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The Korean Crisis : Before and After

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The Effect of Monetary Policy in Exchange Rate Stabilization in Post-Crisis Korea

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I. Introduction

The outbreak of the currency crisis in Asia raised many questions to economists. A main question was, naturally, what was the major cause of the crisis and whether it was predictable.

An equally important question, which we consider here, is whether the policy response was effective: once the stabilization programs were executed and the economic crisis deepened, the macro-policy stance became an important subject for debate. In conformity with the recommendation of the IMF, tight monetary and fiscal policies were followed. Many economists criticized this traditional approach because most Asian countries, unlike Latin American countries, had maintained sound macro-stability in terms of inflation and government budget deficits. Sachs (1997, p.2) was a forerunner in this line of criticism:

The region does not need wanton budget cutting, credit tightening and emergency bank closures. It needs stable or even slightly expansionary monetary and fiscal policies to counterbalance the decline in foreign loans. Interest rates will drift higher as foreign investors withdraw their money, but those rates do not need to be artificially jacked up by a squeeze of domestic credit.

In spite of this criticism, the IMF prevailed upon the crisis countries to sharply raise call rates, largely with the goal of slowing or stopping exchange rate depreciation. Stressing the intention that the high interest rate policy would be maintained only temporarily, Fischer (Fischer (1998, p.4)) expresses the IMF's view as follows:

By the time these countries approached the IMF, the value of their currencies was plummeting, and in the case of Thailand and Korea, reserves were perilously low..... To reverse this process, countries have to make it more attractive to hold domestic currency, and that means temporarily raising interest rates, even if this complicates the situation of weak banks and corporations. .... Once confidence is restored, interest rates should return to more normal levels.

Yet, the criticism did not subside, and some economists even cast doubt on the basic presumption that a high interest rate policy helps stabilize the exchange rate. For example, Furman and Stiglitz (1988) argue that a temporary increase in interest rates can, at best, stabilize the exchange rate temporarily only under stable environments. In countries with unstable financial environments, they further argue, the temporary increase in interest rates could possibly endanger the currency values not only temporarily but also long term by increasing default probability and uncertainty about the future.

The debate gradually subsided after interest rates were lowered and the economies began to recover. To our knowledge, however, there has been no attempt to systematically assess the high interest rate policy in the Asian countries. As a first step, therefore, this paper examines whether the high interest rate policy was indeed effective in stabilizing the exchange rate in Korea, a core country of the Asian crisis for which the high interest rate policy was applied.

We use the daily data on call rate, the won/dollar exchange rate and other variables in the floating period, December 17, 1997 - June 30, 1999. Our key finding is that increases in interest rates are associated with exchange rate appreciation. The daily elasticity is about 1. This result holds both in single equation regressions that control for risk variables such as the bankruptcy rate, and in vector autoregressions. We also find that the major variable driving the stabilization of the financial market in general was the ratio of short-term external debt to reserves, a measure of foreign currency liquidity. Decreases in this ratio seem to account for most of the appreciation of the exchange rate as well as the fall in the call rate that occurred in our sample.

The paper is organized as follows. Section II briefly explains the trends of the relevant financial variables right before and after the crisis. Section III provides an analytic framework to understand the essence of the debate on the relationship between the interest rate and the exchange rate. Section IV presents various regressions whose specifications are motivated by section 3's framework. Section V adds discussion on broader issues regarding the interest rate policy after the crisis in Korea. Section VI concludes.

II. Trends of Financial Variables

Rapid growth of the Korean economy had long hidden vulnerable financial structures. Financial leverage was high and the corporate sector's profit margin low (see Nam et. al. (1998) for example). As the economy entered a recession in 1996, many large conglomerates with fragile financial structures began to go bankrupt and financial markets were trembling.

In July 1997, the currency crisis broke out in Thailand, and its adverse effects rapidly reached the Korean economy. The Korean exchange rate was depreciating (see <Figure 1>) and interest rates were rising (see <Figure 2>). As the credit market was tightened, the bankruptcy rate was increasing (see <Figure 3>), and nonperforming loans were accumulating at explosive rates. Credit ratings of major banks were downgraded, and foreign investors were losing their confidence about the Korean economy. As an indicator of the diminishing confidence of foreign investors, <Figure 4> shows that the risk premium of the dollar denominated KDB (Korean Development Bank) bond over the US Treasury bond rose above 1 percent. As foreign investors squeezed credit lines to the Korean market, the exchange rate faced further depreciation pressures. Under the policy goal of "gradual" depreciation, however, the Korean government often intervened in the foreign exchange market, losing foreign reserves (see <Figure 5>).

In October 1997, currency speculators attacked Hong Kong, and Asian financial markets became even more unstable. As the Korean government kept attempting to defend the currency value, it was widely expected that foreign reserves would be depleted soon. At the same time, the suspicion was rapidly growing that if the debt of off-shore branches were included the size of short-term external liabilities should be far larger than the official statistics (following the IBRD standard) of around $68 billion.

The daily bandwidth on the exchange rate was widened from 2.5 to 10 percent on November 20, 1997. The next day, November 21, 1997, the Korean government finally asked for IMF support. The daily band on the exchange rate fluctuation was completely abolished and the exchange rate system moved into a free floating system from December 17, 1997. After the IMF program started, the Korean government confirmed the suspicion that external liabilities were understated and changed the official statistics to include off-shore liabilities of Korean financial institution's branches. <Figure 5> shows two series of short-term external liabilities, one following the IBRD standard and the other following the IMF standard. According to the new statistics, short-term debt amounted to around $100 billion before the crisis; as depicted in <Figure 6>, this was approximately three times as large as the foreign reserves at that time. The exchange rate kept rising up to 1,860 won/dollar on December 24, 1997, and the monetary authority raised the call rate to over 30 percent from around 20-23 percent. The exchange rate stopped depreciating further, although volatility was still huge.

In February 1998, the Korean government started to bargain with foreign creditors to restructure about $20 billion dollars of short-term private debts into long-term debts with government guarantees. This restructuring was completed successfully, and the Korean economy obtained some breathing space in the foreign exchange market. As domestic demand collapsed by almost 20 percent, the current account was running huge surplus (over 12 percent of GDP in 1998) and foreign reserves kept growing. As a result, the exchange rate has been stabilized in terms of the level as well as volatility. As the exchange rate was stabilized down to 1,200-1,250 won/dollar in July 1999, monetary policy continued to be eased and the call rate was lowered to 10 percent by the end of July.

In August 1998, the Russian moratorium and subsequent currency crisis of Brazil hit the international capital market, and the risk premium of the KDB bond surged to around 10 percent. The exchange rate depreciated to over 1,300 won/dollar again, but this time the call rate continued to be lowered. As the turmoil in the international capital market gradually subsided, both the risk premium and the exchange rate were stabilized. In mid-1999, the call rate went below 5 percent, the lowest level in the Korean history, and the exchange rate fluctuated around 1,200 won/dollar.

III. Debate on Theoretical Justification of High Interest Rate Policy

In accordance with the views of the IMF, the sharp rise of the call rate in December 1997 was intended in large part to slow or stop the depreciation of the won. One simple way to express this view analytically is with *uncovered interest parity*. Let i_t and i_t^* be the net nominal interest rates on Korean and foreign, say U.S., bonds. Let e_t be the logarithm of the won/dollar rate; as in <Figure 1>, a higher value of e_t means a depreciated currency. Then the net return from converting 1 won into dollars, getting return $1+i_t^*$, and converting back into won is approximately $i_t^*+e_{t+1}-e_t$. If exchange rate speculators are risk neutral and the bonds are default-free, speculators should expect to make the same return whether they invest in the Korean or U.S. bond. This means

$$i_t^* + E_t e_{t+1} - e_t = i_t, \quad (3.1)$$

where E_t denotes expectations. Rearranging, we have

$$e_t = i_t^* + E_t e_{t+1} - i_t. \quad (3.2)$$

If we hold i_t^* and $E_t e_{t+1}$ fixed, increases in the domestic interest rate i_t quite evidently are associated with declines, that is appreciation, of e_t. The foreign interest rate i_t^* arguably does not vary with the Korean interest rate i_t. The same cannot be said of the expected exchange rate $E_t e_{t+1}$. But if increases in i_t increase confidence that the exchange rate will stabilize (see Fischer's statement in the Introduction), then increases i_t will cause $E_t e_{t+1}$ to fall, thus reinforcing the effects that result when $E_t e_{t+1}$ is held fixed.

Uncovered interest parity is simple and appealing, but it may not suitably capture the movement in exchange rates. One well-known problem is that speculators apparently are not risk neutral; there is a risk premium, call it v_t, associated with attempting to arbitrage differences in expected returns in Korean and U.S. debt. A second problem, applicable to Korea though probably not developed countries, is that even government debt might not have been perceived as nominally riskless. If the probability of complete default is thought to be say δ_t, then the expected return on a Korean bond is $(1-\delta_t)(1+i_t) \cong 1+i_t-\delta_t$, i.e., the net expected return is about $i_t-\delta_t$. After accounting for both a risk premium and possible default, (3.2) becomes

$$e_t + i_t = i_t^* + E_t e_{t+1} + \delta_t + v_t. \quad (3.3)$$

of course, complete default may seem extreme. But delaying payment of principal or interest was surely a reasonable possibility, and such considerations also lead to an expression like (3.3).

Furman and Stiglitz (1998, p.75) argue that in countries with currency crises, such as Korea, both the default probability δ_t, and the risk premium v_t are increasing functions of the domestic interest rate i_t. A direct reason for this is the presence of unhedged foreign debt. As well, since increases in i_t lead to increases in corporate borrowing cost, businesses will find it difficult to finance operations, and some may even go bankrupt. If this is expected to cause strains on the economy as a whole, speculators may doubt the government's ability to repay and hence δ_t, and v_t will rise. This possibility may have been large particularly in Korea because the government guaranteed most of bank deposits right after the outbreak of the crisis and the accumulated burden of non-performing loans in the banking sector was almost entirely transferred to the government.

We see from (3.3) that if δ_t, and v_t are increasing in i_t, the effect of increases in it are ambiguous, even if we accept the view that $E_t e_{t+1}$ is a decreasing function of i_t. Panel data studies yield mixed evidence on whether increases in interest rates stabilize an exchange rate during a currency crisis. For example, Goldfajn and Gupta (1999) consider currency crises in 80 countries, 1980-98. They find that, on average, and consistent with the IMF's view, dramatic increases in real interest rates have been associated with currency appreciations. But when they focus on a subsample that endured a banking crisis along with a currency crises, the evidence is mixed. Since Korea is exactly such a country, it is an open question whether the interest rate policy stabilized the exchange rate.

IV. Empirical Results

1. Overview

The first three subsections below present single equation regression results for the log of the exchange rate (*LEXCH*), the level of which is plotted in <Figure 1>; the difference in yields between dollar denominated KDB bonds and U.S. Treasury bonds (*SPREAD*), which is plotted in <Figure 4>; and the call rate (*CALL*), which is plotted in <Figure 2>. Subsection 4.5 presents results for a four variable system that includes these variables as well as the ratio of short-term debt to reserves (*ILLIQ*), the variable plotted in <Figure 6>.

All variables are daily (five days per week) and are entered in percentage terms. We used daily data because decisions about interest rate policy were made on a day to day basis right after the crisis. When the policy depends on the variations of endogenous variables, the use of high frequency data may help reduce the simultaneity bias. We do, of course, pay the usual price of not having daily observations on many important variables (for example, reserves and debt: we construct daily values of *ILLIQ* by linearly interpolating the numerator and denominator).

We began by checking stationarity of the variables, and found that it seems advisable to take all the variables except the bankruptcy rate (*BNKRP*) as series with unit autoregressive roots (details available on request). Therefore, our regressions were performed with first-differenced data. We also checked whether there is a structural break in the regressions at 12/17/97 (the date when the complete floating exchange rate system began) and found strong evidence for a break (details available on request). Hence, we report the regression results for the sample period

from 12/17/97 to 6/30/99. In fact, the interest rate policy was not used to stabilize the exchange rate before 12/17/97, and thus analyses for the post-floating data seem to be more relevant to the purpose of this paper.

Throughout this paper's empirical analyses, we also modeled the contemporaneous daily correlation among variables under an assumption of a recursive causal ordering. First, variables determined outside Korea, such as the LIBOR and the yen/dollar exchange rate, are predetermined relative to Korean variables. As predetermined variables, their contemporaneous values are entered on the right hand side of the regressions below. Second, the sizes of the short term external debt and foreign currency reserves (and hence *ILLIQ*, the ratio of debt to reserves) are considered predetermined. Third, the monetary authority determines the call rate day by day, taking as given the current values of the predetermined variables and, of course, lags of all variables. Fourth, risk factors such as Korea's risk premium are determined in light of the call rate and all the predetermined variables (and, of course, lagged variables). Finally, the exchange rate is determined, responding to the contemporaneous values of all these variables (and their lags).

2. Determinants of the Exchange Rate: Single Regression Equation

Some single equation regression results for the exchange rate are reported in <Table 1>. The effect of the call rate (*CALL*) is statistically significant and robust across various specifications. This result is rather surprising, given that the levels of the two variables are positively correlated with high significance. Probably, changes in a third factor contributed to the stabilization of both the call rate and the exchange rate, while the negative correlation between the two variables was maintained. Such a possibility is

<Table 1> **Regressions of the Exchange Rate**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CONST	-0.100	-0.092	-0.183	0.000	0.050	-0.090	-0.098
	(0.101)	(0.100)	(0.141)	(0.116)	(0.120)	(0.146)	(0.146)
ΔCALL	-1.180**	-1.158**	-1.172**	-1.196**	-1.202**	-1.214**	-1.210**
	(0.166)	(0.164)	(0.164)	(0.165)	(0.164)	(0.169)	(0.170)
ΔSPREAD		1.085**	1.036**	1.050**	1.072**	1.021**	1.036**
		(0.343)	(0.348)	(0.343)	(0.342)	(0.351)	(0.352)
BNKRP			0.270			0.503	0.518
			(0.295)			(0.307)	(0.308)
ΔILLIQ				0.141			
				(0.893)			
Δ(-20)ILLIQ					0.011**	0.013**	0.013**
					(0.005)	(0.005)	(0.005)
ΔLEXCH(-1)						-0.030	-0.032
						(0.041)	(0.416)
ΔLIBOR							-0.024
							(0.022)
ΔLYEN							0.090
							(0.086)
R^2	0.120	0.143	0.146	0.149	0.153	0.160	0.166
DW	1.830	1.861	1.874	1.865	1.883	1.886	1.892

Notes : 1) The dependent variable is the log difference of the won/dollar exchange rate, *ΔLEXCH*.

2) *Δ* denotes first difference and the definitions of variables are as follows: *CALL* the call rate; *SPREAD* the risk premium on the dollar denominated KDB bond over the US Treasury bond rate; *BNKRP* the domestic bankruptcy rate; *ILLIQ* the ratio of short-term debt to reserves; *Δ(-20)ILLIQ* the difference of *ILLIQ* at time *t* and *ILLIQ* at time *t*-20; *LIBOR* the 1-month *LIBOR* rate; *LYEN* the log of the yen/dollar exchange rate.

3) All variables are expressed in percent.

4) ** denotes an estimate significant at the 1 percent level, * an estimate significant at the 5 percent level.

suggested by the estimate of the constant drift, 0.1 percent per day (37 percent during the sample period), although this estimate is not statistically significant.

In fact, country risk can be a good candidate for such a third factor. When a country's risk is lowered, either the exchange rate

or the interest rate, or both, can be lowered according to equation (3.3). We considered three variables that can measure the risk of Korea: (i) the risk premium on the dollar denominated KDB bond over the US Treasury bond rate (*SPREAD*), (ii) the domestic bankruptcy rate (*BNKRP*), and (iii) the ratio of short-term debt to reserves (*ILLIQ*). While *SPREAD* is expected to measure the perception of international investors about long-term risk in Korea, both *BNKRP* and *ILLIQ* are expected to capture short-term default risks. In particular, BNKRP is supposed to proxy the default risk in domestic currency, while *ILLIQ* measures the risk associated with the currency convertibility. For *ILLIQ*, the actual values were announced only once (short-term debt) or twice (reserves, after the IMF agreement), and we linearly interpolated to obtain a daily series.

First, the effect of *SPREAD* appears to be significant and robust. In addition, the coefficient estimate is positive, as predicted by the theory. In contrast, *BNKRP* and *ILLIQ* appear to be insignificant. Regarding *ILLIQ*, however, because we obtained the daily series by interpolation, the first difference of this variable is almost constant for each month. For this reason, we also tried the difference between *ILLIQ* today and *ILLIQ* a month ago, so that this variable contains at least one change in the actual information. In our data set, the average number of sample points a month is 20. Using this 20-day difference variable, *ILLIQ* is statistically significant. The size of the coefficient estimate appears to be slightly larger than 1/20 of the estimate for the 1-day difference variable. These results seem to suggest that *ILLIQ* affects the exchange rate at a lower frequency than the daily frequency (this argument will be elaborated in Subsection 4.5). In relation to the aforementioned constant term that is estimated to be almost zero, this variable appears to capture the secular decline of the exchange rate during the sample period.

In order to check impacts of omitted variables, we also experimented with two variables, the short-term *LIBOR* and the yen/dollar exchange rate. Both variables are statistically insignificant. We also included one-day lagged variables, one by one, for all of the explanatory variables (details available on request). Only the lagged variable of *CALL* is significant with another negative sign, and the yen/dollar exchange rate is significant at a 10 percent significance level.

Let us gauge the magnitude of the coefficient estimates in the context of the Korea's crisis, under the admittedly debatable assumption that we can take the estimates in <Table 1> as structural. Recall that Korea's exchange rate depreciated by about 80 percent (from about 1000 to about 1800 won/dollar) during December 1997. The interest rate elasticity of 1.2 in <Table 1> implies that call rates would have to be raised by more than 60 percent (that is, from about 12 to over 70 percent) to pull the exchange rate to the pre-crisis level. A more serious problem with this policy is that the call rate would have to have been permanently maintained at that level to sustain the exchange rate stability, unless other factors change in the directions to stabilize the exchange rate in the mean time.

In practice, the monetary authority raised the call rate by around 20 percent (30 percent minus the pre-crisis level of 12 percent); this partially offset the 80 percent depreciation leaving a net depreciation of approximately 50 percent (say, to around 1,500 won/dollar from the pre-crisis level of 1,000). While the interest rate was maintained at a high level, the Korean government hurried to announce comprehensive economic restructuring plans to recover investor confidence (in order to lower *SPREAD*). At the same time, the government tried to rapidly recover foreign reserves and restructure short-term foreign debts into long-term debts (in order to lower *ILLIQ*).

As for the magnitudes of the effects from the risk factors, most of the exchange rate stabilization can be attributed to the foreign currency liquidity recovery. Taking the daily exchange rate elasticity with respect to *ILLIQ* to be 0.14, the decline of *ILLIQ*

approximately from 300 to 50 percent during the sample period "explains" 35 percent of appreciation of the exchange rate, say from 1,800 to 1,200 won/dollar. In particular, this variable declined rapidly in the initial period of the crisis, contributing to the early stabilization of the exchange rate.

SPREAD (fluctuating between 2 to 10 percent) accounts for less than 10 percent of the exchange rate movement. However, the fluctuation of the exchange rate right after the Russian moratorium, say from August to November 1998, appears to be mostly attributable to this variable. The direct effect of *BNKRP* (fluctuating below 3 percent for the most period of time) on the exchange rate appears insignificant both statistically and economically.

3. Determinants of the Risk Premium: Possibility of Perverse Effects

Although the high interest rate policy appears to have appreciated the contemporaneous exchange rate, it may have generated perverse effects by increasing the risk factors as Furman and Stiglitz (1998) argue. We explore this possibility in this subsection. The proxies for risk factors are *SPREAD*, *BNKRP* and *ILLIQ*. We present regression results for *SPREAD*. We briefly summarize results for *BNKRP*, omitting details because this variable does not appear to be significant in explaining the exchange rate. Finally, we do not analyze *ILLIQ* at all, not only because its actual data frequency is monthly (or bi-monthly), but also because this variable was determined by independent policy efforts.

<Table 2> shows some regression results of *SPREAD*, with the choice of what variables to include contemporaneously once again consistent with the causal ordering described in section 4.1 and our VAR specification given below. A key result is that the estimated coefficient on the call rate is small, suggesting that the high interest rate policy did not have a substantial direct effect on

<Table 2> Regressions of the Risk Premium

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CONST	-0.007	-0.004	-0.048*	-0.035	-0.040	-0.035	-0.034
	(0.151)	(0.015)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
ΔCALL	-0.020		-0.043	-0.055*	-0.048	-0.057*	-0.057*
	(0.025)		(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
ΔLEXCH(-1)		0.019**	0.020**	0.021**	0.020**	0.019**	0.018**
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
BNKRP			0.125**	0.159**	0.142**	0.155**	0.157**
			(0.043)	(0.045)	(0.045)	(0.045)	(0.045)
ΔILLIQ				0.035*		0.034*	0.034*
				(0.014)		(0.014)	(0.014)
$\Delta_{(-20)}$*ILLIQ*					0.001		
					(0.0008)		
ΔSPREAD(-1)						0.074	0.072
						(0.051)	(0.051)
ΔLIBOR							0.373
							(0.326)
ΔLYEN							0.008
							(0.013)
R^2	0.002	0.026	0.053	0.070	0.058	0.075	0.080
DW	1.773	1.859	1.870	1.906	1.879	2.023	2.029

Notes : 1) The dependent variable is the difference between the yields on dollar denominated Korean bonds (KDB) and U.S. Treasury bonds, *ΔSPREAD*.
2) See note 2 to Table 1 for data definitions.
3) All variables are expressed in percent.
4) ** denotes an estimate significant at the 1 percent level, * an estimate significant at the 5 percent level.

SPREAD. In fact, the coefficient estimate is negative in all specifications, significantly so in some. This result is rather consistent with the signaling argument that the high interest rate policy signals a serious commitment of the Korean government about painful reforms in the future. In any case, the size of the effect does not appear to be large: the coefficient estimate of about -.05 implies that an increase in the call rate of 20 percent can account for only a 1 percent decline of *SPREAD*.

Other variables appear to affect *SPREAD* more importantly.

First, the positive and significant estimate of the coefficient on the lagged exchange rate means that depreciation of the exchange rate is associated with increases in *SPREAD*. This is consistent with investors perceiving that exchange rate depreciation increases the potential risk of the Korean market, perhaps because that market is exposed to large unhedged external debts.[1] Although the size of this effect is not so large (only 1 percent decline of *SPREAD*, again, can be attributed to an appreciation of the exchange rate by 50 percent), the fact that the estimate is positive has an important implication regarding the interest rate policy effect on the exchange rate. In addition to the direct stabilization effect discussed in section 4.2, we see now that the high interest rate policy has an indirect effect: high interest rates cause exchange rate appreciation (the direct effect seen in <Table 1>), which lowers *SPREAD* (<Table 2>), which in turn further appreciates the exchange rate (<Table 1>).

Note here that we used a lagged variable of the exchange rate because we attributed (in <Table 1>) the contemporaneous correlation between the two variables to the effect of *SPREAD* on the exchange rate, not the other way around. Of course, this is an untested assumption. If the contemporaneous positive correlation is attributed to the reversed causality, however, the possibility of the perverse effects diminishes even further and the danger of the exchange rate depreciation increases.

Next, we see in <Table 2> that the bankruptcy rate also affects *SPREAD* with statistical significance. Although *BNKRP* does not appear to directly affect the exchange rate in <Table 1>, it may indirectly affect the exchange rate through the channel of *SPREAD*. In addition, if the high interest rate policy leads to the high bankruptcy rate, this indirect effect may then provide a

1. This result appears to be consistent with the recent finding of Hahm and Ryoo (1999) that the exchange rate depreciation had adverse effects on the Korean stock prices.

channel that supports the Furman and Stiglitz (1988) argument.

To investigate this possibility, we estimated equations similar to those in <Tables 1 and 2> with *BNKRP* as the dependent variable. We do not report the results in detail here because they indicated that the magnitude of this indirect effect on the exchange rate is too small to merit serious attention. Specifically, the effect of the first difference of *CALL* on *BNKRP* appears to be less than 0.1, with the statistical significance sensitive to the specification (details available upon request). In fact, this estimate of 0.1 is a large number in explaining the fluctuation of *BNKRP* itself: an increase of *CALL* by 20 percent can raise *BNKRP* by 2 percent, while *BNKRP* fluctuated only between 0 and 3 percent for the most of the sample period. However, the increase of *BNKRP* by 2 percent only raises *SPREAD* by 0.3 ($=2\times0.15$) percent and hence depreciates the exchange rate by a similar magnitude (the coefficient estimate of *SPREAD* in <Table 1> is approximately equal to one). That is, the indirect effect through these many steps can hardly be large.

To return to <Table 2>: In terms of the magnitude of effect on *SPREAD*, *ILLIQ* appears to be the most important single determinant, although this variable does not appear as significant as the exchange rate or bankruptcy rate in terms of statistical significance. The coefficient estimate of 0.035 in conjunction with the decline of *ILLIQ* from 300 to 50 percent implies the decline of *SPREAD* by almost 9 percent.

Other variables such as the *LIBOR*, the yen/dollar exchange rate and lagged variables appear to be relatively insignificant. Nevertheless, it seems worthwhile to mention that the hike of *SPREAD* around September 1998 (see <Figure 4> in section 2) cannot be explained by any variables considered in this paper. In fact, Cho and Hong (1999) argue that most of this hike can be attributable to "contagion effects" of the Russian moratorium and subsequent currency crisis of Latin America, rather than domestic factors. Therefore, there still exists a possibility of omitted variable biases, which we hope are not substantial.

In short, the regression results presented in this subsection suggest that the perverse effect of the high interest rate policy on the exchange rate was either non-existent or negligible in magnitude.

4. Determinants of the Call Rate: Endogenous Policy Reaction Function

We have so far taken the behavior of the call rate as given. As explained in the Introduction, however, the IMF recommended that the call rate be raised only temporarily until the foreign exchange market is stabilized. In this subsection, therefore, we examine whether exchange rate stabilization indeed changed the policy stance, and more broadly which variables have the strongest effects on the call rate. <Table 3> reports some regression results. Once again, the choice of what variables to include contemporaneously is consistent with the causal ordering described in section 4.1 and the other parts of this section: the monetary authority is assumed to set *CALL* based on contemporaneous information about *ILLIQ* but not *SPREAD*, *BNKRP*, or *LEXCH*.

First, the positive estimate of the coefficient on the previous day's exchange rate means that appreciation on one day tends to be followed by lower call rates the next day. This result is interesting, given that the two variables show a significantly negative correlation contemporaneously (see <Table 1>). That is, today's high interest rate tends to appreciate the exchange rate today (<Table 1>), which in turn tends to lower the interest rate next day (<Table 3>). Because the <Table 3> estimate is only about .05, however, the magnitude of this effect is small: the exchange rate appreciation by 60 percent during the sample period can rationalize a 3 percent fall in the call rate. We shall see in the next subsec-

<Table 3> Regressions of the Call Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CONST	-0.039	-0.038	-0.069	0.018	0.014	0.017	-0.034
	(0.031)	(0.031)	(0.043)	(0.036)	(0.037)	(0.036)	(0.044)
ΔLEXCH(-1)	0.050**	0.045**	0.050**	0.052**	0.050**	0.048**	0.045**
	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)
ΔSPREAD(-1)		0.151					0.101
		(0.107)					(0.108)
BNKRP			0.091				0.183
			(0.090)				(0.094)
ΔILLIQ				0.082**		0.087**	0.102**
				(0.027)		(0.027)	(0.029)
$\Delta_{(-20)}$*ILLIQ*					0.004*		
					(0.002)		
ΔCALL(-1)						-0.069	-0.081
						(0.051)	(0.051)
ΔLIBOR							0.221
							(0.684)
ΔLYEN							-0.0003
							(0.027)
R^2	0.041	0.046	0.044	0.064	0.057	0.069	0.083
DW	2.068	2.107	2.090	2.113	2.104	1.992	2.059

Notes : 1) The dependent variable is the difference of the call rate, *Δ CALL*.
2) See note 2 to Table 1 for data definitions.
3) All variables are expressed in percent.
4) ** denotes an estimate significant at the 1 percent level, * an estimate significant at the 5 percent level.

tion that the robust result is not the sign of the response but the fact that the elasticity is small in absolute value.

The most important determinant in magnitude appears to be *ILLIQ* again. The decline of *ILLIQ* by 250 percent can account for 20 percent of the decline in the call rate (with an elasticity of 0.08, see <Table 3>).

In contrast with these two variables, other variables do not appear to substantially affect the monetary authority's decision making. It seems clear that, as the IMF urged, the first priority of

the interest rate policy was the restoration of stability in the foreign exchange market.

5. Vector Error Correction Approach: Dynamic Responses

In this section we report results of estimation of a vector error correction in *CALL*, *SPREAD*, *LEXCH* and *ILLIQ*. Our aim is to trace out the dynamics implied by a system that combines equations such as the ones presented in <Tables 1 to 3>. Our conclusion is that this vector system gives answers congruent with those of the single equation estimates.

We began by testing for cointegration. Using Johansen's procedure, we rejected the null of no cointegration at the 1 percent level. With the coefficient on *LEXCH* normalized to unity, the estimated cointegrating vector was:

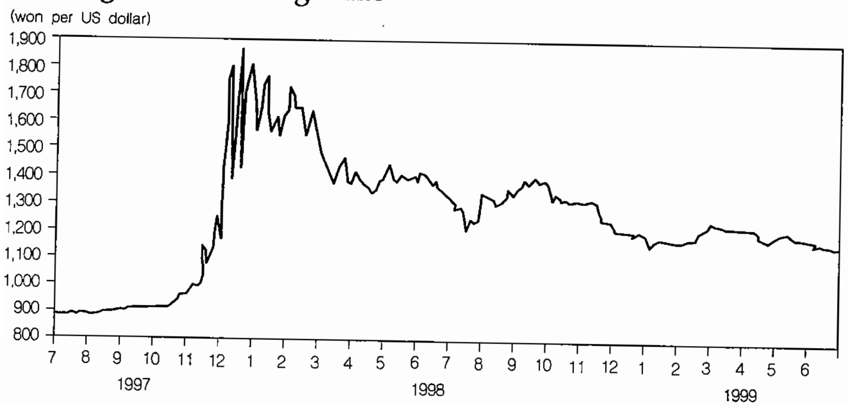
LEXCH	*ILLIQ*	*CALL*	*SPREAD*	(4.1)
1.00	-0.48	1.49	-1.67	
	(-0.19)	(1.11)	(-0.67)	

where numbers in parentheses are standard errors. Since the cointegrating combination is stationary, the error correction term

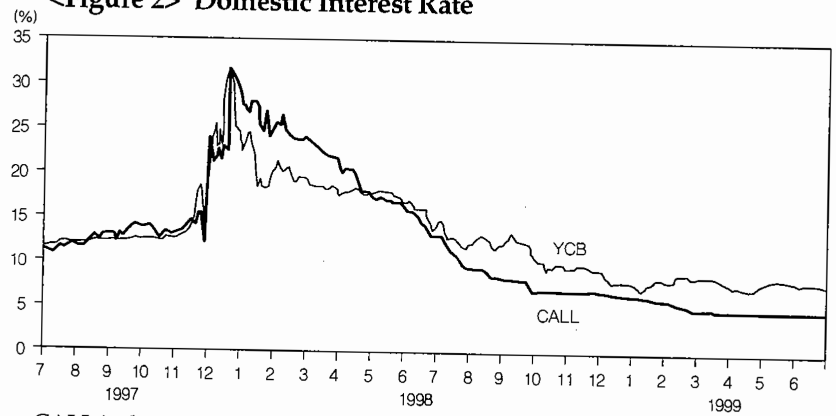
$$LEXCH - .48*ILLIQ + 1.49*CALL - 1.67*SPREAD$$

should be expected to converge to zero over time. Recall that the levels of all four variables declined during our December 1997-June 1999 sample (see <Figures 1, 2, 4 and 6>). In a mechanical sense, stationarity of the combination is then maintained by movements in *ILLIQ* and *SPREAD* (which have negative coefficients) offsetting movements in *LEXCH* and *CALL* (which have positive coefficients). Focusing on the secular movement of the exchange rate, the long-run appreciation is accounted for by the long run declines in the risk factors (or *ILLIQ* and *SPREAD*),

<Figure 1> Exchange Rate

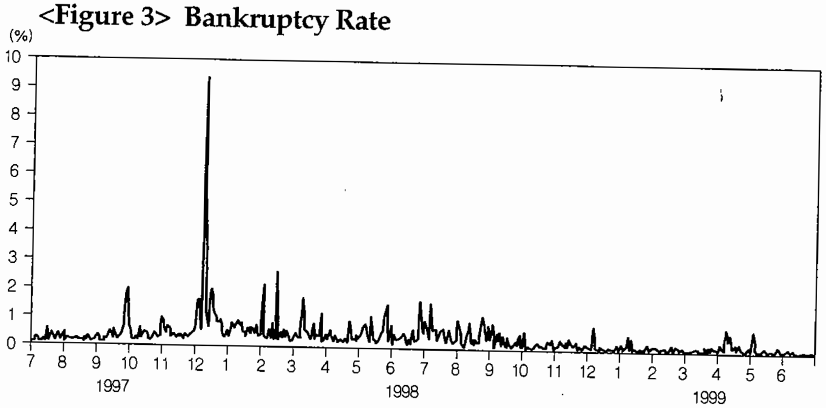


<Figure 2> Domestic Interest Rate

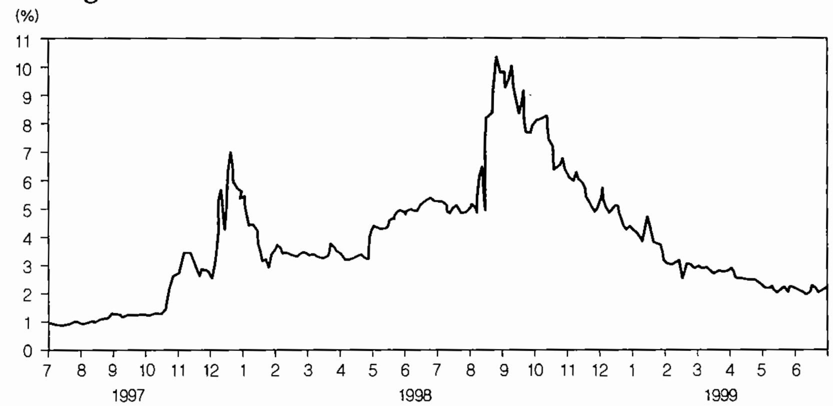


CALL is the one-day inter-bank call rate and YCB is the yield rate on three-year corporate bond.

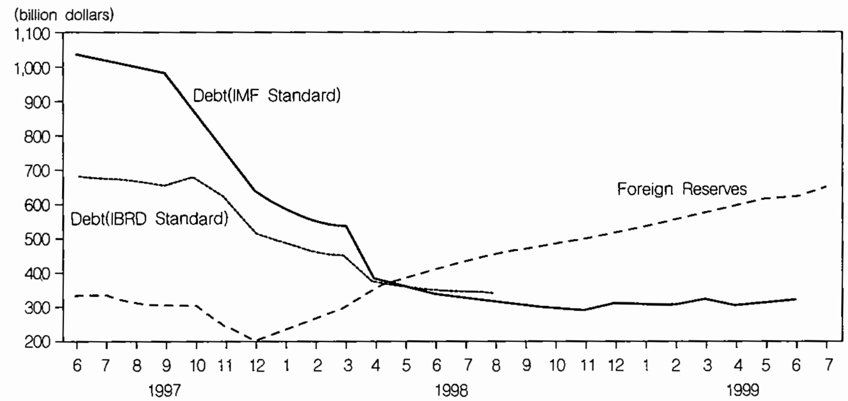
<Figure 3> Bankruptcy Rate



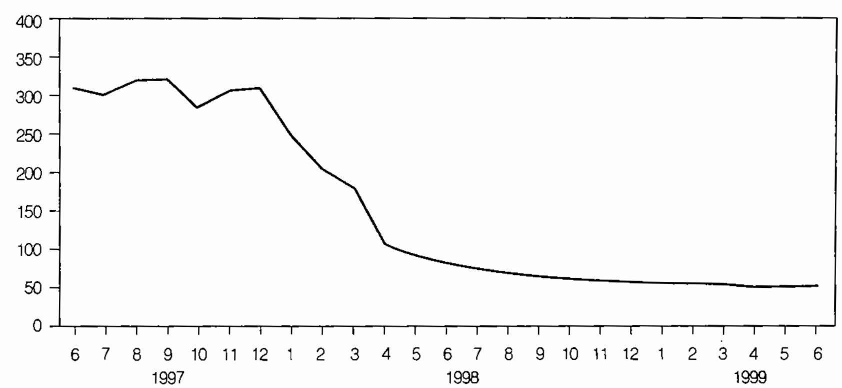
<Figure 4> Risk Premium on the KDB Bond



<Figure 5> Foreign Reserves and Short-Term External Debt



<Figure 6> Short-term External Debt as a Percentage of Foreign Reserves

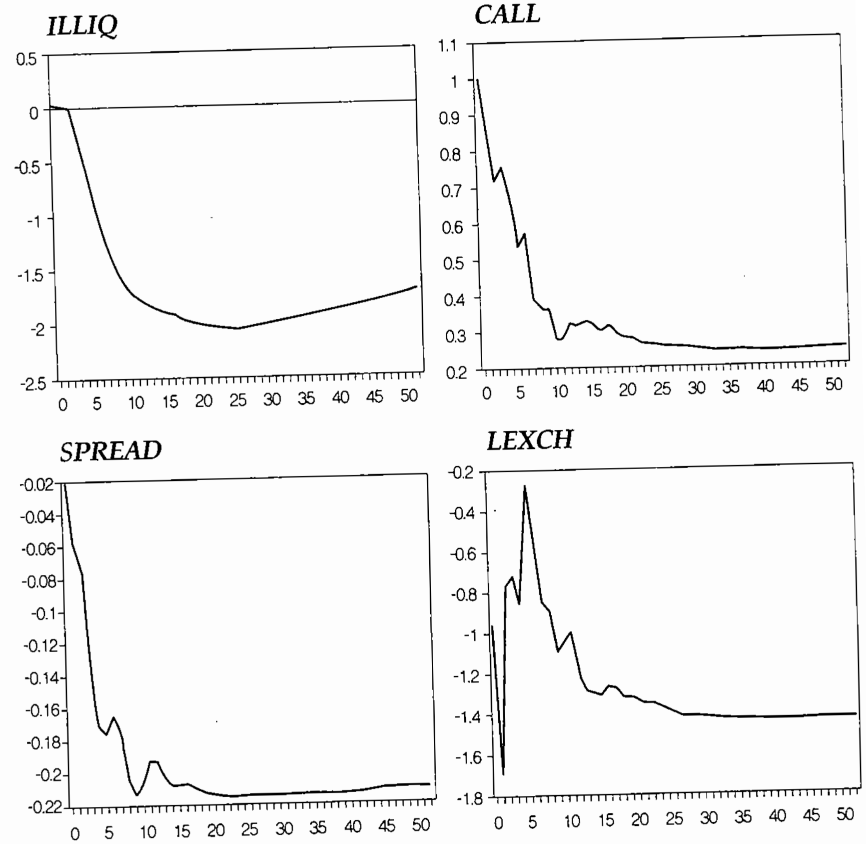


while the steady relaxation of the monetary policy (or long run decline in *CALL*) partially offset these appreciation pressures. This result is consistent with the modified version of the interest parity in Section 3 (see Eq. (3.3)) as well as the result of the single equation estimation in Subsection 4.2 (see <Table 1>). Compared with the short run elasticity estimates in <Table 1>, the coefficient estimates in this long run relationship are slightly larger.

In the dynamic system, we used the Schwartz criterion to select a lag length of five. All regressions also included the error correction term (4.2). We summarize the results by presenting selected impulse response functions of the levels (not the differences) of the variables. To compute these responses, we used a Choleski decomposition, with the variable ordering described at the beginning of this section: *ILLIQ, CALL, SPREAD, LEXCH*. We focus on the impulse responses of the variables with respect to 1 percent positive shocks to *CALL* (<Figure 7>) and *ILLIQ* (<Figure 8>). Period "0" is the contemporaneous (same day) response. Since we measure time in business days, with 5 days per week, the "50" indicates a response 10 weeks out. Note that the vertical scale on each graph is different. By construction, the responses are such that in the long run, the response of the error correction term converges to zero. As it turns out, this response effectively hits zero only after about 50 days; thus there still is considerable persistence in this system.

Let us work through <Figure 7> in detail, which describes the responses of the variables to a shock to the interest rate. This figure says that on a day when there is a 1 percent surprise increase in *CALL*, the exchange rate falls (appreciates) by about 1 percent as in <Table 1>. It then rises (depreciates) for the next several days due to the endogenous decline in *CALL* in response to the stabilized exchange rate (as in <Table 3>) as well as the mean reversion forces of *LEXCH* itself (not documented before). After 6 to 7 days, however, the effects of induced decline in both *ILLIQ* and *SPREAD* tend to outweigh the offsetting effect of the decline

<Figure 7> Responses to a 1 Percent Increase in *CALL*



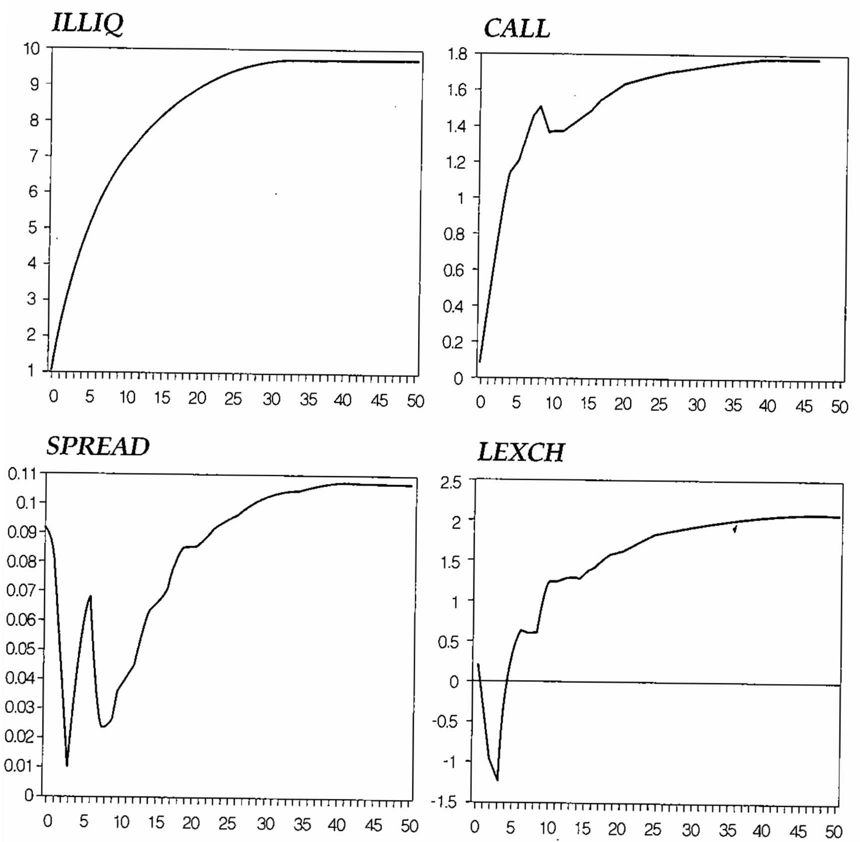
in *CALL*.[2] Eventually exchange rate appreciation levels off at around 1.5 percent.

2. A natural question that arises here is the extent to which *ILLIQ* was affected by (the lagged values of) other variables such as *CALL* or determined by completely independent policy efforts. It seems impossible to suitably answer this question in the context of this paper. But we did experiment with a system in which the estimated *ILLIQ* equation was replaced by one in which *ILLIQ* followed a random walk so that the changes in other variables would not affect *ILLIQ*. The impulse responses were qualitatively the same, but the magnitudes are reduced by a factor of around two-thirds with shorter adjustment periods.

<Figure 8> describes the responses of the system to a 1 percent increase in *ILLIQ*. Since the daily data of *ILLIQ* was constructed through interpolation, the slow adjustment of *ILLIQ* is understandable. It is also consistent with the above single equation results that both *CALL* and *LEXCH* rise in response to the increase of *ILLIQ* in the long run. A rather surprising result is that *SPREAD* is almost insensitive to *ILLIQ* (even the long run response is limited to around 0.1 percent).

All in all, we conclude that this multivariate dynamic system and the single equation estimates tell a consistent story.[3] Increases

<Figure 8> Responses to a 1 Percent Increase in *ILLIQ*



in interest rates tend to be followed by exchange rate appreciation, and the restoration of the foreign currency liquidity position contributes to the stabilization of both the interest rate and the exchange rate. Thus our results are consistent with the view that increases in interest rates are part of the policy objective of stabilizing exchange rates.

Nevertheless, issues regarding the high interest rate policy still remain. These include the question of whether the exchange rate stability ought to be the foremost objective of the monetary policy and the related question of whether the IMF's advice for the interest rate policy was then appropriate. These issues will be briefly discussed in Section V.

V. Assessment of the Interest Rate Policy in a Broader Context

So far in this paper, we have focused on the effect of the high interest rate policy on the exchange rate after the crisis. However, the goal of interest rate (or monetary) policy in general cannot be just the maintenance of exchange rate stability. An assessment of whether the policy reaction was appropriate or too contractionary should be based on analyses about broader aspects. Although a rigorous and comprehensive analysis is beyond the scope of this paper, we can present some informal and incomplete evidence that suggests to us that tight monetary policy initially was appropriate, but may have been maintained for too long.

First, there is a question about what the goal of monetary

3. One slight discrepancy between the multivariate and single equation results is that in the multivariate system, the long run response of *CALL* to a *LEXCH* shock is slightly negative (-.05% [not depicted]). The short run response is, however, positive and comparable in magnitude to that presented in Table 3.

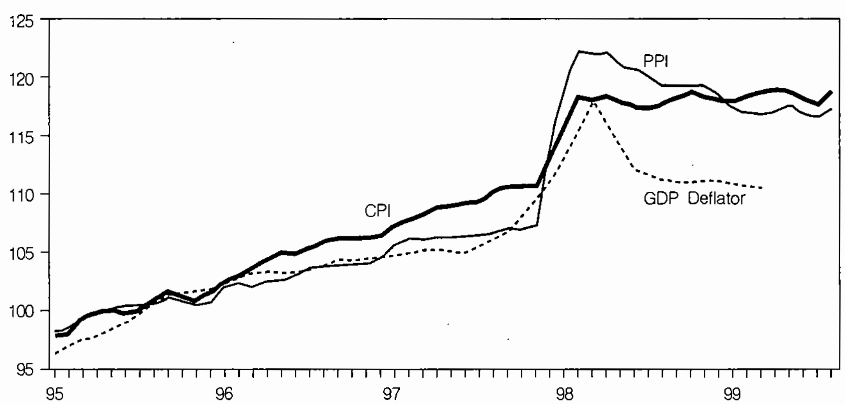
policy should be. A large literature in this field recommends the maintenance of general price stability as the long-run goal of monetary policy. In fact, the law for the Bank of Korea explicitly states that the goal of monetary policy is the maintenance of general price stability.

Under this criterion, a high interest rate policy seems necessary right after the crisis. As shown in <Figure 9>, domestic prices were rapidly rising mainly due to the imported inflation through the depreciated exchange rate. That is, the goal of domestic price stability could not be achieved without exchange rate stability.

Perhaps after April 1998, however, there was room for the monetary authority to relax the policy stance more rapidly. Consumer prices stopped rising, and producer prices started to decline as the exchange rate continued to appreciate. In fact, the GDP deflator declined to a large extent in the second quarter 1998 and stayed there since then (see <Figure 9>).

In addition, if one believes that in the short run monetary policy should consider the real side of the economy, the situation of the real side also suggests that a more relaxed stance may have been advisable. Along with the collapse of domestic demand, the

<Figure 9> Trends of Price Indices



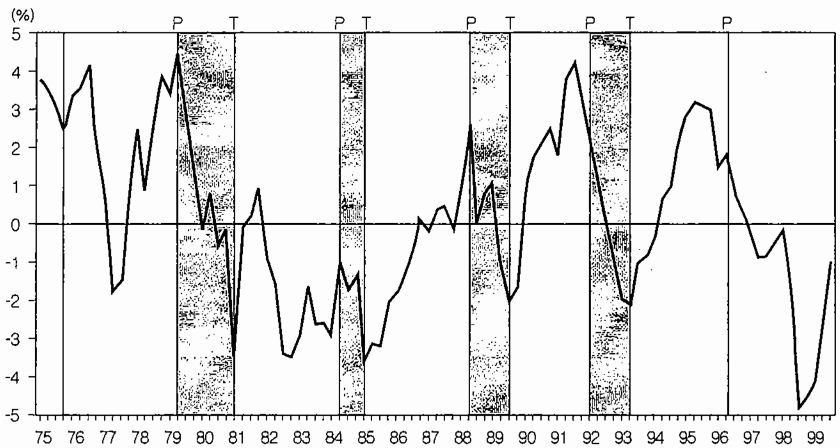
<Figure 10> Trends of Growth and Unemployment

Note : GDP growth is the growth rate of GDP relative to the same quarter of the previous year.

current account surplus was exceeding 10 percent of GDP (not shown). GDP fell by more than 7 percent in the second and third quarters 1998, compared with the levels of the same quarters in the previous year (see <Figure 10>). The rate of unemployment kept rising rapidly (see <Figure 10>), and wages continued to decline (not shown). In short, there was virtually no indicator that suggested the possibility of inflation in the medium-run. If anything, the macro-indicators suggested a possibility of deflation.

An analytical approach to this issue is to estimate the aggregate demand gap from potential output. To this end, we applied the methodology of Blanchard and Quah (1989) to the Korean data. In this approach, the supply-side shock is assumed to have a unit root while the demand-side shock is stationary. Following Kim (1996), we used the seasonally adjusted series of GDP and GDP deflator from 1974. <Figure 11> shows the estimated aggregate-demand-gap series, the GDP component that is driven by demand shocks alone. We also put peaks and troughs as officially defined by the Bureau of Statistics. According to this estimate, there was a large deflation gap (the largest in the series) in the second and third quarters of 1998, which has been rapidly dimin-

<Figure 11> Aggregate Demand Gap



ishing since then.[4] Of course, this methodology does not tell us whether the deflation gap should be attributed to the high interest rate policy or some other factors. Nevertheless, this result seems to indicate that there was room for monetary policy relaxation without endangering price stability.

Even ex post, not to mention ex ante, it is a formidable task to precisely assess the appropriateness of monetary policy. It certainly is possible, for example, that earlier loosening of monetary policy would have proved counterproductive in the long run: no matter what the short- and long-run goals of monetary policy, persuasive analysis of the appropriateness of the policy requires understanding the process by which monetary policy affects the economy. Such an analysis is beyond the scope of this paper. But our partial and informal evidence does suggest that the initial increase in interest rates was broadly appropriate, but that downward adjustment could have been faster.

4. Although the estimate of GDP gap is large from a historical point of view, this may be viewed to be small considering the magnitude of the GDP decline in that period. This implies that the model attributes a substantial part of GDP decline to a negative supply-side shock.

VI. Conclusion

This paper asks whether the high interest rate policy of the IMF was effective in stabilizing the exchange rate. Our reduced form regression results indicate that the answer is generally affirmative. Although the major driving force of the exchange rate stabilization seems to be the recovery of the foreign currency liquidity position, the high interest rate appears to have contributed to stabilizing the exchange rate until the liquidity position was recovered. According to the expression of Furman and Stiglitz (1998), the temporarily high interest rate policy seems to have "bought time" until economic fundamentals recovered. Our reduced form approach does not, however, allow us to distinguish between expectational and other effects of the high interest rate policy.

In addition, we only provide some comments, rather than rigorous empirical results, regarding a more important and broader question, whether the high interest rate policy was appropriate or too contractionary. Even supposing that the goal of the interest rate (or monetary) policy is domestic price stability instead of exchange rate stability, it seems that the high interest rate policy was inevitable right after the crisis. Perhaps after April 1999, however, there was room to relax the policy stance more rapidly. Of course, more comprehensive and rigorous analyses on this issue need to be accumulated before any conclusion is drawn. We hope that this paper has made a contribution to the literature on this issue.

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