〈Note〉

Effects of Foreign Reserve Stock in Asian Countries

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Abstract

The purpose of this short paper is to analyze the extent of sterilization in the foreign exchange markets and the degree of capital mobility in international financial markets of Asian countries. While capital mobility in reality surged in the middle of 2000s, the degree of de facto capital mobility declined after the crisis. There is also evidence of sterilization of foreign reserve accumulation in Asia. Past reserve accumulation has not been a major source of excessive liquidity creation and should be considered a sign that there it has no impact and there is nothing to worry about.

1. Introduction

Asian countries have stockpiled over half of international reserve since the end of 1990s. The main holding countries are China and Japan, but India, Hong Kong, Korea, and Singapore have also held international reserve since the Asian currency crisis occurred in the 1990s.

In countries that were hit by the crisis in Asia, policymakers in central banks appear to have chosen deliberately to amass high levels of reserves for precautionary or self-insurance motives against future crises or exchange rate movements (Aizenman and Marion, 2003; Kurihara, 2008, Rajan et al.,2008)[1]. However, Asian countries have continued stockpiling foreign reserves beyond plausible precautionary levels. This paper

focuses on this aspect.

Some economists have said that rapid reserve growth is a by-product of a desire by central banks to smooth exchange rate movements (Kurihara, 2008). However, such behavior by central banks should have no net impact on reserves. The growth of reserves suggests that intervention in foreign exchange markets is largely asymmetric and that it comes from a desire to maintain stable and competitive exchange rates. A lot of economists expressed concerns that such intervention takes a large risk of inflation and excessive global liquidity. The key points are the extent to which monetary authorities are able to sterilize the domestic monetary effects of reserve accumulation. Most theoretical models assume no sterilization in the markets so that large foreign reserve would automatically lead to rapid growth in domestic money and credit for simplicity. However, high levels of international capital movements would make sterilization impossible in spite of the effects of monetary authorities in reality (Rajan, 2008).

The purpose of this short paper is to investigate the extent of monetary sterilization and the degree of capital mobility. Section 2 employs a set of simultaneous equations to examine the effects between net domestic assets and net foreign assets as a means of estimating the extent of de facto sterilization and capital mobility. Section 3 provides an overview of the data and definitions of variables to be employed. Moreover, this section makes empirical analyses and discusses the results. The main focus of this paper is on this section. Finally this paper ends with a brief summary.

2. Theoretical Analysis

As the introduction in this paper explained, the combination of current account surplus and private capital inflows with active exchange rate

management by central banks, has contributed to the massive reserve accumulation in Asian countries in recent years.

It appears that Asian countries have been actively neutralizing the impact of the reserve build-up DA (net domestic asset), which have been moving in the opposite direction to FA (net foreign asset). The two most commonly employed tools for sterilization are open market operations and changes in legal reserve requirement (Mohanty and Turner, 2005). However, Asian countries have also employed a number of other tools such as shifting public sector or pension funds from commercial banks to central banks (Rajan, 2008).

As the foreign exchange and the domestic monetary markets are strongly interrelated, it is important to recognize the contemporaneous relationship between DA and FA. The typical model specification for a set of simultaneous equation is:

$$\Delta DA = \alpha_1 + \alpha_2 \Delta FA + \gamma_1 \delta_1 \quad (1a)$$

$$\Delta FA = \beta_1 + \beta_2 \Delta DA + \gamma_2 \delta_2 \quad (1b)$$

where γ_1 and γ_2 are the vector of controls in the monetary reaction and balance of payments function. α_2 is the sterilization coefficient. The expected value of the sterilization is -1 if reserve build-up is perfectly sterilized and 0 if the central banks does not sterilize at all. Also, β_2 is the offset coefficient. It is the impact of a change in domestic liquidity conditions on capital flows. The expected value of the offset coefficient is bound by 0 in the event of no capital mobility, and -1 in the event of perfect capital mobility.

When estimating these equations, the choice of control variables is one of the main concerns. Capital flows are sensitive to economic developments domestically and abroad. Many countries would like to minimize the effects of a capital flow shock on the economy and have adopted a policy of sterilization and stable exchange rates. Reducing exchange rate volatility is very important for economic growth. This following model is

based on Rajan (2008).

First, the loss function of the monetary authority is:

$$Lt = \alpha_1(\Delta p_t)^2 + \alpha_2(\Delta Y_t)^2 + \alpha_3(\Delta \sigma_{rt})^2 + \alpha_4(\Delta \sigma_{st})^2 \quad (2)$$

The monetary authority's loss function is determined by the change in the logarithm of the price level, income, and the volatilities of the interest rate and the spot exchange rate. Volatilities are expressed by σ. All the parameters are assumed to be positive.

The evolution of inflation can be determined as follows:

$$\Delta p_t = \pi_1[(\Delta DA + \Delta FA)m_t + MB_t\Delta m_t] + \pi_2\Delta p_{t-1} + \pi_3\Delta s_t \quad (3)$$

where $\pi_1 > 0$, $0 < \pi_2 < 1$, and $\pi_3 > 0$. mt is the money multiplier and MBt is the monetary base. Equation (3) says that inflation is a monetary phenomenon and depreciation of the nominal spot exchange rate could increase inflationary pressures due to increased prices of tradable goods.

The evolution of income[2] is written as follows:

$$Y_t = \phi_1[(\Delta DA + \Delta FA)m_t + MB_t\Delta m_t] + \phi_2\Delta Y_{t-1} + \phi_3\Delta G_t \quad (4)$$

where $\pi_1 > 0$, $0 < \pi_2 < 1$, and $\pi_3 > 0$. Gt is the government expenditure. This model assumes that both expansionary financial and fiscal policies can raise output.

The balance of payments is defined as follows:

$$\Delta FA = CA_t + \Delta K_t \quad (5)$$

where CA is the current account and ΔK is the net capital inflow.

The current account is assumed to depend on output and the one time lagged real exchange rate (RER) in a linear manner.

$$CA_t = \beta_1 + \beta_2 Yt + \beta_3\Delta RER_{t-1} \quad (6)$$

where $\beta_2 < 0$ and $\beta_3 < 0$.

The last capital inflow is thought to depend on the uncovered interest rate parity like (7).

$$\Delta K_t = (1/c)\Delta(s_t - E_t s_{t+1} + r_t - r^*_t) \quad (7)$$

where st is the current exchange rate (logarithm); $E_t s_{t+1}$ is the current expectation of the exchange rate at time t. r_t is the domestic interest rate,

r^*_t is the foreign interest rate and c is the degree of substitutability between domestic and foreign assets, i.e. the degree of international capital mobility. This would be affected by the extent of capital controls.

The interest rate is determined by the change in money supply:

$$\Delta r_t = \phi_1[(\Delta DA + \Delta FA)m_t + MB_t \Delta m_t] \quad (8)$$

It should be noted when the money market is in surplus, the central bank withdraws money to prevent interest rates from falling so that it becomes $\Delta DA < 0$). Therefore, if the money market is in deficit, $\Delta DA > 0$, and the equation can be written as follows (Rajan, 2008):

$$\sigma_{r^t} = \eta\ \sigma_{r^{t-1}} - \theta\ (\Delta DA - d_1 \Delta DA) \quad (9)$$

where d_1 is the dummy which takes on a value of 0 when the money market is in deficit and a value of 2 when it is in surplus.

Also, exchange rate volatility is as follows:

$$\sigma_{s^t} = \kappa\ \sigma_{s^{t-1}} - \varsigma\ (\Delta DA - d_2 \Delta DA) \quad (10)$$

where d_2 is a dummy variable which takes on a value of 0 when the foreign currency is in excess supply and a value of 2 when it is in excess demand. Excess movement in foreign currency should be taken into account.

It is possible to solve for $\partial L / \partial \Delta DA = 0$ and $\partial L / \partial \Delta FA = 0$, and after substituting the constraints into the loss function, the reduced forms of ΔDA and ΔFA can be got.

3. Empirical Analysis

The estimation is based on quarterly data over the sample period of 1987 to 2008. The period is divided into two samples. One is from 1987 to 1996 and the other is from 1999 to 2008. The Asian currency crisis occurred in 1997 and 1998, so the period is omitted. The sample countries are India, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand. By comparing the estimated values of the coefficients in these

two periods, it is possible to ascertain how the extent of sterilization and degree of capital mobility has changed for the economies. After this analysis, China's case is also examined. The result is shown later.

To check for stationary, the Augmented Dickey Fuller (ADF) to each of the variables is implemented and found that all of the variables were stationary at least at 10% level. For output, Hodrick-Prescott method is employed for obtaining the trend of real output. For the exchange rates and interest rates, the standard deviation within the quarter change in the daily against US$ bilateral exchange rates and short-term interest rates are used. If it was impossible to obtain forward exchange rate in these countries, it is assumed that economic agents have either perfect foresight to proxity the expected exchange rates for the next period. Another method is to use ARMA. Here, ARMA (1,1) is employed. Both methods are used for egression.

Two-stage least square (2SLS) method is employed to estimate the equations[3]. The results are reported in Table1 a and Table1 b.

The pre-crises offset coefficients in both the perfect foresight and ARMA exchange rate expectations models are around 0.8, while the sterilization coefficients are about 1. On the other hand, for post crises, while the coefficients fell to 0.6, it seems difficult to draw a conclusion about the sterilization effect. However, they are significant at 1% level.

It should be noted that estimated capital mobility after the crisis falls. One of the reasons for this is the insufficient understanding of exchange rate risk by many international lenders and borrowers (Rajan, 2008). However, there are other reasons that contribute to these results. Monetary authorities may have been prevented from performing these tasks by financial institutions.

The coefficients for money multiplier coefficients are statistically significant and negative. While the coefficient has risen in the case of monetary reaction function, it has declined in the case of the balance of

Table 1a Panel Data with Random Effects (Perfect Foresight)

	First Period		Second Period	
	ΔDA	ΔFA	ΔDA	ΔFA
Intercept	0.0052	0.0143*	0.0063	0.0173*
ΔDA		-0.8021***		-0.5232***
ΔFA	-1.0052***		-1.2220***	
Δmt	-0.4072***	-0.3015***	-0.4968***	-0.3201***
Δp_{t-1}	0.0828	-0.0213	0.0531	-0.1524
Y_{t-1}	-0.0322	0.0081	0.0191	0.0240
ΔG_{t-1}	0.0990*	0.0905	-0.1570**	-0.1552***
$\Delta (r^*_t + E_t s_{t-1})$	-0.3036***	-0.3149***	-0.6839***	-0.4052***
ΔRER_{t-1}	0.1232	0.1542	-0.2552***	-0.1013*
$(d_2\text{-}1)\,\sigma_{s^2_{t-1}}$		0.0040		0.0000
$(d_2\text{-}1)\,\sigma_{r^2_{t-1}}$	0.0023		0.0024**	
Adj.R^2	0.7234	0.7217	0.7933	0.7085

Notes) ***: significant at 1%, **: at 5%, and *: at 10% respectively.

Table 1a Panel Data with Random Effects (ARMA)

	First Period		Second Period	
	ΔDA	ΔFA	ΔDA	ΔFA
Intercept	0.0033	0.0112*	0.0071	0.0210**
ΔDA		-0.787***		-0.5801***
ΔFA	-1.0091***		-1.2075***	
Δmt	-0.3969***	-0.3004***	-0.4977***	-0.3122***
Δp_{t-1}	0.0854	-0.0192	0.0520	-0.1501
Y_{t-1}	-0.0291	0.0072	0.0194	0.0220
ΔG_{t-1}	0.0925*	0.0966	-0.1540**	-0.1581**
$\Delta (r^*_t + E_t s_{t-1})$	-0.3024***	-0.3140***	-0.6812***	-0.4041***
ΔRER_{t-1}	0.1220	0.1531	-0.2590***	-0.1014*
$(d_2\text{-}1)\,\sigma_{s^2_{t-1}}$		0.0039		0.0001
$(d_2\text{-}1)\,\sigma_{r^2_{t-1}}$	0.0022		0.0041**	
Adj.R^2	0.7212	0.7270	0.7912	0.7144

Notes) ***: significant at 1%, **: at 5%, and *: at 10% respectively.

payments function. Monetary authorities may have not been able to control some economic variables sufficiently.

The lagged inflation and output are insignificant. There may be the fact that while the dependent variables are volatile, the inflation and output are stable. In 2008, exchange rates moved greatly and other macroeconomic variables were also affected.

A Chow test with a null hypothesis of no structural change between the pre and post crisis period is performed. The null hypothesis can be rejected in all cases. The results are not reported in this paper.

Finally, China's case is also examined. The method and other hypotheses are the same with the ones employed here. The sample period is from 1999 to 2008. The results are in Table 2. There is not so much difference among the exchange rate hypothesis, so only the result of perfect foresight's case is reported.

It is more apparent that Chinese Authority has successfully completed

Table 2 Panel Data with Random Effects: China (Perfect Foresight)

	First Period		Second Period	
	ΔDA	ΔFA	ΔDA	ΔFA
Intercept			0.0092	0.010*
ΔDA				-0.3455**
ΔFA			-0.967***	
Δmt			-0.4404***	-0.1579**
Δp_{t-1}			0.0021	-0.1959
Y_{t-1}			0.1283*	0.1852**
ΔG_{t-1}			0.0921	0.1609***
$\Delta(r^*_t+Es_{t+1})$			-0.2097**	-0.4122***
ΔRER_{t-1}			0.0918	-0.0903
$(d_2-1)\sigma_{s^2-1}$			0.0040	0.0052
$(d_2-1)\sigma_{r^2-1}$				
Adj.R^2			0.7134	0.684

Notes) ***:significant at 1%, **:at 5%, and *:at 10% respectively.

sterilization and capital mobility. However, the exchange rate system is different from other countries and it may have controlled capital during some periods. The evaluation of the results and the implications are different and should be examined with large care from these countries[4].

4. Conclusions

This paper has employed a simple framework and common methodology to estimate the degree of capital mobility and sterilization in Asian economies including China. While capital mobility in reality surged in the middle of 2000s, the degree of de facto it declined. There is also evidence of sterilization of reserve accumulation in Asian economies. China seems to have effectively accomplished this. Past reserve accumulation has not been a major source of excessive liquidity creation and could be taken as a suggestion that there is nothing to worry about.

The majority of industrial countries use floating exchange rate systems, but their results would be unclear. Exchange rate movements have largely occurred in recent years. Macroeconomic shocks would be largely different among countries including Asia. Under such circumstances, we expect an unsystematic difference between capital inflows and outflows. Monetary authorities should consider the costs of sterilization before implementing such a policy. Further research is needed for this study.

Notes

1. This measure is consistent with modern second generation currency crises models. See, Obstfeld (1994) for the model.
2. It can be stated as 'cyclical' income.
3. Hausman test for checking fixed and random effects were preformed, however, there was no difference between them.
4. Ouyang et al. (2007) found that it had been able to successfully sterilize a

high proportion of its recent reserve increases. China has substantially capital controls, however, it would not necessarily carry over to other countries. See Outyang et al. (2007) in detail.

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