

AN EMPIRICAL ASSESSMENT OF MONETARY POLICY RESPONSES TO CAPITAL INFLOWS IN ASIA BEFORE THE FINANCIAL CRISIS

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This paper highlights monetary policy implemented by monetary authorities in response to a surge of capital inflows in Asia during the period 1985-1996. It statistically assesses the effectiveness of monetary policy responses. Regression results show that Asian countries as a group took the operation of a high rate of sterilization and the foreign exchange market intervention which yielded a small change in the exchange rate. Consequently, they succeeded in keeping nominal exchange rates at desired levels and in limiting increases in monetary growth, despite a surge in capital inflows. The adoption of floating exchange rates, it is concluded, could have avoided the occurrence of financial crisis in Asia. [F32, F41]

1. INTRODUCTION

The financial crisis in Asia followed massive capital inflows into Asia, particularly in the early 1990s, just as the crisis in Mexico and other countries in Latin America occurred after the surge of capital inflows into Latin America countries.¹ Capital inflows supplied finance needed for a high rate of investment, imports and economic growth. At the same time, capital inflows distorted relative goods prices, feeding bubbles into real asset markets and inflationary pressure into the economy.

Many studies have been made of the causes of a surge of capital inflows into Asia, and policy responses to the surge.² These studies are of a qualitative and

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¹The financial crisis in Asia occurred in 1997. Before the crisis began, Asia's economic performance - high growth, low inflation and high saving was envied. Many studies have suggested that the main factors causing a financial crisis in Asia are appreciation in real exchange rates, large current account deficits, large short-term external debts, high leverages of corporations and weaknesses in the balance sheet of financial institutions. For causes of Asian crisis, see Chang and Velasco (1998), Corsetti et al. (1998), International Monetary Fund (1998), Krugman (1998), Kwack (1998, 2000), Letiche (1998), Moreno et al. (1998), and Radelet and Sachs (1998).

²Examples of studies are Bercuson and Koenig (1993), International Monetary Fund (1995),

descriptive nature. Hence, their discussions on the causes of capital inflows and the consequence of policy responses need empirical tests and verifications. The main purpose of this paper is to empirically explore how the monetary authorities in Asia did cope with the surge of capital inflows in the period 1985-1996. It statistically examines the extent to which massive capital inflows influenced the conduct of monetary policy and the effects of the policy of sterilization and intervention in the foreign exchange market. Statistical examinations should shed some light on the issues of whether monetary policy has been effective.

The paper does not undertake a detailed analysis of individual country action; rather, it provides empirical evidence for how a group of seven selected countries across Asia responded. The seven countries considered are Indonesia, Korea, Malaysia, Philippines, Singapore, Thailand, and Taiwan (R.O.C.). The regression is estimated using a panel of 84 observations for the seven countries during 1985-1996.

The rest of the paper is organized as follows. Section 2 describes capital flows to Asian countries and highlights monetary policy implemented by the monetary authority. Section 3 uses a model of the monetary sector of an open economy to analyze the effects of monetary policy instruments used in coping with capital inflows. Section 4 runs regression equations, which provide estimates of parameters in the model. Making use of the estimated parameter values allows assessment of the extent to which the monetary policy of sterilization and intervention in the foreign exchange market attained its primary objective. Section 5 concludes with a summary of the empirical findings.

2. CAPITAL INFLOWS AND RESPONSES OF MONETARY POLICY

A. Capital Inflows

Table 1 is a summary of the balance of payments of seven individual East Asian countries. Singapore and Taiwan kept their current account at a surplus during the period 1985-89 period and in each year during the period 1990-96. The other five Asian countries experienced deficits in their current accounts. Thailand's current account deficit as a percent of GDP is the highest -- above five percent during the period 1990-96. The current account deficit in Korea is somewhat lower compared to the deficits of Indonesia, Malaysia, Philippines, and Thailand for the same period. The deficits in the current account for Thailand and other deficit countries are substantial, above 3 percent of GDP during the period 1995-96.

Koening (1996), Khan and Reinhart (1995), Reisen (1993), and Schadler et al. (1993). Capital inflows are affected in part by internal factors such as high economic growth, liberalizing the financial system and opening the capital market, and in part by external factors. Hong Kong Monetary Authority (1994) contains articles which discuss capital inflow related issues for Pacific Basin countries.

Table 1. Balance of Payments

(in Percent of GDP)

	1985-89	1990	1991	1992	1993	1994	1995	1996
INDONESIA								
Current Account	-2.54	-2.82	-3.65	-2.17	-1.33	-1.58	-3.47	-3.37
Financial Account	3.51	4.23	4.89	4.79	3.56	2.17	5.14	4.77
Direct Investment	0.52	1.03	1.27	1.39	1.04	0.85	1.85	2.46
Portfolio Investment	3.00	3.21	3.61	3.40	2.52	1.32	3.29	2.31
Error & Omissions	-0.87	0.70	0.08	-1.00	-1.86	-0.15	-0.89	0.58
Balance of Payments	0.11	2.12	1.31	1.62	0.38	0.44	0.78	1.98
KOREA								
Current Account	4.28	-0.69	-2.82	-1.28	0.31	-1.01	-1.81	-4.76
Financial Account	-2.35	1.13	2.28	2.26	0.96	2.79	3.77	4.96
Direct Investment	-0.11	-0.11	-0.11	-0.16	-0.23	-0.45	-0.38	-0.43
Portfolio Investment	-2.24	1.24	2.39	2.42	1.19	3.24	4.16	5.39
Error & Omissions	-0.12	-0.79	0.26	0.36	-0.22	-0.45	-0.32	0.22
Balance of Payments	1.67	-0.48	-0.39	1.21	0.90	1.21	1.54	0.29
MALAYSIA								
Current Account	2.41	-2.03	-8.89	-3.72	-4.66	-6.23	-8.43	-5.20
Financial Account	0.63	4.16	11.95	15.00	16.83	1.78	8.50	9.29
Direct Investment	2.36	5.45	8.50	8.89	7.80	5.99	4.73	3.23
Portfolio Investment	-1.73	-1.28	3.45	6.11	9.03	-4.21	3.77	6.06
Error & Omissions	-0.03	2.53	-0.32	0.14	5.65	0.21	-1.97	-1.59
Balance of Payments	2.90	4.56	2.63	11.35	17.68	-4.36	-2.02	2.50
PHILIPINES								
Current Account	-0.54	-6.08	-2.28	-1.89	-5.55	-4.60	-2.67	-4.30
Financial Account	1.44	4.64	6.44	6.06	6.01	7.99	7.16	8.35
Direct Investment	1.04	1.20	1.20	0.43	1.59	2.01	1.46	2.15
Portfolio Investment	0.40	3.45	5.25	5.63	4.42	5.98	5.71	6.20
Error & Omissions	0.87	1.34	-0.30	-0.98	0.16	0.24	-2.82	0.00
Balance of Payments	1.77	-0.10	3.86	3.19	0.62	3.63	1.67	4.06
SINGAPORE								
Current Account	3.59	8.33	11.29	11.38	7.57	17.21	16.97	15.18
Financial Account	2.34	10.54	5.38	3.61	-1.86	-16.09	-2.86	0.55
Direct Investment	9.23	9.46	10.01	1.79	4.57	6.51	4.94	4.93
Portfolio Investment	-6.44	1.09	-4.63	1.82	-6.43	-22.60	-7.80	-4.37
Error & Omissions	0.33	-4.31	-6.96	-2.63	7.39	5.66	-3.96	-7.73
Balance of Payments	6.26	14.50	9.63	12.28	12.99	6.67	10.07	7.86
THAILAND								
Current Account	-2.05	-8.50	-7.67	-5.66	-5.09	-5.65	-8.09	-7.98
Financial Account	4.22	10.62	11.91	8.51	8.40	8.50	13.08	10.58
Direct Investment	1.11	2.69	1.87	1.77	1.26	0.61	0.71	0.76
Portfolio Investment	3.12	7.93	10.04	6.74	7.15	7.89	12.37	9.82
Error & Omissions	0.82	1.66	0.44	-0.13	-0.18	0.06	-0.71	-1.43
Balance of Payments	2.99	3.78	4.68	2.72	3.13	2.91	4.27	1.18
TAIWAN								
Current Account	14.01	6.82	6.95	4.03	3.16	2.70	2.10	4.02
Financial Account	-0.62	-9.46	-1.24	-3.26	-2.09	-0.58	-3.15	-3.22
Direct Investment	-1.07	-2.45	-0.44	-0.51	-0.76	-0.52	-0.55	-0.72
Portfolio Investment	0.45	-7.01	-0.81	-2.74	-1.33	-0.05	-2.60	-2.50
Error & Omissions	0.10	0.29	-0.07	0.06	-0.23	-0.06	-0.22	-0.15
Balance of Payments	13.48	-2.45	5.39	0.64	0.69	1.92	-1.51	0.40

Note: IMF, International Financial Statistics; Central Bank of China, Financial Statistics, and Balance of Payments

The ASEAN countries have been the largest recipients of financial capital since the early 1990s. In recent years, Taiwan exported capital abroad, and Singapore received capital in the form of direct investment. Net financial capital inflows to the other five Asian countries were very substantial during the period 1990-96 compared with those during the period 1985-89. Net direct investments to ASEAN countries were large and rose in recent years to about 5 percent of GDP, an increase resulting from their market opening and low labor costs. Korea made a substantial amount of direct investment abroad, partly reflecting the location of plants of Korea's firms in the areas of low wage costs. Net portfolio investments showed an upward trend. A rising trend is very apparent in Korea, Philippines and Thailand.

Singapore and Taiwan experienced a surplus in the current account. Singapore added a substantial portion of the current account surplus to its foreign exchange reserve assets. In the 1990s, Taiwan used the current account surplus to invest abroad, instead of greatly augmenting its foreign exchange reserve assets. The other five countries experienced a surplus in the financial account. A large portion of the financial account surplus financed the current account deficit. The remaining small amount of the financial account surplus was invested in reserve assets. On the average during the period 1985-89, the balance of payments was positive. Except for 1990 and 1991 in Korea, 1994 and 1995 in Malaysia, 1990 in Philippines, and 1990 and 1996 in Taiwan, all the seven countries showed a balance of payments surplus during the period 1990-96. This together with a surplus in the balance of payments during the period 1985-89 increased the foreign source of the monetary base.

B. Monetary Policy Responses to Capital Inflows

Other things being equal, a capital inflow generates monetary expansion and pressure for exchange rate adjustment. It poses an important policy question as to how to deal with capital inflows. The monetary authorities in Asia were uncertain whether capital inflows would last long. To minimize the unfavorable impact of capital inflows on the economy, Asian countries utilized four categories of policy measures to minimize the impact of capital inflows. The first policy category was to control them. The second category was to encourage capital outflows and to increase imports of goods and services. The third category was to reduce the impact on the money supply and exchange rate. The fourth was to implement tight fiscal policy. Asian countries utilized a combination of policy instruments in all four categories, but primarily the third policy category of measures.³

The main objective of monetary policy in these countries was twofold: to maintain the intermediate target of money supply and the fixed (desired) level of exchange rates. The monetary authority conducted contraction of the domestic

³Detailed descriptions and discussions on policy instruments are found in IMF (1995) and Reinhart and Reinhart (1998).

source in the monetary base of the central bank, a rise in reserve requirements on bank deposits, and other measures. Sterilization operations were primarily directed to offset an increase in the money supply resulting from an increase in the net foreign assets of the central bank which arises from the exchange rate intervention.⁴ At the same time, the monetary authority intervened in the foreign exchange market. The intervention in foreign exchange markets is primarily designed to moderate the exchange rate appreciation generated by capital inflows. In addition, reserve requirements ratios were raised to lower the money supply multiplier and reduce the money supply (see International Monetary Fund, 1995, p. 83).

3. A MODEL OF MONETARY SECTOR

Statistical examination is undertaken in the next section to evaluate the consequence of monetary policy in the face of substantial capital inflows during the period 1985-1996. In this section, a systematical analysis of the subject is made using a model of the monetary sector. There is the empirical evidence that capital inflows to Asia were largely determined by world interest rates and were somewhat affected by the domestic interest rates. Although capital inflows are partially exogenously determined, it is assumed that capital flows are exogenously determined.⁵

A model of the monetary sector is proposed that provides an appropriate framework for analyzing the effects of sterilization policy with intervention in foreign exchange markets, which was the most important instrument of monetary policy used by Asian countries.

The model of the monetary sector consists of money demand, money supply, sterilization, and foreign exchange intervention. The demand for real money balance is positively related to aggregate income and negatively related to the domestic interest rate:

$$m-p = a + fy - mi \quad f > 0, m > 0 \quad (1)$$

⁴This operation represents a reaction of the monetary authority. Sterilization differs from negative response of capital flows to a change in the domestic source of the monetary base. The response of capital flows, which offsets a change in the domestic source, determines the effectiveness of monetary policy. See Herring and Marston (1977) and Argy and Kouri (1974).

⁵Kwack (2000) presents empirical evidence that the Asian crisis was related to LIBO interest rates, indicating that capital inflows were determined by world interest rates. Calvo, Leiderman and Reinhart (1993) find that capital inflows in Latin America were affected by U.S. Interest rates. Khan and Reinhart (1995) and Koenig (1996) suggest the important role of domestic interest rates in affecting capital flows. In the text below, it is assumed that domestic interest rates are exogenously determined. This assumption is consistent with the assumption of exogenous determination of capital flows.

where m , p , and y are the nominal money stock (M), the price level (P), and the aggregate output (GDP) measured logarithmically, and i is the domestic interest rate.

The money demand specification is a well-known specification used by Tseng and Corker (1991) in estimating money demand equations for Asian countries. It is assumed that the money demand is not a function of foreign interest rates because residents in the majority of Asian countries were very restricted in holding foreign assets, and the shares of money holdings by foreigners were low.

The money supply is linked to the monetary base (MB) through the money supply multiplier (Q). The monetary base of the central bank consists of net domestic assets (DA) and net foreign assets (FA). Hence, the money supply is determined by:

$$M = Q MB = Q (DA + FA) \quad (2)$$

The rate of change in the money supply can be approximated by

$$\Delta m = \Delta q + \Delta d + \Delta f \quad (3)$$

where $\Delta m = \Delta M/M_{-1}$, and $\Delta q = \Delta Q/Q_{-1}$, $\Delta d = \Delta DA/MB_{-1} = (DA/MB)(\Delta DA/DA_{-1})$, and $\Delta f = \Delta FA/MB_{-1} = (FA/MB)(\Delta FA/FA_{-1})$.

Equality of money demand and supply determines the price level. Equation (1) is differentiated with respect to time to solve for the rate of inflation. The resulting differentiated equation and equation (3) are solved for the rate of inflation as follows:

$$\Delta p = \Delta q + \Delta d + \Delta f + m\Delta i - f\Delta y \quad (4)$$

Equation (4) states that inflation represents an excess of the growth in money supply over the rate of growth in money demand. If output and the interest rates are assumed to be constant, namely $\Delta y = 0$ and $\Delta i = 0$, the rate of inflation is the same as the rate of growth in the money supply.

Asian countries have begun in recent years to liberalize their financial markets and to open their capital markets to foreigners. Using recent financial market liberalization and market openings, the domestic interest rates are assumably determined by money market conditions, foreign interest rates, exchange rate expectation, and risk premium. The available empirical evidence for this

assumption appears to be inconclusive.⁶ Market forces have been weak in affecting interest rates. It is assumed that interest rates in Asia as a whole are determined by the monetary authority. When it is reasonable to assume that international capital transactions and domestic interest rates are determined by market conditions, a model that takes domestic interest rates and capital flows endogenously can be considered.

In the face of capital inflows, the monetary authority seems to have conducted a sterilization operation as well as an intervention in foreign exchange markets. The monetary authority desired to keep the money supply at a desired level. To achieve this desire, the monetary authority performs open market operations in such a way that a rise in the net foreign assets is offset by a decrease in the net domestic assets and the money supply multiplier. The sterilization operation of the central bank is explicitly introduced as follows:⁷

$$\Delta d = -\gamma(\Delta f + \Delta q) \quad 0 \leq \gamma \leq 1. \quad (5)$$

In equation (5), $\gamma = 0$ and $\gamma = 1$ indicate no sterilization and complete sterilization, respectively. It is assumed that the change in net domestic assets as proportions of the monetary base responds to a change in the net foreign assets as proportions of the monetary base in the same as it responds to a rate of change in the money supply multiplier. The assumption is made for an expository simplification and is replaced in the empirical specification by the assumption that the change in the net domestic assets responds differently.

It is assumed that the monetary authority desires the nominal exchange rate to follow the relative prices of home goods. In the presence of capital inflow surges and an excessive surplus in the balance of payments, the monetary authority concludes that an exchange rate adjustment is necessary. It intervenes in the foreign exchange market to attain a desired exchange rate appreciation rather than to change the direction of movement in the exchange rate.⁸ The intervention operation in Asian countries is a policy of bending with

⁶Frankel and Chinn (1993) conclude that barriers keep Pacific Basin countries' interest rates largely independent. Kwack (1996) provides evidence for declining gaps in the interest rates between the United States and Korea. Montiel (1994) shows that the degree of capital mobility in Asia is neither high nor low. Chinn and Maloney (1998) find empirical evidence for co-movement between domestic interest rates and foreign interest rates in recent years when financial liberalization has implemented.

⁷Sterilization is defined in the literature as the operation through which a rise in the net foreign assets is offset by a decrease in the net domestic assets; in this case, the monetary base remains constant. For discussions on macroeconomic policy implications, see Frankel (1994). For in-depth studies, see Kletzer and Spiegel (1996).

⁸Glick and Moreno (1994) note that a number of East Asian countries allow their exchange

the wind, “going with the flow.” Hence, the nominal exchange rate is adjusted positively to inflation at home, negatively on inflation abroad, and negatively to the rate of foreign exchange reserve accumulation. The mechanism of an exchange rate change is written by

$$\Delta e = \Delta p - \Delta pf - \mathbf{b} \Delta f \quad \mathbf{b} > 0, \quad (6)$$

where e is the nominal exchange rate (E) in logarithm and Δe is a currency depreciation against the U. S. dollar. pf is foreign prices in logarithm. \mathbf{b} is a parameter which characterizes foreign exchange market intervention of the monetary authority.

Equations (1)-(6) constitute the monetary sector framework for policy analysis. Substitution of Δp in (6) by equation (4) yields the reduced-form equation to determine the exchange rate change:

$$\Delta e = \Delta q + \Delta d + (1 - \mathbf{b}) \Delta f - \Delta pf + \mathbf{m} \Delta i - \mathbf{f} \Delta y \quad (7)$$

Equation (7) shows that the exchange rate is adjusted to changes in the supply and demand conditions in the money market, as postulated by a monetary approach to the exchange rate.⁹ A rise in the money supply depreciates the exchange rate, whereas a rise in the money demand appreciates it. A rise in the interest rate determined by the central bank reduces the demand for money, thereby leading to a rise in the price level and an exchange rate depreciation. In the monetarist model, a change in the interest rate does not have a direct effect on the exchange rate. Capital inflows affect the exchange rate through its raising international reserve assets and the money supply.

The substitution of Δd in equations (3), (4) and (7) by equation (5) yields a system of three reduced form equations that show the determination of the money supply, domestic prices and the exchange rate:

$$\Delta m = (1 - \mathbf{g}) (\Delta q + \Delta f) \quad (8)$$

rates to adjust. Taiwan, Korea, Singapore, and Malaysia allowed some real exchange rate appreciation. For Asian countries in detail, see Hong Kong Monetary Authority (1994). For discussion on foreign exchange market intervention, see Dominguez and Frankel (1993), Watanabe (1994) and Weymark (1998).

⁹For discussion, see Frenkel (1976) and Mussa (1976). Despite the limitation of the approach, it is useful for the analysis of countries in which interest rates are highly regulated.

$$\Delta p = (1 - g)(\Delta q + \Delta f) + m\Delta i - f\Delta y \quad (9)$$

$$\Delta e = (1 - g - b)\Delta f + (1 - \gamma)\Delta q - \Delta pf + m\Delta i - f\Delta y \quad (10)$$

Equations (8)-(10) show that the money supply, domestic prices, and the exchange rate are determined jointly with net foreign assets held by the monetary authority, income, policy determined interest rates, and foreign prices.

Capital inflows increase net foreign assets held by the monetary authority f in equations (8)-(10). The effects of a capital inflow on the money supply, the rate of inflation and the rate of change in the nominal exchange rate can be analyzed from the system of equations (8)-(10) and known parameter values. Consider two interesting cases: 1) no sterilization, $g = 0$, and no exchange market intervention, $b = 0$, and 2) complete sterilization, $g = 1$, and exchange market intervention, $b > 0$. All other things being equal, the first case yields that an additional capital inflow causes prices to rise and the exchange rate to depreciate. This is a result of an induced rise in the money supply. In the second case, there is an exchange rate appreciation and no price changes.

4. ESTIMATED EQUATIONS AND MONETARY POLICY EFFECTS

A monetary policy response influences all the endogenous macro-economy variables. Thus, the effects on an endogenous variable include its direct and indirect induced effects. In order to analyze its effects in great detail, a well-structured model of an economy is necessary. The statistical analysis in this paper is limited, however, to the estimation of the direct effect on the rate of inflation and exchange rate. To carry out the task, information is needed on the money demand, the sterilization coefficient, g , and foreign exchange market intervention coefficient, b .

The following seven countries that received substantial capital inflows from abroad were selected: Indonesia, Korea, Malaysia, the Philippines, Singapore, Thailand, and Taiwan. The exchange rate systems of these countries are close to a pegged or managed floating system. Almost all the data except Taiwan's were obtained from IMF's *International Financial Statistics*. Data on MB, FA, GDP, P, E, i, and BOP are listed in line 14, line 11- line 16c, line 99b.p, line 99b / line 99b.p, line rf, line 60b, and line 78cbd of *International Financial Statistics*, respectively. DA, Q, d, f, and BOPM are computed on the basis of their respective definitions. The data on the Taiwan economy are from *Financial Statistics* and *the Balance of Payments* published by the Central Bank of China. Foreign price, pf , is an equal weighted average of the U. S. dollar-measured GDP price deflators for the United States and Japan in logarithm.

For the seven countries as a group, regression equations are estimated with panel data across countries and the time period from 1985 to 1996 using the ordinary least squares method (OLS). The OLS estimation of coefficients does not allow for possible changes over time. Rolling regressions can be used to see changes in the coefficients, but are not done here because they require significantly more observations. In addition, equation (12) for sterilization operation is estimated for individual countries.

A. Money Demand

When the money demand, equation (1), is estimated, aggregated output is represented by real GDP, interest rate by money market interest rates (listed in line 60b of IMF's *International Financial Statistics*) and/or corporate bond yields (line 60bc). The price level is the implicit price deflator for GDP. The estimated equation for the Asian countries as a group is set out in Table 2 as (1e). The estimated value of income elasticity, f , is 1.49 and is significant at the one percent level of significance. As expected, the income variable is the most important determinant of money demand. An income elasticity estimate larger than 1, namely 1.4, suggests that the broad money is "luxury goods" as found in most industrial countries including the United States and may reflect an increasing desire to hold wealth in the form of time-deposits as private wealth rises. The estimated value of quasi-interest rate elasticity, m is -0.004, significant at the five percent level. The estimated income and interest rate coefficients are not much different from the estimates given by Tseng and Corker (1991) for individual countries in Asia.

B. Sterilization

Much empirical research has been done on the sterilization subject, notably by Herring and Marston (1977), Cumby and Obstfeld (1980), Obstfeld (1983), and Kwack (1994). The following sterilization equations are specified on the basis of equation (5):

$$\Delta d = g_1 + g_2 \ddot{A}f \quad (11)$$

$$\Delta d = g_1 + g_{21} \ddot{A}f + g_{31} \Delta q \quad (12)$$

$$\Delta DA = g_1 + g_{22} \Delta FA + g_{32} \Delta Q \quad (13)$$

Δd , Δq , and Δf are expressed in percent. The money stock used in calculating the money supply multipliers is the money stock in M2. Equations (11) and (12) eliminate the difference in the size of the monetary base among the countries, and thus they take into account the possible heterogeneity. It may note that the estimates by the OLS method are subject to a simultaneous bias when capital flows are endogenously determined. But a simultaneous bias question does not arise here because of the assumed exogenous determination of capital flows.

Table 2. Sterilization and Money Demand

Equation	\bar{R}^2	SEE	DW
(11e) $\Delta d = 16.6 - 0.95 \Delta f - 0.2 DK + 0.4 DM$ (5.4) (30.8) (0.0) (0.1) + 1.5 DP - 10.5 DR - 2.6 DT - 3.6 DW (0.3) (2.3) (0.6) (0.8)	0.94	10.4	1.81
(12e) $\Delta d = 24.1 - 0.94 \Delta q - 0.94 \Delta f - 5.7DK$ (13.1) (12.9) (54.0) (2.3) - 9.2 DM - 4.9 DP - 15.2 DR - 9.0 DT - 8.8 DW (3.6) (2.0) (6.1) (2.6) (3.6)	0.98	5.5	1.28
(13e) $\Delta DA = 2850 - 1441 \Delta Q - 0.89 \Delta FA - 1156DK$ (7.4) (5.5) (13.9) (2.5) - 2996 DM - 2788 DP - 2599 DR - 2661 DT - 2493 DW (3.6) (2.0) (6.1) (2.6) (3.6)	0.70	1098	1.50
(1e) $m - p = -2.99 + 1.49 y - 0.004 i + 0.04 DK$ (11.5) (30.6) (13.9) (2.5) - 2.61 DM + 1.12DP - 2.44 DR + 1.22 DT + 1.40 DW (3.6) (2.0) (6.1) (2.6) (3.6)	0.99	0.05	0.48

Note: DK, DM, DP, DR, DT, and DW represent dummy variables identifying Korea, Malaysia, Philippine, Singapore, Thailand, and Taiwan; 1 for a country and 0 for the other countries.

Table 2 presents the coefficient estimates of equations (11)-(13) for the seven Asian countries as a group. The g_2 coefficient estimated is -0.95. The estimated values of g_{21} and g_{22} are -0.94 and -0.89. The estimates of g_{31} and g_{32} are -0.94 and -1441 (Note that the estimate of g_{32} , -1441, contains a value of scale factor). The estimated coefficients are statistically significant at the one percent level of significance. The estimated coefficients of net foreign assets variables, g_2 , g_{21} , and g_{22} , are above -0.9 or higher. These estimates indicate that the degree of

sterilization of the monetary authority is very high. This result appears to contrast with the estimate of sterilization, -0.41, reported by Fry (1993, pp. 153-56) for the six Pacific Basin economies--Indonesia, Korea, Malaysia, Philippine, Thailand and Taiwan during 1970-1990. Both results are comparable, however, because the sample of Fry's regression does not include the period 1991-96 when large sterilization operations were undertaken. Other things being equal, an active sterilization effort would raise the size of the sterilization coefficient. This is supported by Kwack (1994) in the case of Korea. The sterilization coefficient estimate, 0.90, obtained in this study is higher than the estimated figure, 0.8, for the sample period 1980-1990 reported by Kwack (1994). The estimated 0.63 in the sub-sample period 1980-85 is lower than the estimate of 0.86 in the sub-sample period 1985-1990.

The estimated coefficients of the money supply multiplier, Δq in equation (12e) and ΔQ in equation (13e) in Table 2 are highly significant. This finding suggests that the sterilization was undertaken to control the money supply rather than to control the monetary base. This is what we would expect from the fact that the intermediate target of monetary policy is a money supply aggregate, mostly represented by M2.

As stated earlier, the estimated coefficient of sterilization by the pooling observations assumes that the sterilization policies pursued by different countries were identical during the sample period. An effort to empirically test the validity of this assumption estimated equation (12) for seven individual countries. As summarized in Table 3, the sterilization coefficients for Indonesia, Korea, Malaysia, and Singapore are above -0.97. While the coefficients for Philippines and Taiwan are -0.94, the coefficient for Thailand is -0.81. These estimates for individual countries are not significantly different from the estimated coefficient of -0.94 for the group. Hence, the assumption that the intensity of sterilization is identical can not be rejected. The coefficients of the money supply multiplier for individual countries vary considerably; less than -1.6 for Korea, Malaysia, and Taiwan; around -0.8 for Indonesia, Philippines, and Thailand; virtually zero for Singapore. Hence, the individual coefficients of the money supply multiplier differ from the coefficient of -0.94 for the group.

C. Foreign Exchange Rate and Market Intervention

Based on equation (6), the following equations are specified:

$$\Delta e = \hat{a}_1 + \hat{a}_2 \Delta p + \hat{a}_3 \Delta pf + \hat{a}_4 \Delta f \quad (14)$$

$$\Delta e = \hat{a}_1 + \hat{a}_{21} \Delta p + \hat{a}_{31} \Delta pf + \hat{a}_{41} BOPM \quad (15)$$

$$\Delta e = \hat{a}_1 + \hat{a}_{22} \Delta p + \hat{a}_{32} \Delta pf + \hat{a}_{42} BOP \quad (16)$$

$$\Delta e = \hat{a}_1 + \hat{a}_{43} BOPM \quad (17)$$

where Δe and Δpf are in percent. Three related variables are used to represent the amount intervened in the foreign exchange market; the ratio of a change in the net foreign assets to the monetary base (Δf), the ratio of the balance of payments to the monetary base (BOPM), and the balance of payments (BOP). BOPM is $100 \times 0.001 \times BOP \times E / MB_{-1}$ where BOP is the balance of payments in millions of U.S. dollars, and MB is the monetary base in the billions of home currency (in the millions of home currency for Malaysia and Singapore).

Table 3. $\Delta d = \gamma_1 + \gamma_{31} \Delta q + \gamma_{21} \Delta f$

Country	Coefficients			\bar{R}^2	SEE	DW
	γ_1	γ_{31}	γ_{21}			
Indonesia	23.9 (7.6)	-0.81 (4.2)	-0.99 (16.1)	0.96	7.53	1.76
Korea	19.2 (12.6)	-1.16 (12.9)	-0.97 (17.2)	0.97	3.69	2.16
Malaysia	12.7 (2.6)	-1.26 (2.3)	-0.99 (8.11)	0.96	8.61	0.52
Philippine	18.9 (10.1)	-0.74 (3.6)	-0.94 (19.9)	0.98	6.28	1.58
Singapore	8.72 (2.7)	-0.09 (0.4)	-0.99 (22.3)	0.98	3.53	1.11
Thailand	9.23 (5.7)	-0.84 (4.1)	-0.81 (20.4)	0.98	2.33	2.68
Taiwan	16.4 (14.4)	-1.42 (10.8)	-0.94 (60.3)	0.99	3.17	1.88

Table 4 lists the equations estimated for the Asian countries as a group, (14e)-(17e). The estimated coefficients for inflation at home and abroad are not statistically significant. The estimated coefficients of three alternative indicators for the foreign exchange market intervention are found to be statistically significant

at the one percent level of significance. They are: $b_4 = -0.05$, $b_{41} = -0.05$, $b_{42} = -0.0004$.¹⁰ When the insignificant inflation variables are excluded, we obtain $b_{43} = -0.05$, which suggests that a one percent rise in the ratio of the change in the net foreign assets to the monetary base at the beginning of period leads to 0.05 percent appreciation. The estimated coefficient of the balance of payments, $b_{42} = -0.0004$ in equation (16e) indicates that a one billion dollar rise in the balance of payments leads to a 0.4 percent nominal exchange rate appreciation. The estimated intervention coefficients are surprisingly low. While further investigation seems to be warranted, the result that the effect of the intervention in the foreign exchange market is small is consistent with an observation that the exchange rates in most of the Asian countries moderately moved in the direction dictated by capital inflows.

Table 4. Foreign Exchange Rate and Market Intervention

Equation	\bar{R}^2	SEE	DW
(14e) $\Delta e = 11.6 + 0.05\Delta p + 0.22\Delta pf - 0.05\Delta f - 7.1DK$ (2.8) (0.29) (0.23) (2.7) (3.1) $-5.9DM - 3.8DP - 2.5DR - 5.5DT - 9.2DW$ (5.4) (30.8) (0.0) (0.1) (3.6)	0.28	5.45	1.78
(15e) $\Delta e = 6.5 + 0.12 \Delta p - 0.05 \Delta pf - 0.05 BOPM - 6.6DK$ (2.5) (0.63) (0.54) (2.88) (2.9) $-5.2DM - 2.9DP - 7.7DR - 4.8DT - 8.1DW$ (2.0) (1.3) (2.9) (1.9) (3.1)	0.28	5.4	1.71
(16e) $\Delta e = 6.6 + 0.10 \Delta p + 0.04 \Delta pf - 0.0004 BOP - 6.2DK$ (2.6) (0.53) (0.42) (3.13) (2.7) $-5.7DM - 3.4DP - 8.8DR - 5.3DT - 7.6DW$ (2.2) (1.5) (3.4) (2.2) (2.1)	0.30	5.37	1.68
(17e) $\Delta e = 8.1 - 0.05 BOPM - 7.0DK$ (5.1) (2.88) (3.2) $-6.1DM - 2.8DP - 8.6DR - 5.4DT - 8.9DW$ (2.7) (1.3) (3.7) (2.4) (4.0)	0.30	5.37	1.74

Note: DK, DM, DP, DR, DT, and DW represent dummy variables which identify Korea, Malaysia, Philippines, Singapore, Thailand, and Taiwan.

¹⁰We calculate the value of b_{41} from the estimate of $b_{42} = -0.0004$ by utilizing the relation between BOPM and BOP, $BOPM = 0.001146 BOP$ at the sample means. The calculated value of b_{41} is -0.035 , which seems to be close to the estimate of $b_{41} = -0.05$.

D. Effects of Sterilization and Foreign Exchange Market Intervention

The estimated regression equations show that the sterilization coefficient is very high and the intervention coefficient is very small. This suggests that the monetary policy leads for a capital inflow to yield negligible effects on the exchange rate with small positive effects on the money supply and the price level. Consequently, real exchange rates appreciate by a small amount. On the whole, the monetary authorities succeeded in limiting increases in monetary growth, despite a surge of capital inflows.

The effects on the money supply, the rate of inflation, and the exchange rate can be calculated by using equations (8)-(10) with the estimate of the sterilization coefficient $g = 0.95$ and the estimate of the coefficient of foreign exchange market intervention $b = 0.05$. The difference in a yearly financial account balance of a country on the average of the seven countries between the two periods 1985-1989 and 1990-1996 is about \$5 billion (if Singapore and Taiwan are excluded, the difference is about \$8 billion). Suppose there is \$10 billion additional capital inflows per year during 1990-1996 period: the additional \$10 billion in capital inflows is about a one percent rise in the ratio of a change in the balance of payments to the monetary base. This rise raises the ratio of a change in net foreign assets to the monetary base by 0.83 percent (as measured at the mean values during the sample period 1985-1996). The contribution to the money supply is about 0.4 percent additional money supply growth. The contribution to the rate of inflation is about 0.4 percent, that is, about 6 percentage points of actual inflation. No contribution is made to the exchange rate, since $(1 - g - b)$ is close to zero. Hence, the real exchange rate is appreciated by 0.4 percent per year, and over the seven years, the exchange rate appreciation would be higher by 3 percent than would have been expected in the absence of the capital inflows. While the calculated price and exchange rate effects are subject to an error, they clearly illustrate the direction of the price and exchange rate effects of monetary policy changes.

5. CONCLUSIONS

Capital flows are sensitive to economic and political developments at home and abroad. A change in foreign financial market conditions may reverse capital inflows. The sudden reversal of capital flows can cause a severe turmoil in the economy, especially in an economy with high short-term external liabilities.

Asian countries desired to keep the effect of a capital flow shock on the economy at a minimum level and, therefore, adopted a policy of extensive sterilization and stable exchange rates. Empirical results show that the degree of sterilization is very high and the effect of foreign exchange market intervention on

the exchange rate is small during the sample period 1985-1996.¹¹ Consequently, these nations attained a primary objective of monetary policy in response to a surge in net capital inflows to their economies.

The majority of industrial countries allow their exchange rates to float and do not restrict capital flows. Under such world conditions, it is expected that capital inflows as well as capital outflows might occur unsystematically. If the monetary authorities in Asian countries took the view that capital flows are of a permanent nature, they would not have adopted extensive sterilization--the cost of sterilization becomes high if sterilization policies last a long time.¹² Then the monetary authorities would have allowed the exchange rate to respond to market forces. Increased fluctuations and uncertainty in exchange rates might have discouraged highly speculative and quickly reversible capital inflows. In that situation, Asian countries could have avoided the financial crisis.

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¹¹During the period 1990-1996, real exchange rate appreciation of the Asian currencies against the U.S. dollar is not substantial. In 1996, real exchange rate of individual Asian currencies appreciated by more than thirteen percent against the Japanese yen, primarily because of sixteen percent depreciation of the Japanese yen against the U.S. dollar. Chinn (1998) finds evidence of overvaluation before the Asian crisis for the Malaysian ringgitt, Philippines peso, Taiwan dollar, and Thai bhat. The Korean won was undervalued, while the evidence for the Indonesian rupiah was mixed.

¹²Sterilization substitutes foreign exchange reserve assets with low rates of interest for domestic assets with high rates of interest rates. Thus, when sterilization is undertaken, it creates a financing burden, what is referred to in the literature as the cost of sterilization or quasi-fiscal cost of sterilization. The cost of sterilization depends on the scale of the operations by the monetary authority and the size of interest rate differentials, as well as the instruments used.⁸ The longer the sterilization operation continue, the cost will be higher. The high cost makes it difficult for sterilization policy to last over a long period. Calvo (1991) argues that sterilization could bring about credibility problems. In this case, the cost of sterilization is excessively high.

In Latin America cases, the cost is estimated to be high. For example, Calvo, Leiderman, and Reinhart (1993) estimated quasi-fiscal costs in Columbia in 1991 of 0.5 percent of GDP. Annual cost in Chile during 1990-93 and in Mexico during 1990-93 is estimated to be about 0.5 percent of GDP and 0.25 percent of GDP, respectively (see Velasco and Cabezas, 1998, pp. 142-143). In the case of Korea, Kwack (1994) estimated that interest payments on the Monetary Stabilization Bonds, which amounted to 3.5 percent of M2 in 1989, implying that the cost of sterilization is high. Kletzer and Spiegel (1996) argued that the costs of sterilization in the Pacific Basin countries are not large. The quasi-fiscal costs in 1987 and 1992 are estimated to be 0.12 and 0.22 percent of GDP for Indonesia; the cost in 1988 is estimated to be 0.28 percent of GDP for Korea.

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