact on the liquidity and deposits of the banking system.

In this context, this paper seeks to answer a few important questions. First, how has the balance sheet structure of the banking system changed after the financial crisis of 1997-1998? Second, has the accumulation of international reserves had any significant impact on the balance sheet of the banking system? This paper has taken five East Asian countries – Thailand, South Korea, Malaysia, Philippines and Indonesia – affected by the Asian crisis to explore the answer to these questions[3]. This paper will particularly investigate the relationship of the selected balance sheet variables of the banking system such as liquid assets, private sector credits and deposits with the international reserve accumulation by the central bank using the panel data technique. It is hypothesized that reserve accumulation will increase the liquidity and deposits in the banking system, which may help maintain financial stability in emerging countries. In fact, reserve accumulation should be reflected in the balance sheets of both central bank and the banking system.

The remainder of the paper consists of five sections, which is structured as follows. Section 2 presents the linkage between the central bank and the banking system. Section 3 examines the changing structure of balance sheets of both central banks and banking systems in the sample countries. Section 4 provides empirical evidence on the impact of international reserves on the balance sheet variables. Finally, section 5 concludes the discussion.

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[3] These countries have highly bank-based financial systems (see Subhanij, 2010).

2 Linkage between the Balance Sheets of Central Bank and the Banking System

Balance sheets of the central bank and the banking system are inter-connected. Table 1 presents a typical balance sheet of the central bank. The central bank's assets consist of foreign currency and domestic assets, while its liabilities comprise currency, banking system's reserves, securities, other liabilities and equity capital. The currency and banking system's reserves are monetary liabilities, while the other items in the liability side are non-monetary liabilities. Of these, currency is largely determined by public's demand for cash balances, and equity capital represents government transfers to the central bank. The remaining liabilities are within the control of the central bank. In the balance sheet of the central bank, without increase in equity capital, the accumulation of foreign currency reserves requires a financing in some forms which increase other liabilities (Mohanty and Turner, 2006).

Table 1: A Typical Central Bank Balance Sheet

Assets	Liabilities
Net Foreign Assets (NFA)	Monetary Liabilities
Domestic Assets(DA)	(i) Currency in Circulation (C)
(i) Government Securities	(ii) Banking system's Reserves (R)
(ii) Loans to commercial banks	Non-Monetary liabilities CBC)
(iii) Other Domestic Assets	(i) Central bank securities
	(ii) others
	(iii) Equity Capital

The monetary liabilities are also considered as central bank liquidity, which the central bank can create through its operations. Any increase (or decrease) in central bank's assets can create (or destroy) the central bank liquidity in parallel. Any transaction between the banking system and the central bank creates (or destructs) money-market liquidity which increases (or decreases) the banking system's reserve balances with the central bank. This reserve balance is an important component of the monetary base (Brink and Kock, 2009). The balance sheet of the central bank as shown in Table 1 is written as

$$R + C + CBC = DA + e.NFA \tag{1}$$

where R denotes the banking system's domestic currency reserves in the central bank (including required reserves), C denotes the currencies held by the public, CBC is the non-monetary liability of the central bank. On the asset side, DA denotes the total domestic assets of the central bank and NFA denotes the net foreign assets[4]

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[4] The flows in the net foreign assets represent the interactions of three sets of factors: i) foreign exchange interventions ii) aid receipts by the Government, and iii) interest income generated by foreign currency assets itself (Jadhav et al., 2003).

Table 2: Simplified Aggregate Balance Sheet of the Banking System

Assets	Liabilities
Loans (L)	Deposits (D)
Net foreign assets (NFA)	Other liabilities (OL)
Investment (including government securities) (G)	(i) bonds
Reserves in central bank (R)	(ii) equity

and e is the exchange rate[5]. Here, the monetary base is $RM = R + C$. Brink and Kock (2009) argue that monetary base RM has historically been the most important component of liquidity management on the liability side of the central bank.

The banking system, as part of the monetary sector, further expands the scope of fiat money by accepting deposits and extending credits. Banks are unique in the sense that they are the only institutions authorized by law to take (checking) deposits from the public for the purpose of credit creation. Table 2 presents a simplified aggregate balance sheet of the banking system. Major asset side items of the balance sheet of the banking system are loans (L), net foreign assets (NFA), investment (on bond and securities), and reserve balances with the central bank (R). On the other hand, major liability side items include deposits of different types and other liabilities such as bond and equity. The balance sheet identity of the banking system is written as

$$D + OL = e.NFA_b + L + R + G \qquad (2)$$

where D denotes deposits, OL denotes other liabilities such as bonds and capital, NFA_b is the net foreign assets of the banking system, e is the exchange rate, L denotes loans to the private sector, R is the reserve balance with the central bank[6], and G is investment (including purchase of government securities).

In the above two equations, R is a common item, which is a part of the monetary base. The sources and uses of the banking system directly impact the central bank's balance sheet through this common item, R. Changes in bank reserves, in fact, mirror the changes in the banking system's portfolios and corresponding change in the central bank balance sheet.

Indeed, several transactions between the central bank and the banking system bring change in the banking system's reserve with the central bank. They include open market operations (OMO), foreign exchange interventions, and discount window or refinance facilities. There could be some other transactions such as reserve requirement (including statutory liquidity requirement), and credit/deposit auctions. Among the transactions, the open market operations refer to a sale and purchase of securities, normally government securities, while the foreign exchange

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[5] domestic currency price of foreign currency

[6] R broadly represents the claims of banking system on the central bank, because it also includes the cash held by the banking system, but it does not include the central bank's securities.

interventions denote the sale and purchase of foreign currencies in the foreign exchange markets by the central bank.[7] Through discount window or refinance facilities, central banks provide liquidity in case of emergency. In addition, some central banks impose the reserve requirement on deposit liabilities of the banking system, which is a mandatory parking of a certain portion of deposit liabilities as reserves in the central bank. In order to influence the banking system liquidity, some central banks even have the provision of credit and deposit auction systems. The deposit facility changes the composition of the central bank's liabilities to the banking system. In this way, the balance sheets of central banks and the banking system change as a result of various central banking functions.

In case of the foreign exchange operations with the banking system, purchasing (selling) foreign exchange injects (mops up) liquidity by increasing (reducing) the central bank's claims on nonresidents on the one hand and the banking system's reserves on the other. If the foreign exchange interventions are sterilized through open market operations, it changes the other items of the balance sheets of both the central bank and the banking system – mainly the holding of the securities (issued by the government as well as central bank's). With the change in banking systems' reserves with the central bank emanating from the foreign exchange interventions, the banking systems make a decision on lending or changing the portfolio, which itself affect the size of the central bank balance sheet (and reserve money and bank liquidity) through positive feedback effects.

The nature of exchange rate system in fact determines the necessity of foreign exchange interventions. In case of a freely floating exchange rate, there should not be any flows into or out of the central bank's foreign exchange reserves. On the other hand, in case of a fixed exchange rate, the central bank has no freedom to control its foreign exchange reserves. In between these two extremes, which is a situation generally observed in many emerging and developing economies, the central bank heavily participates in foreign exchange markets through interventions for exchange rate stability (Caprio and Honohan, 1990). Foreign exchange intervention is now considered a balance sheet policy, which transmits through two main channels - signaling and portfolio (Borio and Disyatat, 2009). While signaling channel works through reflecting the central bank's intention in foreign exchange interventions, the portfolio channel brings change in relative supplies of assets (and liabilities). Since assets are imperfect substitutes, any change in the composition of portfolios alters the behavior of banks. Under the portfolio channel, the purchase or sale of foreign currencies from the banking system results in a change in foreign currency portfolios of the central bank with a corresponding change in banking system's reserves with the central bank. In addition to the banking system, money from abroad may also flow to domestic non-banks. However, the domestic non-banks ultimately pass on the holding of foreign currency to the banking system, which are by far the most prominent dealers in the foreign exchange markets (Almekinders, 1995).

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[7] Usually, the banking system is a major counterpart of foreign exchange interventions.

It is indeed the foreign exchange market through which international reserve accumulation of the central bank brings changes in the balance sheet of the banking system. The impact of which later transmits to the other components of the banking system. In this way, any foreign currency inflows into the economy either from the current account or capital account would change the balance sheets of both the central bank and the banking system. Thus, both the central bank and the banking system actively manage their balance sheets with different motives[8].

3   Changing Pattern of Central Banks and the Banking System Balance Sheets

This section presents the change in balance sheet structure of central banks and banking systems in the selected countries based on the data taken from the IMF's International Financial Statistics. The balance sheet structure of both central banks and the banking system in the selected sample countries has changed substantially in the post-Asian crisis.

3.1   Balance Sheets of Central Banks

Table 3 shows the changing pattern of major items – NFA, NDA, Total Assets and RM as a percentage of GDP– in the balance sheet of central banks in the sample countries for two periods: pre-crisis (1986-1996) and post crisis (1999-2009) on average. On the other hand, Figure 1 illustrates the movement of same variables for the whole sample period (1973-2009) depending on data availability.

Total assets of the central banks have increased substantially in all selected countries in the post-crisis period compared to the pre-crisis period. Malaysia observed more than 20 percentage point increment, followed by Thailand (19.48), South Korea (9.84), Indonesia (9.38) and Philippines (8.11). Of the total assets, the main item which observed a substantial rise is NFA. This seems to be due to persistent reserve accumulation. For example, NFA as a percentage of GDP in India increased from 16.06 percent in 1986-96 period to 29.8 percent in 1999-2009 period (Table 3). Similarly, South Korea observed a growth of NFA from 5.20 to 22.52 percent, Malaysia from 27.23 percent to 41.18 percent, Philippines from -5.55 to 16.44 percent and Indonesia from 8.17 to 10.78 percent. In contrast, the NDA/GDP ratio has substantially declined in the post-crisis period compared to that of the pre-crisis period. However, the magnitude of change in Indonesia remained low relative to other countries. This indicates that central banks in these countries substantially sterilized foreign exchange interventions. As a result, RM as a percentage of GDP declined in South Korea, Malaysia, and the Philippines, and increased slightly in Thailand and Indonesia. It seems that reserve accumulation in Indonesia remained

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[8]   The banks' liquidity preference approach suggests that banks pursue active balance sheet policies instead of passively accommodating the demand for credit (Bibow, 2009).

Table 3: Changing Structure of the Central Banks' Balance Sheets (% of GDP)

		NFA	NDA	Total Assets	RM
Thailand	1986-1996	16.06	-7.30	21.23	8.76
	1999-2009	29.80	-18.43	40.71	11.37
South Korea	1986-1996	5.20	1.99	17.06	7.19
	1999-2009	22.52	-17.12	26.90	5.40
Malaysia	1986-1996	27.23	-9.51	30.52	17.72
	1999-2009	41.18	-30.43	50.98	10.74
Philippines	1986-1996	-5.55	18.04	20.22	12.49
	1999-2009	16.44	-5.69	28.33	10.75
Indonesia	1986-1996	8.17	-1.97	19.89	6.20
	1999-2009	10.78	-0.66	29.27	10.12

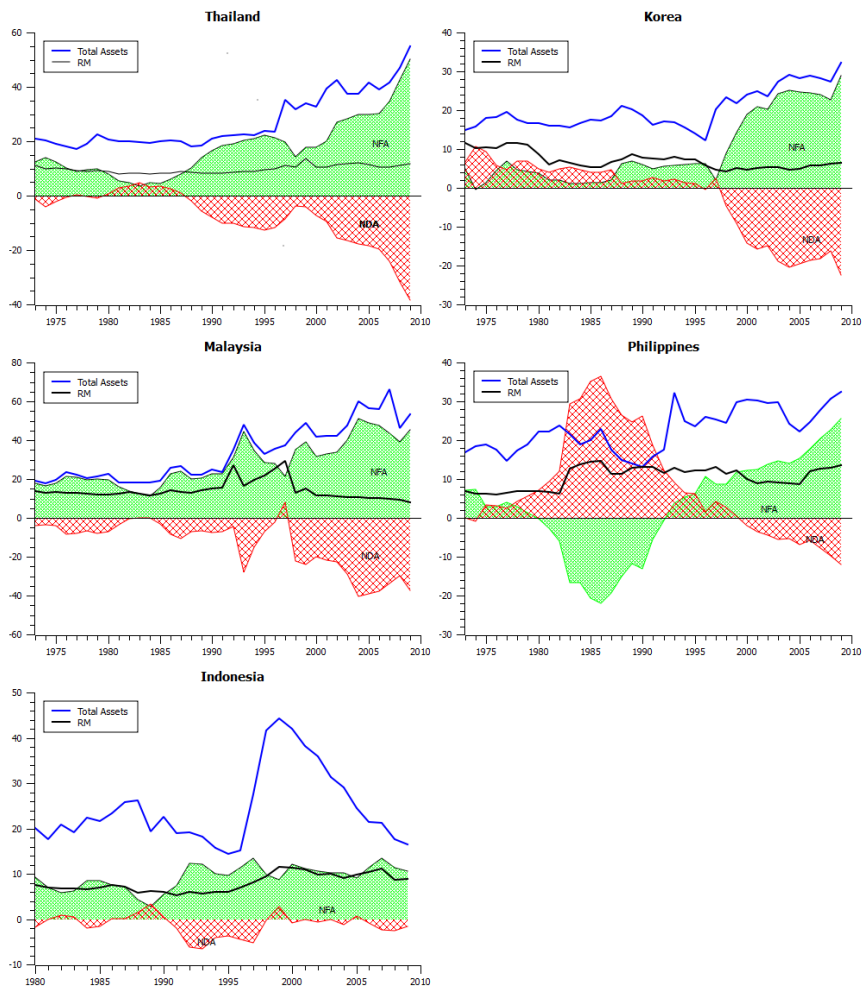Source: IMF's International Financial Statistics, online database

relatively low and it did not sterilize foreign exchange interventions as much as others.

Dynamics of these variables are further illustrated in Figure 1. Central banks in these countries accumulated substantial amount of NFA in the post-crisis period. The only exception is Indonesia where the balance sheet structure of the central bank is slightly different. However, RM remained more or less constant or below the pre-crisis level because of sterilization, which might be due to the fear of inflation following the inflation targeting framework. In Indonesia, the total asset to GDP ratio followed a quite different pattern than in other countries in the sample period. During the peak of the crisis, it increased largely due to substantial drop in GDP. In the post-crisis period, it declined gradually with the recovery of GDP. Another difference in the balance sheet of Bank Indonesia (the Central Bank of Indonesia) is that NFA as a percentage of GDP remained more or less stable since the first half of 1990s, while the NDA to GDP ratio is marginally negative in the post-crisis period (Figure 1).

3.2 Balance Sheets of the Banking System

The balance sheets of banking systems of these countries have also undergone substantial changes along with the change in the balance sheets of central banks through the reserve accumulation process. A large-scale reserve accumulation typically raises the underlying liquidity position of the banking system (Mohanty and Turner, 2006). Even sterilized reserve purchases have an effect on domestic financial markets because they alter the mix of financial instruments held by the private sector and the banking system (Higgins and Klitgaard, 2004). In recent years, sterilized interventions have been associated with large-scale issuance of central bank securities because of insufficient government treasury bills. Since

Figure 1: Changing Balance Sheet Structure of Central Banks in East Asian Countries

Source: Author's calculation based on the data from IMF's International Financial Statistics online database.

Table 4: Changing Structure of the Banking System's Balance Sheets (% of GDP) in East Asian Countries

		FA	FL	PC	LA	D	TA
Thailand	1986-1996	3.7	13.1	95.4	6.0	70.9	113.1
	1999-2009	10.7	8.2	101.8	12.0	102.3	140.5
South Korea	1986-1996	4.6	6.2	50.3	-1.0	35.2	64.0
	1999-2009	6.0	9.1	88.9	10.1	64.8	109.1
Malaysia	1986-1996	5.4	9.1	100.2	30.9	99.1	143.8
	1999-2009	8.4	10.7	117.1	28.7	119.2	173.2
Philippines	1986-1996	8.7	7.0	24.0	9.9	31.9	49.3
	1999-2009	11.5	8.4	34.4	19.2	55.3	72.3
Indonesia	1986-1996	4.9	4.0	41.3	-3.2	34.2	54.3
	1999-2009	4.7	3.4	21.6	23.0	41.5	54.8

Note: Banking system refers to other depository corporations considered in International Financial Statistics of IMF, which are allowed to take deposits and lending. They are mainly commercial banks.
FA=Foreign Assets, FL=Foreign Liability, PC = Private Sector Credit, LA = net Liquid Assets, D = Deposits, TA = Total Assets
Source: IMF's International Financial Statistics online database

banks are the primary counter party of foreign exchange interventions and open market operations, the balance sheets of the banking system should response to reserve accumulation.

For illustration, similar to Table 3 for the central bank, Table 4 presents the average values of key balance sheet variables as a percentage of GDP for two periods: 1986-1996 and 1999-2009. These balance sheet variables include foreign assets (FA), foreign liabilities (FL), private sector credit (PC), net liquid assets (LA),[9] deposits (D), and total assets (TA).[10] Some interesting facts can be drawn on the changing pattern of the balance sheets of the banking system in these countries. First, the FA holdings of the banking system as a percentage of GDP in all selected countries have increased in the post-crisis period except Indonesia. On the other hand, foreign liabilities on average have declined in Thailand and Indonesia but increased in other countries. Figure 2 depicts more clear picture of the movement of these variables. As seen in this figure, the ratio of FL to GDP remained higher than the ratio of FA in all selected countries in the pre-crisis period. For example, foreign liability in Thailand was as high as 50 percent of GDP at the outset of the crisis, which was one of the reasons triggering the crisis in Thailand in 1997. In contrast,

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[9] Net liquid assets are derived as a sum of claims on the central bank (currency, reserve with central bank, other claims on central bank) less borrowing from the central bank plus net claims on the government.
[10] Total assets are consolidated total assets obtained from IMF's International Financial Statistics.

the holding of FL declined in the post-crisis period. Malaysia was an exception where FL remained higher than FA even in the post-crisis period, though it was not so high comparatively. This might led Malaysia to close the capital account until 2005. On the other hand, in Korea, after remaining lower than the foreign assets until 2001, foreign liability started rising above FA beginning around 2002, and reached as high as 21 percent in 2008, before declining again in the aftermath of the recent global financial crisis of 2007-2008.

Second striking feature is that, in the post-crisis period, LA as a percentage of GDP increased substantially in all selected countries (Table 4), except Malaysia, where such a ratio was already quite high. Over the period, LA to GDP ratio followed a V shaped except in the Philippines and Indonesia in the 1990s (Figure 2). Moreover, Malaysia observed a fall in the LA to GDP ratio in 1990, which seemed to be due to a substantial expansion of credits.[11]

Third, deposits to GDP ratio has also increased substantially in the post-crisis period in all selected countries. However, such a ratio is relatively lower in the Philippines and Indonesia. Moreover, like the LA to GDP ratio, the D to GDP ratio witnessed a sharp fall in Malaysia in 1990. Fourth, although the private sector credit to GDP (PC) remained higher on average in the post-crisis period (Table 4), except in Indonesia, this in fact, followed a hill-shaped movement, peaking up until the outbreak of crisis. After which it started declining except in South Korea, as shown in Figure 2.

In summary, the banking system in the selected countries appeared to have built up comfortable ratios of liquid assets, while lending remained relatively subdued. Lending volumes are, in fact, influenced by both demand and supply conditions. A number of factors may have contributed to such a subdued private sector credit flows. One demand side reason is a shift in business financing away from banks towards domestic (or foreign) equity and debt securities markets. Increasing numbers of high rated firms in these countries are now able to borrow directly from domestic and international capital markets, lowering their reliance on banks[12] (Turner, 2006). Second demand side reason is the sluggishness in investment in these countries in the post-crisis period (Adams, 2008; Turner, 2006). On the other hand, on the supply side, banks in these countries have been strengthening their balance sheets by being risk averse, which led them to ration the credit supply.

Likewise, there could be a number of reasons for holding up liquid assets by the banking system. For example, Agenor et al. (2004) argue the role of increased uncertainty or risk of default as a rationale for the banking system's voluntary buildup of liquid assets. Institutional factors, for example, poorly developed inter-bank markets and difficulties encountered by banks in tracking their position at the central bank may have also encouraged the banking system to hold higher liquid

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[11] The Malaysian economy recovered from the recession in the first half of 1980s and witnessed a substantial growth of GDP in 1990. To control the economy from over heating, Statutory Reserve Requirement (SLR) was increased gradually from 3.5 percent in 1990 to 9.5 percent in 1994.

[12] These countries have gradually developed domestic bond markets and increased the role of mutual funds in intermediating household savings through equity markets (Turner, 2006).

Figure 2: Trend of Balance Sheet Structure of the Banking System (% of GDP) in East Asian Countries
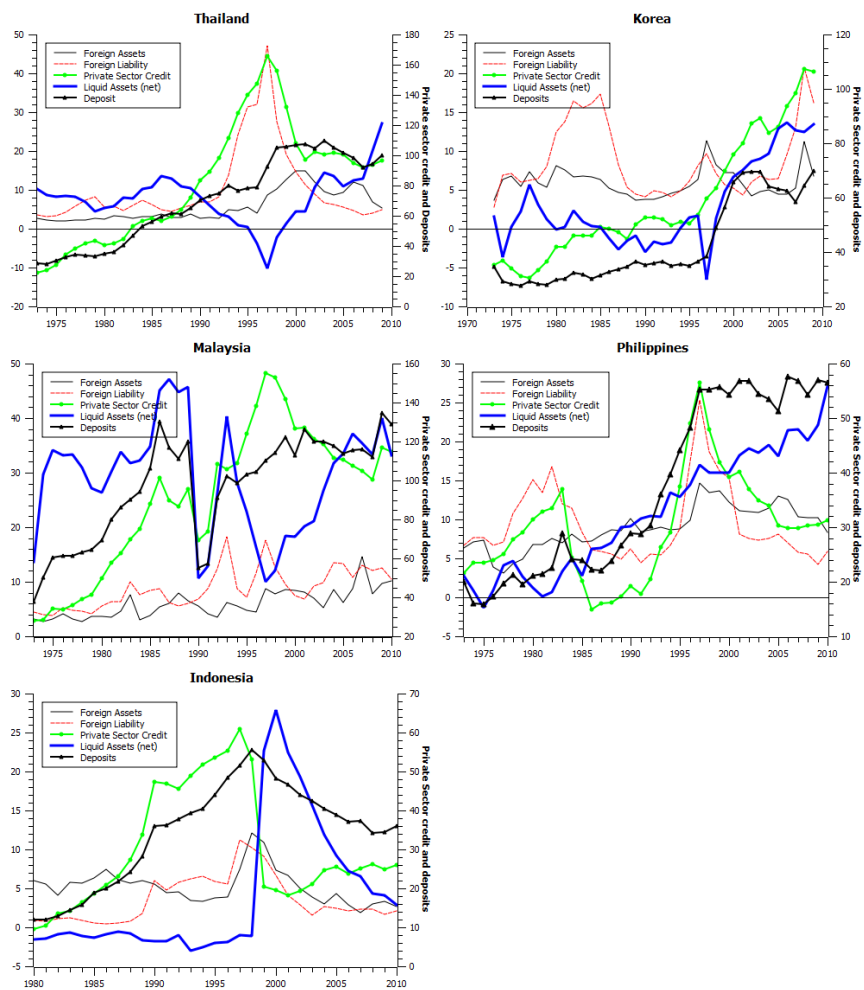
Source: Author's calculation based on the data from IMF's International Financial Statistics online database.

assets. Such a pattern of holding liquid assets suggests an increased risk aversion in the banking system. However, no study has so far linked the growing liquid assets to international reserves.

4 Impact of Reserve Accumulation on the Balance Sheets of the Banking System

This paper presents empirical evidence on the impact of reserve accumulation by central banks on major balance sheet variables of the banking system such as liquid assets, credits to the private sector and deposits. Annual data for the selected five East Asian economies over the period of 1980-2010 are used to assess the impact. The panel data technique is applied, which allows to control for unobservable variables, like cultural factors or difference in countries, due to heterogeneity[13]. More importantly, this technique increases degree of freedom by pooling the data. Since the selected countries are in the same region and were affected by the similar external shocks and follow a similar type of business cycle, the panel data technique seems to be appropriate.

The impact of reserve accumulation is investigated by using the following regression equation (3). Most of panel data applications utilize a one-way error component model for the disturbance (Baltagi, 2008). Since the cross-sectional units are just five here, the one-way cross-sectional fixed effect model is used.

The basic model is:

$$L_{it} = \alpha + X_{it}^{'}\beta + \varepsilon_{it}, \ i = 1....,N; \ t = 1,....,T \tag{3}$$

$$\varepsilon_{it} = \mu_i + v_{it}$$

$$E(v_{it}) \sim N(0, \sigma^2)$$

where i and t are the country and time indices respectively; β is $Kx1$ coefficient vector and X_{it} is a vector of K explanatory variables, μ_i denotes the unobservable individual specific effect and v_{it} denotes the disturbance term. L_{it} is the ratio of balance sheet variables to GDP – liquid assets, private sector credit and deposits. X_{it} is a set of explanatory variables, which includes international reserves to GDP ratio (ir) and other variables that can affect the balance sheet of the banking system.

There is no unique way of measuring liquidity ratio of the banking system. Bunda and Desquilbet (2008) use five different measures of bank assets liquidity to study the impact of exchange rate regime on bank liquidity using panel data of commercial banks in emerging countries between 1995 and 2000. They are: (i) liquid assets to total assets, (ii) net loans to total assets, (iii) liquid assets to short-term funding, and (iv) liquid assets to total deposits and borrowing. In a similar way, Vodová (2011) examines four types of liquidity ratio in Czech banks, namely

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[13] see Baltagi (2008) for the benefits of panel data technique.

Table 5: Descriptive Statistics of the Selected Variables

	la	*pc*	*dp*	*ir*	*lr*	*bd*	*gr*
Mean	12.03	64.75	61.46	17.09	12.59	-2.04	5.57
Max	47.13	165.72	134.71	52.81	32.15	-16.67	13.23
Min	-10.18	14.85	12.07	2.05	5.02	4.75	-13.13
SD	13.04	37.68	32.36	12.53	5.63	3.17	4.22

Source: Author's calculation

(i) liquid assets to total assets, (ii) liquid assets to sum of deposits and short-term borrowing, (iii) loans to total assets, and (iv) loans to sum of deposits and short-term borrowing. However, this paper uses simply (i) LA to GDP (*la*), since the banking system is taken into consideration as a whole. In addition, other balance sheet variables like PC to GDP ratio (*pc*) and D to GDP ratio (*dp*) are also considered as dependent variables to study whether international reserve accumulation has any impact on them in addition to liquidity.

On the other hand, there is no unique set of variables explaining the liquidity ratio of the banking system. In addition to *ir*, following the studies of Bunda and Desquilbet (2008), Vodová (2011), Agenor et al. (2004) and considering the availability of data, a set of controlling variables are considered such as (i) lending rate (*lr*) representing the opportunity costs[14]; (ii) budget deficits/GDP to take into account the supply side factors in the market for liquid assets (*bd*);[15] (iii) the rate of GDP growth (*gr*), which indicates better perspectives for borrowers and more profitable lending for banks, and (iv) the realization of financial crisis (dummy variable for the Asian crisis period 1997 and 1998).

Most of the data are taken from the IMF's International Financial Statistics online database. However, the budget deficit data are taken from various sources such as Asian Development Bank's Key Indicator 1999 and 2010, Basic Statistics 2011, and the websites of the Central Bank of Malaysia and Indonesia, Remolona (1985) and Nimgaonkar (2009). Considering the availability of data, the paper uses annual data for the sample period of 1980-2010, forming a balanced panel for empirical estimation.

Table 5 reports the descriptive statistics of the variables used in the panel estimation. The LA to GDP ratio (*la*) ranges from minus 10.2 percent to 47.1 percent with 12.0 percent being the average; the PC to GDP ratio (*pc*) averaged at 64.8 percent, ranging from minimum 14.8 percent to maximum 165.7 percent. Similarly, the average value of D to GDP ratio (*dp*) is 61.5 percent, international reserves to GDP (*ir*) is 17.1 percent, lending rate (*lr*) is 12.59 percent, budget deficit to GDP ratio (*bd*) is -2.04 percent, and average growth rate of GDP (*gr*)

[14] Adverse selection can lead to credit rationing, as shown by Stiglitz and Weiss (1981), so that high interest rates may well be associated with high bank liquidity.

[15] Bunda and Desquilbet (2008) include public expenditure as a percentage of GDP for the same purpose

**Figure 3:** Overall Movement of Variables (Mean) under Considerations
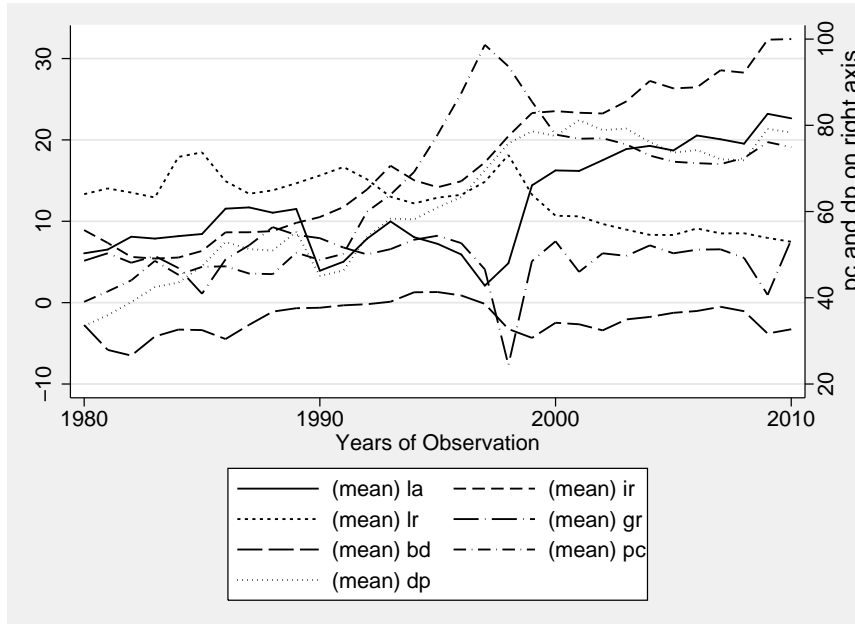
Source: Author's calculations

is 5.6 percent (see Table 5). Among the chosen variables, *pc* exhibits the highest volatility, followed by the *dp* as shown by the standard deviation (SD).

Figure 3 reports the overall movement of cross-sectional averages of these variables during the sample period. After a fall during the crisis of 1997-1998, *la* exhibits an upward trend in the post-crisis period in all selected countries, but *pc* is on a downward trend. Further, while *dp* and *ir* show an upward trend, *lr* exhibits a downward trend in the post-crisis period. After a higher deficit in the 1980s, these countries had budget surpluses or balanced budgets in the first half of the 1990s, before the crisis hit them. After the crisis, these countries have budget deficits of varying degrees (see Figure 3). Regarding the GDP growth (*gr*), it fell sharply during the crisis in 1997, recovered after that, but observed a slight fall recently in the aftermath of the global financial crisis of 2007-2008.

Further, Table 6 presents cross-correlations of the variables under consideration. The variable *ir* is positively correlated to *la*, *pc*, *dp*, while *lr* is negatively correlated to all except *bd*. Figure 4 also shows a positive correlation between *ir* and selected balance sheet variables. On the other hand, *gr* is negatively correlated to *pc*, *dp*, *ir* and *lr*, albeit the correlation coefficients with respect to *pc*, *dp*, *ir* are relatively low (Table 6). A negative correlation of *gr* with *lr* indicates the fact that a higher interest rate lowers economic growth. Moreover, the growth rate *gr* is positively correlated to the budget deficit *bd*, which might be due to the increase in effective demand from higher government expenditure. More importantly, the cross-correlations among explanatory variables such as *ir*, *lr*, *bd* and *gr* are not so high (Table 6). Hence, the

Figure 4: Scatter Plot of *la*, *pc* and *dp* over *ir* in a pooled data
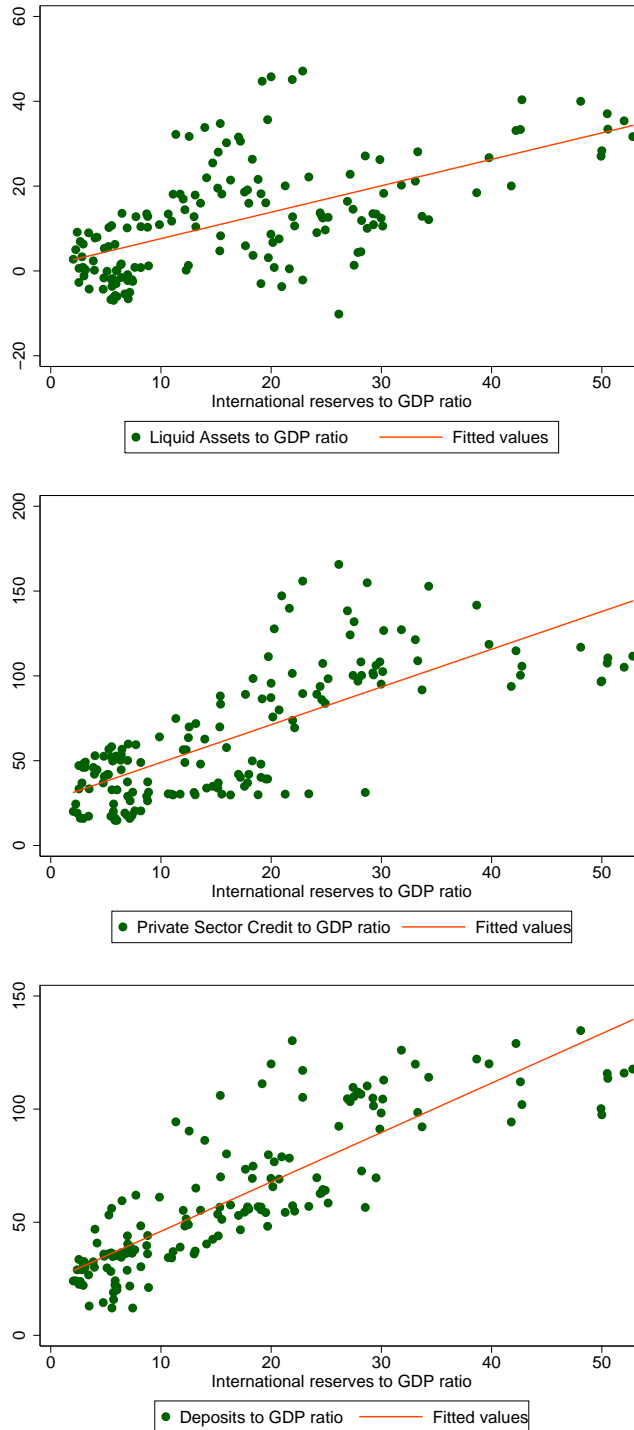
Source: Author's calculations

Table 6: Cross Correlations of variables used in the model

	la	pc	dp	ir	lr	bd	gr
la	1						
pc	0.29	1					
dp	0.63	0.86	1				
ir	0.60	0.74	0.85	1			
lr	-.34	-0.56	-0.55	-0.59	1		
bd	-.37	0.01	-0.23	-0.10	0.026	1	
gr	0.067	-0.08	-0.04	-0.057	-0.36	0.23	1

Source: Author's calculations

possibility of multicollinearity among the explanatory variables can be ruled out to a larger extent.

4.1 Empirical Results

4.1.1 Traditional Panel Estimation

An examination of the impact of international reserves on selected balance sheet variables starts from the estimation of simple pooled OLS. Such a pooled estimation is appropriate for the constant-coefficients or random effects models (Cameron and Trivedi, 2005). Table 7 reports the estimates of simple pooled OLS regression with robust standard error.[16] Here, ir is found to positively affect all three balance sheet variables (la, pc, and dp). The coefficients of ir are statistically significant in all cases. The variable lr only affects pc significantly and it is negative as expected. The gr has a significant impact only on la. However, bd has significant positive impacts on la and dp[17]. The crisis dummy (dum) is statistically significant in all three cases, suggesting that the financial crisis of 1997-98 seriously affected banking systems of these countries.

4.1.2 Fixed Effect Model

Although the pooled OLS estimations permit the estimation of coefficients of time-invariant regressors, these estimators are inconsistent if the fixed effects model is correct (Cameron and Trivedi, 2005). Hence, the fixed effects model is examined next.[18] Table 8 presents the estimates of the fixed effects model, which allow the individual heterogeneity among cross-sectional units. The redundant fixed effect

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[16] Cameron and Trivedi (2005) suggest for using panel-corrected standard errors and t-statistics for statistical inference in the pooled estimation.

[17] Coefficients in front of bd are negative, but since the budget deficit is presented as a negative number, a higher budget deficit means positive impact on the dependent variables.

[18] Period fixed effect is also examined but found insignificant, hence it is not reported.

Table 7: Simple Pooled OLS Estimates

Number of Obs = 155
White (diagonal) Robust Standard error

Independent Variables	Dependent variables		
	_la_	_pc_	_dp_
_c_	-9.23(0.02)*	66.63(0.00)**	26.64(0.00)**
_ir_	.69(0.00)**	1.66 (0.00)**	2.00(0.00)**
_lr_	0.33(.103)	-2.09 (0.00)**	-0.50 (0.08)+
_gr_	0.53(0.01)**	-0.72(0.22)	0.44 (0.31)
_bd_	-1.4 (0.00)**	1.06(0.11)	-1.63(0.00)**
dum	-7.13(0.06)*	33.06 (0.00)**	14.4 (.02)*
$AdjR^2$	0.49	0.63	0.74
$F-stat$	30.90(0.00)	53.27 (0.00)	89.5 (0.00)

+ significant at 10%; ∗significant at 5%; ∗∗significant at 1%
$p-value$ in the parenthesis.
Source: Author's calculations

test shown in Table 8 rejects the null hypothesis of no fixed effect. Hence, the fixed effects model seems to be better than simple pooled OLS presented in Table 7.

With the fixed effect estimation, the coefficients of some variables have changed. The value of coefficient of _ir_, which is the main variable of concern, has declined but is still statistically significant with expected signs. It has positive impacts on all selected balance sheet variables (_la_, _pc_ and _dp_). However, the impact of _gr_ on the _la_ has become insignificant, while that on _pc_ became statistically significant. The impact of _bd_ has declined in case of _la_ but is still significant. More importantly, the coefficient of _bd_ has become statistically significant in case of _pc_, where it has a negative impact, indicating the possibility of crowding out effects. The dummy variable for the crisis period still retains statistical significance on all selected variables. But the coefficient of _lr_ is statistically significant only for _pc_, not for _la_ and _dp_.

4.1.3 Diagnostic Checks

The above estimates are based on the assumptions that the regression disturbance term is homoskedastic with the same variance across time and individuals, and no serial correlation. Cross-sectional dependence is a problem in macro panels with long time series (over 20-30 years). Once the fixed (or random) individual-specific effects are included, the serial correlation in errors can be greatly reduced, but it may not be completely eliminated (Cameron and Trivedi, 2005). Additionally, one may need to control for potential heteroskedasticity as is normally done for cross-section data.

Table 8: Fixed Effects Model

Number of Obs = 155

Independent Variables	Dependent variables		
	la	*pc*	*dp*
c	2.09(0.68)	69.4(0.00)**	42.77(0.00)**
ir	0.46 (0.00)**	0.98 (0.00)**	1.29(0.00)**
lr	0.03 (0.89)	-1.0 (0.01)**	-0.27(0.37)
gr	0.17 (0.43)	-1.1 (0.00)**	-0.18(0.55)
bd	-0.62 (0.02)*	2.07(0.00)**	-0.23(0.53)
dum	-8.55(0.01)**	26.58 (0.00)**	9.35(0.03)*
$AdjR^2$	0.60	0.84	0.88
$F-stat$	26.66(0.00)	90.03(0.00)	123.3 (0.00)
Redundant Fixed Effect test			
Cross section F	10.99(0.00)	49.42(0.00)	42.1(0.00)
Cross Section χ^2	41.06(0.00)	133.3(0.00)	119.5(0.00)

+ significant at 10%; *significant at 5%; **significant at 1%

$p-value$ in the parenthesis.

Source: Author's calculations

Table 9 reports the tests of cross-sectional dependence, heteroskedasticity and serial correlation. The Breusch-Pagan /LM test of independence shows the rejection of the null of no correlation of residuals across entities. Similarly, the Wald test for heteroskedasticity rejects the null of homoskedasticity of residuals and the Wooldridge test for serial correlation indicates the existence of autocorrelation in the residuals (Table 9).

4.1.4 Final Estimation

Finally, Table 10 reports the re-estimation of the fixed effects model by feasible GLS which corrects for cross-sectional heterokedasticity, contemporaneous correlation and serial correlation with robust estimators. AR(1) disturbance is included for correcting serial correlation. These corrections should give us the robust estimation of the model. As shown in Table 10, the coefficient of *ir* has increased in case of *la*, but substantially declined in case of *dp* and turned into insignificant in case of *pc*. In this way, the impact of *ir* on *la* and *dp* seems to be robust. The impact of other control variables, except the dummy variable, became insignificant in the case of *la*. Only the *lr* is found to affect *pc*.

As shown in Table 10, the main determinant of *pc* is found to be *lr*, after controlling the significant impact of the dummy variable (*dum*). Regarding the impact on *dp*, only *ir* retains the statistical significance.

Table 9: Diagnostic Checks of Fixed Effects Model

Model with dependent var	H0	la	pc	dp
Breusch–Pagan LM test of independence	$Cov(v_{it}v_{st}) = 0 \forall i \neq s$	67.8 (0.00)	42.29(0.00)	50.11(0.00)
Modified Wald test for group-wise heteroskedasticity	$E(v_{it}v_{it} \mid X_{it}) = \sigma^2$	1225.96 (0.00)	148.62(0.00)	201.96(0.00)
Wooldridge test for autocorrelation	$correl(\varepsilon_{it}, \varepsilon_{is}) = \frac{\sigma_\mu^2}{\sigma_\mu^2 + \sigma_v^2}$	195.98(0.00)	18.87(0.01)	56.67(0.00)

Source: Author's calculation

Note: done in STATA

Table 10: Fixed Effects Model: A feasible GLS Estimates with AR(1) Disturbance

Correcting for both cross-section heterokedasticity and contemporaneous correlation with White Robust estimators

Independent Variables	dependent variables		
	la	*pc*	*dp*
c	3.43 (0.19)	81.5(0.00)**	68.4(0.00)**
ir	0.57(0.00)**	0.06 (0.17)	0.42(0.00)**
lr	-0.04 (0.54)	-0.14 (0.00)**	-0.01(0.89)
gr	0.03 (0.55)	-0.04(0.12)	-0.11(0.27)
bd	-0.098(0.40)	-0.12(0.09)+	-0.008(0.97)
dum	-5.53(0.00)**	6.90 (0.00)**	0.30(0.87)
$AR(1)$	0.84(0.00)**	0.93(0.00)**	0.91(0.00)**
$AdjR^2$	0.94	0.98	0.98
$F-stat$	255.04(0.00)	1044.9(0.00)	607.5 (0.00)
$DWstat$	1.97	1.67	1.68

+significant at 10%; ∗significant at 5%; ∗∗significant at 1%

$p-value$ in the parenthesis.

Source: Author's calculations

5   Conclusion

This paper has examined the changes in the balance sheet structure of the central banks and the banking systems in five East Asian countries – Thailand, South Korea, Malaysia, Philippines and Indonesia– which were seriously affected by the 1997 financial crisis and have been accumulating foreign currency reserves thereafter. As a result of reserve accumulation, the NFA to GDP ratio has increased in all selected countries in the post-crisis period. In the balance sheet of the banking system, in contrast to the findings of Mohanty and Turner (2006), bank credit to the private sector has not increased in these countries with the large reserve buildup. However, holding of liquid assets has increased across the board in these economies.

A panel data estimation shows that international reserves to GDP ratio *ir* is a robust factor, contributing to increase in liquid assets and deposits of the banking system, even after taking the possible impacts of other potential variables. Hence, it can be concluded that reserve accumulation not only provides international liquidity; it also generates domestic liquidity in the banking system. Such a holding of liquid assets provides a cushion to withstand any external shock by the banking system. This may be one reason that has made the banking systems of these countries resilient to the recent global financial crisis. However, any serious unwinding of global imbalances will have serious implication for the banking systems of theses countries.

This study can be extended in several directions. First, the panel estimation can be done by extending the sample countries, which could include not only

Asian countries but also Latin American and African countries. Second, other controlling variables could be incorporated to examine the robustness of the impact of international reserves on balance sheet variables of the banking system. Third, other econometric techniques such as a VAR could be used to verify the empirical results of this study.

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