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Exchange Rate Constraints and Money Control in Korea

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Working Paper 1995-011A
<http://research.stlouisfed.org/wp/1995/95-011.pdf>

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EXCHANGE RATE CONSTRAINTS AND MONEY CONTROL IN KOREA

July 1995

JEL CLASSIFICATION: E51, E58, F31, F32

KEYWORDS: Capital mobility, Money control, Offset coefficient, Sterilization policies

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The author wishes to thank Bill Dewald, Cletus Coughlin, Bill Gavin, Patricia Pollard, Chris Neely and Mike Pakko for their helpful comments and suggestions and Richard Taylor for research assistance.

Abstract

This paper applies two traditional empirical approaches to investigate how successfully Korea managed to control money supply in response to the changes in foreign reserves since 1980. One is to estimate offset coefficients and the other is to estimate sterilization coefficients. The estimation results are as follows. Reflecting strict and effective capital controls, the domestic monetary policies were partially offset mainly by short-term capital flows. The Bank of Korea pursued sterilization policies very actively. Particularly, sterilization was more active during the late 1980s of huge current account surplus than during the early 1990s of a surge in capital flows. There were over-sterilization during the early 1980s when foreign reserves kept dropping, which implied that monetary policies were directed to worsening the balance of payments deficit rather than improving it.

I. Introduction

In small open economies with exchange rate constraints and high capital mobility, the scope of monetary control is greatly limited by the offsetting changes in foreign exchange reserves mainly by capital flows, unless the central banks actively sterilize them.

During the 1980s after a long period of fixed exchange rate system, Korea adopted multiple pegged exchange rate system which allowed exchange rates to change frequently but mostly under the government control. Korea, therefore, had to continue strict capital controls in order to ensure monetary control. They experienced and are now experiencing big pressure of money growth from the foreign sector: a huge current account surplus in the late 1980s and a surge in capital inflows in the 1990s. Korea is now speeding up deregulating capital transactions, and it will damage the controllability of money supply, unless they move toward free floating exchange rate system.

This article deals with an issue of how successfully Korea managed to control money supply under exchange rate constraints since 1980. First, the effectiveness of capital controls is explored by estimating offset coefficients. Secondly, the sterilization policies of the Bank of Korea are investigated by estimating sterilization coefficients.

This paper proceeds as follows. In section two, a general discussion is presented on the controllability of money supply under exchange rate constraints. In section three, the Korean monetary experiences are described in some detail. In section four, some pieces of relevant empirical studies are undertaken, and the final section five is reserved for evaluation and prospects as a conclusion.

II. General Discussion

The swings of money supply through the foreign sector are unavoidable under exchange rate constraints, because exchange rates do not move freely to remove the balance of payments imbalance. This gives much trouble to the central bank of a small open economy in keeping money supply under control. Particularly, capital market linkages among countries limit substantially the controllability of the national monetary authorities over the money supply and the domestic interest rates through offsetting capital flows (Frenken, J.A. & M.L. Mussa [1981]). For example, a decrease in the domestic credit to combat the inflationary pressure may increase domestic interest rates or enforce firms to finance abroad, and thus will induce a capital inflow and corresponding increase in foreign exchange reserves that will rapidly increase the money supply back.

The unfavorable effects of these offsetting capital flows on money control were empirically found in West Germany during the period of fixed exchange rate system between 1960 and 1972 (Porter [1972], Kouri & Porter [1974], Neuman [1978], Obstfeld [1980]), and in some South American countries such as Columbia, Mexico, Venezuela during the 1970s when these countries ran the crawling peg exchange rate system (Cumby & Obstfeld [1981], Kamas [1986], Rennhack & Bonangelino [1988]).

During the 1970s there were lots of research on these offsetting capital flows to see how feasible monetary control can be under fixed exchange rate system and high capital mobility. An assertion was made on the basis of the monetary approach to the balance of payments that monetary control is totally infeasible in the short run as well as in the long run because of

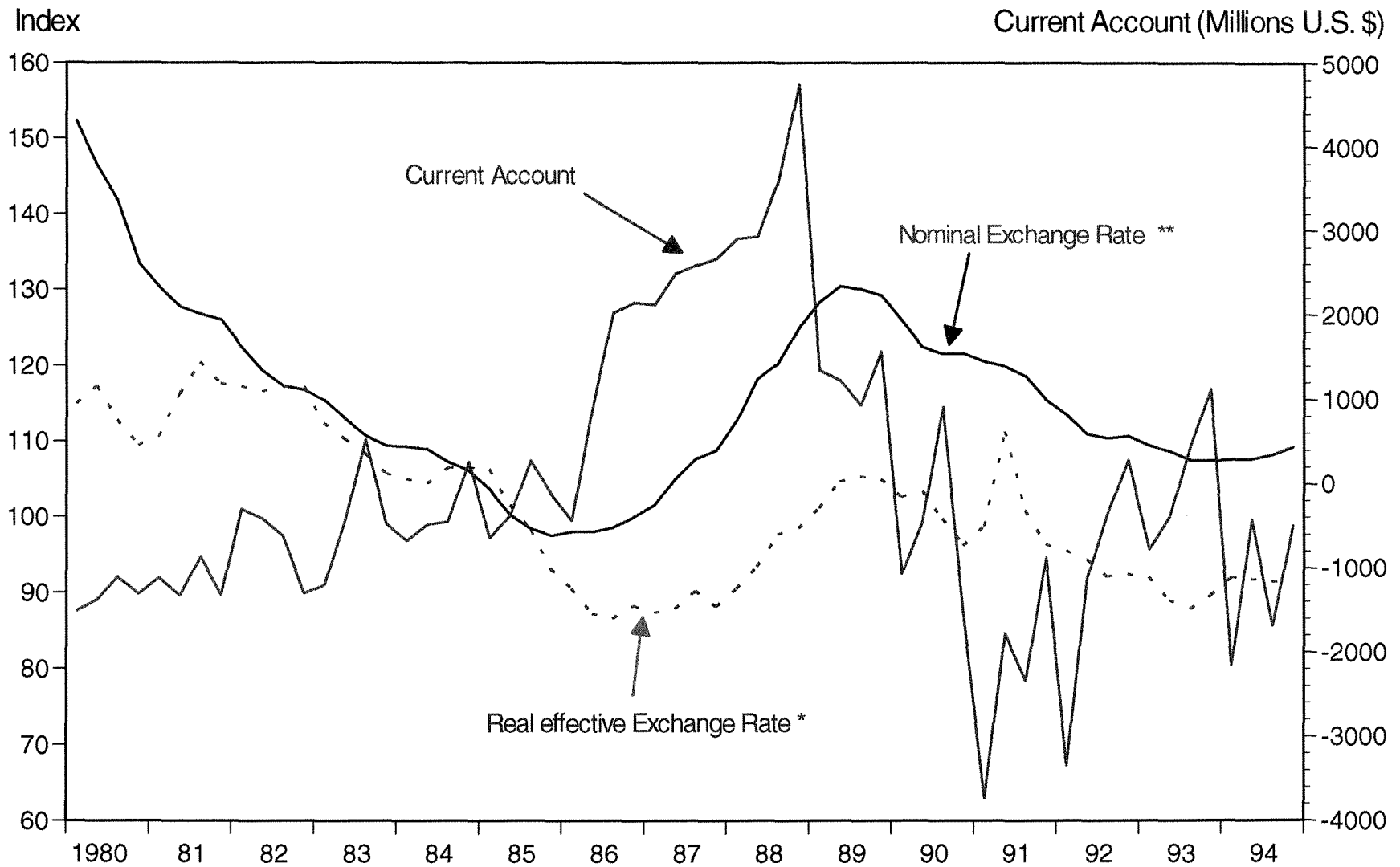
complete offsetting capital flows responding to the domestic interest rate movements(Mundell[1961], Swoboda[1973]). According to their view any attempt to sterilize capital flows through domestic credit measures cannot succeed, even temporarily because it induces another offsetting massive capital flows without the initial money effects of monetary policy measures.¹ There was a different view that money control is somewhat feasible ,because capital flows can not offset domestic monetary policy completely in a real case where bonds denominated in different currencies are not perfect substitutes(Branson[1970], Obstfeld [1980]). They had a different view on the capital movements: capital movements are not simply continuing flows of foreign exchange but largely once-and-for-all stock adjustments of investors' portfolios made in response to change in interest rate differentials. They insist that the sterilization policies of a central bank may insulate domestic money supply from changes in foreign exchange reserves at least in the short run or medium run. But, in the long run, sterilization cannot sustain a money supply that differs from the equilibrium level of money demand.

From the practical and theoretical prospective, we can conclude that whether a small country can control money supply properly under exchange rate constraints depends not only on how effectively a country can control capital flows to prevent them from offsetting changes in domestic credit but also on how actively a central bank sterilizes changes in foreign exchange reserves in a world of highly integrated capital markets.

¹ Some critics were made respect to this assertion. (1) if we take outside money into consideration, complete offset is not possible under perfect capital mobility (Frtianni[1977]), (2) complete offset by capital flows are not sufficient condition for an emasculated monetary control (Kanniainen[1977]).

(Graph 1): Exchange Rate Movements in Korea

Quarterly Data



1) Index, in terms of foreign currencies, calculated based on exchange rates and CPIs of seven major trading partners (U.S., Japan, England, Germany, Canada, Singapore, Taiwan) (1985 = 100).

2) Index, in terms of U.S. dollars (1985=100).

III. The Korean Experience

Foreign Exchange and Capital Controls

In Korea, up until 1990 the exchange rates were not determined in the market but controlled by the authorities.² During this time the exchange rates were controlled to satisfy purchasing power parity condition by and large lest the exporting goods should be uncompetitive in the world market by the unfavorable exchange rates movements. This was considered necessary because export growth was essential for the continued economic growth. As the foreign exchange market grew rapidly in size, a new exchange rate system, so-called market-average exchange rate system, was adopted in March 1990 to allow market forces to determine the won/dollar rate in the domestic foreign exchange market within a band set by the authorities.³

Reflecting these realities, the movements of the nominal and real exchange were closely related to current account position as shown graph 1.⁴ During the period of current account

² From early 1970s until January 1980, Korea maintained a peg to the U.S. dollar. Subsequently, it was replaced by the multiple-basket pegged system in which the exchange rates were set by the authorities daily on the basis of a basket of currencies comprising a trade-weighted basket and SDR basket as well as of judgements of authorities on the other economic factors such as domestic and foreign price trends, and the balance of payments position. Under this system the exchange rates were floating but managed by the authorities to keep them at the desired level.

³ Under the new system, the daily exchange rate is determined by the weighted average of won-dollar transactions conducted on the previous business day among foreign exchange banks with a band set by the authorities. This band was widened from 0.4% above or below the prevailing rate to 0.6% in September 1991 and was again enlarged to 0.8% in July 1992 and was further expanded to 1.0% in October 1993 in order to enhance the role of the exchange rate as a price variable and boost market transactions.

⁴ It is empirically asserted that the changes in nominal exchange rates had clear effects on the trade balance as theory indicates in Korea.

deficit(1980-1985),both the nominal and real exchange rates continued to rise(won depreciated), while they dropped(won appreciated) considerably during the period of surplus(1986-1989). Since Korea opened its stock market partially in 1992, they are greatly affected by the capital flows.

Under these exchange rate constraints, Korea had to put strict controls on the capital flows in order to enhance monetary control.⁵ Until early 1990s when the capital market liberalization proceeded rapidly, most of the capital transactions taking place out of purely financial motives were prohibited and only those which had some connections with real sector were permitted with limits. Reflecting these controls on capital transactions, most of the capital transactions during 1980s were real-sector-related ones such as loans, trade credit, and direct investment as shown table 1. However, since 1990 capital transactions out of financial motives in the form of equities and debenture issued surged enough to give trouble in controlling money stock. It is also remarkable that both the capital controls and its relaxations⁶ have been pursued as one of the efforts to effectively control money supply. For example, during the latter part of 1980s when persistent current account surplus was a big pressure for money growth, the capital outflows were deregulated, while capital inflow were kept under strict control, and vice versa.

⁵ The other aims of capital controls are (I) to channel foreign saving to the strategically important sectors, and (ii) to protect the underdeveloped domestic financial sectors from outside competition,(iii) to make efficient use of limited foreign currency funds.

⁶ Since the early 1980s a number of measures have been taken to remove or ease these controls. The government substantially loosened the foreign exchange concentration system and the ceilings of the exchange position of foreign exchange banks has been raised several times. It also abolished or relaxed the regulations on capital transactions such as foreign investments and overseas portfolio investment. Noticeably, the Korean securities market were partially opened in January, 1992 by allowing foreign securities companies to own up to 10% of the paid-in capital of large Korean securities companies.

Table 1: Capital Flow Trend in Korea

(million dollars)

	1980-1984		1985-1989		1990-1994	
	inflow	outflow	inflow	outflow	inflow	outflow
loans ¹⁾	17542	8077	12402	23629	4258	10583
direct investment						
domestic	574	125	3103	195	4524	660
abroad	-	-	347	1016	862	7217
portfolio investment						
domestic	799	165	2175	1437	40005	12233
abroad	-	-	1012	1083	9420	10321
import credit	59803	57913	71060	71047	150410	144407
short-term	58259	56238	69232	69670	146377	141147
long-term	1544	1675	1828	1377	4033	3260
export credit	8176	9021	9165	10635	24494	20462
short-term	3287	3099	1545	2196	2582	2876
long-term	4889	5922	7620	8439	21912	17586
total ²⁾	86894	75301	99264	109042	233973	205883

1) public loans + commercial loans + bank loans

2) The other items which have net balance such as advances under red-clause L/C are excluded

Foreign Reserve Changes and Money Control

Due to the wide opening of Korean economy to the world, combined with relatively inflexible exchange rate, the foreign reserves have been a dominant source of the reserve base in Korea as shown in graph 2. During the early 1980s when Korea continued to have balance of payment deficit, domestic monetary policy could enjoy degree of freedom, because foreign sector was a net reserve demand sector. But, since the late 1980s foreign reserves developed hardships in keeping money growth at the target rate, because it switched to a net supply sector.⁷

A huge current account surplus between 1986 and 1989 was a big pressure for money growth, which threatened to accelerate inflation and had long served to absorb liquidity since then. The active sterilization policies were pursued to keep money growth under control. Domestic credit was greatly contracted through a substantial reduction in policy loans and a tighter control over bank loans to large firms. Since it was not enough, sales of monetary stabilization bonds by the Bank of Korea exploded and reserve requirements ratios were increased more than double to absorb the liquidity. In addition to these monetary reactions, the government allowed the won to appreciate against the dollar, restricted some capital inflows, and liberalized some capital outflows.

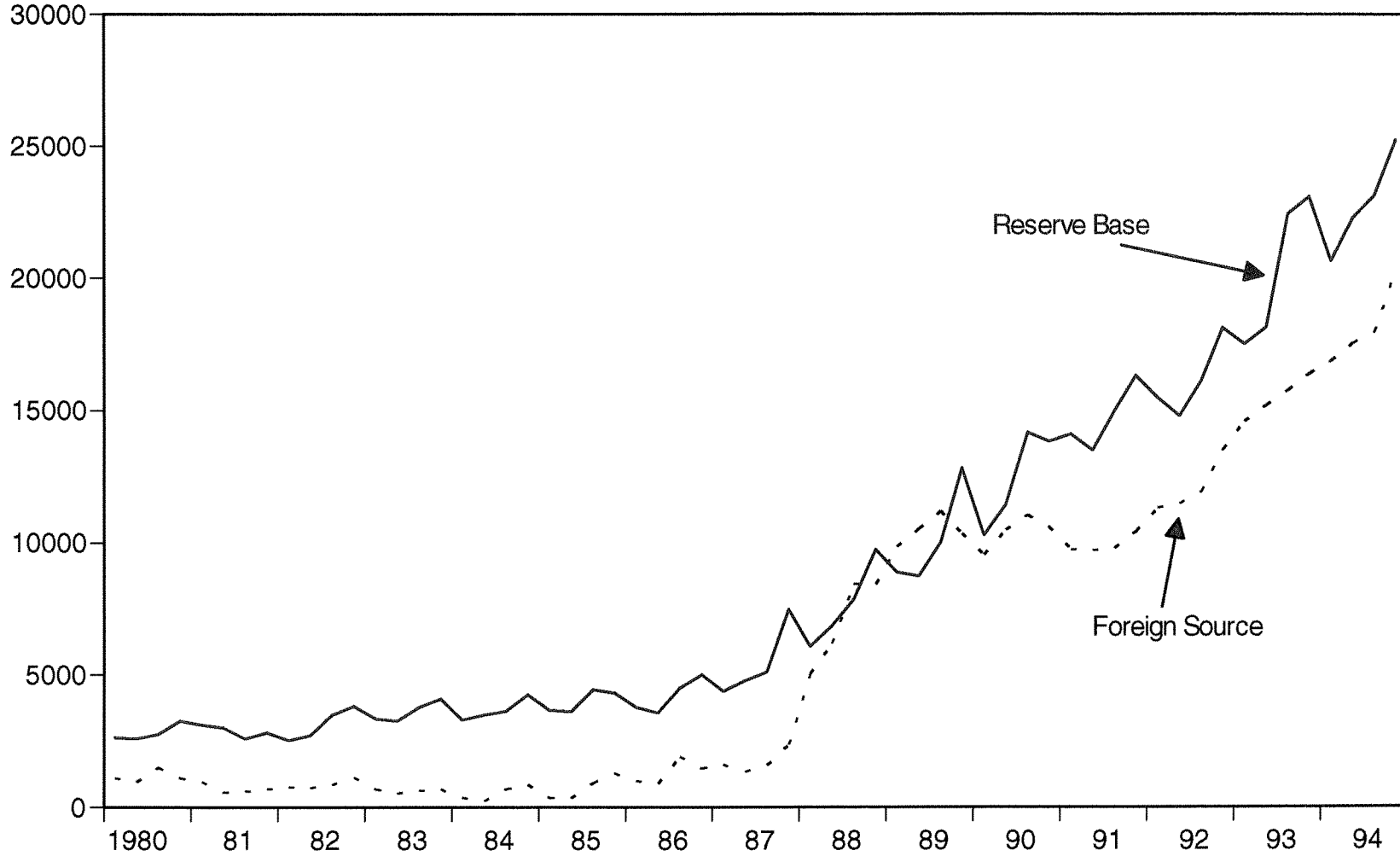
As the restrictions on capital flows were remarkably lifted in the early 1990s ,ie a partial opening of stock market in January 1992, the surge in capital inflows continuously expands

⁷ Since 1957 Korea has established monetary targeting as the basic monetary policy regime in order to efficiently tackle the inflationary pressures. The annual target rates of money growth are set mainly on the basis of real GNP growth rate and target inflation rate. From 1979 onwards, a certain point(recently a certain range)of annual growth rate of Consisting of currency in circulation plus total deposits of banking institutions has been a main monetary target.

(Graph 2): Reserve Base and its Foreign Source

Quarterly Data

Millions of Won



foreign reserves in spite of recent consecutive current account deficit as shown table 2. Since this huge capital inflow is putting tremendous pressure for won appreciation, the purchase of foreign exchange by the central bank is required to keep exchange rate at proper level. This intervention in the market necessitates the central bank to practice sterilization policies to keep money growth at target level.

Table 2: Balance of Payments Trend in Korea

(net, million dollars)

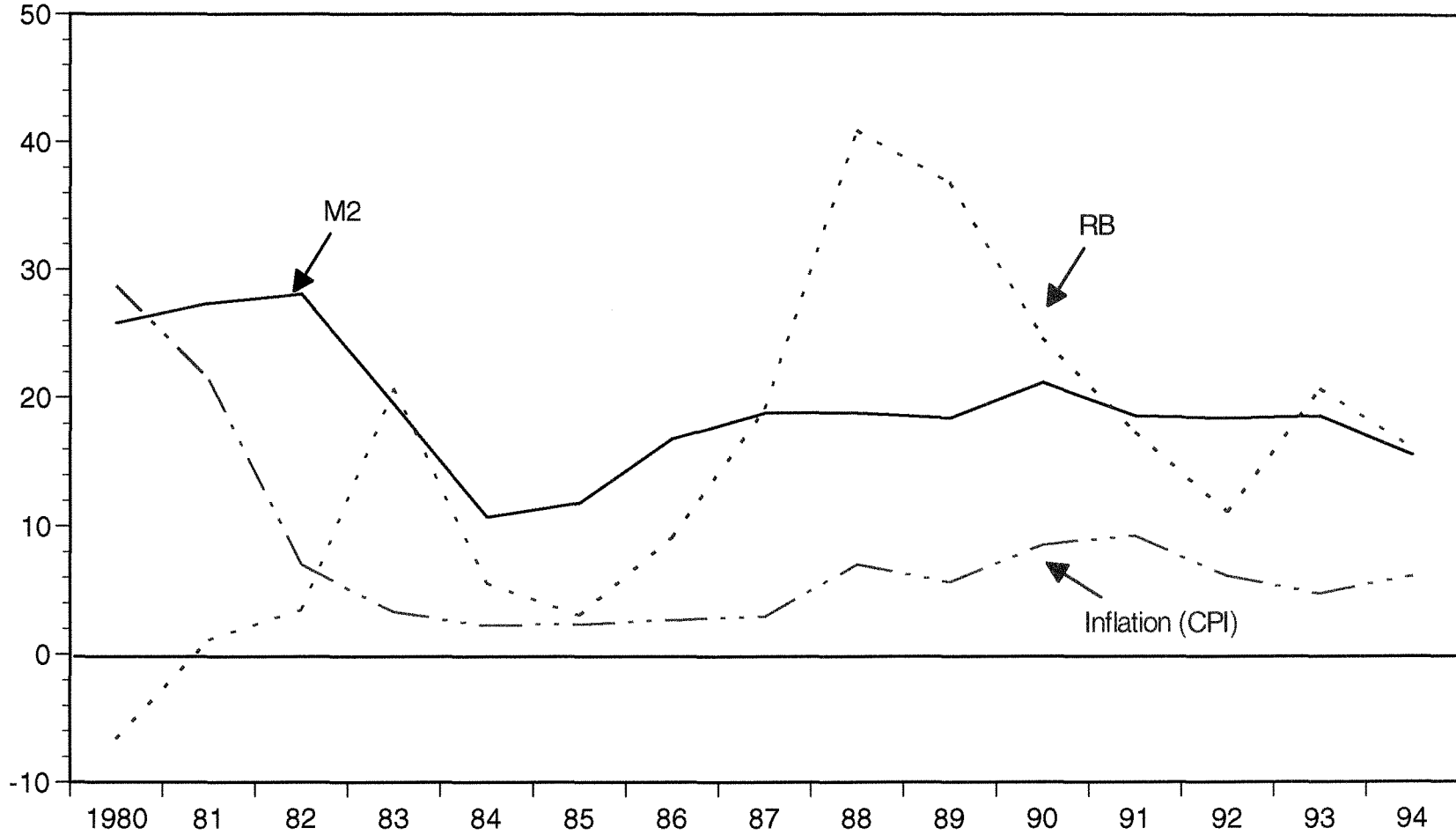
	1981-85	1986- 89	1990	1991	1992	1993	1994
current account	-11,162	33,686	-2,179	-8,728	-4,528	385	-4,778
capital account	7,980	-12,916	3,882	4,227	8,343	6,879	9,086
long-term	8,511	-13,913	548	4,186	7,233	8,900	6,134
short-term	-531	997	3,334	41	1,110	-2,021	2,952
overall account	-7,605	21,530	-274	-3,741	4,898	6,542	2,802

Even if the Bank of Korea struggled to keep money growth under control against the external pressure as described above , it is undeniable that the movements of foreign exchange reserves had significant effects on money growth and thus inflation as shown in graph 3. During the early 1980s Korea could sustain low inflation rate except 1980 and 1981 when Korea had the second oil shock thanks to relatively lower rate of monetary base growth. But after 1986 the rate of money growth(M_2) rose substantially due to the continued huge current account surplus, which put Korea under tremendous inflationary pressure even until early 1990s. The recent increase in the rate of monetary base is believed to be associated with a surge in capital flows.

(Graph 3): Money Growth and Inflation in Korea

Annual Data

Percent



IV. Empirical Findings

In this section two pieces of empirical studies are presented to investigate how effectively Korea managed to control money stock in response to big changes in foreign reserves since 1980: both offset coefficients and sterilization coefficients are estimated.

(1) offsetting capital flows

One of the empirical approaches to measure the controllability of the money stock is to estimate the offset coefficient: the fraction of a given change in the domestic credit that is offset by capital flows. Traditionally, the offset coefficient was estimated in the context of monetarist or portfolio balance model in either of two ways. The reduced capital-flow equation is estimated directly; alternatively, the structural asset demand equations are estimated, and then, the offset coefficient is calculated from the estimated interest-sensitivities.⁸

In this paper, the offset coefficients are estimated in a reduced-form model of capital flows developed from a general equilibrium model of the Korean financial markets.

Accommodating the theoretically derived capital-flow equation as much as possible⁹, the following capital-flow equation is set up for estimation. Model derivation and sources of data

⁸ The reduced-form estimates tend to be biased toward -1 if the central banks systematically attempt to sterilize reserve flows(Kouri and Porter 1974, Obstfeld 1982) or unless speculating capital flows are properly captured in the capital flow equation(Obstfeld 1982, Laskar 1982). The structural estimates are biased toward 0 if private agents internalize the government budget constraint(Pasula 1994).

⁹ Among the explanatory variables in the derived capital flows equation, the change in capital transactions motivated by the capital market liberalization is captured by a dummy variable representing partial stock market opening in 1992.1 and the capital flows accompanied by trade is reflected the current account.

used in regressions are provided in Appendices.

$$TC_t = a_0 + a_1\Delta NDA_t + a_2CA_t + a_3\Delta(i^* + E)_t + a_4\Delta Y_t + a_5\Delta W_t + a_6DUMMY + \varepsilon_t$$

Here, TC is capital inflow, NDA is domestic source of monetary base, CA is current account surplus, I^* is foreign exchange rate, E is expected rate of depreciation, Y is real income, W is nominal wealth, DUMMY is a dummy variable representing the period after January, 1992, and ε is a disturbance term. In order to find out sources of offsetting capital flows in more detail, some of the combinations of short-term capital flows, long-term capital flows, and error & omissions are used as dependent variables in the capital-flow equation. The estimation results are provided in Table 3.¹⁰

Some implications can be drawn from these estimation results. First, in spite of

¹⁰ The Hausman's test for exogeneity is applied in order to detect the problem of simultaneous bias which may come from the endogeneity of the domestic credit variable ΔNDA_t . To implement the Hausman test, add to (1) the variable ΔNDA_t , which is the predicted value from an OLS regression of ΔNDA_t on the instrumental variables, including the other regressors in (1). The hypothesis of no simultaneous bias is equivalent to the hypothesis that the coefficient of ΔNDA_t is zero. The result of OLS estimation (with t-statistics in parentheses) is

$$TC_t = -32.72 - 0.351 \Delta NDA_t - 0.496 CA_t - 159.6 \Delta(I^* + E)_t + 0.452 \Delta Y_t + 0.616 \Delta W_t - 0.045 \Delta \hat{NDA}_t +$$

(1.359) (0.214) (3.182) (0.234) (3.190) (5.887) (1.278)

$$1102.1 DUMMY \quad R^2 = 0.708, \quad DW = 1.801$$

(2.140)

The hypothesis that the coefficient of $\Delta \hat{NDA}_t$ is zero is not rejected. So OLS or GLS regression methods are applied for estimation. As shown in table the estimated offsetting coefficient using 2SLS method makes little difference.

Table 3 : Capital Flow Equation (1980:1 to 1994:4)

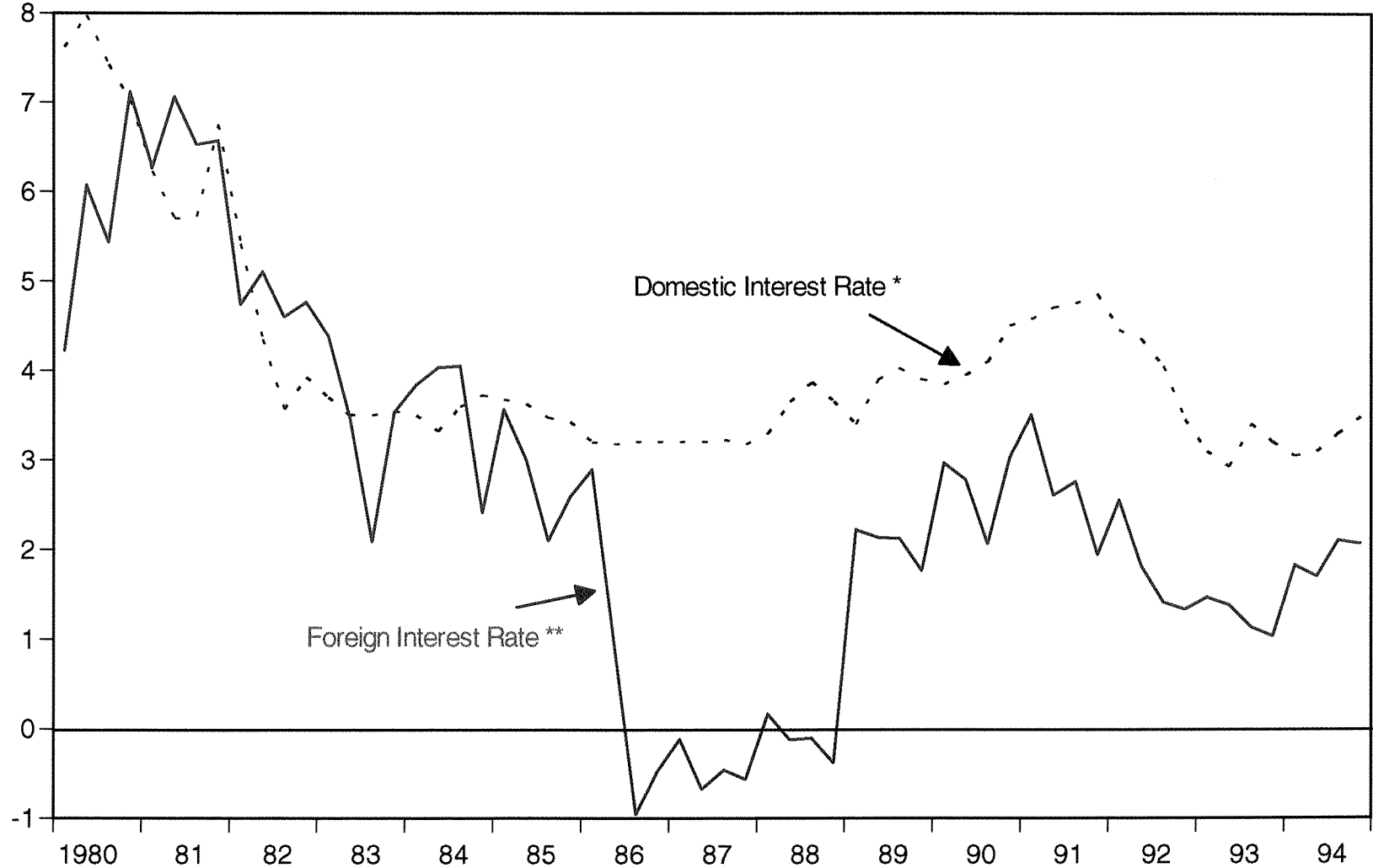
	constant	ΔNDA	$\Delta NDA - \Delta RR$	CAB	$\Delta(i^* + E)$	ΔY	ΔW	Dummy	R^2	DW
STC	-51.87 (0.559)	-0.259 (3.663)	-0.243 (3.532)	-0.104 (2.020)	98.22 (1.075)	0.025 (1.739)	0.073 (2.524)	-367.9 (1.693)	0.258	1.886
LTC	41.78 (0.421)	-0.107 (1.410)	-0.053 (0.721)	-0.385 (6.954)	-258.8 (2.648)	0.019 (1.255)	-0.017 (0.560)	1499.7 (6.446)	0.742	1.919
TC1	-10.09 (0.084)	-0.366 (3.977)	-0.297 (3.194)	-0.490 (7.272)	-160.6 (1.351)	0.044 (2.369)	0.056 (1.481)	1130.8 (4.000)	0.708	1.804
TC2									0.707	
OLS	-107.1 (1.004)	-0.437 (5.374)	-0.377 (4.545)	-0.523 (8.132)	-70.05 (0.623)	0.032 (1.815)	0.053 (1.514)	1090.3 (4.164)		1.801
2SLS	-32.72 (0.236)	-0.396 (2.224)		-0.495 (5.937)	-159.6 (1.289)	0.045 (2.158)	0.062 (1.371)	1102.1 (3.209)		

1) t-statics are in parentheses. TC1 = STC+LTC, TC2= TC1+ERR

(Graph 4): Domestic and Foreign Interest Rate Differential

Quarterly Data

Percent



1) Corporate bond yield rate (3 Year maturity).

2) LIBO (3 months) + expected rate of depreciation.

strict capital controls in Korea, monetary policies were partially offset by capital flows, mainly the short-term capital transactions. Because the regulations on the portfolio transactions were extremely strict, these offsetting capital flows were largely associated with borrowing and repayments by firms or non-bank financial institutions rather than interest-sensitive capital flows like portfolio investment. Short-term borrowing are mainly connected with import transaction, while long-term borrowing are composed of bank loans, commercial loans, trade credits, debentures issued. These offsetting capital transactions were made by large firms in order to substitute domestic sources of fund for foreign sources whenever loan availability ran out domestically in the event of tight monetary policies. Moreover, they could take cost advantage over domestic loans by borrowing money abroad, because foreign interest rates stayed mostly far lower than domestic interest rates as shown in graph 3. As capital market liberalization proceeds rapidly during 1990s, the portion of interest-sensitive capital flows which offset monetary policy is suspected to rise. Secondly, capital flows in Korea are more associated with monetary policies or current account than portfolio choice behavior. Particularly, short-term capital flows were largely motivated by monetary conditions, and trade transactions, while long-term capital transactions were largely made to offset current account imbalances. This can be well explained by the estimation results that the explanatory variables such as foreign interest rate, domestic income and wealth are much less significant than other variables like changes in domestic source of money supply and current account. This reflects the fact that there were stringent restrictions on portfolio adjustments in financial markets. Thirdly, the frequent changes in reserve requirement ratio during 1980s were not detected to cause offsetting capital flows. This implies that reserve requirement policies were not so effective as to influence the liquidity conditions in

the market.

(2) sterilization policies

The ability to neutralize changes in foreign reserves originating in persistent balance of payment imbalances or foreign exchange market intervention is a prerequisite for controlling money supply in non-reserve economies. Thus, many central banks are undertaking active sterilization policies to maintain their controllability of money stock.

Sterilization policies are systematic attempts by the central banks to neutralize the monetary impact of changes in their foreign reserves by opposite movements in their holdings of domestic assets. The basic way we measure the degree of sterilization by a central bank is by estimating a money-supply reaction function which provides a formal statement of the behavior of the monetary authorities. The degree of sterilization is measured by the sterilization coefficient - coefficient of net foreign asset in the reaction function.

Following Cumby and Obstfeld(1981), the money supply reaction function for the Bank of Korea is modeled as a function of change in net foreign assets, government deficit, real effective exchange rate and production growth.¹¹

¹¹ Since the Bank of Korea views the transmission of monetary policy as depending on M_2 rather than bank reserves, ΔNDA , ΔNFA and $BUDDEFT$ are scaled by the predetermined, required reserve ratio. After multiplying through by the predetermined, required reserve ratio (q_{t-1}), I obtain the expression for the money supply reaction function in the next page (Herring and Marston(1977)).

$$\Delta NDA_t = a_0 + a_1 \Delta NFA_t + a_2 \text{BUDDEFT}_t + a_3 q_{t-1} \text{REER}_t + a_4 q_{t-1} \text{GIPI}_t + \sum_{i=1}^3 S_i + \varepsilon_t$$

Here, NFA is net foreign asset of the Bank of Korea, BUDDEFT is government deficit, REER is real effective exchange rate, and GIPI is industrial production growth, S_i is seasonal dummies, q is reserve requirement ratio, and ε is a disturbance term. The coefficient a_1 is the sterilization coefficient, which measures the extent to which the Bank of Korea attempts to neutralize the money creation resulting from change in its foreign reserves through countervailing domestic monetary measures. If a_1 is 0, then there is no sterilization, because the balance of payments lead to a proportionate increase in the money supply. If a_1 is -1, then complete sterilization is practiced. Values of a_1 between -1 and 0 indicate partial sterilization.¹²

First, the money-supply reaction function is estimated over the period from 1980:I to 1994:I applying GLS and 2SLS method. Then, it is estimated separately during two periods of balance of payment deficit and surplus to compare the sterilization behavior of the Bank of Korea between them. The estimation results are provided in table 4.¹³

¹² A positive value of a_1 would be an evidence that monetary policy aimed at external balance rather than internal one.

¹³ The Hausman's test for exogeneity is also applied to detect the problem of simultaneous bias in the equation. The hypothesis of no simultaneous bias is not rejected. As shown in table 4, the estimated sterilization coefficients using 2SLS method makes a small difference.

$$\begin{aligned} \Delta NDA_t = & 258.0 - 0.756 \Delta NFA_t + 0.307 \text{BUDDEFT}_t + 46.77 q_{t-1} \text{REER}_t - 920.8 q_{t-1} \text{GIPI}_{t-2} + 0.196 \Delta NFA_t - \\ & (0.627) \quad (7.502) \quad (4.400) \quad (2.523) \quad (2.512) \quad (1.497) \\ & 1203.1 S1 - 196.1 S2 - 11.58 S3 \quad R^2 = 0.790, \text{DW} = 2.237, \rho = 0.565 \\ & (1.985) \quad (0.647) \quad (0.020) \end{aligned}$$

Table 4: Money Supply Reaction Function(1980:1 to 1994:4)

period	constant	Δ NFA (1)	Δ NFA (2)	BUDDEFT	REER (T-1)	GIPR (T-2)	S1	S2	S3	R ²	ρ	D.W
80:1-94:4												
GLS	441.5 (1.11)	-0.640 (9.82)	-0.701 (10.40)	0.282 (4.11)	46.40 (2.48)	-104.6 (2.80)	-1406 (2.34)	-263 (0.87)	-169 (0.28)	0.780	-0.57	2.23
2SLS	267.9 (0.57)	-0.558 (6.36)		0.306 (3.67)	45.92 (2.09)	-942.5 (1.99)	-1192 (1.75)	-161 (0.44)	-50 (0.07)		-0.57	2.09
SURPLUS	337.4 (0.81)	-0.664 (9.05)	-0.731 (9.70)	0.306 (4.27)	49.07 (2.48)	-910.6 (2.37)	-1080 (1.72)	-148 (0.47)	-15 (0.02)	0.755	-0.57	2.07
DEFICIT	-223.9 (0.41)	-2.802 (4.28)	-2.86 (4.16)	0.355 (3.67)	44.1 (1.11)	-1188.2 (2.32)	-1643 (2.45)	-75 (0.16)	-234 (0.37)	0.532		2.27

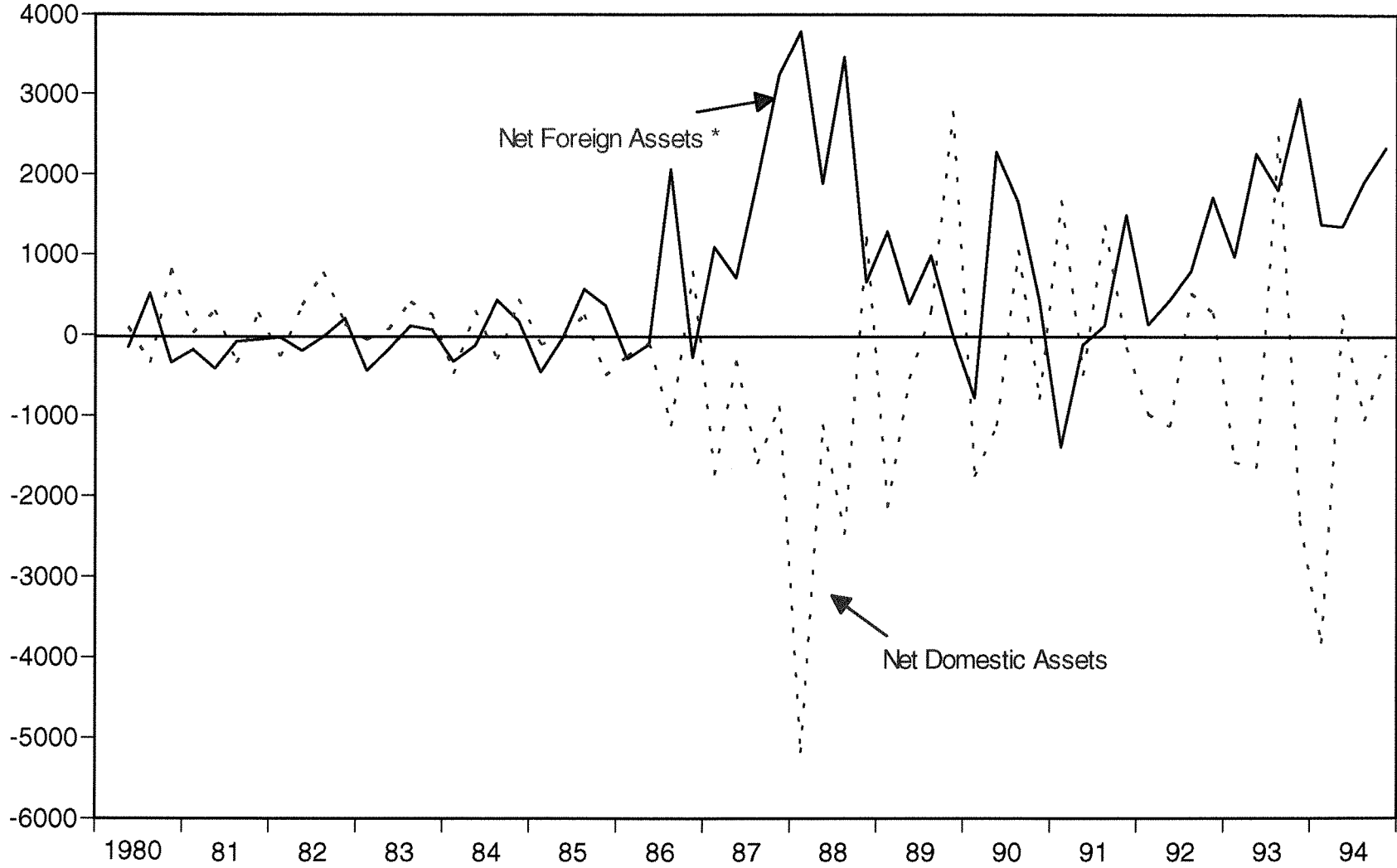
1) t-statics are in parentheses.

2) The columns of Δ NFA(1) and Δ NFA(2) represent estimated coefficients of Δ NFA when the dependent variable is $\Delta B - \Delta$ TNFA and $\Delta B - \Delta$ NFA - Δ RR respectively.

(Graph 5): The Bank of Korea: Changes in Domestic and Foreign Assets

Quarterly Data

Billions of Won



* Foreign currency deposits at domestic banks by the Bank of Korea is included.

All the coefficients have the expected signs. The estimation results provide strong evidence that the Bank of Korea pursued a policy of systematic sterilization as easily seen in graph 4. During the period of balance of payments deficit mostly from 1980 to 1985, over-sterilization policies were pursued. They were intended to support the economic growth by a rapid increase in domestic credit even though tight monetary policies were necessary to combat the balance of payment imbalance. During the surplus period, active sterilization policies were practiced to reduce the inflation pressure accelerated by the surge in money supply from the foreign sector. In addition to this, the extent to which the Bank of Korea attempted to sterilize the increase in foreign reserves is compared between during the period of current account surplus and the recent period of capital account surplus using a dummy variable.

$$\Delta NDA_t = 285.7 - 0.516 \Delta NFA_t - 0.219 \Delta(NFA \cdot D)_t + 0.341 \text{BUDDEFT}_t +$$

(0.687) (5.013) (1.942) (4.786)

$$28.51 q_{t-1} \text{REER}_{t-1} - 811.86 q_{t-1} \text{GIPI}_{t-2} - 771.9 S1 + 31.13 S2 + 191.1 S3$$

(1.316) (2.161) (1.177) (0.100) (0.297)

$$R^2 = 0.780, \text{ DW} = 2.228, \rho = -0.570$$

The above result shows that the Bank of Korea pursued more active sterilization policies during the period of current account surplus in the late 1980s than recent period of capital account surplus. This result can be explained by the facts that during recent period (1) sterilization policy instruments such as monetary stabilization bond which were most frequently used are severely limited due to the burden of interest payments (2) exchange rates are becoming more flexible

enough to absorb the external monetary disturbances (3) changes in foreign reserves are more frequent so that it is hard to neutralize them effectively and consistently.

V. Conclusion

Under the exchange rate constraints, the more effective the capital controls and the more active the sterilization policies are, the more effectively a central bank can control money supply. This paper applied two traditional empirical approaches to investigate how effectively Korea managed to control money supply in response to the changes in foreign reserves since 1980s. One is to estimate offset coefficients which measure the effectiveness of capital controls and the other is to estimate sterilization coefficients which inform how actively the monetary policies are directed to offset the changes in foreign reserves to keep money supply under control.

The estimation results are as follows. Since Korea undertook capital controls strictly and effectively, only some of capital transactions such as trade credits and loans were able to offset domestic monetary policies to some degree. Moreover, the Bank of Korea pursued sterilization policies very actively. Particularly, sterilization was stronger and almost complete during late 1980s of huge current account surplus than early 1990s of a surge in capital flows. There were over-sterilizations during early 1980s when foreign reserves kept dropping, which implied that monetary policies were directed to worsening the balance of payments deficit rather than improving it.

Since 1990s the interest rates and capital transactions has been deregulated very rapidly in Korea, it is essential for Korea to move quickly toward more flexible exchange rate system to maintain controlling money supply to a desirable extent.

Appendix I

Derivation of reduced-form capital flow equation

Suppose that there are four financial assets in a small open economy; money, government bond, foreign financial assets, and other domestic financial assets owned by foreigners. And this economy is composed of three sectors i.e, government, private sector, and foreign sector. The government sector includes the central bank, while the banking sector is a part of the private sector. This economy undertakes capital control which limits the kind and amount of financial assets that private sector obtains and supplies abroad. Thus, it is assumed that the private sector is allowed to own some portion(α_t)of the amount of foreign assets that otherwise they would have, and to supply some portion(β_t) of domestic financial assets that otherwise they would supply. Besides, foreigners are not allowed to own domestic currency and government bond, but can own equity and claims on loans such as bank loans, trade credits, commercial loans, and so on. Then the general equilibrium portfolio balance model of this economy is expressed as follows.

The demand for reserve base is given by

$$M_d = pL(I, y, W) \quad (1)$$

The demand for government bond (B^G) is

$$B_d^G = F(I, y, W) \quad (2)$$

The realized demand for foreign financial assets(B^*) is

$$B^*_d = \alpha J(I, I^* + E, y, W) \quad (3)$$

The realized supply of domestic financial assets to foreigners(B^F) is

$$B^F_s = \beta H(I, I^* + E, y) \quad (4)$$

Here, M is reserve base, I is domestic interest rate, p is domestic price, I^* is foreign interest rate, E is expected rate of depreciation, y is domestic real income, and W is domestic nominal wealth. In addition, we have four identity equations to complete the model.

$$M_s = NFA + NDA \quad (5)$$

$$\Delta NFA = TC + CA \quad (6)$$

$$TC = \Delta B^F_s - \Delta B^*_d - k(TB) \quad (7)$$

$$W = M + B^G + B^* \quad (8)$$

Here, NFA is net foreign asset of the central bank, NDA is net domestic asset of the central bank, TC is capital inflow, CA is current account surplus and k which is a function of trade account surplus (TB) is trade -connected capital flows such as trade credits, advances under red-clause L/C , and so on. Assuming infinity elasticity of foreign demand for domestic financial assets, we get to the following reduced-form capital inflow equation through comparative static

analysis with equilibrium conditions in each asset market.

$$\Delta i = \frac{1}{L_i - \beta H_i + \alpha J_i} \Delta NDA + \frac{1}{L_i - \beta H_i + \alpha J_i} CA + \frac{\beta H_{i^*+E} - \alpha J_{i^*+E}}{L_i - \beta H_i + \alpha J_i} \Delta(i^* + E) - \frac{L_y + \alpha J_y}{L_i - \beta H_i + \alpha J_i} \Delta y - \frac{\alpha J_w + L_w}{L_i - \beta H_i + \alpha J_i} \Delta W + \frac{(\Delta \beta H - \Delta \alpha J) - k}{L_i - \beta H_i + \alpha J_i}$$

$$TC = \frac{\beta H_i - \alpha J_i}{L_i - \beta H_i + \alpha J_i} \Delta NDA + \frac{\beta H_i - \alpha J_i}{L_i - \beta H_i + \alpha J_i} CA + \frac{(\beta H_{i^*+E} - \alpha J_{i^*+E})(\beta H_i - \alpha J_i)}{L_i - \beta H_i + \alpha J_i} \Delta(i^* + E) - \left[\frac{(L_y + \alpha J_y)(\beta H_i - \alpha J_i)}{L_i - \beta H_i + \alpha J_i} + J_y \right] \Delta y - \left[\frac{\alpha J_w + L_w}{L_i - \beta H_i + \alpha J_i} + J_w \right] \Delta W + \frac{L_i}{L_i - \beta H_i + \alpha J_i} (\Delta \beta H - \Delta \alpha J) - \frac{L_i}{L_i - \beta H_i + \alpha J_i} k$$

The capital flow equation derived above shows that capital transactions are motivated by domestic monetary policy (ΔNDA), current account situation (CA), portfolio behavior of the private sector ($\Delta(I^* + E)$, Δy , ΔW), capital market liberalization ($\Delta \beta H - \Delta \alpha J$), and trade.

Appendix 2

Notes on the data

This appendix describes the data series underlying the estimates presented in this paper.

We employ the following abbreviations:

MBBOK = Monthly Bulletin of the Bank of Korea

IFS = International Finance Statistics

FFK = Flows of Funds in Korea

(1) capital flow equation

STC: surplus on short-term capital account, in millions of dollars. Source:MBBOK

LTC: surplus on long-term capital account, in millions of dollars. Source:MBBOK

ERR: errors and omissions, in millions of dollars. Source: MBBOK

CA: current account surplus, in millions of dollars. Source:MBBOK

B : high-powered money, in billions of won. Source:MBBOK

NFA: net foreign assets of the Bank of Korea, in billions of won including DOME.

Source: MBBOK

DOME: deposit of the Bank of Korea at domestic banks in foreign currency which is counted as one of the net domestic assets of the Bank of Korea, in billions of won. Source: MBBOK.

NDA: net domestic assets of the Bank of Korea, in billions of won.

Calculated as $\Delta B - \Delta NFA$. Source:MBBOK

q: reserve requirement ratio(quarterly average). Source:MBBOK

L: total deposits of deposit money banks, in billions of won(quarterly average).

Source: MBBOK

ΔRR : change in reserve requirements. Calculated as $(q_t - q_{t-1}) * L_{t-1}$

I^* : London Interbank Offer Rates on US dollar deposits(3 month maturity). Source: IFS

E : expected depreciation rate of won. Generated from the following estimated equation. Source:MBBOK

$$E = 0.004 - 0.512 CA/B_{-1} \quad R^2 = 0.526, \quad DW = 1.828$$

(2.29) (7.89)

y : real Gross National Product in billions of won(1985=100) Source: MBBOK

W : nominal wealth in billions of won. The series is the sum of government bonds, money(M_2) and foreign asset owned by private sector including banking sector.
Source: FFK

(2) monetary policy reaction function

BUDDEFT: government budget deficit, in billions of won. Source:MBBOK

GIPI: growth rate of industrial production during the previous quarter. Calculated using industrial production index in Korea(1990=100). Source: MBBOK

REER: real effective exchange rate index in Korea(1985=100). Calculated based on exchange rates and CPIs of seven major trading partners(U.S., Japan, England, Germany, Canada, Singapore, Taiwan).

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