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DISORDERLY ADJUSTMENTS TO EXCHANGE RATE MISALIGNMENTS: THE EXPERIENCE OF KOREA

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Disorderly adjustments to exchange rate misalignments: The experience of Korea

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Abstract

This paper analyzes Korea's exchange rate dynamics before and during the crisis of 1997-98 by estimating the long-run fundamental exchange rate and the associated error correction model. The analysis suggests that although Korea's exchange rate was substantially overvalued before the crisis, the subsequent exchange rate dynamics could not fully be accounted by the need to correct misalignments. It was found that there was a large deviation from the short-run fundamental value of exchange rates, indicating the presence of "overshooting of the overshooting equilibrium" during the crisis. The findings have important policy implications for crisis management in emerging market economies.

JEL Classification: C22; C32; F31; F32; F41

Keywords: Exchange rate misalignments; Overshooting; Crisis; Small open economy; Autoregressive distributed lag model; Error correction model.

1. Introduction

Korea experienced sharp real exchange rate depreciations following the sudden stop of capital inflows during the crisis of 1997-98.[1] The sharp depreciations were accompanied by a large reduction in domestic spending, resulting in deep recessions. It appears that disorderly exchange rate adjustments had significant contractionary effects on Korea's economic activities, transforming the initial financial instability into a fully-fledged economic crisis.[2]

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[1] See Calvo and Reinhart (2000) for the empirical analysis of sudden stops episodes including the Asian crisis. Kaminsky, Reinhart, and Végh (2003) identify the factors that bring about "fast and furious" financial contagion, which appears to have played a critical role in triggering the sudden stops in Korea.

[2] The exchange rate depreciations could have had contractionary effects on the economy of Asian crisis countries through various channels. A number of analysts place emphasis on the adverse balance-sheets effects of depreciations; that is, with an extensive currency mismatch in the balance sheets of domestic financial institutions, the exchange rate depreciations might have induced severe credit crunch, causing a disruption in economic activity (Goldstein 1998; 2002, Eichengreen 1999, Mishkin 1999, Kenen 2001). Kinkyo (2004a), however, find evidence which suggests that the depreciation had an adverse impact on

One of the most fundamental issues that have critical implications for crisis management in emerging market economies is whether there was an exchange rate overshooting during the Korean crisis. Given the fact that the post-crisis level of real exchange rate remained substantially undervalued relative to the pre-crisis level, it is possible that Korea's exchange rate was overvalued before the crisis and thus the depreciation was inevitable to correct misalignments. However, a significant part of depreciations was in fact reversed once the stability of currency market was recovered, indicating the possibility of overshooting in the midst of the crisis (see Figure 1 below). Had the exchange rate adjustments been more smooth and orderly, the economic impact of capital flow reversals might have been much less severe.

The objective of this paper is to investigate whether Korea's exchange rate was seriously overvalued before the crisis and, if so, to what extent the subsequent sharp depreciations can be explained by the need to correct misalignments. To that end, Korea's exchange rate dynamics is analyzed in terms of its long-run relationship and short-run interactions with economic fundamentals. The extent of misalignments is evaluated using the "long-run fundamental exchange rate" as a benchmark. The long-run fundamental exchange rate here refers to the "anchor" exchange rate towards which the real exchange rate will gravitate through the interaction with economic fundamentals over the long run. It is derived from the macroeconomic balance condition given by a standard "dependent open economy model". The long-run fundamental exchange rate and the associated error correction model that captures the short-run dynamics of exchange rates are estimated using the testing and estimation method developed by Pesaran *et.al.* (1996) and Pesaran and Shin (1997).

The remainder of this paper is organized as follows: Section 2 derives the long-run relationship between real exchange rates and economic fundamentals based on a three-good, small open economy model. The empirical methodology and estimation results of the exchange rate model are presented in Section 3 and 4, respectively. Using the estimated exchange rate model, Section 5 analyses Korea's exchange rate dynamics over the past two decades. Section 6

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the Korean economy largely through a rise in the prices of imported inputs, rather than a reduction in credit supply.

examines the short-run dynamics of exchange rates during the crisis of 1997-98. Section 7 discusses the policy implication of the empirical findings.

2. The long-run fundamental exchange rate

2.1. PPP versus macroeconomic balance approach

There are broadly two approaches to modelling the long-run fundamental exchange rate: Purchasing Power Parity (PPP) approach and macroeconomic balance approach. The former assumes that the PPP holds over the long run and thus the long-run real exchange rate is constant.[3] In the latter, the long-run fundamental exchange rate is derived from the long-run relationship between exchange rates and fundamentals implied by macroeconomic balance conditions.

The PPP is the most commonly used benchmark for assessing the degree of misalignments and determining exchange rate parities. Indeed, much of the modern literature on international macroeconomics assumes implicitly or explicitly that the PPP will hold at least in the long run. The empirical evidence, however, is not as robust as is generally envisaged in the literature. The recent empirical studies show that the deviation from the PPP tends to persist long and the adjustment speed is very slow. Most estimates suggest that it takes nearly three to five years for half of a disturbance to the PPP to be reversed.[4] Such empirical evidence suggests that the PPP may not provide a useful yardstick for the exchange rate management of national governments because the time frame for their macroeconomic policies will be shorter than that for adjustments to PPP deviations.[5]

Moreover, painfully slow adjustment speed revealed by empirical analyses may simply reflect the existence of other important fundamental determinants for real exchange rates. When there are important fundamental factors that drive the long-run fundamental exchange rate away from

[3] The PPP hypothesis states that the exchange rate equals the ratio of national prices.

[4] See the survey by Froot and Rogoff (1995) and Sarno and Taylor (2002).

[5] Moreover, the body of empirical literature on PPP focused on developing countries is quite thin and, as Edwards and Savastano (2000) point out, it is not readily apparent which, if any, of the empirical regularities concerning PPP hold in the case of developing countries.

the PPP, using the PPP as the benchmark for measuring misalignments could be quite misleading. For these reasons, the PPP approach is not employed in the analysis below.

An alternative approach to modelling the long-run fundamental exchange rate focuses on the long-run relationship between exchange rates and economic fundamentals implied by macroeconomic balance conditions. This macroeconomic balance approach has its theoretical foundations in the so-called dependent economy model developed, among others, by Salter (1959), Swan (1963), Bruno (1976), and Corden and Neary (1982). In this class of model, the real exchange rate is commonly defined as the relative price of traded to non-traded goods (i.e., internal real exchange rate), which affects the relative incentives to produce and consume traded and non-traded goods. The exchange rate that simultaneously achieves the internal and external balance is referred to as the equilibrium exchange rate.

Most empirical approaches to estimating the equilibrium exchange rate are based on single-equation models.[6] In these models, the equilibrium exchange rate is related to a set of fundamental variables, such as terms of trade, the productivity differential between traded and non-traded goods sectors, government spending, openness, and net foreign assets. Many studies use the cointegration technique to derive the long-run (cointegrating) relationship between real exchange rates and fundamental variables. Then, the long-run fundamental exchange rate is calculated as a proxy for the equilibrium exchange rate, using this long-run relationship and the actual value of fundamental variables.

It should, however, be noted that the estimated long-run fundamental exchange rate can be a reasonably good proxy for the equilibrium exchange rate only if there has been a strong tendency for real exchange rates to gravitate towards the equilibrium rate over the estimated period. Such a condition is likely to be met in a small open economy, such as Korea. Most developing countries cannot afford substantial delays in correcting severe misalignments relative to the equilibrium rate because they could be the source of economic instability or even

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[6] See the survey by Edwards and Savastano (2000). Alternatively, the equilibrium exchange rate can be estimated using general equilibrium simulation models. See, for example Williamson (1994), and Haque and Montiel (1999).

crises. This would particularly be the case for a small open economy where the adverse effect of misalignments is generally much more pronounced. In such an economy, the adjustment to misalignments eventually takes place either through changes in nominal exchange rates or underlying fundamentals, by either policy interventions or market forces over time. Accordingly, the equilibrium exchange rate is likely to serve as an anchor for the real exchange rate in the long run.

2.2. Three-good small open economy model

In what follows, a simple three-good, small open economy model is developed drawing on a standard dependent economy model. Using that, the long-run relationship between real exchange rates and key economic fundamentals is derived. The model assumes that the economy produces non-traded and exported goods and consumes non-traded and imported goods. The internal balance is attained when the output is at full employment level and the supply of and demand for non-traded goods are balanced:

$$\alpha\bar{Y} = \beta A_P + \gamma A_G \tag{1}$$

where α is the share of non-traded goods in production, $\bar{Y}$ is the real output at full employment level, A_P and A_G are the absorption (final consumption) of private and government sectors, respectively, and β and γ is the share of non-traded goods in each absorption. Other things being equal, real exchange rate appreciation (depreciation) switches expenditure towards imported (non-traded) goods and thus decreases (increases) β and γ. At the same time, it switches production factors towards the non-traded (exported) goods sector, increasing (decreasing) α:[7]

$$\partial\alpha / \partial q > 0, \partial\beta / \partial q < 0, \partial\gamma / \partial q < 0 \tag{2}$$

where q is the internal real exchange rate defined as the ratio between non-traded-goods prices and the traded-goods price index:

[7] Note that real output is fixed at full employment level and thus there is no income effect on the distribution of absorption between traded- and non-traded goods.

$$q = P_N / P_X{}^{\theta} P_{IM}{}^{1-\theta} \tag{3}$$

where P_N, is the domestic currency price of non-traded goods and P_X, and P_{IM} are those of exported and imported goods whose weights are θ and $1-\theta$, respectively.

The economy is in external balance when the current account balance, which equals the real output less the total absorption, is at a country's target level:

$$CA^T = \overline{Y} - (A_P + A_G) \tag{4}$$

where CA^T is the current account target.[8] The current account target would differ from country to country depending on its policy priority. Some countries might actively manage exchange rates to achieve the desirable current account position which is consistent with the medium-term saving-investment position. Others might run a current account deficit in an attempt to absorb capital inflows induced by a domestic investment boom. The bottom line, however, is that any current account target has to be sustainable in the sense that it would achieve a sustainable external debt position over the medium run. Other things being equal, a large external debt is likely to require the build up of larger current account surplus over time to stabilize the ratio of external debt to GDP or exports at a sustainable level.[9] Conversely, a small external debt may allow a country to run current account deficits without seriously undermining the debt sustainability. The external debt position would thus set the boundary within which the current account target has to be selected.

The choice of current account target would also be subject to the constraint on the availability of foreign capital. Compared with developed countries, developing countries generally confront much more limited and variable access to international capital markets largely because of the presence of asymmetric information problems and, more importantly, because of uncertain probabilities of balance-of-payment crises. Thus, there is no guarantee that developing countries can finance the targeted current account deficit by borrowing capital internationally. A higher risk of balance-of-payment crises would have an adverse effect on developing countries' access

[8] For simplicity, net income transfer is ignored here.

[9] The conventional rule of thumb holds that the maximum safe ratios of the external debt to GDP and the external debt to exports are 40 percent and 200 percent, respectively (Williamson 1994).

to international capital markets.

On top of unsustainable debt positions, the shortage of foreign exchange liquidity is also a major source of vulnerability to balance-of-payment crises. The most commonly used indicator to assess the risk of liquidity shortage is the adequacy of the foreign exchange reserve position, such as the ratio of reserves to money stock or short-term external debt. The latter helps gauge the risk associated with sudden stops to the rollover of short-term credit, while the former provides a measure of the potential impact of capital flight out of the domestic currency. In either case, a smaller reserve position would imply a higher risk of liquidity shortage and thus a greater probability of balance-of-payment crises.

Another source of vulnerability to balance-of-payment crises that has attracted much attention recently is the fragility of financial systems, particularly banking systems. As demonstrated by the recent emerging market crises in Asia and elsewhere, a balance-of-payment crisis is often accompanied by a banking crisis. These two types of crises tend to be mutually reinforcing and one could be the trigger for the other.[10] Banks are inherently fragile because they are usually highly leveraged, exposed to maturity mismatches, and operate in the market where asymmetric information problems are more pronounced. On top of these, banks in developing countries are often exposed to currency mismatches which make them much more vulnerable to external shocks that induce a large variation in exchange rates.[11] Hence, a greater degree of currency mismatches in bank balance sheets might be associated with a higher risk of banking crises and thus balance-of-payment crises.

To sum up, the choice of a current account target would be subject to the constraint imposed by the sustainability of the external debt position, the adequacy of the reserve position, and the fragility of the financial system originating particularly from extensive currency mismatches. Other things being equal, a deterioration in external debt and reserve positions as well as the weakening of the financial system are likely to necessitate a country to achieve an improved current account balance. Conversely, a significant improvement in external debt and reserve

[10] See Kaminsky and Reinhart (1999)

[11] See Eichengreen and Hausmann (1999) and Calvo and Reinhart (2000).

positions as well as the strengthening of the financial system might allow a country to run a sizable current account deficit for a longer period.

Drawing on the above analysis, the present model which focuses on the case of Korea assumes that the level of current account target is negatively related to the ratio of net foreign assets of the banking system (the sum of net foreign assets of monetary authorities and banks) to the stock of broad money, namely M2:

$$\partial CA^T / \partial (nfa / m) < 0 \qquad (5)$$

where *nfa* denotes the net foreign assets of the banking system and *m* denotes M2. The net foreign assets of the banking system are used instead of overall net foreign assets for two reasons. Firstly, the data on Korea's international investment positions has been available only on an annual basis. At the very least, quarterly data is needed to analyze the development of exchange rates during the Korean crisis. Secondly, banks have been the major channel for external borrowing in Korea and the foreign assets and liabilities of monetary authorities (including reserve assets) and banks have constituted the majority of total non-equity foreign assets and liabilities at least up to the early 1990s (see Table 1). Therefore, focusing on the net foreign assets of the banking system might not be critically misleading.

Moreover, this variable can be considered as an indicator for the risk of liquidity shortage. The foreign assets of monetary authorities are largely equivalent to foreign exchange reserves,[12] while a large share of the foreign assets and liabilities of banks is at short-term maturities.[13] Accordingly, the net foreign assets of the whole banking system would roughly measure the availability of foreign exchange liquidity for the economy in the event of sudden stops to capital inflows, given the fact that banks are the major channels for external borrowing in Korea. The ratio of net foreign assets of the banking system to M2 could therefore provide a measure for the potential impact of capital flight out of domestic currency.

[12] The major difference between monetary authorities' foreign assets and foreign exchange reserves arises from the different treatment of IMF credits. While the disbursement of IMF credits improves the reserve positions, the outstanding IMF credit is counted as foreign liabilities.

[13] The shares of short-term assets and debt in total assets and debt of banks are on average 66 percent and 55 percent over the period 1995-2000, respectively (Bank of Korea *External Debt and Asset*).

Finally, this variable also helps to evaluate the significance of currency mismatches in bank balance sheets provided that most of the foreign assets and liabilities are denominated in foreign currency. If, for example, the net foreign assets of monetary authorities are larger than the net foreign liabilities of banks (and assuming that the long-term foreign assets and liabilities of banks largely offset each other), then, in theory, banks will have access to sufficient amount of foreign exchange liquidity required for the repayment of foreign-currency short-term debt. In other words, the monetary authorities are capable of accommodating a temporary withdrawal of foreign credits through the provision of foreign exchange liquidity support to banks. Moreover, to the extent which such liquidity support finances the balance-of-payment disequilibrium, the magnitude of exchange rate adjustment will be reduced. Consequently, the risk of a banking crisis arising either from liquidity shortage or adverse balance sheet effects of depreciation will be mitigated.

Now, substitute (1) into (4) to eliminate A_P:

$$-CA^T / \overline{Y} = (\alpha / \beta - 1) - (\gamma / \beta - 1) A_G / \overline{Y} \ . \qquad (6)$$

The condition necessary to maintain the internal and external balance simultaneously is given by Equation (6). Using this condition, the long-run relationship between real exchange rates and the relevant fundamentals can be derived. As discussed below, the long-run fundamental exchange rate can be expressed as a function of four key variables:

$$\overline{q} = f(\overset{+/-}{tot}, \overset{+}{pro}, \overset{+}{gsb}, \overset{+}{nfam}) \qquad (7)$$

where $\overline{q}$ is the long-run fundamental exchange rate, *tot* is terms of trade, *pro* is the productivity differential, *gsb* is government spending bias, and *nfam* is the ratio of net foreign asset to money supply. The signs above the right-hand-side variables denote the partial derivatives. The plus sign implies that a rise in the value of the variable is associated with real exchange rate appreciation.

Terms of trade *tot*: The terms of trade is the relative price of exported to imported goods. An improvement in terms of trade may increase the share of export goods in production (a decline in α) because of a rise in the relative price of exported to non-traded goods (production substitution effect). At the same time, it may increase the share of imported goods in absorption (a decline in β and γ) due to a fall in the relative price of imported to non-traded goods (expenditure switching effect). In the former case, macroeconomic balance can be restored by real exchange rate appreciation that raises α while reducing β and γ.[14] Conversely, in the latter case the macroeconomic balance condition requires real exchange rate depreciation. The overall effect of terms-of-trade shocks on real exchange rates therefore depends on the relative strength of these two opposing effects.[15]

Productivity differential *pro***:** With real exchange rates being unchanged, a rise in the relative productivity in the traded goods sector will increase the marginal product of factors and thus draw resources out of the non-traded goods sector, leading to a rise in the production share of exported goods (a decline in α). In order to restore macroeconomic balance, Equation (6) suggests that real exchange rate appreciation is needed.[16]

Government spending bias *gsb***:** Equation (6) indicates that if the share of non-traded goods in government absorption is higher than in private absorption ($\gamma > \beta$), a rise in the level of government absorption will require real exchange rate appreciation to restore macroeconomic balance.[17]

Ratio of net foreign asset to money supply *nfam***:** As the ratio of net foreign assets to M2 is assumed being negatively related to the current account target, a rise in the ratio will require real exchange rate appreciation to maintain macroeconomic balance.

[14] In what follows, it is assumed that β and γ vary proportionally to changes in real exchange rates, so that the ratio between them remains constant.

[15] Since the real output is assumed to be fixed at full employment level, the income effect of terms of trade is not considered here.

[16] Corden and Neary (1982) examine the effect of productivity gain in the traded goods sector on real exchange rates in a three-good dependent economy model.

[17] There is empirical evidence to suggest that the level of government spending is positively related to the relative price of non-traded goods. See, for example, De Gregorio, Giovannini, and Wolf (1994).

3. Empirical methodology

In the following empirical analysis, the long-run relationship implied by the Equation (7) is tested and the associated error correction model is estimated for Korea's exchange rates. The testing and estimation method used is the autoregressive distributed lag (ARDL) procedure developed by Pesaran *et.al.*(1996) and Pesaran and Shin (1997). The ARDL procedure is chosen because it can be applied to the estimation of long-run relationships irrespective of whether the underlying regressors are integrated in the order of zero or one ($I(0)$ and $I(1)$, respectively, hereafter). Accordingly, it can circumvent the pre-testing problem associated with a standard cointegration analysis which requires the classification of the variables into $I(0)$ and $I(1)$.

The model for Korea's exchange rate is estimated using the quarterly data over the post-Bretton Woods period (1973Q1-2000Q4). The period 2001Q1-2001Q4 is retained for out-of-sample forecasts. All data are obtained from the IMF *International Financial Statistics*. The definitions of the variables are given below.

Real exchange rate q: Assuming that the law of one price holds for traded goods, the internal real exchange rate in foreign currency is defined as

$$q = \log(NEER) + \log(CPI_k) - \log(PPI_f) \qquad (8)$$

where CPI_k is Korea's consumer price index (CPI), PPI_f is the foreign producer price index (PPI), $NEER$ is Korea's nominal effective exchange rate in terms of the foreign currency. As a proxy for the prices of non-traded and traded goods, Korea's CPI and foreign PPI were used respectively because CPI contains both traded and nontraded goods while PPI is heavily weighted with traded goods.[18] The foreign PPI is defined as the weighted average of the PPI in Korea's major trading partners, namely the United States, Japan, and the European Union (EU). The weights are computed by using the share of Korea's trade with these regions.[19] As a proxy

[18] See Hinkle and Nsengiyumva (1999) for the discussions on the definition and measurement of real exchange rates.

[19] The weights are 0.45 for the United States, 0.35 for Japan, and 0.2 for the EU. These weights are computed by dividing each region's trade share (the sum of the share of export and import) by the sum of these trade shares. The trade share of the Western Hemisphere is also added to that of the United States

for the PPI of the EU, the PPI of Germany is used. The nominal effective exchange rate is defined as the weighted average of the bilateral exchange rate against the US dollar, Japanese yen, and German mark. The same weights as those for the foreign PPI are used for the calculation. The bilateral exchange rate against the German mark is used as a proxy for the exchange rate against the EU.[20]

Terms of trade *tot*: This variable is defined as the ratio of the Korea's export unit value to the import unit value relative to the equivalent foreign ratio. The foreign export (import) unit value is defined as the weighted average of export (import) unit value of the United States, Japan, and Germany. The same weights as those for the foreign PPI are used for the calculation. The variable is expressed in logarithms.

Productivity differential *pro*: Assuming that the productivity growth in the non-traded goods sector is much slower than that of the traded goods sector and thus can be treated as constant, the productivity differential between the traded goods sector and the non-traded goods sector is measured by the ratio of a seasonally adjusted industrial production index to the manufacturing employment index. The variable is expressed in logarithms.

Government spending bias *gcy*: The effect of government spending bias is measured by the ratio of government consumption to trend GDP. The trend GDP is obtained by filtering the series using the Hodrick-Prescott procedure.

The Ratio of net foreign assets to money supply $nfam$: This variable is defined as the ratio of net foreign assets of the banking system (the sum of net foreign assets of monetary authorities and deposit money banks) to M2.

since most of the developing countries in this region used to peg to the dollar and still tend to focus mainly on the dollar. The trade share is computed using the trade data of 1993 drawn from the IMF *Direction of Trade Statistics*.

[20] The bilateral exchange rate against the German mark after 1999Q1 when the euro was introduced is computed by using the market rate of the euro and the fixed conversion rate for the German mark (1euro = 1.95583 mark).

4. Estimation results

Table 2 reports the F-statistic for testing the significance of the lagged level variables in the error correction model explaining the first difference of real exchange rate, Δq, for two cases. As quarterly data are used, the maximum lag of four was chosen for the test. In the first case where *gcy* is not included as the explanatory variable, the F-statistic exceeds the upper bound of the critical value bound and thus the null of no long-run relationship between *q* and other variables can be rejected at 99 percent level, irrespective of the order of their integration. On the other hand, the null of no relationship between *q* and other variables cannot be rejected at the 99 percent level in the second case where *gcy* is also included, though it can be rejected at 95 percent level. This suggests that there might not be a statistically significant long-run relationship between *gcy* and *q*. In fact, the estimated long-run coefficient of *gcy* given by the underlying ARDL model was not significant. Therefore, *gcy* was dropped from the model.

Table 3 presents the F-statistics for testing the significance of the lagged level variables in the error correction models explaining Δtot, Δpro, and $\Delta nfam$, respectively. The F-statistics for Δtot, Δpro, and $\Delta nfam$ all fall well below the lower bound of the critical value band at the 95 percent level, indicating that the null hypothesis that the level variables do not enter significantly in the equations for Δtot, Δpro, and $\Delta nfam$ cannot be rejected, irrespective of the order of their integration. These results suggest that *tot*, *pro*, and *nfam* can be treated as the long-run forcing variables for the explanation of Δq.

The estimates of the underlying ARDL model are reported in Table 4. The maximum lag of four was used for the selection of the lag order and the Akaike Information criterion (AIC) selects the ARDL (4,4,1,1) specification.[21] The residual diagnostic statistics suggest that there is no evidence of serial correlation and hetroscedasticity, indicating that the selected model

[21] The Schwartz Bayesian criterion (SBC) selected ARDL (2,0,0,0) specification. Although the point estimates of long-run coefficients based on the SBC were very similar to those based on the AIC, the residual diagnostic statistics suggested that the model selected based on the SBC did not satisfy the white noise assumption. It is for this reason that the model selected based on the AIC was used in the present analysis despite the fact that the SBC is a consistent estimator and more robust to non-normal disturbances.

satisfies the white noise assumption.

The estimates of the associated error correction models are reported in Table 5. Most of the coefficients are statistically significant at the conventional significance level. The coefficient of the error correction terms has the correct sign and suggests that the deviations from the long-run fundamental exchange rate will be eliminated by about 25 percent within one quarter.

The estimates of the long-run coefficients are reported in Table 6. All coefficients are correctly signed and statically significant at the conventional significance level. The long-run relationship between real exchange rates and fundamental variables can be summarized by the following equation:

$$\hat{q} = 0.71934tot + 0.18745pro + 0.2733nfam + 4.2862 \ . \quad (9)$$

The long-run fundamental exchange rate can be computed by inserting the actual value of the fundamental variables into Equation (9).

5. Korea's exchange rate dynamics over the past two decades

The estimated long-run fundamental exchange rate and fitted value given by the estimated ARDL model are plotted against the actual real exchange rate in Figure 2. Note that the log values of exchange rates were transformed by taking their exponential in the figure. There are five important points worth mentioning here.

5.1. Overvaluation in 1982-1983

Firstly, Korea's real exchange rates were substantially overvalued during the period 1982-1983. After the second oil shock, Korea experienced a severe stagflation in 1980. The real GDP fell by about 2 percent and the inflation rate rose to more than 28 percent, while the ratio of current account deficit to GDP exceeded 8 percent (see Table 7). The policy response to this stagflation included a tightening of macroeconomic policies and the devaluation of the Korean won.

In the latter connection, the exchange rate system was changed from a US dollar peg to a more flexible multiple currency basket peg (MCBP) system, in which the won-dollar rate was determined according to the undisclosed currency basket and discretionary policy judgments. There was a great deal of speculation that the factor of policy judgments was the most important determinant of the won-dollar rate. The major objective of Korea's exchange rate policy appeared to be the stabilization of current account balance.[22]

The adjustment policies in response to the stagflation proved to be successful: The economic growth resumed and the inflation rate fell to single-digits by 1982, while the ratio of the current account deficit to GDP more than halved by 1982. However, as the US dollar strengthened against the major currencies, the won appreciated sharply on a real effective basis in 1981. On the other hand, the long-run fundamental exchange rate was on a declining trend primarily due to the deterioration in Korea's net foreign asset position relative to money supply. Consequently, the won became overvalued by 8-9 percent during the period 1982Q2-1983Q1.[23]

The Korea continuously devalued the won-dollar rate in an attempt to improve the current account balance. As a result, the magnitude of misalignment was almost halved from the peak level by the end of 1984. At the same time, the current account deficit declined to less than 2 percent of GDP. The won, however, became significantly overvalued again in the fist half of 1985 as the US dollar strengthened against the major currencies. The misalignment was corrected substantially only after the adjustment of exchange rates among major currencies occurred (i.e., the depreciation of US dollar against the Japanese yen and the German mark) following the Plaza accord of September 1985.

5.2. Undervaluation in 1986-1987

Secondly, Korea's real exchange rate was significantly undervalued during the period

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[22] The won-dollar rate under the MCBP system was determined according to the following equation:

$$E = \beta B_1 + (1-\beta)B_2 + \alpha$$

where E is official won-dollar rate, B_1 and B_2 are the won-dollar rate given by the special drawing rights (SDR) basket and the independent basket, respectively. The variable β and $1 - \beta$ are the weights attached to these baskets and α represents the policy factors. The composition of the independent basket and relative weights between the two baskets were never disclosed to the public. See Rhee and Song (1999).

[23] The misalignments are calculated as percentage of the actual exchange rate.

1986-1987. Korea experienced unprecedented economic booms in 1986-1988. The average growth rate exceeded 10 percent during this period, while the current account surplus rose to 8 percent of GDP in 1988. The major driving forces behind the boom were the so-called “three low”－low oil prices, low world interest rates, and the low US dollar rate. The significant improvement in Korea’s terms of trade and the relative net foreign asset position led to a sharp appreciation in the long-run fundamental exchange rate, while the substantial appreciation of the Japanese yen against the dollar resulted in a steep depreciation in the won rate on a real effective basis. Consequently, the won became undervalued on average by about 8 and 15 percent in 1986 and 1987, respectively.

When Korea’s current account registered a sizable surplus－largely with the United States－in 1986, the Korea came under immense pressure form the US government to let the won-dollar rate appreciate.[24] Following the rise in the won-dollar rate, the real effective rate appreciated sharply and the misalignment was almost eliminated by 1989. At the same time, the growth rate of export volume fell to less than one percent from the previous three years’ average of 16 percent and the current account surplus fell below 3 percent of GDP in 1989.

5.3. No substantial misalignment from 1990 to early 1995

Thirdly, there was no substantial misalignment from 1990 to early 1995. Korea adopted a new exchange rate system known as the Market Average Rate (MAR) system in March 1990. Under this system, the basic won-dollar rate was determined by market forces, though, only within the limits of daily fluctuation bands set around the weighted average interbank rates of the previous day.[25] To keep the won-dollar rate within the band, the Bank of Korea (BOK) frequently intervened in the market. The intervention was effective because the size of Korea’s foreign exchange market was small relative to the amount of the BOK’s foreign exchange reserves.[26] In

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[24] Nam and Kim (1999)

[25] At the beginning, the width of the band was plus/minus 0.4 percent, and it was widened in several steps to plus/minus 2.25 percent in December 1995.

[26] The average daily turnover of foreign exchange transactions in the won-dollar market was only 1.2

addition, the BOK exercised window guidance with the aim of preventing large fluctuations even inside the band and thus the banks tended to refrain from quoting rates close to the upper or lower bounds of the band.

The evidence shows that the volatility of won-dollar rate under the MAR system was not significantly higher than that under the MCBP system, indicating that much emphasis was placed on the stability of the won-dollar rate under the MAR system as well.[27] As the long-run fundamental exchange rates were relatively stable due to the absence of large shocks to underlying fundamentals, the exchange rate policy seeking stability under the MAR system happened to be successful in avoiding serious misalignments from 1990 to early 1995.

5.4. Overvaluation before the Crisis

Fourthly, Korea's real exchange rates were significantly overvalued during the period before the crisis of 1997-98. During the period 1997Q1-1997Q3, the magnitude of misalignments reached nearly 20 percent, which was much larger than those observed in the past two decades.

The long-run fundamental exchange rate declined substantially over the period 1996-1997, while the actual rate appreciated sharply in 1995. The major factor behind the decline in the long-run fundamental exchange rate was the deterioration in terms of trade which stemmed from a cyclical decline in semiconductor prices from the end of 1995. On the other hand, the appreciation of the actual rate arose from the strengthening of the US dollar against major currencies. The appreciation of the US dollar against the Japanese yen led to a rise in the won-yen rate by about 24 percent between 1995Q2 and 1996Q2. This was primarily due to the fact that much emphasis was placed on the stability of the won-dollar rate under the MAR system. It is important to emphasize that the misalignments were generated by external shocks, namely the deterioration in terms of trade and a change in the yen-dollar rate trend, along with the inflexibility of Korea's exchange rate system.

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billion dollars during 1991-95, while the BOK held 21.3 billion dollars on average during the same period (Rhee and Song 1999).

[27] Rhee and Song (1999)

5.5. Overshooting after the onset of the crisis

Lastly, and most importantly, Korea's real exchange rate overshot the long-run fundamental exchange rate by a large margin in 1998Q1. Korea was hit by a crisis and forced to abandon the MAR system in December 1997. Following that, the won-dollar rate depreciated dramatically and the real effective rate fell to a record-low level, which was about 24 percent undervalued relative to the long-run fundamental exchange rate, in 1998Q1. Although the real exchange rate rebounded steeply in 1998Q2, it took another eight quarters for most of the misalignments to be eliminated.

The key findings of the above observations can be summarized as follows: Firstly, under the relatively inflexible exchange rate systems, serious misalignments emerged repeatedly during the past two decades. While the ensuing adjustments proceeded in an orderly way in the case of the mid-1980s, others were either awkward (the adjustment under the US pressure in the late 1980s) or disastrous (the crisis of 1997-98). Secondly, misalignments frequently emerged due to the large variations of exchange rates among major currencies, notably the US dollar and the Japanese yen. This is mainly because too much weight has been attached to the stability of won-dollar rate under the Korean exchange rate system despite Korea's diversified foreign trade patterns. Finally, the fact that the exchange rate was substantially overvalued before the crisis of 1997-98 suggests that at least a part of the subsequent depreciations were unavoidable in order to correct misalignments. It is, however, not clear from the preceding analysis to what extent the sharp depreciation during the crisis can be explained by the short-run dynamics of exchange rates induced by the response to the misalignments.

6. Overshooting of the overshooting equilibrium

Figure 3 displays the developments of misalignments and residuals over the period between 1995Q1 and 2000Q4. The residual is the difference between the actual real exchange rate and the fitted value given by the estimated ARDL model, measured as the percentage of the actual exchange rate. As mentioned above, the degree of misalignments started to increase sharply in early 1996 and reached nearly 20 percent of the actual rate before the crisis. Then, the actual rate fell steeply, overshooting the long-run exchange rate by about 24 percent in 1998Q1.

What is most striking here is the exceptionally large size of residual in 1998Q1. It was about 3.6 times larger (in absolute terms) than the standard deviation of residuals over the estimated period. In fact, about 65 percent of the overshooting in 1998Q1 can be accounted for by this large deviation from the short-run fundamental value of exchange rates. To put it differently, only less than half of the overshooting can be explained by the short-run dynamics of exchange rates implied by the estimated error correction model. Borrowing Frankel's (1996) term, there seems to have been a substantially large "overshooting of the overshooting equilibrium" in nominal exchange rates, which in turn caused a large deviation of real exchange rates from the fundamental value given the downward stickiness of the prices of non-trade goods.

As shown by Jeanne and Rose's (2002) model on noise trading, such an excessive nominal rate overshooting can be attributed to the distorting effect of noise trading on exchange rate determinations in the currency market. A rise in the number of active noise traders might have generated a higher exchange rate volatility relative to underlying fundamentals, which could in turn have heightened risk premium, thereby further fueling noise trading.[28]

Indeed, a sharp rise in Korea's nominal exchange rate volatility was observed during the crisis. Figure 4 shows the conditional standard errors of daily won-dollar rate given by the estimated GARCH (generalized autoregressive conditional heteroscedastic) model. Table 8 reports the estimation results of the model. As can be seen from the figure, there was a steep increase in the degree of volatility in won-dollar rate between the period December 1997 and

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[28] In their model, there are two types of foreign exchange traders: informed traders who act on rational expectations and noise traders who trade on the basis of noise. The presence of noise traders is the source of excessive exchange rate volatility unrelated to fundamentals. The market entry of noise traders depends on risk premium and exchange rate volatility as well as entry costs. At the same time, risk premium and exchange rate volatility are functions of the number of noise traders. Due to this circularity, multiple equilibria—a good one with few noise traders and low exchange rate volatility and a bad one with many noise traders and high exchange rate volatility—could arise. The observed excessive overshooting during the Korean crisis can be understood as the outcome of a shift from a good equilibrium to bad one in the wake of currency turmoil.

January 1998. It seems that exchange rate determinations in the market had increasingly been distorted by “noise” under the heightened economic uncertainty following the collapse of the MAS system. The resulting prevalence of noise trading appears to have generated an excessive exchange rate fluctuation, causing the overshooting of the overshooting equilibrium. The nominal rate overshooting might in turn have driven the real exchange rate away from its fundamental value given the sluggish adjustment of the relative prices of non-trade goods.

7. Concluding remarks

This paper analyzed Korea’s exchange rate behaviour before and during the crisis of 1997-98 by estimating the long-run fundamental exchange rate and the associated error correction model. It has found that there was a substantial overvaluation of real exchange rate before the crisis, indicating that at least part of subsequent depreciations were unavoidable to correct misalignments. In addition, it has found that there was not only the overshooting of real exchange rates but also a large deviation from the short-run fundamental value of real exchange rates during the crisis, suggesting that the sharp depreciation in the wake of capital flow reversals could not be explained by the adjustment to misalignments alone: there seems to have been an substantially large overshooting of the overshooting equilibrium in Korea’s exchange rates during the crisis. As suggested by Jeanne and Rose (2002), such an excessive nominal rate overshooting can be induced by the prevalence of noise trading in the currency markets. The evidence suggests that the exchange rate determination in the Korean currency market might have increasingly been distorted by noise under the heightened economic uncertainty following the collapse of the MAS system.

The key lessons for exchange rate management drawn from the above empirical findings are two-fold. Firstly, serious misalignments have to be prevented to avoid destabilizing adjustments. Clearly, substantially misaligned exchange rates are not sustainable and could be the cause for abrupt and large changes in exchange rates. Disorderly sharp exchange rate depreciations could in turn have a serious contractionary impact on economic activities particularly in a small open economy where the import content of production is high and there are extensive currency-mismatches in the balance sheets of domestic banks and firms. In such an economy, a high priority should be given to preventing serious misalignments in exchange rate management.

Secondly, when exchange rate adjustments become unavoidable due to either the need to correct misalignments or a non-temporary reduction in capital inflows that necessitates current account improvement, the first priority of exchange rate management should be to stabilize market expectations and thus discourage noise trading in the currency market. As shown by the analyses of this paper, sharp exchange rate deprecations could arise from excessive exchange rate fluctuations unrelated to fundamentals. To prevent the overshooting of the overshooting equilibrium that could result in costly adjustments, the government's adequate exchange rate management aimed at stabilizing market expectations in the midst of turmoil would be critically important.

However, the recent dramatic increase in the mobility of global capital flows has increasingly undermined the ability of emerging market economies to manage their exchange rates. A grater risk of sudden stops of capital inflows and associated Asian-type crises is likely to make capital flows to emerging market economies more volatile and thus greatly increase the difficulty of maintaining the targeted exchange rate. Confronted with such challenge, one possible solution would be to employ some institutional mechanisms that help reduce excessive volatility in capital flows and exchange rates. Options might include the imposition of restrictions and taxes on capital and foreign exchange transactions.

Another solution would be to improve access to supplemental financing that would enhance the capacity of national governments to deal with destabilizing market pressures against their currencies. Establishing regional exchange rate arrangements that involve effective financing facilities would serve such a purpose.[29] With the enhanced ability to stabilize exchange rates, emerging market economies would better deal with panic-driven capital flow reversals, which

[29] Nissanke (2003) discusses the case for the "two-tier Tobin tax" originally proposed by Spahn (1995; 1996) as an instrument to enhance the manageability of exchange rates in developing countries. In a similar vein, Kinkyo (2004b) argues the case for regional exchange rate arrangement in the context of East Asia.

could otherwise result in economic disaster.

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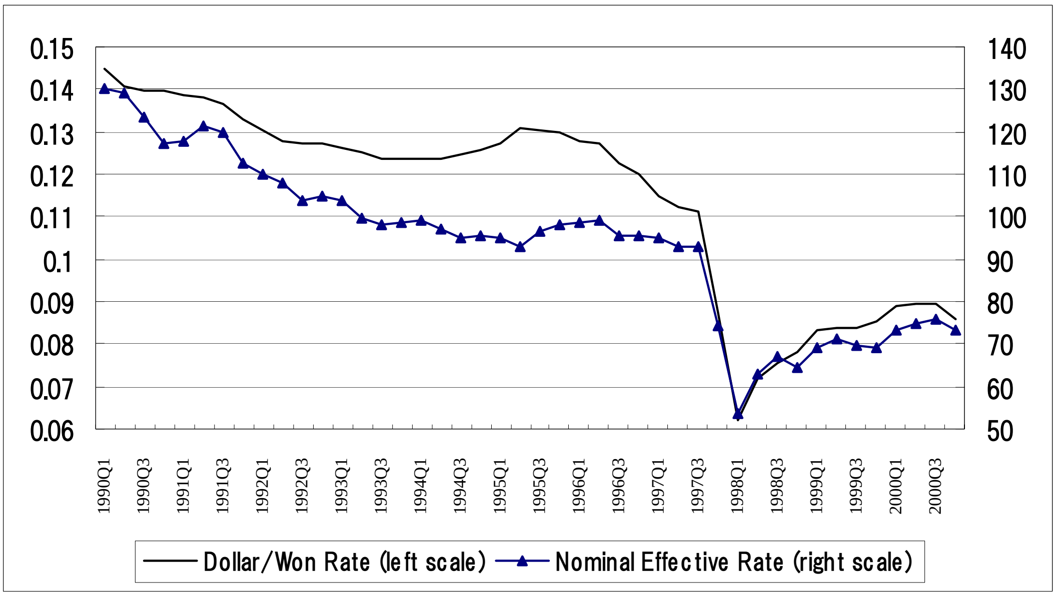

Fig. 1. US dollar per 100 Korean won rate and nominal effective rate (quarterly average)

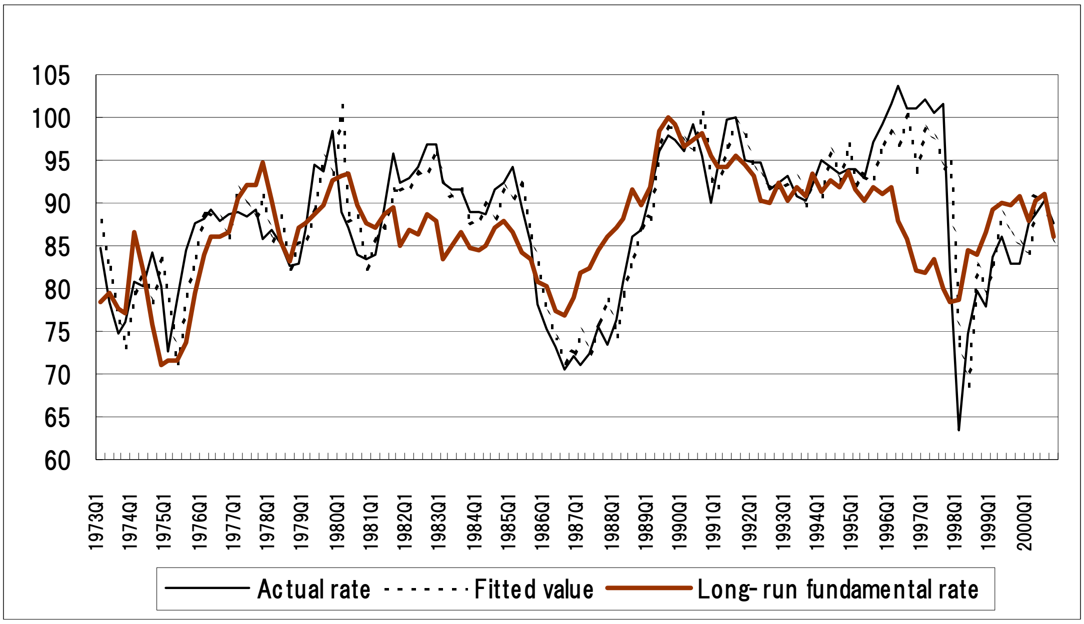

Fig. 2. Actual real exchange rate, fitted value, and long-run fundamental rate

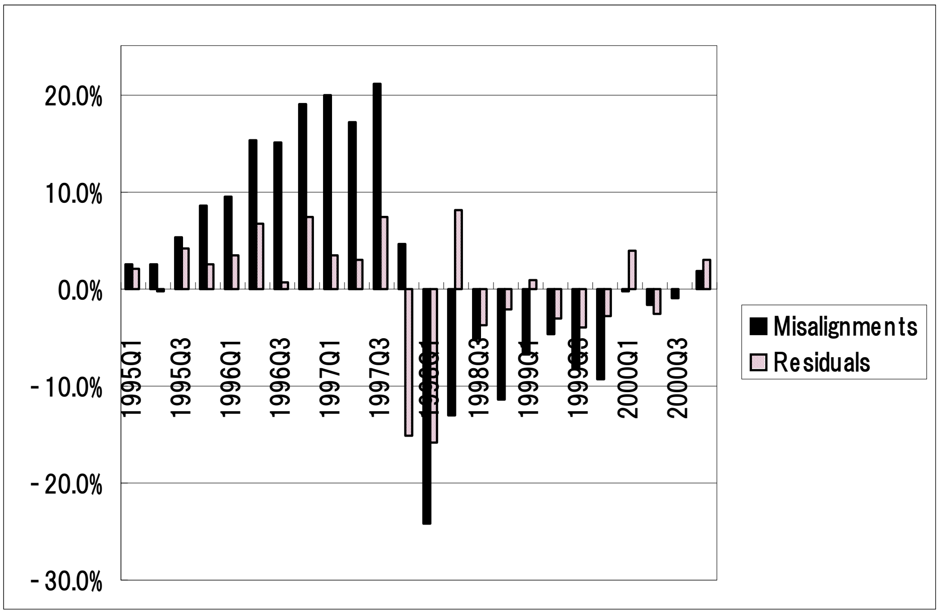

Fig. 3. Misalignments and residuals (as percentage of the actual real exchange rate)

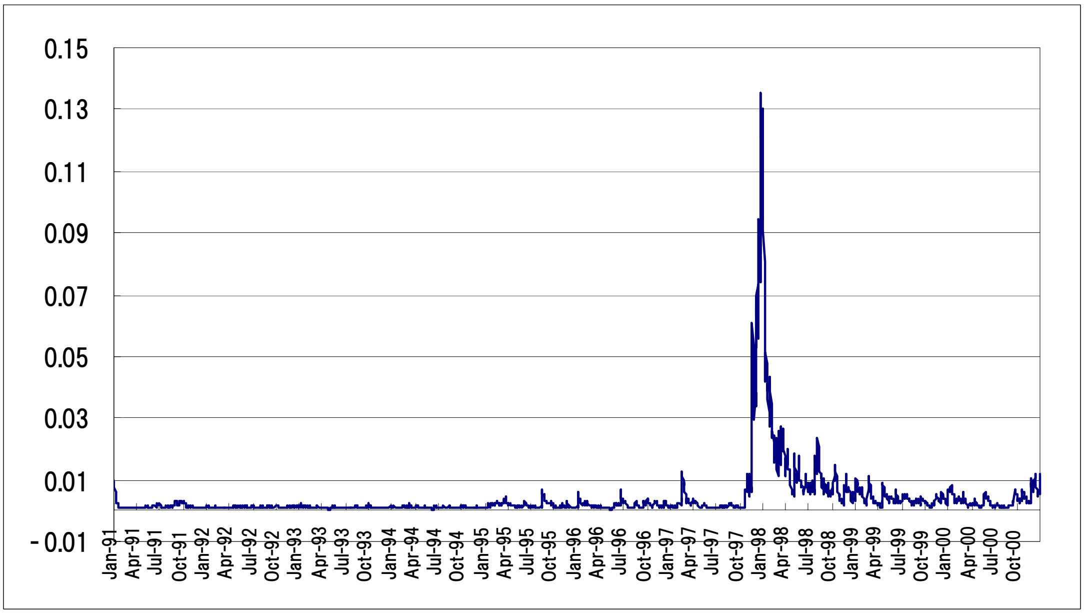

Fig. 4. Conditional standard errors for daily won per US dollar rate

Table 1

The composition of international investment position in Korea

(%)

	1980-1984 average	1985-1989 average	1990-1994 average	2001
Total assets	100.0	100.0	100.0	100.0
Equity investment	3.3	4.9	11.4	11.5
Direct investment	3.3	4.9	11.4	10.8
Portfolio equity	n.a.	n.a.	n.a.	0.7
Non-equity investment	96.7	95.3	88.6	88.3
Debt securities	n.a.	0.3	1.0	4.1
Other investment	23.8	33.9	42.8	28.6
Monetary authorities	n.a.	n.a.	n.a.	0.4
General Government	n.a.	n.a.	0.0	0.5
Banks	7.6	23.9	32.5	22.6
Other sectors	16.2	10.1	10.3	5.1
Reserve assets	72.9	61.0	44.8	55.6
Total liabilities	100.0	100.0	100.0	100.0
Equity investment	7.8	16.1	26.3	48.1
Direct investment	7.4	14.7	14.6	20.1
Portfolio equity	0.4	1.4	11.7	28.0
Non-equity investment	92.3	83.9	73.7	51.7
Debt securities	3.0	8.8	21.1	14.1
Other investment	89.3	75.1	52.6	37.7
Monetary authorities	9.2	4.7	0.4	0.2
General Government	n.a.	n.a.	n.a.	7.2
Banks	80.0	70.4	52.2	11.6
Other sectors	n.a.	n.a.	n.a.	18.7

Note: 1. The comparable data for the period between 1995-2000 are not available.
2. The non-equity investment (assets) include reserve assets.

Source: IMF *International Financial Statistics*

Gross external asset and debt

(1995-2000 average; % share)

Total assets	100.0
General government	0.7
Monetary authorities	41.4
Banks	44.6
Other sector	13.3
Total debt	100.0
General government	8.1
Monetary authorities	5.9
Banks	52.1
Other sector	34.0

Source: Bank of Korea

Table 2

F-statisitcs for testing the significance of the lagged levels of the variables

Dependent variable	Explanatory variables	F-statistics	Critical value bounds			
			95%		99%	
			I(0)	*I(1)*	*I(0)*	*I(1)*
q	***tot, pro, nfam***	6.0261	3.219	4.378	4.385	5.615
q	***tot, pro, gcy, nfam***	4.9556	2.85	4.049	3.817	5.122

Table 3

F-statisitcs for testing the significance of the lagged levels of the variables

Dependent variable	Explanatory variables	F-statistics	Critical value bounds			
			95%		99%	
			I(0)	*I(1)*	*I(0)*	*I(1)*
tot	***q, pro, nfam***	2.2852	3.219	4.378	4.385	5.615
pro	***q, tot, nfam***	2.4197	3.219	4.378	4.385	5.615
nfam	***q, tot, pro***	1.8967	3.219	4.378	4.385	5.615

Table 4
Autoregressive distributed lag estimates
Dependent variable: *q*

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
q (-1)	1.0193	0.094717	10.7615[.000]
q (-2)	-0.48086	0.12827	-3.7487[.000]
q (-3)	0.38009	0.13027	2.9178[.004]
q (-4)	-0.17303	0.087565	-1.9760[.051]
tot	0.48997	0.13286	3.6878[.000]
tot (-1)	-0.30691	0.13491	-2.2749[.025]
pro	0.31369	0.15232	2.0594[.042]
pro (-1)	-0.26599	0.15837	-1.6796[.096]
nfam	-0.15672	0.13246	-1.1832[.240]
nfam (-1)	0.22627	0.13364	1.6931[.094]
const	1.0908	0.24689	4.4181[.000]

Diagnostic Tests

	Lagrange Multiplier Test	F Test
A:Serial Correlation:	CHSQ(4)=2.3615[.670];	F(4, 97)= .52232[.720]
B:Heteroscedasticity:	CHSQ(1)= 1.8343[.176];	F(1, 110)= 1.8315[.179]

A:Lagrange multiplier test of residual serial correlation
B:Based on the regression of squared residuals on squared fitted values

Table 5
Error correction representation for the selected ARDL model
Dependent variable: *dq*

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dq1	0.2738	0.085745	3.1932[.002]
dq2	-0.20706	0.085847	-2.4120[.018]
dq3	0.17303	0.087565	1.9760[.051]
dtot	0.48997	0.13286	3.6878[.000]
dpro	0.31369	0.15232	2.0594[.042]
dnfam	-0.15672	0.13246	-1.1832[.239]
const	1.0908	0.24689	4.4181[.000]
ecm(-1)	-0.25449	0.056599	-4.4964[.000]

List of additional temporary variables created:
dq = q-q(-1), dq1 = q(-1)-q(-2), dq2 = q(-2)-q(-3), dq3 = q(-3)-q(-4)
dtot = tot-tot(-1)
dpro = pro-pro(-1)
dnfam = nfam-nfam(-1)
ecm = q - 0.71934*tot* - 0.18745*pro* - 0.27330*nfam* - 4.2862*const*

Table 6

Estimated long run coefficients

Dependent variable: *q*

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
tot	0.71934	0.20267	3.5493[.001]
pro	0.18745	0.069204	2.7087[.008]
nfam	0.2733	0.12564	2.1752[.032]
const	4.2862	0.056906	75.3211[.000]

Table 7
Major Economic Indicators in Korea

(%)

	Won-Dollar Rate	Current Account (Ratio to GDP)	Rate of Change				Overnight Call Rate
			CPI	Real GDP	Export Volume	Import Volume	
1970	310.6	n.a.	16.1	8.8	26.4	4.5	n.a.
1971	347.1	n.a.	13.4	8.6	26.9	21.4	n.a.
1972	392.9	n.a.	11.7	4.9	51.8	2.6	n.a.
1973	398.3	n.a.	3.2	12.3	55.8	28.4	n.a.
1974	404.5	n.a.	24.3	7.4	9.5	3.2	n.a.
1975	484.0	n.a.	25.3	6.5	23.2	3.2	n.a.
1976	484.0	-1.1	15.3	11.2	35.4	23.1	n.a.
1977	484.0	0.0	10.2	10.0	19.3	21.4	18.1
1978	484.0	-2.2	14.5	9.0	14.4	30.3	19.3
1979	484.0	-6.5	18.3	7.1	-1.0	11.5	18.9
1980	607.4	-8.5	28.7	-2.1	11.3	-9.1	22.9
1981	681.0	-6.6	21.3	6.5	17.6	11.0	18.1
1982	731.1	-3.4	7.2	7.2	6.6	1.0	14.2
1983	775.7	-1.9	3.4	10.7	16.2	13.3	13.0
1984	806.0	-1.4	2.3	8.2	15.7	15.5	11.4
1985	870.0	-0.9	2.5	6.5	7.5	5.9	9.4
1986	881.5	4.4	2.7	11.0	12.2	8.1	9.7
1987	822.6	7.4	3.0	11.0	23.8	20.9	8.9
1988	731.5	8.0	7.1	10.5	13.0	14.3	9.6
1989	671.5	2.4	5.7	6.1	0.9	16.1	13.3
1990	707.8	-0.8	8.6	9.0	6.2	12.0	14.0
1991	733.4	-2.8	9.3	9.2	9.9	16.7	17.0
1992	780.7	-1.3	6.3	5.4	9.0	2.7	14.3
1993	802.7	0.3	4.8	5.5	14.5	6.1	12.1
1994	803.4	-1.0	6.2	8.3	13.6	22.5	12.5
1995	771.3	-1.7	4.4	8.9	22.3	24.1	12.6
1996	804.5	-4.4	5.0	6.7	17.4	15.6	12.4
1997	951.3	-1.7	4.4	5.0	14.8	2.0	13.2
1998	1401.4	12.7	7.5	-6.7	19.2	-25.1	15.0
1999	1188.8	6.0	0.8	10.9	12.0	29.0	5.0
2000	1131.0	2.7	2.2	9.3	20.6	19.0	5.2
2001	1291.0	1.9	4.1	3.1	0.7	-2.3	4.7

Source: IMF *International Financial Statistics*

Table 8

The estimation results of GARCH (1.1)

Dependent variable: DLKREX (daily changes in logarithm of won-dollar rate)

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	.9911E-5	.2206E-4	.44932[.653]
DLKREX(-1)	.21970	.022572	9.7334[.000]

Parameters of the Conditional Heteroscedastic Model
Explaining H-SQ, the Conditional Variance of the Error Term

	Coefficient	Asymptotic Standard Error
Constant	.7290E-7	.1530E-5
E-SQ(- 1)	.29527	.022865
H-SQ(- 1)	.76142	.011937

H-SQ stands for the conditional variance of the error term.

E-SQ stands for the square of the error term.