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INTERNATIONAL RESERVES MANAGEMENT AND CAPITAL MOBILITY IN A VOLATILE WORLD: POLICY CONSIDERATIONS AND A CASE STUDY OF KOREA

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ABSTRACT

This paper characterizes the precautionary demand for international reserves driven by the attempt to reduce the incidence of costly output decline induced by sudden reversal of short-term capital flows. It validates the main predictions of the precautionary approach by investigating changes in the patterns of international reserves in Korea in the aftermath of the 1997-8 crisis. This crisis provides an interesting case study, especially because of the rapid rise in Korea's financial integration in the aftermath of the East-Asian crisis, where foreigners' shareholding has increased to 40% of total Korean market capitalization. We show that the crisis led to structural change in the hoarding of international reserves, and that the Korean monetary authority gives much greater attention to a broader notion of 'hot money,' inclusive of short-term debt and foreigners' shareholding.

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1. Introduction

The 1997-8 East Asian crisis has led to a rethinking of policy design in developing countries. Several countries in East Asia have reacted by more active management of international reserves and external debt positions, and a large build up of international liquidity. These changes were triggered by the recognition that even the "Asian Tigers" were not immune to sudden stops of short-term capital flows.[1] Countries averse to the costs of sudden stops of capital flows would tend to manage precautionary savings, in the form of international reserves. These reserves may provide a line of defense against sudden stops of capital flows. Another intriguing adjustment of several countries (including Korea) has been growing financial openness coupled with greater flexibility of the exchange rate. Figure 1 provides a vivid illustration of the remarkable opening of the Korean equity market in the aftermath of the 1997 crisis, increasing foreigners' equity position as a percentage of Korean GDP from close to 2% prior to the crisis to about 23 % within six years! The greater flexibility of the exchange rate may provide a line of defense against sudden stops of capital flows. However, the large share of foreign ownership of Korean stocks implies now that a sudden capital flow reversal exposes Korea to the risk of sharp real exchange depreciation coupled with the collapse of the Korean stock market. In these circumstances, precautionary management of international reserves may mitigate these risks. Such observations are consistent with Figures 1-2: in the aftermath of the crisis, the international reserves/GDP ratio increased sizably, reaching the ratio of the external debt/GDP. Indeed, the increase in the international reserves/GDP ratio is positively correlated with the foreigners' equity position in Korea as a share of Korean GDP.

In this paper we provide theoretical and empirical interpretations for the build up and active management of international reserves. In Section 2 we outline a model that may explain the patterns observed in Figures 1-2. Specifically, we extend Aizenman and Marion (2004), to account for the possibility that sudden stops may trigger large output costs, due to higher cost of credit or banking crises. In these circumstances, international reserves may reduce the probability of a full-blown liquidity crisis, thereby increasing welfare. We find that exposure to sovereign risk and downside output risk associated with a costly debt crisis provides the rationale

[1] See Calvo (1998) and Calvo and Mendoza (2000) for further discussion on sudden stops of short-term capital flows.

for precautionary savings and management of international reserves. The hoarding of reserves associated with mitigating the expected output costs connected with sudden stops is shown to depend positively on the expected output cost associated with the liquidity squeeze. The demand for reserves also increases with the effectiveness of international reserves in mitigating the probability of the crisis, and decreases with the opportunity costs of reserves.

In section 3 we present an overview of key developments associated with the patterns of international reserves in Korea in recent years, and evaluate empirically the management of international reserves by the Korean Central Bank. The evaluation is consistent with a structural brake in the patterns of hoarding and managing international reserves. The timing of the brake is the 1997-8 Korean sudden stop crisis, which was associated with a sharp drop in output, and major policy adjustments in Korea. The aftermath of the crisis has also been associated with rapid financial opening of Korea. As the Lucas Critique would suggest, we should expect that these events would lead to profound changes in the econometric association of variables, and structural brakes in the patterns of correlations among the various variables. We confirm this prediction, finding significant structural changes in the patterns of international reserves in the aftermath of the 1997-8 crisis. The shortness of the sample suggests that one should not expect stable results that would be robust across possible specifications, as indeed we find in our empirical results. Yet, the data are consistent with the patterns depicted in Figure 2 --- the 1997-8 crisis has led to a structural increase in the demand for international reserves, linking the actual level of IR with the exposure of liabilities to foreign creditors and equity holders.

Specifically, our investigation shows that, while trade openness was significant in explaining international reserves before the crisis, it loses significance after the crisis. This is consistent with the notion that the rapid integration of Korea with the global financial system increases the weight of financial openness, and may reduce the weight of trade openness, in accounting for the patterns of international reserves. We also find that export receipts volatility was not significant before the crisis, but turns positive after the crisis. Higher foreigners' shareholding is associated with higher hoarding of international reserves. Furthermore, this effect gains statistical significance after the crisis. Of course, the large increase in the domestic exposure to foreigners' shareholding in Korea implies that it plays a much more important role in accounting for the recent patterns of international reserves in the aftermath of the crisis. Coefficients on short-term external debt were negative and not significant before the crisis, but

turn positive and significant after the crisis. This is consistent with the view that the crisis has led to a drastic change in attitude towards short-term debt, and a new policy that attempts to mitigate the exposure to hot money by increasing international reserves in tandem with short term debt and foreigners' shareholding in Korea. Volatility of the won/dollar exchange rate becomes significant after the crisis and exhibits negative coefficients, which is consistent with the theoretical prediction associated with allowing greater flexibility of the exchange rate.

Section 4 closes the paper with discussion of the main finding and possible extensions.

2. On the precautionary demand for international reserves

The demand for international reserves stems from several sources. The earlier literature focused on using international reserves as part of the management of an adjustable peg or managed floating exchange rate regime [Frenkel (1983), Edwards (1983); see Flood and Marion (2001) for a literature review]. The recent financial crises afflicting countries with limited access to international borrowing, suggest another aspect of international reserves – namely, they serve as an asset affecting the developing country's exposure to sovereign risk and costly adjustment. These considerations suggest that international reserves may be viewed as a form of precautionary saving for economies with conditional access to global capital markets and costly domestic tax collection. Formally, both costly taxation, and imperfect integration with the global capital market due to sovereign risk generate nonlinearities that make precautionary balances welfare-improving. Aizenman and Marion (2004) examine the contribution of reserves and external debt to tax smoothing for the case where future productivity is random, showing the welfare gain associated with hoarding a potentially large stockpile of international reserves. It is noteworthy that sizable precautionary demand for international reserves exists even if agents are risk-neutral: the nonlinearities associated with costly taxation and sovereign risk suffices to induce a first order demand for reserves, independent of risk aversion.

In this section we extend the above argument to account for the possibility that sudden stops of short-term capital flows may trigger large output costs, due to higher cost of credit or banking crises. In these circumstances, international reserves may reduce the probability of a full-blown liquidity crisis, thereby increasing welfare. We outline below a simple model to account for this possibility. The model is designed to capture an important feature of recent

crises: time consuming and costly debt renegotiation. Even when the resolution of the debt crisis is reasonably fast, partial default and debt restructuring frequently leads to further short run declines in output, as was highlighted by Ben-Bassat and Gottlieb (1992). Unlike Aizenman and Marion (2004), where the distribution of output is independent of the default decisions, in this section we focus on the case where the default decision impacts the distribution of output, raising the possibility of costly recessions. To simplify the discussion, we strip fiscal considerations from the problem, and identify the precautionary demand for international reserves that is independent of the inefficiencies associated with costly taxes.

We study a two-period emerging-market economy where second period output, Y_2, is subject to productivity shocks. The country can borrow internationally in the first period, but because there is some chance it will default in the second period, it faces a credit ceiling. The central bank actively targets the stock of reserves. Even so, a variety of exchange-rate arrangements are possible, such as a fixed exchange rate or a managed float, because the balance sheets of the central bank and treasury are consolidated. The emerging market borrows B in period 1 at a contractual rate r and owes $(1+r)B$ in period 2. If it faces a bad enough productivity shock in the second period, it defaults. Default, however, is not without penalty. International creditors can confiscate some of the emerging market's export revenues or other resources equal to a share α of its output. The more open the economy, the greater α is likely to be. We assume that the defaulting country's international reserve holdings are beyond the reach of creditors.[2]

In the second period, the country repays its international obligations if repayment, $[(1+r)B]$, is less costly than the expected default penalty, assuming to be a fraction α of the expected output, $\alpha E[Y_2]$. The country ends up transferring S_2 real resources to international creditors in the second period, where:

$$(1) \qquad S_2 = MIN\left[(1+r)B;\ \alpha Y_2\right], \qquad 0 < \alpha < 1.$$

[2] This is a realistic assumption. For example, on January 5, 2002, *The Economist* reported "[President Duhalde] confirmed that Argentina will formally default on its debt, an overdue admission of an inescapable reality. The government has not had access to international credit (except from the IMF) since July. It had already repatriated nearly all of its liquid foreign assets to avoid their seizure by creditors." (*The Economist*, p. 29)

To simplify, we focus on a two states of nature example, where the second period exogenous productivity shock is either high (δ), or low ($-\delta$). We assume that all agents are risk neutral. High enough external debt would lead to partial default in the bad state of nature. With probability *p*, the default would lead to a liquidity crunch or banking crisis, inducing a further drop of output at rate ε, from low level ($1-\delta$), to very low level [$(1-\delta)(1-\varepsilon)$]. The sequence of events is the following:

I. In the first period the country borrows externally B , and hoards international reserves *R*.

II. At the beginning of the second period, nature moves: the exogenous random output shock, δ or - δ, is realized.

III. Next, the decision maker moves, deciding whether to default or to repay fully.

IV. A partial default decision would have further repercussions: with probability *p*, it would magnify the output drop, reducing output from $1-\delta$ to $(1-\delta)(1-\varepsilon)$.

The reduced form of the GDP in period i (i = 1, 2) is:

(2)

$$Y_1 = 1; \quad Y_2 = \begin{cases} 1+\delta; \ \Pr\ 0.5 \\ 1-\delta; \ \Pr\ 0.5 \xrightarrow{III} \begin{cases} no\ \ default \rightarrow output\ \ remains\ \ 1-\delta \\ default \xrightarrow{IV} \begin{cases} output\ \ remains\ 1-\delta\ ; & \Pr\ 1-p\ . \\ output\ \ drops\ \ to\ \ (1-\delta)(1-\varepsilon)\ ; \ \Pr\ \ p \end{cases} \end{cases} \end{cases}$$

The time line stages III and IV are pointed out above the corresponding arrows.

Suppose the risk-free interest rate is r_f . The interest rate attached to the country's acquired debt, r , is determined by the condition that the expected return on the debt is equal to the risk-free return:

(3) $\quad E[S_2] \ = \ (1+r_f)B$

Applying the above assumptions, for debt level *B* and interest rate *r*, partial default would take place in the bad state of nature (at stage III of the time line stated above) if it raises the

expected consumption: $1-\delta-B(1+r)<(1-p)(1-\alpha)(1-\delta)+p(1-\alpha)(1-\varepsilon)(1-\delta)$, which is equivalent to $(1-\delta)[\alpha+p\varepsilon(1-\alpha)]<B(1+r)$.[3] Consequently, for $\alpha(1+\delta)>B(1+r)>(1-\delta)[\alpha+p\varepsilon(1-\alpha)]$, the expected debt service is

$$(4)\qquad E[S_2]=0.5\left[(1+r)B+(1-p)\alpha(1-\delta)+p\alpha(1-\delta)(1-\varepsilon)\right].$$

The credit ceiling facing the economy, $\overline{B}$, is the discounted expected repayment when the debt is large enough to induce partial default in all states of nature (discounting by the risk free interest rate, r_f):

$$(5)\qquad \overline{B}=\frac{0.5\left[(1+\delta)\alpha+(1-p)\alpha(1-\delta)+p\alpha(1-\delta)(1-\varepsilon)\right]}{1+r_f}=\frac{\alpha[1-0.5p\varepsilon(1-\delta)]}{1+r_f}.$$

For exposition simplicity, we assume no independent fiscal objectives for the government, and zero initial debt and stock of reserves. In a two-period model, there is no need to hold reserves beyond the second period. Thus the terminal demand for reserves is zero. Consequently, for $\alpha(1+\delta)>B(1+r)>(1-\delta)[\alpha+p\varepsilon(1-\alpha)]$, the budget constraints facing the representative agents are:[4]

[3] Partial default in the bad state of nature [following the output shock $-\delta$] changes the second period expected consumption cost of external debt form $B(1+r)$ to $(1-\delta)[\alpha+p\varepsilon(1-\alpha)]$. The term $(1-\delta)[\alpha+p\varepsilon(1-\alpha)]$ is the sum of the expected repayment to creditors [equals a fraction α of the expected output, $\alpha(1-\delta)(1-p\varepsilon)$], plus the expected consumption loss associated with the adverse output effect of partial default [$(1-\delta)p\varepsilon$]. The first is a transfer to creditors, the second is the deadweight loss associated with partial default. Note also that for $(1-\delta)[\alpha+p\varepsilon(1-\alpha)]>B(1+r)$, the country is better off repaying the contractual debt.

[4] We assume lump sum taxes and transfers, and that the net income of the consolidated central bank and the treasury are rebated to the public.

$$C_1 = 1 + B - R;$$

(6)

$$C_2 = \begin{cases} C_{2,h} = 1 + \delta - B(1+r) + (1+r_f)R & \Pr \quad 0.5 \\ C_{2,l} = (1-\delta)(1-\alpha) + (1+r_f)R & \Pr \quad 0.5(1-p) \\ C_{2,vl} = (1-\delta)(1-\alpha)(1-\varepsilon) + (1+r_f)R & \Pr \quad 0.5p \end{cases}$$

where the vector of indexes (*h*, *l*, *vl*) corresponds to second period states characterized by (high, low, very low) consumptions, respectively. The policy maker chooses the level of foreign debt and international reserves to acquire in the first period in order to maximize the representative consumer's expected utility:

(7)

$$\underset{B,\,R}{MAX}\left\{C_1 + \frac{0.5}{1+\rho}[C_{2,h} + (1-p)C_{2,l} + pC_{2,vl}]\right\}$$

where ρ is the discount rate.

Partial default on external debt may lead to further liquidity squeezes, as would be the case if it would induce some lenders to liquidate their portfolio, or if it would make it harder to obtain trade credit, etc. We summarize the output effects of the liquidity squeeze in a reduced form, postulating that the probability *p increases* with the partial default in state *l*/international reserve ratio. The resultant partial default, denoted by Λ_l, is the gap between the contractual repayment and the actual planned repayment in state *l*: $\Lambda_l = B(1+r) - \alpha(1-\delta)$. Consequently, the probability that the partial default would trigger further output collapse is:

(8)

$$p = \begin{cases} p[\dfrac{\Lambda_l}{(1+r_f)R}] \quad if \quad \Lambda_l \geq 0 \\ \qquad\qquad\qquad\qquad\qquad ; \quad p' > 0. \\ 0 \qquad\qquad if \quad \Lambda_l < 0 \end{cases}$$

Equation (8) is in line with Edwards (2004), finding that current account reversals associated with sudden stops have a negative effect on real growth that goes beyond their direct effect on investment, and that the probability of a country experiencing a current account reversal depends negatively on international reserves. It can be viewed as a reduced form of a more complex, three period model, akin to Diamond and Dybvig's (1983) liquidity model, where in the second period, a random fraction of foreign lenders attempts to liquidate their loan.

The optimal borrowing and reserve accumulation is obtained by maximizing the expected utility (7), subject to (6) and (8). It is easy to verify that borrowing would increase with the subjective discount rate, ρ. For exposition simplicity, let us assume that the subjective discount rate is high enough to push the borrowing to the credit ceiling, $B = \overline{B}$, given by (5). This reduces the complexity of the problem, allowing us to focus on a single first order condition characterizing the optimal international reserve level corresponding to $B = \overline{B}$. Applying (6) to (7), we infer that

$$(9) \qquad 1 - \frac{\mathrm{d}\overline{\mathrm{B}}}{\mathrm{dR}} = \frac{1}{1+\rho}\left[(1+r_f) - 0.5\frac{d[B(1+r)]}{dR}\Big|_{B=\overline{B}} + 0.5\frac{\mathrm{dp}}{\mathrm{dR}}\Big|_{B=\overline{B}}\left\{C_{2,vl} - C_{2,l}\right\}\right].$$

Note that when borrowing is at the credit ceiling ($|_{B=\overline{B}}$), the contractual repayment equals the default penalty in the *best* state of nature. Hence, $B(1+r)|_{B=\overline{B}} = \alpha(1+\delta)$. Thus, $\frac{d[B(1+r)]}{dR}\Big|_{B=\overline{B}} = 0$.[5] Applying this result to (9), it simplifies it to

$$(9') \qquad 1 - \frac{\mathrm{d}\overline{\mathrm{B}}}{\mathrm{dR}} = \frac{1}{1+\rho}\left[1 + r_f - 0.5\frac{\mathrm{dp}}{\mathrm{dR}}\Big|_{B=\overline{B}}\left\{C_{2,l} - C_{2,vl}\right\}\right]$$

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[5] Note that $B(1+r)|_{B=\overline{B}} = \alpha(1+\delta)$ implies that $(1+r)\frac{d\left[\overline{B}\right]}{dR} + \overline{B}\frac{dr}{dR} = 0$, such that $\frac{d\left\lfloor B(1+r)|_{B=\overline{B}}\right\rfloor}{dR} = 0$. The economic interpretation is that hoarding reserves reduces the probability of the "very bad" output associated with the default decision, hence it reduces the equilibrium interest rate, increasing the debt ceiling.

The LHS is the first period cost of a marginal unit of international reserve: the direct resource cost, minus the extra external borrowing induced by mitigating the credit ceiling. The RHS is the expected second period discounted value of the marginal benefit associated with *d R = 1*. It is the sum of two terms: the first term evaluates the increase in second period purchasing power associated with the interest income, $(1+r_f)$. The second term evaluates the gains associated with reducing the probability *p* (the probability that the partial default would induce further collapse of output), leading to a future expected gain of $-0.5\frac{\mathrm{dp}}{\mathrm{dR}}|_{B=\bar{B}}\{C_{2,l}-C_{2,vl}\}$ [recall from (8) that $\frac{\mathrm{dp}}{\mathrm{dR}}<0$]. Applying (6), (9') is simplified to

$$(9'') \qquad \frac{1}{1+\rho}\left[(1+r_f)-\{\frac{\mathrm{dp}}{\mathrm{dR}}|_{B=\bar{B}}\}0.5\varepsilon(1-\delta)(1-\alpha)\right]=1-\frac{\mathrm{d}\bar{\mathrm{B}}}{\mathrm{dR}}$$

Applying (5) and (8) to (9") we infer that[6]

$$(10) \qquad \mathrm{R}|_{B=\bar{B}}=0.5\varepsilon(1-\delta)p\eta[\frac{1}{\rho-r_f}+\alpha\frac{1}{1+r_f}];$$

where $\eta=\frac{d\log p}{d\log\frac{\Lambda_l}{(1+r_f)R}}$ denotes the elasticity of the probability of *p* (output collapse) with respect to the partial default/international liquidity ratio.

The hoarding of reserves depends positively on the expected output cost associated with the liquidity squeeze, $0.5\varepsilon(1-\delta)p$. The demand for reserves also increases with effectiveness

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[6] Applying (5), it follows that $\bar{B}-\frac{\alpha[1-0.5p\varepsilon(1-\delta)]}{1+r_f}=0$. Applying (8) and the observation that $\Lambda_l|_{B=\bar{B}}=B(1+r)-\alpha(1-\delta)=\alpha(1+\delta)-\alpha(1-\delta)=2\alpha\delta$, we infer that $\frac{dp}{dR}|_{B=\bar{B}}=-\frac{p}{R}\eta$. Applying the implicit function theorem and the above two equations, we infer $\frac{dB}{dR}|_{B=\bar{B}}=-\frac{\alpha 0.5\varepsilon(1-\delta)}{1+r_f}\frac{dp}{dR}|_{B=\bar{B}}=\frac{\alpha 0.5\varepsilon(1-\delta)p}{(1+r_f)R}\eta$. Equation (10) is obtained by applying the last two equations to (9"), collecting and simplifying terms.

of international reserves in mitigating the probability of the crisis, as measured by the elasticity η. The hording of reserves depends negatively on the opportunity costs of reserves, $\rho - r_f$.

Our analysis can be extended in several ways. It can be verified that similar results apply for an internal equilibrium, where borrowing is below the credit ceiling. To simplify, we assumed that ε, the size of the endogenous output distress, is exogenously given. The analysis can be readily extended by allowing both p and ε to depend positively on our financial distress measure (i.e., on the partial default/international liquidity ratio).

Evaluation of the patterns of output in Korea (see Figures 6-7), as well the results reported in Kaminsky and Reinhart (1999) and Hutchison and Noy (2002) are consistent with the notion that sudden stops are associated with large output losses. Hence, the 1997-8 crisis concentrated the minds of policy makers and economists on the potential hazards associated with exposure to sudden stops, and the potential benefits of hoarding international reserves. Figure 8 reveals that the opportunity cost of hoarding international reserves has decreased significantly in the aftermath of the crisis. These factual developments imply a sizable increase in the precautionary demand for international reserves by Korea. We turn now to a more formal econometric assessment of these issues.

3. Management of International Reserves: Korea

In this Section we evaluate empirically the management of international reserves by the Korean monetary authority. We first illustrate what factors are behind the large accumulation of international reserves in the aftermath of the crisis by taking a look at the evolution of international reserves and other related macroeconomic variables.

International reserves were 9 billion dollars (in terms of usable amount) at the end of 1997, but rapidly built up to 155 billion dollars by the end of 2003. As a fraction of GDP, international reserves rose from 3% to 30% over the same period. A swift glance at the data indicates that a large current account surplus, coupled with continued inflows of foreigners' equity investment, played an important role in the rapid accumulation of international reserves. Over the period 1998-2003, the cumulative current account surplus reached 103 billion dollars, and net portfolio inflows accumulated up to 56 billion dollars, among which 54 billion dollars were in the form of equity inflows (see Figure 3). Foreigners were allowed to directly purchase up to 10 % of the outstanding shares of a company in total, effective January 3, 1992. The total ceiling was gradually raised to 26%, 50%, and 55% on November 3, December 11, and December 30, 1997 respectively. The ceiling was finally lifted completely on May 25, 1998. In response to these liberalization policies, foreigners' shareholding as a percentage of the total market capitalization has risen from 12% at the end of 1997, to 40% by the end of 2003 (see Figure 4).

In order to assess the responsiveness of international reserves to those factors noted above, we run reduced-form regressions. These regressions relate change in international reserves to current account and net equity, debt, and other investment inflows in the balance of payments; and to changes in foreigners' equity position and short-term external debt.

Table 1(a) shows that current account and equity inflows are significant at the 1% level in the post-crisis period. Specifically, a 1 dollar increase in the current account surplus led to a 0.75 dollar increase in international reserves. Further, after the crisis, a 1 dollar increase in equity inflows led to a 0.64 dollar increase in international reserves. This finding confirms our prior conjecture that large current account surplus and equity inflows are the main driving forces behind the post-crisis build-up of international reserves.

It is noteworthy that the 1997 crisis increased significantly the responsiveness of the international reserves position to external debts. In Table 1(a) the coefficient on debt inflows

was negative in the pre-crisis period, though not significant. However, it changes sign and gains significance at the 10% level in the post-crisis period, suggesting that debt inflows of 1 dollar led to an increase in international reserves by 0.5 dollar. The results in Table 1(b) are consistent with this finding. For example, in Table 1(b), a 1% point increase in short-term debt/GDP ratio led to an increase of international reserves/GDP ratio by about 0.4% point before the crisis, and about 1.2% point after the crisis.

One lesson to draw from the financial crisis is that the monetary authority should take into careful consideration capital flows, and relate the level of international reserves to short-term external debt [for example, see Greenspan (1999) and Wijnholds and Kapteyn (2001)].[7] In Korea, the short-term external debt/GDP ratio reached 20% at the end of 1997, fell to 11% at the end of 1998, and thereafter has remained stable around 10% (see Figure 2). Throughout the pre-crisis period, the international reserves/GDP ratio fell short of the ratio of short-term external debt to GDP. However, it outpaced the short-term debt/GDP ratio in 1998:3Q for the first time, and thereafter continued to rise well above the short-term debt ratio. Throughout this period, foreigners' equity position/GDP ratio was 2% at the end of 1997, but sharply increased to 23% by the end of 2003. This suggests that the large accumulation of international reserves may be related to the sharp increase in foreigners' shareholding. It is noteworthy that the ratio of international reserves to GDP tends to converge to the (short-term debt + foreigners' shareholding)/GDP ratio (see Figure 5).[8] This fact suggests that in the aftermath of the 1997-8

[7] See Kim, Li, Rajan, Sula and Willett (2005) for a recent analysis judging reserve adequacy in Asia based on the behavior of different types of capital flows during currency crises.

[8] The Korean monetary authority unofficially maintains the view that international reserves should be enough to cover short-term external debt plus some portion of foreigners' shareholdings:

> "Kim Woong-bae, director general of the central Bank of Korea (BOK), made clear that the Korean government would retain the current dollar stockpiles for the time being. "I don't think the ample reserves will put pressures on monetary policy, including inflation, as the global economy is in a low-inflation era," he said. Most of all, Korea needs to gear up for a sudden outflow of so-called hot money, he added. An estimate put the amount of speculative capital in the country's stock and bond markets at $500 billion (Korea Times, http://times.hankooki.com, October 23, 2003)."

crisis, the Korean monetary authority gives much greater attention to a broader notion of hot money, inclusive of foreigners' shareholding, rather than to short-term debt alone.[9]

Using structural models, we now formally investigate whether equity inflows and short-term external debt have played a significant role in the rapid accumulation of international reserves in the post-crisis period. For this purpose, we start with a benchmark Regression (1) that adds foreigners' equity position/GDP ratio and short-term external debt/GDP ratio to the traditional determinants of the demand for international reserves such as scale factor, trade openness, and volatility of exports:

$$(11) \quad \ln(IR/GDP)_t = a_0 + a_1 \ln(RGDP)_t + a_2 \ln(API)_t + a_3 \ln(SDEX)_t + a_4 \ln(FEP/GDP)_t + a_5 \ln(SED/GDP)_t,$$

where IR is international reserves, RGDP is real GDP, API is the share of imports of goods and services in GDP, SDEX is the volatility of export receipts, FEP is foreigners' shareholding, and SED is short-term external debt.[10]

Regressions (2) – (5) in Table 2 add, respectively, contemporaneous and lagged current account (CA), log of the deviation of the real effective exchange rate from its equilibrium value (LDEVREER), and log of the volatility of the won/dollar exchange rate (LSDWON), to the explanatory variables employed in Regression (1). In Regressions (6) and (7) all explanatory variables are included, the former with contemporaneous current account and the latter with lagged current account.

These specifications are adopted to allow for the possible effects of structural changes in Korean economy on international reserves that developed in the aftermath of the 1997 crisis. The current account is added to capture the policy response to changes in the status of Korea's current account. Over the period 1990-1997, Korea recorded current account deficits that amounted to 58 billion dollars in total. In sharp contrast, however, starting in 1998 the current

[9] Notice that in Table 1(b) the ratio of foreigners' equity position to GDP gains significance at 5% after the crisis.

[10] Total external debt/GDP and short-term external debt/total external debt ratios are also considered. However, they turn out to be insignificant and are not reported.

account deficit turned into a surplus and remains in surplus to the present day. Over the period 1998-2003, Korea accumulated a current account surplus of 103 billion dollars. When the current account is in surplus, a central bank is inclined to purchase foreign exchanges to mitigate appreciation pressure on the national currency.

Asian countries are often blamed for manipulating their exchange rates to maintain international competitiveness. The Korean monetary authority may have intervened in the foreign exchange market to prevent real appreciation of the won. To explore this possibility we consider the deviation of the real effective exchange rate from its equilibrium.

As of December 16, 1997, Korea has adopted a floating exchange rate regime and allows the won to float. Theoretically, a free-floating exchange rate regime reduces the demand for international reserves, but practically it may increase the demand because of 'fear of floating'. The monetary authority may need more international reserves to stabilize the exchange rate in the face of rapidly growing foreign exchange transactions and increasingly volatile exchange rate. In order to empirically assess the relative importance of the two conflicting effects, we include the volatility of the won/dollar exchange rate.

Table 2 presents regression results, both for the pre-crisis and post-crisis periods. The data set begins from 1992:1Q, when direct purchases of the Korean stocks were first allowed to foreigners, and ends in 2003:4Q. We split the whole sample into two subsets: 1992:1Q-1997:2Q and 1998:3Q-2003:4Q in order to investigate whether there are significant structural changes in the patterns of international reserves after the 1997 crisis. The time spans before and after the crisis are well balanced, each period covering 5 years and 2 quarters. We exclude 1997:3Q-1998:2Q from the estimation, during which Korean financial markets were experiencing extraordinary turbulence due to the ongoing Asian financial crisis.

As shown in Regression (1), real GDP does not appear to play any important role, both before and after the crisis. It is statistically significant only in Regression (4) in the post-crisis period, but not significant in all other cases.[11] Trade openness was significant before the crisis, but loses its significance after the crisis in Regression (1). The same result obtains in Regressions (3) and (4). The volatility of export receipts was not significant before the crisis, but

[11] This result is not surprising, considering that the dependent variable is already deflated by GDP. Dropping real GDP from the explanatory variables does not alter the major results of the

becomes significant after the crisis in Regressions (1), (2), (3), and (4). These findings suggest that Korea is more concerned about the uncertainty than the magnitude of export receipts in the post-crisis period, during which current account is in continued surplus.

The result, that foreigners' shareholding leads to an increase in international reserves, is more significant in the post-crisis period. The ratio of foreigners' shareholding to GDP is significant both before and after the crisis in Regressions (1), (2), and (4). On the other hand, in Regressions (5) – (7) foreigners' equity position is not significant before the crisis, but becomes statistically significant after the crisis**.**

An interesting finding is that prior to the crisis the coefficient on short-term external debt is negative, though not significant in most cases, but after the crisis it turns to a positive value and becomes significant. The results are robust across all the other Regressions (2) – (7). This finding indicates that short term external debt was considered a substitute for international reserves before the crisis. International transactions can be financed by external debt, thereby reducing the demand for international reserves (Eaton and Gersovitz, 1980). The 1997 financial crisis, however, has dramatically changed the attitude towards short-term debt, as indicated by the Korean government's attempts to mitigate the exposure to hot money by changing international reserves in tandem with short term debt. This is consistent with the notion elaborated in the previous section: the crisis has led to a large increase in precautionary demand for international reserves.

The current account, either contemporaneous or lagged, does not exhibit any significant effect on international reserves in both periods. The signs of its coefficient differ, depending on model specifications (specifically, contemporaneous or lagged). As discussed above, a current account surplus tends to increase international reserves via foreign exchange market bank intervention on the supply side, but at the same time it may decrease the demand for international reserves by reducing the perceived vulnerability of a country to external shocks.

Exchange rate deviation from its equilibrium value is significant in Regression (4), both before and after the crisis. It has a positive coefficient before the crisis, implying that overvaluation of the won led to an increase in international reserves. This may be due to purchases of foreign exchanges by the central bank in an effort to prevent appreciation of the

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paper, and in most regressions increases the level of statistical significance of foreigners equity position and short-term debt in the post-crisis period.

won. After the crisis, however, its sign becomes negative as shown in Regression (4). Note that in the post-crisis period the exchange rate deviation is also significant at the 5% level in regression (6), where current account and the volatility of exchange rate are included, but its sign is still negative.[12]

This puzzling result may be due to the lack of a reliable measure of the equilibrium exchange rate or change in exchange rate policies after the crisis. Korea introduced inflation targeting in 1998, devoting more attention to stabilizing the price level than to preventing real appreciation of the won. Appreciation of the won contributes much to a fall in the inflation rate by lowering the costs of imported materials and final goods. The Korean monetary authority, therefore, has less incentive to prevent appreciation of the won under inflation targeting.

Consistent with the theoretical prediction, in the aftermath of the crisis, the exchange rate volatility coefficient is negative and becomes significant at the 1% level in Regressions (5) and (7) under the flexible exchange rate regime.

4. Concluding remarks

One interpretation of the recent hoarding of international reserves by East Asian countries is as a result of precautionary demands. Our discussion suggests that the precautionary demand depends positively on the ability of international reserves to mitigate the probability of output collapse induced by sovereign partial default, and the ability of international reserves to alleviate shortages of fiscal resources in bad states of nature. While the data reviewed in Section 3 is consistent with this interpretation, we do not argue that the present level of international reserves observed in East Asia is optimal. Some of the demand for international reserves is driven by factors beyond the scope of this paper. These may include reserve accumulation triggered by concerns about export competitiveness, an explanation advanced recently by Dooley, Folkerts-Landau and Garber (2003). Short of having better data and more detailed econometric investigations, the precautionary motive and the mercantilist interpretations for hoarding international reserves may be observationally equivalent. Yet, the two interpretations are associated with different welfare effects. Another difference between the two approaches is that

[12] This finding, together with the lack of statistical significance of the current account coefficient, is in contrast with the popular view that Asian countries manage exchange rates to preserve

the precautionary demand identifies an “optimal” stock of international reserves, whereas the Dooley at al. (2003) approach views the level of international reserves as a residual, and does not attempt to identify its optimal size. Testing and identifying the differential impact of precautionary versus mercantilist motives on international reserves remains a task for future research.

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export competitiveness. Of course, addressing this issue in depth requires not only accurate measures of foreign exchange market intervention, but also more formal models.

Data Appendix

IR	international reserves minus gold.
CA	current account balance.
EQIN	net equity inflows in the balance of payments.
DEBTIN	net debt inflows in the balance of payments.
OIIN	other investment inflows in the balance of payments, including loans, trade credits, and currency and deposits.
FEP	foreigners' equity position based on market value of shareholding. *Source*: Financial Supervisory Service of Korea, http://www.fss.or.kr.
SED	short-term external debt.
LRGDP	real GDP, logged.
LAPI	the percentage share of imports of goods and services in GDP, logged.
LSDEX	volatility of exports. Volatility is calculated using the previous 12 quarters data and is the standard deviation of annual growth rates of export receipts, logged.
LFEPY	the ratio of foreigners' equity position to GDP, logged.
LSEDY	the ratio of short-term external debt to GDP, logged.
CA(-1)	current account balance, lagged one period.
LDEVREER	deviation of the real effective exchange rate from equilibrium, logged. A rise in the real effective exchange rate indicates a real appreciation of the won. Two measures of equilibrium exchange rate are considered. One is calculated by the HP filter, and the other by average rates of the actual real effective exchange rate in the two sub-periods. Source: JP Morgan, http://www2.jpmorgan.com/MarketDataInd/Forex for the data of the real effective exchange rate.
LSDWON	volatility of the exchange rate, logged. Volatility is calculated using the previous 24 months of data and is the standard deviation of monthly percentage changes in the won/dollar exchange rate.

All data are from Bank of Korea, http://www.bok.or.kr, unless otherwise indicated.

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Table 1. Reduced Form Equations

(a) Dependent variable: D(IR)

	1992:1-1997:4		1998:1-2003:4	
Variable	Coefficient	t-value	Coefficient	t-value
CA	0.4177*	1.80	0.7482***	5.14
EQIN	1.7106***	4.15	0.6424***	3.17
DEBTIN	-0.2509	-0.65	0.5077*	1.79
OIIN	0.7040***	4.22	0.6863***	4.17
C	-2165.7***	-3.04	1826.8***	2.27
Adjusted R^2	0.5898		0.6509	
DW	1.3591		2.2107	

Notes: D(IR) is change in international reserves (IR), CA is current account surplus, EQIN is net equity inflows, DEBTIN is net debt inflows, and OIIN is other investment inflows (loans, trade credits, and currency and deposits) in BOP. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Zivot and Andrews (1992) unit root tests that allow for a single structural break in the intercept, the trend or both reveal that all explanatory variables are stationary around segmented intercept, and intercept and trend that occurred in 1997:3Q or 1997:4Q.

(b) Dependent variable: D(IR/GDP)

	1994:4-1997:3		1998:3-2003:4	
Variable	Coefficient	t-value	Coefficient	t-value
CA/GDP	0.6965*	1.85	0.6934***	2.84
D(FEP/GDP)	0.3526	1.44	0.1292**	2.26
D(SED/GDP)	0.3747**	2.94	1.2202***	7.80
C	0.3624	1.35	0.1424	0.57
Adjusted R^2	0.6827		0.8551	
DW	1.9063		2.6081	

Notes: D(IR/GDP) is change in the ratio of international reserves (IR) to GDP, CA is current account surplus, FEP is foreigners' equity position, and SED is short term external debt. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2. Determinants of Reserve Holding

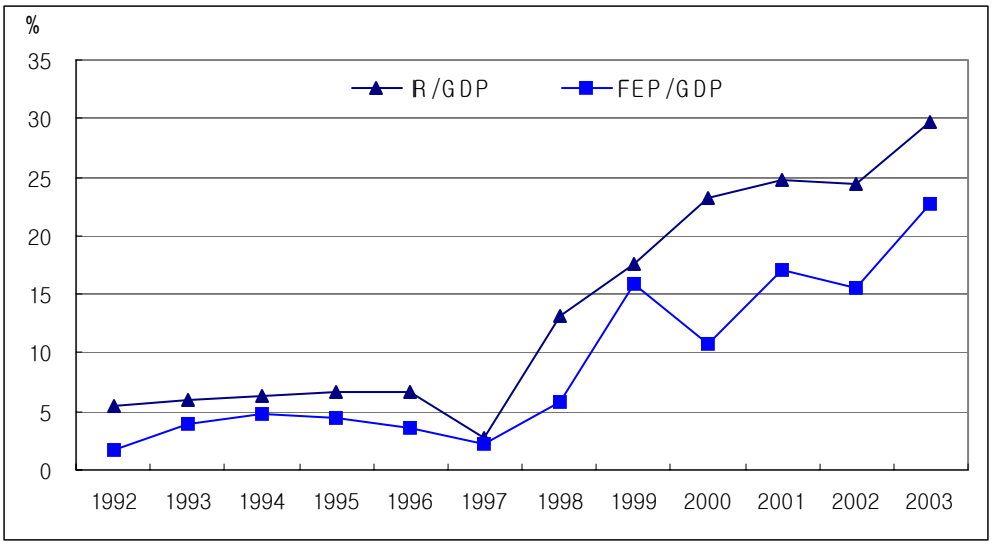
	(1)		(2)		(3)		(4)	
Variable	Before	After	Before	After	Before	After	Before	After
LRGDP	0.6008	0.4830	0.5134	0.5117	1.1735	0.5151	0.4123	0.6621*
	(1.25)	(1.19)	(0.91)	(1.12)	(1.56)	(1.21)	(1.23)	(1.84)
LAPI	0.6304*	0.1218	1.4075	0.1123	2.3971*	0.0780	1.6449**	0.4896
	(2.00)	(0.32)	(1.34)	(0.29)	(2.12)	(0.19)	(2.93)	(1.36)
LSDEX	0.0087	0.3708***	0.0130	0.3565**	-0.0190	0.3940**	-0.0816	0.2424*
	(0.07)	(2.83)	(0.10)	(2.16)	(-0.16)	(2.60)	(-0.94)	(1.93)
LFEPY	0.5126***	0.1338*	0.5037**	0.1296*	0.5485**	0.1567	0.3619**	0.1488**
	(3.38)	(1.97)	(3.05)	(1.72)	(3.50)	(1.60)	(3.08)	(2.50)
LSEDY	-0.3184	0.8301**	-0.2679	0.8372**	-0.4986	0.8947**	-0.3875*	0.9035***
	(-1.12)	(2.27)	(-0.81)	(2.20)	(-1.47)	(2.12)	(-1.97)	(2.83)
CA	-	-	-0.0036	-0.0017	-	-	-	-
			(-0.39)	(-0.15)				
CA(-1)	-	-	-	-	0.0125	0.0051	-	-
					(0.98)	(0.34)		
LDEVREER	-	-	-	-	-	-	1.6386**	-1.3067**
							(2.78)	(-2.47)
LSDWON	-	-	-	-	-	-	-	-
C	-10.6419	-6.31291	-8.9965	-6.5768	-19.3888	-6.8165	-8.0207	-9.6344**
	(-1.41)	(-1.27)	(-0.98)	(-1.21)	(-1.66)	(-1.28)	(-1.53)	(-2.12)
Adjusted R^2	0.6905	0.8562	0.6397	0.8469	0.6888	0.8478	0.8541	0.8911
DW	2.2838	1.4308	2.3751	1.4146	2.8091	1.3997	3.2883	2.3212

	(5)		(6)		(7)	
Variable	Before	After	Before	After	Before	After
LRGDP	0.1260	-0.0783	0.5222	0.7384	0.1028	-0.1450
	(0.23)	(-0.35)	(0.80)	(1.72)	(0.13)	(-0.54)
LAPI	0.9484	0.5869**	1.8924	0.3304	1.4880	0.4805*
	(1.06)	(2.87)	(1.81)	(0.66)	(1.38)	(2.08)
LSDEX	-0.0528	0.0280	-0.0848	0.1266	-0.0740	0.0555
	(-0.45)	(0.33)	(-0.66)	(0.60)	(-0.73)	(0.60)
LFEPY	0.3304	0.0925**	0.3805	0.1364*	0.3623	0.1167**
	(1.74)	(2.61)	(1.53)	(2.03)	(2.08)	(2.31)
LSEDY	-0.0656	0.4105*	-0.4735	0.9688**	-0.4847	0.4351*
	(-0.21)	(2.08)	(-1.03)	(2.77)	(-1.33)	(1.85)
CA	-	-	0.0017	-0.0057	-	-
			(0.13)	(-0.57)		
CA(-1)	-	-	-	-	-0.0125	0.0074
					(-0.80)	(0.93)
LDEVREER	-	-	1.8854	-1.3481**	2.9714	0.3461
			(1.28)	(-2.38)	(1.80)	(0.77)
LSDWON	0.0499	-0.1209***	-0.0101	-0.0508	-0.0435	-0.1349***
	(1.42)	(-6.77)	(-0.11)	(-0.44)	(-0.76)	(-5.30)
C	-2.9530	0.5562	-9.9762	-9.6964	-3.8852	1.5109
	(-0.33)	(0.20)	(-0.97)	(-1.71)	(-0.33)	(0.43)
Adjusted R^2	0.7353	0.9622	0.7684	0.8795	0.8077	0.9602
DW	2.8124	2.1079	3.2386	2.3099	3.1172	2.0565

Notes: Dependent variable is the log of the international reserves/GDP ratio.

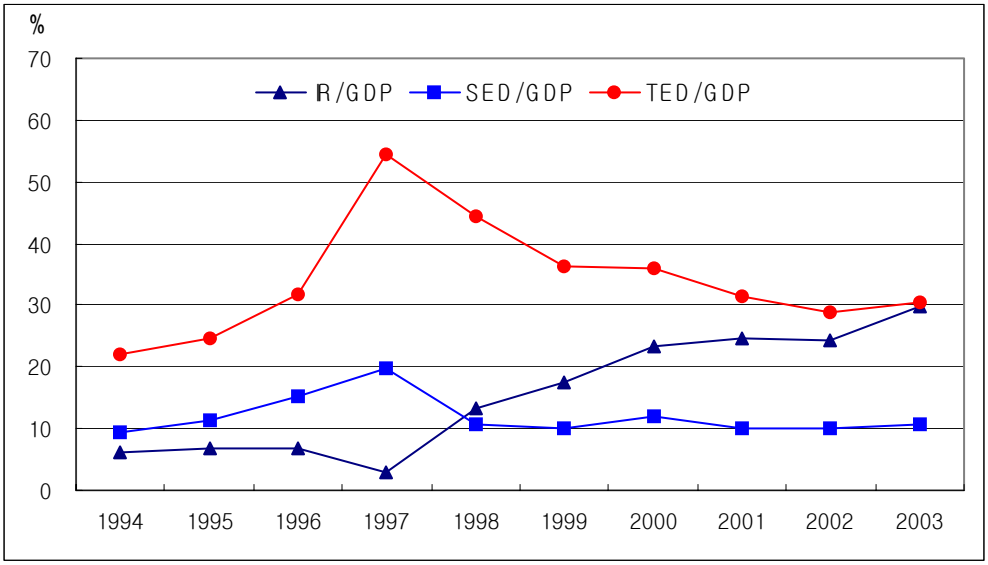
***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

<Figure 1> International Reserves and Foreigners' Equity Position



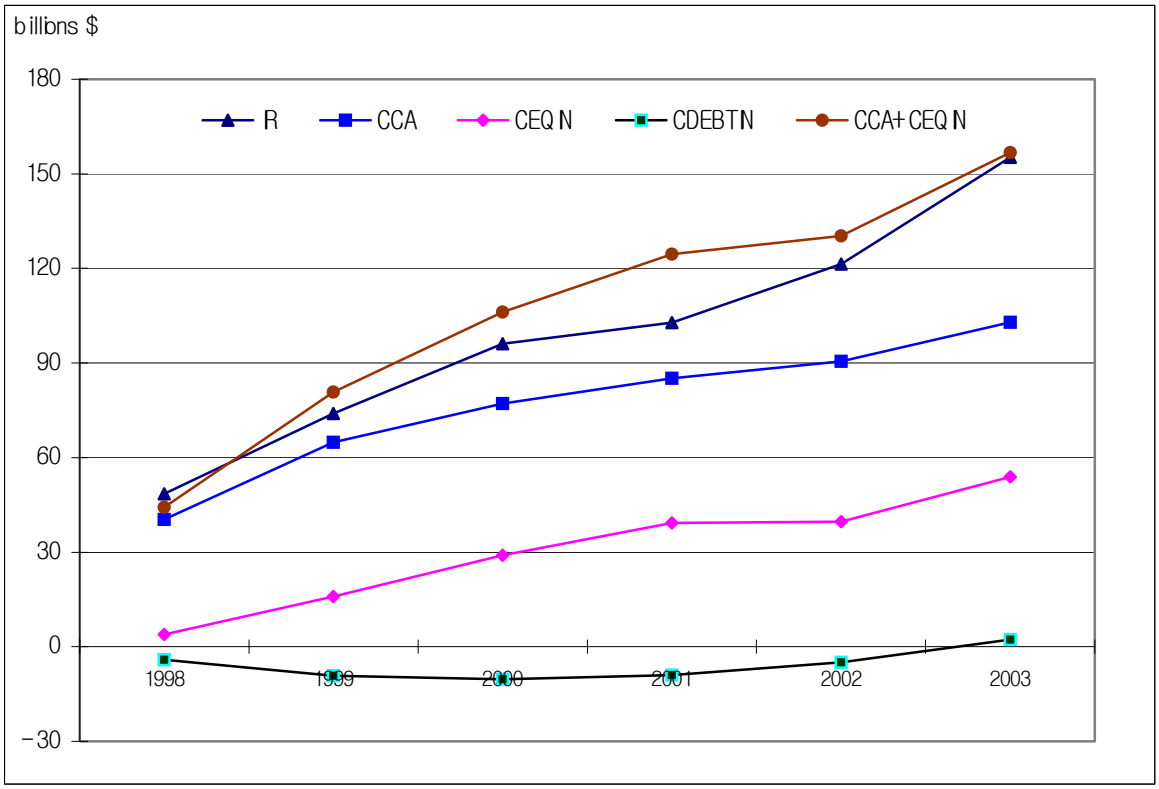
Notes: IR is international reserves, and FEP is foreigners' equity position based on market value of foreigners' shareholdings. The correlation between the two ratios is +0.44 before the crisis (1992:1Q-1997:3Q), but increases to +0.79 after the crisis (1998:2Q-2003:4Q).

<Figure 2> International Reserves and External Debts



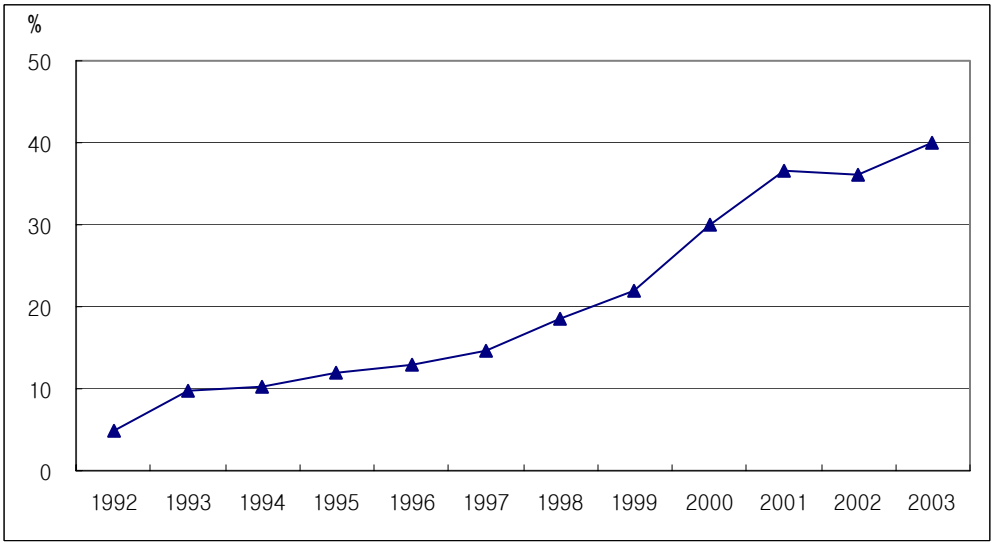
Note: IR is international reserves, SED is short-term external debt, and TED is total external debt.

<Figure 3 > International Reserves and Balance of Payments



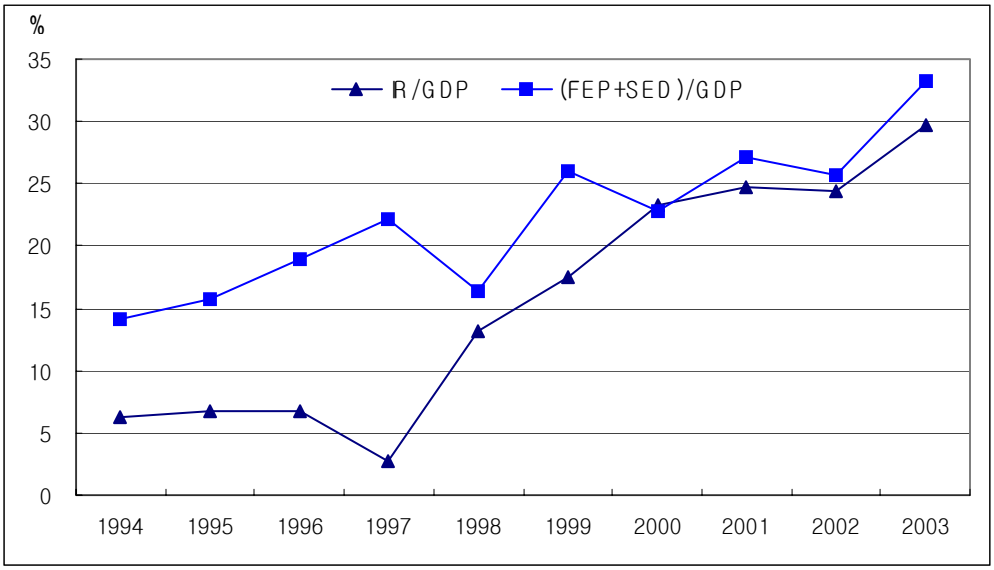
Note: CCA is cumulative current account surplus, CEQIN is cumulative equity inflows, and CDEBTIN is cumulative debt inflows in the balance of payments. All variables accumulated since 1998.

<Figure 4> Foreigners' Shareholding



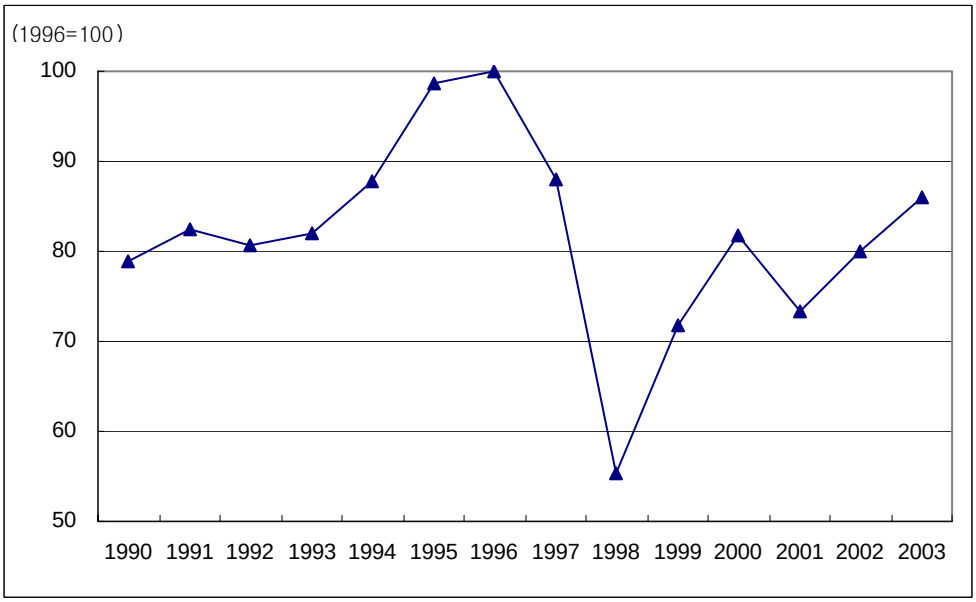
Note: Foreigners' shareholding as a percentage of the total market capitalization has risen from 12.4% at the end of 1997 to 40.1% by the end of 2003.

<Figure 5> International Reserves and FEP+SED

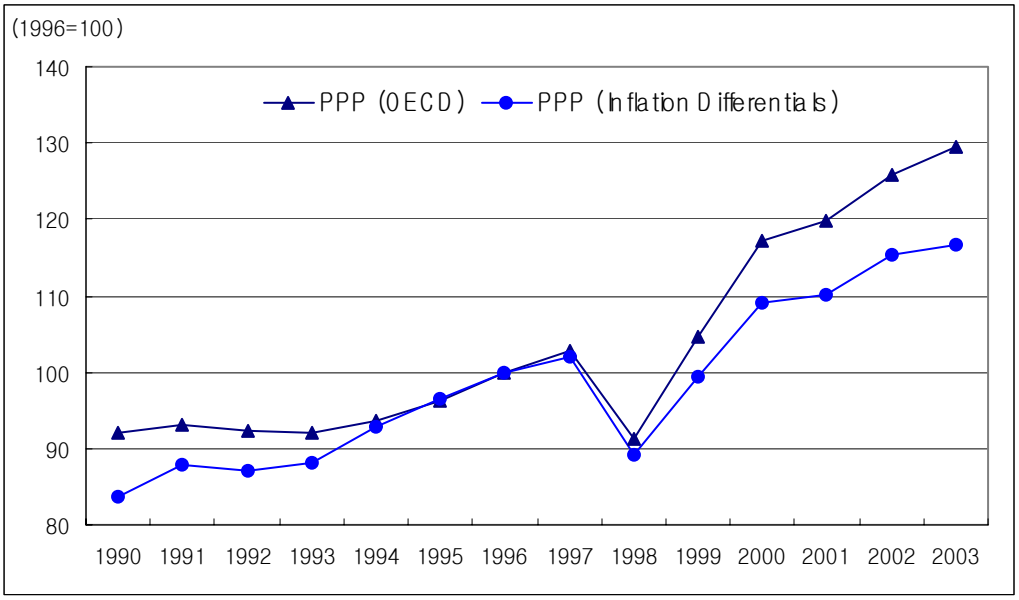


Note: The correlation between the two ratios is +0.40 before the crisis (1994:4Q-1997:3Q), but increases to +0.81 after the crisis (1998:2Q-2003:4Q).

<Figure 6> Real GDP per Capita in Current US Dollars

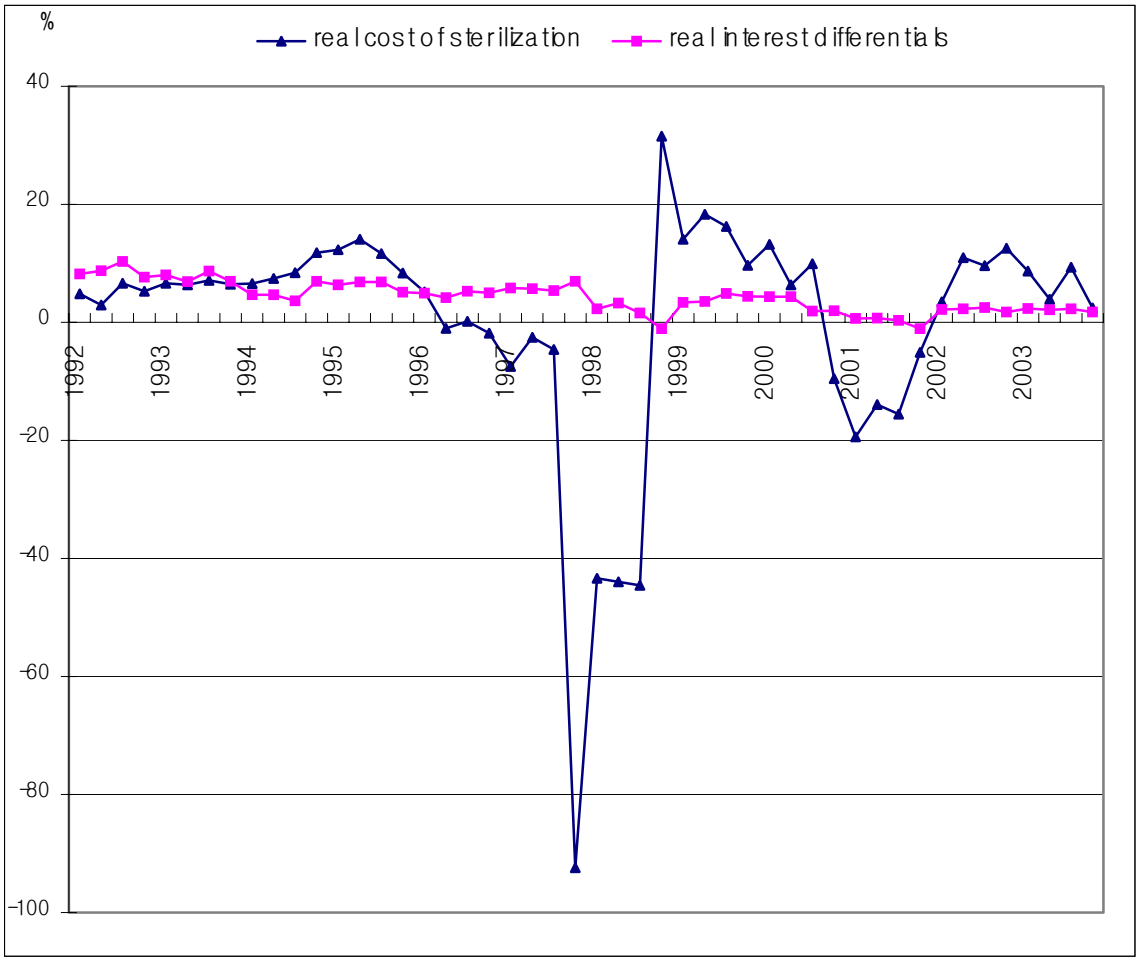


<Figure 7> Real GDP per Capita in PPP US Dollars



Notes: PPP (OECD) is based upon PPP exchange rate data published by the OECD (www.oecd.org/std/ppp), and PPP (Inflation Differentials) is based on the PPP exchange rate calculated from inflation differentials between Korea and US.

<Figure 8> Cost of Holding International Reserves



Notes: Real cost of sterilization is $[(1+i)-(1+i^*)(1+x)]/(1+\pi)$, where i is Monetary Stabilization Bonds yield, i^* is T-Bill rate, x is the depreciation rate of the won/dollar exchange rate, and π is the CPI inflation rate of Korea. Real interest differentials are $(i-\pi)-(i^*-\pi^*)$, where π^* is the CPI inflation rate of the US.
Monetary Stabilization Bonds yield reflects the cost of sterilizing the accumulation of international reserves and a large portion of international reserves has been invested in T-Bills. Monetary Stabilization Bonds are the central bank's interest-bearing bonds that are directly backed by printing money, unlike government bonds that are primarily backed by legal taxation. The Korean monetary authority has actively sterilized a large current account surplus and capital inflows by selling the Monetary Stabilization Bonds. In this sterilization process, the Bank of Korea incurs the high quasi-fiscal cost associated with purchasing low-yielding foreign assets and selling high-yielding Monetary Stabilization Bonds. See Seo (2002).