Sources of Fluctuations of the Real Exchange Rate of Korea and Equilibrium Real Exchange Rate by a Long-Run Restriction VAR Model

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Assuming no long-run effects of monetary shocks on the real exchange rate, this paper examines the long-run effects of real domestic and foreign macroeconomic shocks on the real exchange rate based on a long-run restriction structural VAR methodology. In this paper, yen/dollar exchange rate shock is especially chosen as a foreign shock because of its assumed importance for the external competitiveness of Korea during the covered period. The long-run effects of real shocks on the real exchange rate become the basis for calculating a kind of equilibrium real exchange rate and the deviations of the real exchange rate from the equilibrium real exchange rate are compared to the current account's movements.

In particular, the deviations of the real exchange rate in the period of 1995Q3 - 1997Q3 show overvaluation of the real exchange rate and are positively correlated to current account deficits. Such overvaluation of the real exchange rate appears due to the sluggish adjustment of the real exchange rate to the sharply depreciated equilibrium real exchange rate owing to yen/dollar exchange rate shocks, and also to the monetary shocks that caused a temporary appreciation of the real exchange rate.

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Key words: long-run restriction structural VAR, real exchange rate, equilibrium real exchange rate, yen/dollar exchange rate shock, real shock, monetary shock

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Ⅰ. Introduction

With the fast integration of the world economy in progress, the external sector appears more important in implementing the macroeconomic policy of a country, and there is a growing recognition that the real exchange rate(RER) is one of the most important macroeconomic variables in maintaining both the internal and the external economic equilibrium of a country. The fluctuations of the RER, however, have suffered from substantial volatility since the end of Bretton Woods regime in 1973 in both developed and developing economies, and a large body of research has focused on the issue of RER volatility beyond the purchasing power parity theory, which assumes long-run stability of the RER, examining the long-run eqilibrium changes in the RER dynamics and the misalignment between the actual RER and the equilibrium RER.

Along these lines, the paper examines the long-run equilibrium changes by domestic and foreign real shocks in the RER fluctuations of South Korea assuming no long-run effects of monetary shocks on the RER, and calculates a kind of equilibrium real exchange rate(ERER) based on the equilibrium changes due to structural real shocks and then finally compares the current account movements with the deviations of the actual RER from the ERER. In this paper, the yen/dollar exchange rate shock is specially selected as a foreign shock because of its assumed importance for the external competitiveness of South Korea during the covered period.

In terms of the empirical methodology, the paper uses a long-run restriction structural VAR model. The structural VAR model begins with a criticism of Sims(1980)′ standard VAR approach which lacks any economic content, and instead imposes contemporaneous or long-run restrictions for an identification of the underlying shocks in a VAR model. In the structural VAR models that deal with the RER fluctuations, the long-run restriction model dates back to Lastrapes(1992)′s two-variable model of real and nominal exchange rates which is an early application of Blanchard and Quah(1989)′s long-run restriction VAR model, and thereafter the two-variable long-run restriction VAR model is expanded into multi-variable models.

As for empirical studies of the RER fluctuations of South Korea using a long-run restriction structural VAR methodology, Koo(1996) and Chen and Wu(1997) apply a Lastrapes(1992)′s two-variable model in their studies, and Kim(1994) uses a three-variable model to analyze the RER fluctuations of South Korea in the 1980s. In this paper, the methodology follows Ahmed et al.(1993) who expanded Blanchard and Quah(1989)′s two-variable model into a multi-variable model and also Rogers and Wang(1995) who applied the methodology of Ahmed et al.(1993) to the analysis of the RER fluctuations. The purpose of such a multi-variable model is to estimate a long-run restriction VAR model more correctly by identifying precisely the structural shocks which cause different responses of the RER.

The paper is organized as follows: in Chapter Ⅱ, a long-run restriction VAR model is introduced as a basis for an empirical study of the RER fluctuations of South Korea. In Chapter Ⅲ, an interpretation of the structural shocks of the long-run restriction VAR model is provided, and the endogenous variables and exogenous shocks are defined. In Chapter Ⅳ, the long-run restriction VAR model is estimated and an ERER is calculated based on the estimation results. Also, the deviation of the actual RER from the ERER is defined as a disequilibrium misalignment of the RER and its correlation with the current account is examined. Finally, Chapter Ⅴ rounds off the discussion with some conclusions.

Ⅱ. The Long-run Restriction VAR Model

Now consider a vector of stationary observable endogenous variables X and a vector of unobservable exogenous structural shocks e. The structural model can be written as:

$$X_t = C(L)e_t,\ Var(e_t) = I, \qquad (1)$$

where $C(L) = \sum_{j=0}^{\infty} C_j L^j$ (L is a lag operator, C_j is a nonsingular matrix) is assumed to be invertible, e_t is a vector of unobservable exogenous shocks that are serially and mutually uncorrelated at all leads and lags, the covariance matrix is assumed to be the identity matrix by normalization, and the intercept terms are left for convenience.

The structural model (1) can be rewritten as a structural VAR:

$$A(L)X_t \equiv A^*(L)\Delta X_t - BX_{t-1} = e_t \qquad (2)$$

where $A(L) = C(L)^{-1}$, $A(L) = (A(L) - A(1)L) + A(1)L \equiv \Delta A^*(L) - BL$.

Thus, $B = -A(1)$. Since $A(1)$ is the inverse of $C(1)$, it inherits the long-run restrictions imposed on $C(1)$. The long-run structural coefficient matrix, $C(1)$ is assumed to be lower-triangular by the long-run restrictions, so that B is also lower-triangular.

Now, an estimable reduced-form model that matches with (2) is:

$$\Gamma(L)\Delta X_t - \Phi X_{t-1} = e_t^* \qquad (3)$$

where $\Gamma(0)$, the leading coefficient matrix of $\Gamma(L)$, is an identity matrix, and Φ and $\mathrm{Var}(e_t^*) = \Omega$ are unrestricted nonsingular matrices.

Then, the structual VAR of (2) can be recovered uniquely from the estimation of (3) using the assumptions of the lower triangularity of $C(1)$ and the diagonal covariance matrix of innovations as follows. First, multiply both sides of (3) by the inverse of Φ to obtain :

$$\Phi^{-1}\Gamma(L)\Delta X_t - X_{t-1} = \Phi^{-1}e_t^* \qquad (4)$$

Next, multiply (4) by the inverse of the Cholesky factor P such as $\Phi^{-1}\Omega\Phi^{-1\prime} = PP'$ to obtain:

$$P^{-1}\Phi^{-1}\Gamma(L)\Delta X_t - P^{-1}X_{t-1} = P^{-1}\Phi^{-1}e_t^* \qquad (5)$$

The Cholesky factor, P is uniquely determined if the signs of the diagonal elements of $C(1)$ are assumed to be fixed based on the theoretical model.[1] Then, the structual VAR (2) is recovered uniquely by the esimation of (3) since the covariance matrix of (5) is an identity matrix.

Note : 1) The lower-triangularity of C(1) with fixed signs on its diagonal elements and the diagonal covariance matrix of innovations determines the Cholesky, P uniquely as follows: (3) can be obtained when (2) is premultiplied by some matrix Z such that. such that $ZA^*(0) = I$. Then, $\Gamma(L) = ZA^*(L), \Phi = ZB$, and $e_t^* = Ze_t$. In (5), $PP' = \Phi^{-1}\Omega\Phi^{-1\prime} = V_{ar}(\Phi^{-1}e_t^*) = V_{ar}(\Phi^{-1}Ze_t) = \Phi^{-1}ZIZ'\Phi^{-1\prime} = (ZB)^{-1}ZZ'(ZB)^{-1\prime} = B^{-1}B^{-1\prime}$. That is, $PP' = B^{-1}B^{-1\prime}$, or $P = B^{-1}$. Since $B = -A(1) = -C(1)^{-1}$, $B^{-1} = -C(1)$, so that $P = B^{-1} = -C(1)$ is lower-triangular and its diagonal elements are fixed. Since there exists a unique triangular factorization of a symmetric positive definite matrix, $W = PP'$ such that $W = PP' = HDH' = (HD^{1/2})(HD^{1/2})'$, where H is lower-triangular with 1s along the principal diagonal and D is diagonal with positive entries along the principal diagonal, P is uniquely determined if the signs of the diagonal elements of P are fixed.

Ⅲ. Structural Interpretation

In the long-run structural VAR model above, the long-run relations between the endogenous variables and the exogenous shocks can be written as $X = C(1)e$, and the key assumptions in estimating the model lie in the lower-triangular scheme of the long-run coefficient matrix, $C(1)$ imposed by the long-run structural restrictions. In this chapter, the structural interpretation of the lower-triangular scheme of the long-run coefficient matrix, $C(1)$ is given based on Rogers and Wang(1995)'s intertemporal general equilibrium optimizing model for a small open monetary economy.[2]

Now, if we let the endogenous variables of the VAR model in Chapter II be the yen/dollar exchange rate(￥/$), real GDP(y), the RER(R)[3], and real money balances(m), then, using Rogers and Wang(1995)'s model, the structural shocks of the model can be interpreted as yen/dollar exchange rate shock(e^f), supply shock(e^y), demand shock(e^d)[4], and monetary shock(e^m). Also, the following long-run restriction assumptions can be justified to satisfy the lower-triangular scheme of the long-run coefficient matrix, $C(1)$: first, the yen/dollar exchange rate is exogenous in the long-run, second, the effects of demand and monetary shocks on real GDP are zero in the long-run, and lastly, the effect of a monetary shock on the RER is zero in the long-run.

Now, consider a stylized dynamic model of a small open economy in which the infinitely lived representative consumer with perfect foresight decides the optimal composition of consumption of nontraded and traded goods, C_N and C_T, respectively. The RER is defined as $R \equiv (sP_T^*)/P_N$(sdenotes the domestic currency price per unit of U.S. currency). Let πbe the rate of change of the monetary price of nontraded goods(P_N). The foreign price of traded goods(P_T^*) is

2) Rogers and Wang(1995)'s dynamic general equilibrium optimizing model has the advantage that various exogenous structural shocks to the RER can be defined easily, satisfying long-run restrictions. On the other hand, in the model, currency substitution is possible, and a monetary shock is defined as the inflation differential between the domestic and foreign(US) currencies, having a negative(-) long-run effect on real money balances(m) which are represented in units of US currency. The theoretical negative(-) long-run effect of a monetary shock on real money balances(m) can be justified in the Korean economy by the fact that the correlation coefficient during the covered period is -0.24 between the inflation rate differential of South Korea and the US and real money balances(m) in units of US currency.

3) The RER is defined as the relative price of tradable with respect to nontradable goods between South Korea and the US: $R \equiv (sP^*_T)/P_N$(s denotes the domestic currency price per unit of US currency). By such a definition, the RER is recognized to affect more directly the current account than by the PPP definition(Edwards, 1990). In the paper, the US WPI is used for the price of traded goods(P_T^*), and South Korean CPI is used for the price of nontraded goods(P_N).

4) A demand shock is defined as a preference shift from nontraded to traded goods.

assumed to be constant. The real values of domestic and foreign currency is defined in units of U.S. currency: $m \equiv M/(sP_T^*) = (M/P_N)/R$ and $m^* \equiv M^*/P_T^*$ (M and M^* are the nominal stocks of domestic and foreign(U.S.) currency by the representative agent). Then, the optimization problem of the representative agent is:

$$\max \int_0^\infty [\alpha \ln C_N(t) + (1-\alpha)\theta \ln C_T(t)] e^{-\rho t} dt \qquad (6)$$

subject to

$$(C_N/R) + C_T + \dot{m} + \dot{m}^* = (1-\tau)((y_N/R) + y_T) - \pi m + h \qquad (7)$$

$$(C_N/R) + C_T \leq \beta m^{\gamma} (m^*)^{1-\gamma} \qquad (8)$$

where y_N and y_T are the outputs of nontraded and traded goods, $\rho(>0)$ is the time preference rate, h is a lump-sum real money transfer, τ is the general income tax rate, $0<\alpha<1$, $\beta>0$, and $0<\gamma<1$. Finally, θ is a shift parameter, the increase of which captures a change of preference toward traded goods.

Equation (7) is a standard budget constraint, and equation (8) formulates a generalized cash-in-advance constraint in which the right-hand side measures the cash services required for consumption purchases.

Given the first-order conditions for the above optimization problem of (6) to (8) and the steady-state assumptions of $\pi = \mu$ (μ captures the inflation rate differential between domestic and foreign(U.S.) currency) and $h = \mu m$, the RER and real money balances are derived as follows:

$$R = \theta[(1-\alpha)/\alpha](y_N/y_T) \qquad (9)$$

$$m = [\beta\theta(1-\alpha)]^{-1}[\gamma/(1-\gamma)]^{1-\gamma}(1-\tau)[\rho/(\rho+\mu)]^{1-\gamma} y_T \qquad (10)$$

Also, the outputs of nontraded and traded goods are specified as:

$$y_N = A(n_N)^v,\ y_T = A^{\Phi}(n_T)^v \qquad (11)$$

where and n_N are n_T labor forces in nontraded and traded goods industries, and they are specified as $n_N = B_N \exp(b_N t)$ and $n_T = B_T \exp(b_T t)$; A is the productivity measure reflecting changes in technology; and $0<v<1$, and $\Phi>1$ indicate that traded goods production is more sensitive to technological changes.

Now, the stochastic processes of the first differences of the inflation rate

differential(μ) between domestic and foreign currencies, the productivity measure(A), and the preference shift from the nontraded to traded good(θ) are assumed to be specified as follows:

$$\Delta \mu = \delta^m + e^m \qquad (12)$$
$$\Delta ln(A) = \delta^y + e^y \qquad (13)$$
$$\Delta ln\, \theta = e^d \qquad (14)$$

where e^m, e^y and e^d are white noise, and δ^m and δ^y are drift terms.

The structural shocks, e^m, e^y and e^d are interpreted as monetary, supply, and demand shocks, respectively.

Then, taking logs of (9) and (10), differencing them and using (11) yield:[5]

$$\Delta ln(m) = \overline{m} - e^d + \Phi e^y - [(1-\gamma)/\rho] e^m \qquad (15)$$
$$\Delta ln(R) = \overline{R} - (\Phi - 1)e^y \qquad (16)$$

where $\overline{R} = -(\Phi-1)\delta^y$, $\overline{m} = \Phi\delta^y - [(1-\gamma)/\rho]\delta^m$.

Also, taking a log of the real GDP(y) and differencing it yields:

$$\Delta ln y = \overline{y} + (1+\Phi)e^y \qquad (17)$$

where $\overline{y} = (1+\Phi)\delta^y$.

Therefore, from the equations (15), (16), and (17), the first differences of real GDP, the RER and real money balances, which are endogenous variables of the model, are related in the long-run to the supply, demand and monetary shocks in a lower-triangular scheme like this:

$$\begin{bmatrix} \Delta ln(y) \\ \Delta ln(R) \\ \Delta ln(m) \end{bmatrix} = \begin{bmatrix} \overline{y} \\ \overline{R} \\ \overline{m} \end{bmatrix} + \begin{bmatrix} C_{11} & 0 & 0 \\ C_{21} & C_{22} & 0 \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \begin{bmatrix} e^y \\ e^y \\ e^m \end{bmatrix} \qquad (18)$$

where $C_{11} = 1 + \Phi > 0$, $C_{22} = 1$, and $C_{33} = -[(1-\gamma)/\rho] > 0$.

Finally, since the yen/dollar exchange rate is independent of the domestic supply, demand and monetary shocks, its stochastic process can be specified thus:

5) Without loss of generality, it is assumed for convenience of calculation that $b_N = b_T = 0$ and the initial value of $\mu = 0$.

$$\Delta ln(¥/\$) = e^f \tag{19}$$

where e^f is white noise and is interpretated as a yen/dollar exchange rate shock.[6)]

Now, from (18) and (19), the structural VAR model whose endogenous variables are yen/dollar exchange rate(¥/\$), real GDP(y), the RER(R) and real money balances(m) satisfies the following long-run relations:

$$X = \overline{X} + C(1)e \tag{20}$$

where $X = \begin{bmatrix} \Delta ln(¥/\$) \\ \Delta G \\ \Delta ln(R) \\ \Delta ln(m) \end{bmatrix}$, $C(1) = \begin{bmatrix} C_{11} & 0 & 0 & 0 \\ C_{21} & C_{22} & 0 & 0 \\ C_{31} & C_{32} & C_{33} & 0 \\ C_{41} & C_{42} & C_{43} & 0_{44} \end{bmatrix}$, $e = \begin{bmatrix} e^f \\ e^y \\ e^d \\ e^m \end{bmatrix}$

and $C_{11}, C_{22} > 0$, $C_{33}, C_{44} < 0$[7)]

Ⅳ. Analysis of RER Fluctuations of South Korea

1. Data Analysis

As the endogenous variables of the VAR model in Chapter Ⅲ were assumed to be the yen/dollar exchange rate(¥/\$), real GDP(y), the RER(R), and real money balalances(m), the structural shocks could be interpreted as the yen/dollar exchange rate(e^f), supply(e^y), demand(e^d), and monetary(e^m) shocks, respectively, satisfying the lower-triangular scheme of the long-run coefficient matrix, $C(1)$.

In estimating the long-run restriction structural VAR model, however, the endogenous variables are assumed to be a vector of stationary variables.

6) For the arguments of yen/dollar exchange rate shock to the RER, refer to the second section of Chapter Ⅳ.

7) Since C_{11} is a long-run effect of a yen/dollar exchange rate shock on the change of the yen/dollar exchange rate, and C_{22} is a long-run effect of a supply shock on the change of real GDP, it is self-evident that C_{11} and C_{22} have positive values. C_{33} is a long-run effect of a demand shock(a preference shift from nontraded to traded goods) on the change of the RER, and the positive sign of is due to the effect of a demand shock on the price of nontraded goods(Edwards(1989, 1990)). C_{44} is a long-run effect of a monetary shock on the change of real money balances which is represented in units of US dollars. The negative value of C_{44} can be justified by the fact that the correlation coefficient between the inflation rate differential(μ) of South Korea and the US and real money balances(m) defined in units of US currency is -0.24 during the covered period. The fixed signs of C_{11}, C_{22}, C_{33}, and C_{44} are used to uniquely determine the Cholesky factor, P in Chapter Ⅱ.

Therefore, the unit-root test of the endogenous variables should be presented before proceeding with the VAR analysis.

[Table 1] shows an Augmented Dickey-Fuller Test of log values of the yen/dollar exchange rate[ln(¥/\$)], real GDP[ln(y)], the RER[ln(R)], and real money balances[ln(m)] for quarterly data over the period of 1973Q1 to 1997Q3.[8)] According to [Table 1], all the variables are charaterized to be integrated of order one[I(1)], and, in all of them, the null hypothesis of unit root is not rejected at the 10% significance level.

Table 1 Augmented Dickey-Fuller Unit-Root Test (1973Q1-1997Q3)

Ho:Unit Root	t(ρ=1)	F(α=0, ρ=1)	Optimal lag length
$ln(¥/\$)$	-1.7389	3.2625	1
$\Delta ln(¥/\$)$	-6.3188**	19.9640**	0
$ln(y)$	-0.5988	53.3442**	0
$\Delta ln(y)$	-10.4959**	55.0968**	0
lnR	-1.1889	1.4669	2
ΔlnR	-7.4820**	28.0029**	0
$ln(m)$	-0.9902	1.6728	5
$\Delta ln(m)$	-3.7640**	7.1279**	3
Critical Values 5%	-2.89	4.71	t-test: If entry value is less than critical value, reject Ho.
10%	-2.58	3.86	F-test: If entry value is less than critical value, reject Ho.

Notes : 1) Estimated regression is: $y_t = \xi_1 \Delta y_{t-1} + \xi_2 \Delta y_{t-2} + \cdots + \xi_{p-1} \Delta y_{y-p+1} + \alpha + \rho y_{t-1} + \varepsilon_t$.
2) The optimal lag length is chosen using the BIC model selection criterion.
3) Critical values are from D-F table.
4) (**) denotes rejection of Ho at 10%.

Data : The Bank of Korea, IFS-CD

Next, with the permanent exogenous shocks being mutually uncorrelated, the lower-triangular property of C(1) implies no cointegration among the nonstationary endogenous variables. Therefore, the cointegration test of the endogenous variables should be presented also before preceeding with the VAR analysis.

In [Table 2], Johansen's Cointegration Test is applied to four nonstationary endogenous variables[ln(¥/\$), ln(y), ln(R), ln(m)]. According to [Table 2], the Trace Test does not reject the null hypothesis of no cointegration at the 10% significance level.

8) The data after 1997Q3 are not covered in the paper because the won/dollar exchange rate saw drastic change toward the end of 1997 during the Korean foreign exchange crisis.

Table 2 Johansen's Cointegration Test

Variables	(ln¥/$) $ln(y)$ lnR $ln(m)$) (VAR lag = 6) Ho	Ha	Statistic	90%
Trace Test	r = 0	r = 1	38.37	43.84

Note : r is the number of cointegration vectors among nonstationary endogenous variables.

2. The yen/dollar Exchange Rate and RER

In Chapter Ⅲ, the yen/dollar exchange rate was assumed to be determined independently of Korean domestic economic variables. The Korean RER, however, can be affected by the yen/dollar exchange rate in two ways.

First of all, in the context of the Korean economy, Japan plays an important role as a leading competitor in third markets. Therefore, a depreciation of the yen against the dollar aggravates Korean competitiveness and its current account, leading to a Korean RER depreciation as a result.

Next, if Japan appears as a major exporting country to Korea and the US appears as a major importing country from Korea, the yen/dollar exchange rate change can affect Korean terms of trade, and, in turn, the change of Korean terms of trade can affect the Korean RER.

According to [Table 3], during the period of 1973 to 1998, Japan accounted for an average share of 28.3% of Korean imports, and the US accounted for an average share of 28.7% of Korean exports. To explain the importance of the yen/dollar exchange rate for the Korean terms of trade in such a situation, the following hypothetical example may be considered:[9)]

Assume that Korea exports only to the U.S. in dollars and imports only from Japan in yen. If $e_{¥}$ is the won/yen exchange rate and $e_{\$}$ is the won/dollar exchange rate, then export prices are $p_{\$}e_{\$}$ and import prices are $p_{¥}e_{¥}$. The term of trade will then be $p_{\$}e_{\$}/p_{¥}e_{¥} = (p_{\$}/p_{¥})e_{¥/\$}$, where $e_{¥/\$}$ is the yen/dollar exchange rate. If dollar prices and yen prices remain relatively stable, the terms of trade will fluctuate with the yen/dollar exchange rate, no matter what happens to $e_{¥}$ or $e_{\$}$.

Now, in order to show a relationship between the terms of trade and the RER, consider a three goods-exportables (X), importables (M), and nontradables (N)-small open economy. Following the RER definition in Chapter Ⅲ, the RER is defined as $R = (sP_T^*)/P_N$ where $P_T^* = P_X^{*\alpha}P_M^{*(1-\alpha)}$. The price of the traded good is

9) The arguments are quoted from Black, S.W.(1996), Issues in Korean Exchange Rate Policy, NBER Working Paper #5747.

Table 3 Exports and Imports of South Korea by the US and Japan

Period: 1973-1998	Exports(%)		Imports(%)	
	US	Japan	US	Japan
Average	28.7	18.4	22.9	28.3

Source : The Bank of Korea

given by the world price while the price of the nontraded good is determined domestically. The RER in logarithm is:

$$
\begin{aligned}
lnR &= lns + \alpha lnP_X^* + (1-\alpha)\, lnP_M^* - lnP_N \\
&= lns + \alpha(lnP_X^* - lnP_M^*) - lnP_M^* - lnP_N \\
&= lns + \alpha ln(P_X^*/lnP_M^*) + ln(1/P_M^*) - lnP_N
\end{aligned}
$$

where (P_X^*/P_M^*)denotes the terms of trade.[10)]

Therefore, the RER depends on the nominal exchange rate(s), the terms of trade, and the price of nontraded goods(P_N). The total effect of the terms of trade on the RER consists of the direct effect(α) and the indirect effects via s and P_N because the terms of trade also works as a factor in determining s and P_N.

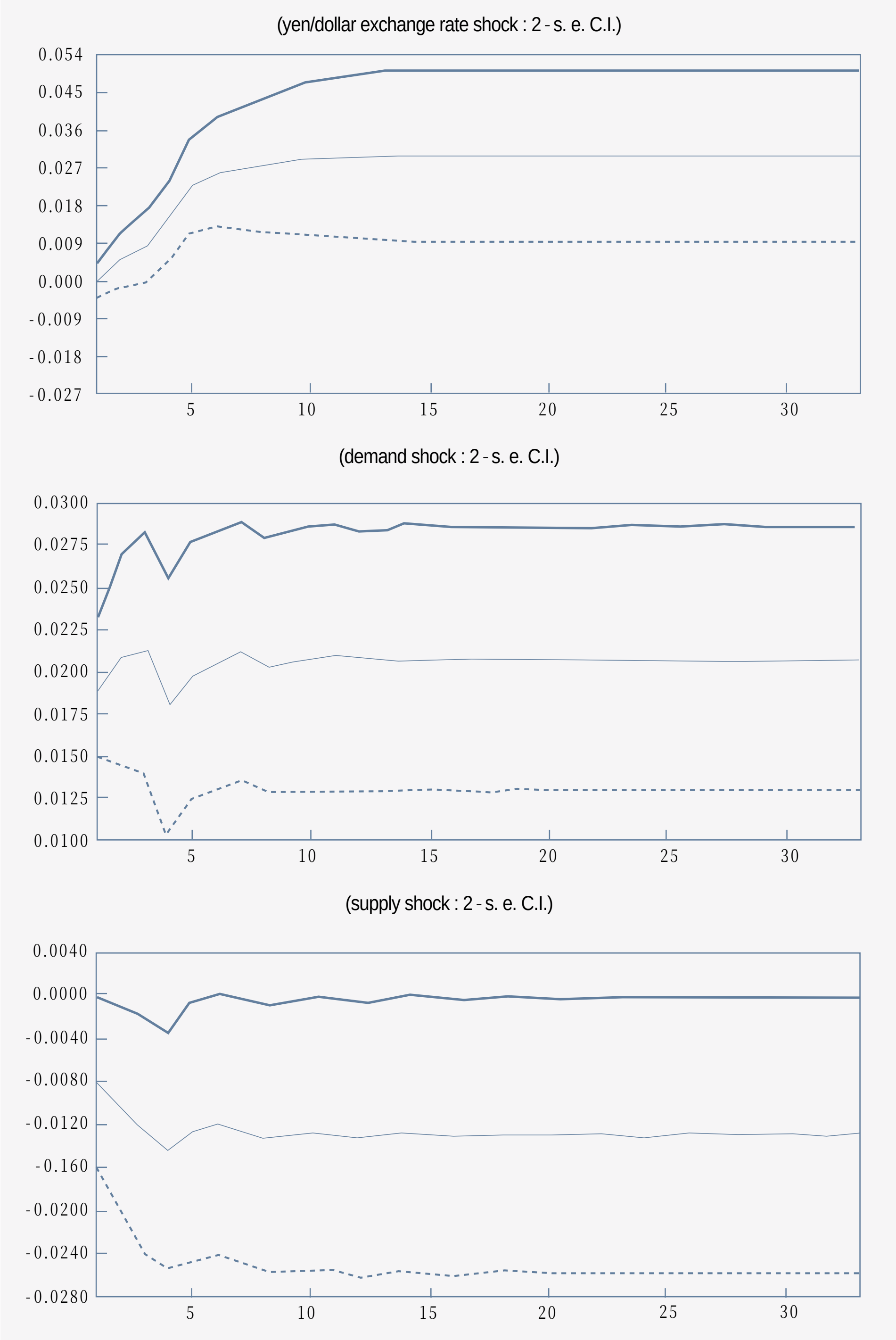
3. Estimation Results

The long-run restriction structural model of Chapter Ⅲ can be estimated by the estimable reduced-form VAR model in Chapter Ⅱ, that is, $\Gamma(L)\Delta X_t - \Phi X_{t-1} = e_t^*$. The empirical results from the estimation can be examined by the impulse response function(IRF)s of the RER, the long-run coefficient matrix, and variance decomposition(VDC)s of the RER fluctuations. The IRF describes the future responses of the RER to an impulse of a structural shock, the long-run coefficient matrix reports permanent responses of the endogenous variables to the structural shocks, and the VDC describes each contribution of the structural shocks to the RER fluctuations over time.

Now, [Figure 1] plots, in log levels, the IRFs due to the yen/dollar exchange rate, demand, supply, and monetary shocks, respectively. According to the IRFs, yen/dollar exchange rate and demand shocks cause a permanent depreciation of the RER. On the other hand, a supply shock causes a permanent appreciation of the RER. Those permanent effects of the structural shocks on the RER are again

10) If the price of export goods is normalized as one ($P_X^* = 1$), $(1/P_M^*)$ denotes the terms of trade.

Figure 1



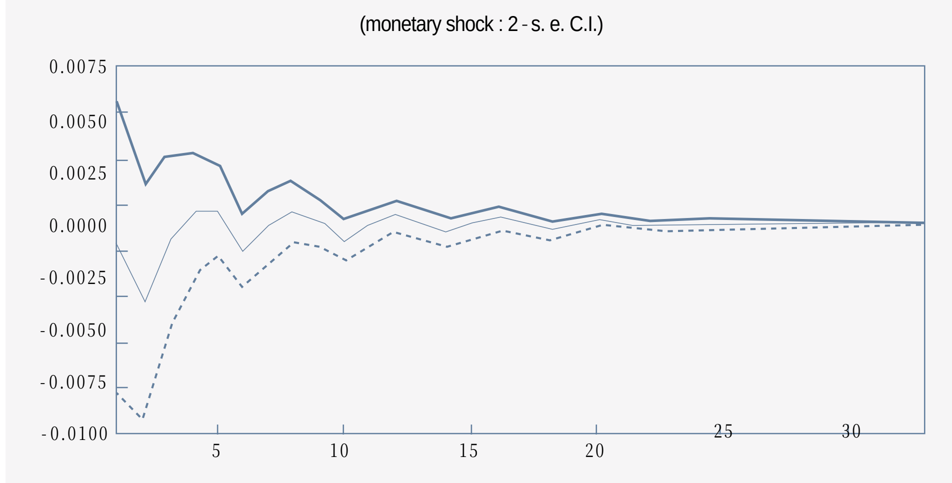


Table 4 Long-run Coefficient Matrix C(1)

$$C(1) = \begin{bmatrix} 0.0762 & 0 & 0 & 0 \\ -0.0109 & 0.0128 & 0 & 0 \\ 0.0299 & -0.0131 & 0.0207 & 0 \\ -0.0557 & 0.0459 & -0.0231 & -0.0423 \end{bmatrix}$$

Table 5 Variance Decomposition of $\Delta \ln R$ (%)

Quarters	Yen/Dollar exchange rate shock	supply shock	demand shock	monetary shock
1	0.01	16.30	83.51	0.18
2	6.30	15.81	75.86	2.03
3	7.59	16.16	72.48	3.77
4	14.92	14.73	66.68	3.67
8	24.12	13.28	58.41	4.19
12	24.24	13.22	58.09	4.45
16	24.22	13.22	58.03	4.53
24	24.21	13.21	58.02	4.56
30	24.21	13.22	58.01	4.56

summarized in [Table 4] by the coefficient values on the third row of the long-run coefficient matrix, $C(1)$.

According to the coefficient values on the third row of the long-run coefficient matrix, $C(1)$, the third column value that represents the permanent change of the RER by a demand shock is much larger in magnitude when compared to the second column value that represents the permanent change of the RER by a supply shock. However, the first column value that represents the permanent change of the RER by a yen/dollar exchange rate shock greatly surpasses in magnitude the permanent changes of the RER by the demand and supply shocks, suggesting a high sensitivity of the Korean economy with respect to a yen/dollar exchange rate shock.

Lastly, in [Figure 1], the initial effect of a temporary monetary shock on the RER appears as an appreciation of the RER and takes approximately one year to attain a zero effect on the RER.

Next, [Table 5] shows the evidence of VDC in the changes of the log RER across the four structural shocks. In [Table 5], the influence of yen/dollar exchange rate shocks on RER fluctuations is trivial(0.01%) in the first quarter, but it increases rapidly after the first quarter and explains over 24% of the RER fluctuations after two years. The demand shocks explain 83.5% of the RER fluctuations at the first quarter, but their influence rapidly decreases after the first quarter and explains about 58% of the RER fluctuations after two years. On the other hand, the supply shocks explain 16.3% of the RER fluctuations at the first quarter, and their influence slowly decreases over time, making up a stable 13.2% share of the RER fluctuations after two years. Lastly, the influence of monetary shocks increases gradually over time and explains over 4% after two years.

Next, the empirical results above are compared with other empirical studies that used a long-run restriction structural VAR model to examine the Korean RER fluctuations with respect to the US. Koo(1996) and Chen and Wu(1997) use a two-variable structural VAR model to distinguish the effects of real and nominal shocks on the RER fluctuations under the assumption that the nominal shocks have no long-run effect on the RER. According to Koo(1996), the real shocks explain 86.9% to 99.8% of the RER variation up to six years based on the producer price index(PPI) and the quarterly data of 1980:1 to 1994:4. On the other hand, Chen and Wu(1997) uses the consumer price index(CPI) and the quarterly data of 1981:1 to 1994:4, showing that the real shocks make up about 95% of the RER variation at all the quarterly forecast horizons of six years. Those empirical results coincide with the evidence of the paper.

Kim(1994) uses a three-variable structural VAR model to distinguish the effects of the supply, demand, and nominal shocks on the RER fluctuations, assuming that the nominal shock does not affect the RER in the long-run and

also that the nominal and demand shocks do not affect in the long-run the relative production level between South Korea and the US. Based on the monthly data of 1980:1 to 1990:12 and the wholesale price index(WPI), Kim(1994) shows that supply, demand, and nominal shocks explain, after two years, 10%, 77%, and 13% of the RER fluctuations, respectively, while the supply, demand, and monetary shocks in this paper account for 13.2%, 58.4%, and 4.2% of VDC, respectively, at the same forecast horizon.

Kim(1994) interprets the demand shock as a change in government expenditure or investment, and emphasizes the influential role of government intervention through fiscal and monetary policies in stahilizing the RER fluctuations. In this paper, however, a demand shock which is interpreted as a preference shift from nontradable to tradable goods accounts for 58.4% of the RER variation at the two year forecast horizon, and the monetary shock for only 4.2% at the same forecast horizon.

4. ERER and Actual RER

Since the real shocks(yen/dollar exchange rate, supply and demand shocks) appear to have a permanent effect on the RER in the section above, equilibrium changes of the RER can be calculated based on the estimated long-run coefficients and the estimated permanent real shocks.

In the structural interpretation of ChapterⅢ, the long-run relations of the structural VAR model was specified by the following equation system: $X = \overline{X} + C(1)e$. Now, corresponding to the third row of the long-run coefficient matrix, $C(1)$, the permanent change of the RER by an impulse of real shocks runs like this: $\Delta\, ln(R) = C_{31}e^{f} + C_{32}e^{y} + C_{33}e^{d}$. That is, given the long-run coefficient estimates of C_{31}, C_{32}, C_{33} and the estimation of the time series of the permanent real shocks (e^{f}, e^{y}, e^{d}), the time series of the equilibrium changes of the RER can be calculated.

The calculation of the time series of the ERER, however, needs an assumed equilibrium period of the RER in addition to the estimation of the equilibrium changes of the RER.[11]

The assumed equilibrium period of the RER is chosen when the current account appears to be almost in equilibrium. In this paper, first, five equilibrium periods are chosen, and then the resulting five time series of the ERER are

11) In purchasing power parity(PPP) theory, the ERER is assumed to be constant over time, but, in this paper, the ERER is derived by adding the equilibrium changes of the RER to the RER at a particular period where the current account seems to be almost in equilibrium.

Table 6 The Ratio of the Current Account Surplus(Deficit) to GDP(%)

Period	CA/GDP(%)	Period	CA/GDP(%)
1985 Q1	-3.18	1993 Q1	-0.85
Q2	-1.65	Q2	-0.30*
Q3	1.26	Q3	0.71
Q4	-0.35*	Q4	1.31
1992 Q1	-4.57	1994 Q1	-2.26
Q2	-1.24	Q2	-0.30*
Q3	-0.25*	Q3	-1.47
Q4	0.49	Q4	0.09*

Note : (*) denotes that the ratio of the current account surplus(deficit) to GDP is less than 0.4% in absolute terms.
Data : The Bank of Korea

compared with the actual RER movements to determine the most relevant equilibrium period.[12)]

According to [Table 6], the five quarterly equilibrium periods where the percentage ratio of current account(CA) to GDP is less than 0.4 in absolute terms appear as 1985Q4, 1992Q3, 1993Q2, 1994Q2 and 1994Q4. Then, the five time series of the ERER can be calculated by adding the time series of the equilibrium changes of the RER to the actual RER of the five respective equilibrium periods.

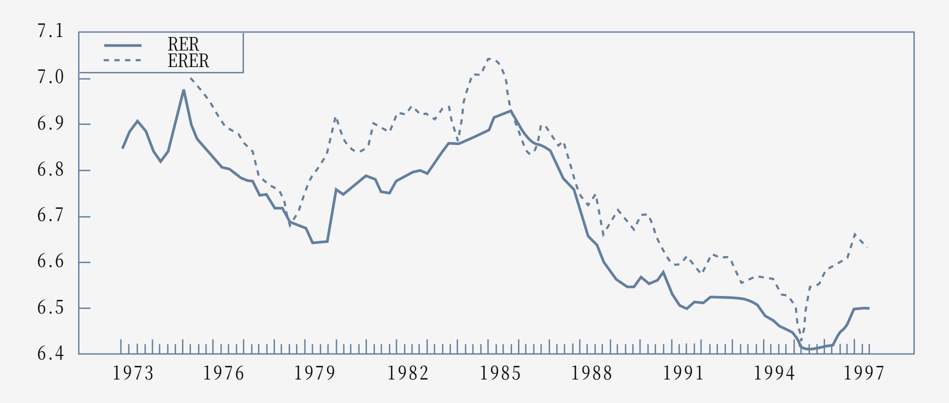
[Figure 2] to [Figure 6] compare the RER movements with the ERER movements during the period of 1975Q1 to 1997Q3, corresponding to the five respective equilibrium periods. First, in [Figure 2], when the equilibrium period is 1985Q4, the ERERs are above the RERs for extensive periods such as 1975Q1 - 1979Q2, 1981Q2 - Q3, 1987Q1 - 1989Q4, 1990Q2, 1991Q1 - 1991Q3 and 1992Q4 - 1995Q3, while the RER declines(appreciates) in the same periods. Since the ERER consists of the permanent real shocks, the decline of the RER when the ERER is above the RER implies that the opposite influence of temporary monetary shocks dominate the influence of permanent real shocks.

According to the VDC evidence of [Table 5], however, the influence of temporary monetary shocks is no more than 4.6% of the RER variation. Since the VDC evidence does not seem consistent with the dominant role of temporary

12) The criterion by which the most relevant equilibrium period is determined is the variance decomposition(VDC) evidence of [Table 5] that the permanent real shocks dominate the RER movements, explaining over 95% of the RER variance, but it is possible that in a particular period, the effects of temporary monetary shocks on the RER movements can offset the effects of real shocks on the RER movements.

monetary shocks in the RER movements over extensive time periods, the equilibrium period of 1985Q4 can not be justified.

Figure 2 ERER and RER(in log levels) : equilibrium period = 1985 : 4



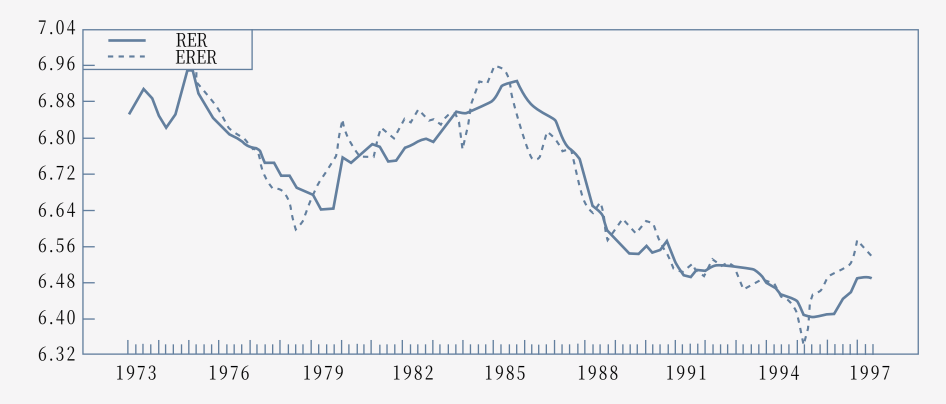
Similarly, in [Figure 3] where the equilibrium period is 1992Q3, the effects of monetary shocks on the RER dominate the equilibrium changes of the RER by the permanent real shocks in the periods of 1975Q1 - 1976Q4, 1979Q2, 1980Q2, 1980Q4 - 1981Q4, 1983Q1, 1885Q4, 1988Q3, 1989Q1 - Q4, 1990Q2, 1990Q4, 1991Q2 - Q3, 1992Q4, and 1994Q1.[13)]

Also, in [Figure 4] where the equilibrium period is 1993Q2, monetary shocks dominate real shocks in the periods of 1975Q1 - 1977Q3, 1979Q1 - Q2, 1980Q2, 1981Q2 - Q4, 1983Q1, 1988Q3 - 1989Q4, 1990Q2, 1991Q1 - Q3, and 1992Q4 - 1995Q1, and in [Figure 5] where the equilibrium period is 1994Q2, monetary shocks dominate real shocks in the periods of 1975Q1- 1976Q4, 1979Q2, 1980Q2, 1980Q4 - 1981Q4, 1983Q1, 1983Q4, 1985Q4, 1989Q1 - Q4, 1990Q2, 1990Q4, and 1991Q3. Lastly, in [Figure 6] where the equilibrium period is 1994Q4, the more influential monetary shocks happen in the periods of 1975Q1 - 1977Q1, 1979Q2, 1980Q2, 1981Q1 - Q4, 1983Q1, 1985Q4, 1988Q3, 1989Q1 - Q4, 1990Q2, 1990Q4, 1991Q2 - Q3, 1992Q4 - 1993Q1 and 1994Q2 - Q3.

From the above, in [Figure 5] where the equilibrium period is 1994Q2, there

13) The influential monetary shocks which dominate the equilibrium changes of the RER by the real shocks can be considered to happen where the RER rises(depreciates) when the ERER is below the RER as well as in cases where the RER declines(appreciates) when the ERER is above the RER.

Figure 3 ERER and RER(in log levels) : equilibrium period = 1992 : 3



exists the shortest range of periods where monetary shocks dominate real shocks in RER movements. Considering that the monetary shocks explain at most 4.6% of the RER variation, the period of 1994Q2 is chosen as the most relevant equilibrium period of the RER .

Now, in [Figure 5], the overvaluations of the actual RER with respect to the ERER appear during the periods of 1975Q1 - 1977Q1, 1979Q2 - 1980Q3, 1981Q2 - 1983Q3, 1984Q4 - 1985Q3, 1989Q2 - 1990Q3, 1991Q3, and 1995Q3 - 1997Q3 because the actual RERs are located below the ERERs over the corresponding periods.

Such overvaluations can be considered to happen when the actual RER is gradually adjusted to the ERER or the effects of monetary shocks on the RER are opposite in direction to ERER movements. Therefore, if actual RER is being adjusted downward because the ERER is below actual RER, a positive monetary shock that causes an initial real appreciation will expedite adjustment of actual RER to the ERER.

5. Misalignment of RER and Current Account

Now, the misalignment of the RER is considered a disequilibrium deviation of actual RER from the ERER(DRER = RER - ERER). Then, a positive(+) value of the deviation represents an undervaluation of actual RER and a negative(-) value of the deviation represents an overvaluation of actual RER.

Since the disequilibrium deviations are considered to occur through sluggish adjustment of the RER toward the ERER or the temporary effects of monetary shocks on the RER, the disequilibrium deviations will make up a stationary time

Figure 4 ERER and RER(in log levels) : equilibrium period = 1993 : 2

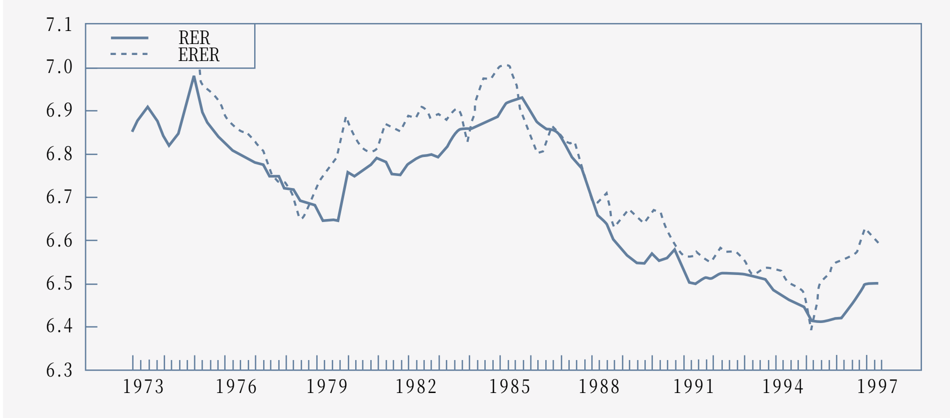


Figure 5 ERER and RER(in log levels) : equilibrium period = 1994 : 2

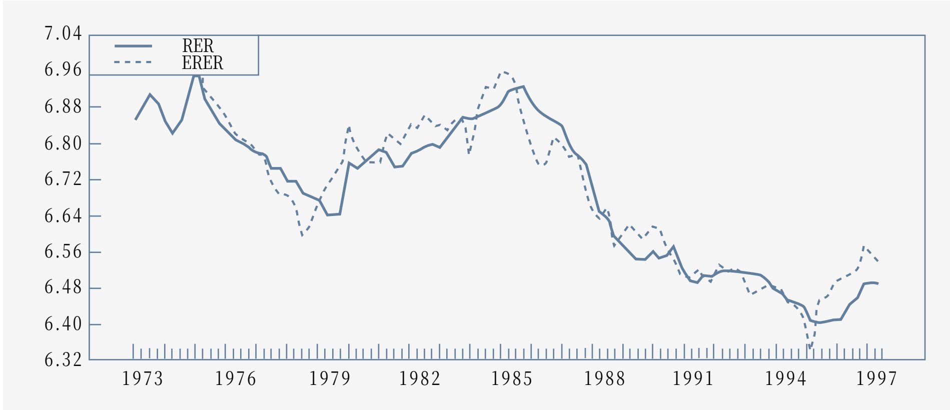
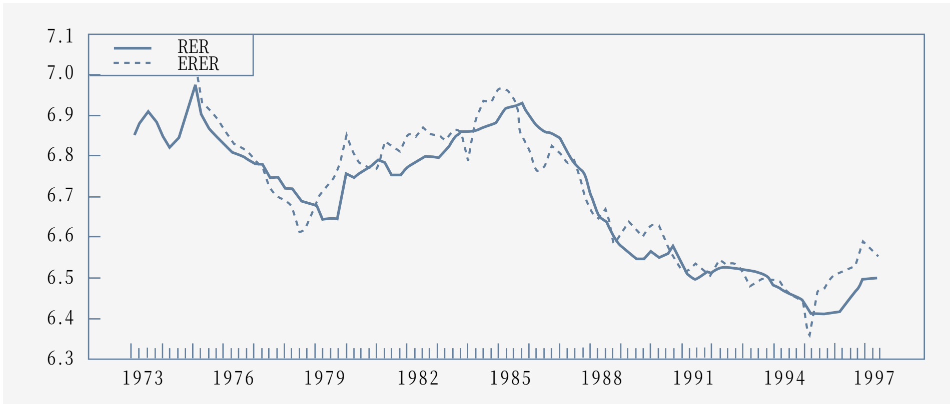


Figure 6 ERER and RER(in log levels) : equilibrium period = 1994 : 4



series. According to the Augmented Dickey-Fuller Test of [Table 7], the disequilibrium deviations does not have a unit-root at the 5% significance level, which confirms the stationarity of the disequilibrium deviations.

Table 7 Augmented Dicky-Fuller Unit-Root Test of DRER

Ho:Unit - Root	Case 1[1)] $t(\rho=1)$	Case 2[2)] $t(\rho=1)$	$F(\alpha=0,\ \rho=1)$	Optimal lag length[3)]
DRER	-3.5331*	-3.5629*	6.3477*	0

Notes: 1) Estimated regression is: $y_t = \xi_1 \Delta y_{t-1} + \xi_2 \Delta y_{t-2} + \cdots + \xi_{p-1} \Delta y_{y-p+1} + \rho y_{t-1} + \varepsilon_t$
2) Estimated regression is: $y_t = \xi_1 \Delta y_{t-1} + \xi_2 \Delta y_{t-2} + \cdots + \xi_{p-1} \Delta y_{y-p+1} + \alpha + \rho y_{t-1} + \varepsilon_t$
3) The optimal lag length for the ADF regression is chosen using the BIC model selection criterion.
4) (*) denotes rejection of Ho at 5%

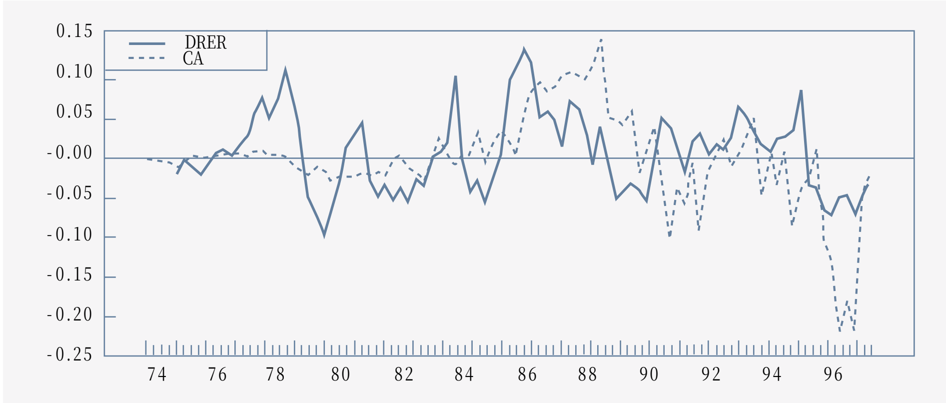
On the other hand, since the ERER is defined based on the current account equilibrium, the disequilibrium deviations of the RER reflect a disequilibrium state of the current account. That is, the positive(+) disequilibrium deviation which implies an undervaluation of the RER causes an improvement of external competitiveness leading to a current account surplus, and the negative(-) disequilibrium deviation which implies an overvaluation of the RER causes an aggravation of external competitiveness leading to a current account deficit.[14)]

Next, [Figure 7] compares the disequilibrium deviations with the current account movements. According to [Figure 7], in the whole period, there appears a positive(+) correlation between the disequilibrium deviations and the current account movements[15)], and the positive(+) correlation appear more evident in such periods as 1985Q4 - 1988Q4, 1992Q3 - Q4, 1993Q3 - Q4, and 1995Q3 - 1997Q3.[16)] Such more evident positive correlations can be considered due to the increased influence of yen/dollar exchange rate shocks over the ERER caused by the rapid fluctuations of the yen/dollar exchange rate[17)] in a situation of heated competition between South Korea and Japan in third markets since the mid 1980s.

Especially, in the period of 1995Q3 to 1997Q3, which preceded the Korean foreign exchange crisis, the disequilibrium deviations of the RER show conspicuous overvaluation of the RER and are positively correlated to current account deficits. Such conspicuous overvaluation appears due to sluggish adjustments of the RER to the sharply depreciated ERER because of yen/dollar exchange rate shocks, and also monetary shocks that cause temporary appreciation of the RER.[18)] Since actual RER rises in the period of 1995Q3 to 1997Q3, however, the effects of monetary shocks on the RER do not offset the equilibrium adjustments of the RER due to yen/dollar exchange rate shocks.

On the other hand, as other empirical studies on the RER overvaluation in the period which preceded the Korean foreign exchange crisis, Park and Choi(2000) and Kim and Kim(1999), both, constitute a time series of ERER by estimating in a different way the permanent components of the RER fluctuations,[19)] and

Figure 7 ERER and Current Account Movements



14) Edwards(1990) indicates that the tradable to nontradable goods definition of the RER affects the current account more directly than the PPP definition of the RER.

15) The correlation coefficient in the whole period of 1973Q1 to 1997Q3 is 0.37, and after the period of 1985Q1 where the competition in third markets between South Korea and Japan began to be heated, the correlation coefficient is 0.45.

16) In the periods of 1985Q4 - 1988Q4 and 1992Q3 - Q4, 1993Q3 - Q4, a positive correlation exists between the RER undervaluation and the current account surplus, and in the period of 1995Q3 to 1997Q3, which preceded the Korean foreign exchange crisis, a positive correlation exists between the RER overvaluation and the current account deficit.

17) The rapid fluctuations of the yen/dollar exchange rate are shown as -39.5% in 1985Q4 to 1988Q4, -13.4% in 1992Q3 to 1993Q4, and +24.7% in 1995Q3 to 1997Q3. If other real shocks are constant, the ERER falls rapidly when the yen/dollar exchange rate falls rapidly, and with the rapid fall of the ERER, the actual RER will also fall if the monetary shocks are not so dominant in their effects on the RER as to offset the equilibrium adjustments of the RER. Therefore, when the yen/dollar exchange rate falls rapidly, an undervaluation of the RER might easily occur and the resulting improved competitiveness might lead to a current account surplus. Similarly, when the yen/dollar exchange rate rises rapidly, an overvaluation of the RER might easily occur and the resulting aggravated competitiveness might lead to a current account deficit.

18) As the major monetary shocks that affect the RER in the period of 1995Q3 to 1997Q3, the positive(+) monetary shocks are 12.8% in 1994Q4, 23.9% in 1995Q, 4,10% in 1996Q3 and 3.9% in 1996Q4. The negative(-) monetary shocks are 4.9% in 1995Q1, 11.8% in 1996Q1 and 10.9% in 1997Q1.

19) Park and Choi(2000) calculate the ERERs by estimating a cointegration equation between the tradable to nontradable goods RER and real variables. Kim and Kim(1999) estimate real permanent components of the CPI-based real effective exchange rate fluctuations using a state-space model.

compare the ERER movements with the actual RER movements.

Park and Choi(2000) indicate that the fall of the RERs through nominal appreciation arising from huge capital inflows into South Korea and the rise of the ERERs due to real shocks are the reasons for the persistent overvaluation of the RER since 1994, but their paper can not explain why the RER rose from the first quarter of 1996.[20)]

In Kim and Kim(1999), as for the RER overvaluation from the beginning of 1995 to the end of 1997, the excessive temporary capital inflows into South Korea are also indicated as bringing about, through nominal appreciation, the RER's appreciation against the ERER. Their paper, however, does not explain what factors affect the ERER movements.

Ⅴ. Conclusion

Assuming no long-run effects of monetary shocks on the RER, the paper examined the long-run effects of real domestic and foreign macroeconomic shocks on the Korean RER using a long-run restriction structural VAR methodology, and calculated a kind of equilibrium real exchange rate(ERER) based on long-run equilibrium changes due to structural real shocks, and then finally compared the current account movements with the deviations of the actual RER from the ERER. In this paper, especially, the yen/dollar exchange rate shock was chosen as a foreign shock because of its assumed importance for the external competitiveness of Korea during the covered period.

Now, the conclusion of the paper can be set out as follows. First, according to the impulse response functions, which describe the future responses of the RER to the structural shocks, all real shocks, comprising yen/dollar exchange rate, supply and demand shocks, bring about permanent(equilibrium) changes in the RER. Among those real shocks, the yen/dollar exchange rate and demand shocks cause real depreciation, and supply shocks cause real appreciation. The temporary effects of monetary shocks cause an initial appreciation of the RER.

Second, according to variance decomposition which describes each contribution of structural shocks to the RER fluctuations over time, the influence of yen/dollar exchange rate shocks on the RER fluctuations is trivial(0.01%) in

20) In this paper, the rise of the RER since the first quarter of 1996 is interpreted as follows: as the ERER rises rapidly with a rapid increase of the yen/dollar exchange rate, the equilibrium adjustment effect causing the RER to rise dominates the temporary real appreciation effect of a monetary shock.

the first quarter, but it increases rapidly after the first quarter and explains over 24% of the RER fluctuations after two years. Demand shocks explain 83.5% of the RER fluctuations within the first quarter, but as the influence of yen/dollar exchange rate shocks increase after the first quarter, the influence of demand shocks rapidly decreases and explains only about 58% of the RER fluctuations after two years. On the other hand, supply shocks explain 16.3% of the RER fluctuations at the first quarter, and their influence slowly decreases over time, accounting for a stable share of the RER fluctuations at 13.2% after two years. Lastly, the influence of monetary shocks increases gradually over time and explains about 4% of the RER fluctuations after two years.

Third, when comparing the ERER movements with the RER movements in [Figure 5], for the most part of the period from 1975Q1 to 1997Q3, the RER appreciates if the disequilibrium deviation of the RER from the ERER(RER-ERER) is positive(undervaluation of the RER), and the RER depreciates if the disequilibrium deviation is negative(overvaluation of the RER), which shows that the majority of the RER movements are due to real shocks that cause equilibrium changes in the RER.

In the periods of 1975Q2-1976Q4, 1979Q2, 1980Q2, 1981Q2-Q4, 1989Q1-Q4, 1990Q2, and 1991Q3, however, the RER appreciates although the disequilibrium deviation is negative(overvaluation of the RER), showing that the effects of the positive(+) monetary shocks on the RER dominate the equilibrium adjustments of the RER.[21)] If the disequilibrium deviation is positive (undervaluation of the RER), the positive(+) monetary shocks will expedite the equilibrium adjustments of the RER.

Fourth, according to [Figure 7], in the whole period of 1973Q1 to 1997Q3, the correlation coefficient between the disequilibrium deviations and the current account movements is 0.37, and after the period of 1985Q1, the correlation coefficient is 0.45. Notably, in such periods as 1985Q4-1988Q4, 1992Q3-Q4, 1993Q3-Q4, and 1995Q3-1997Q3, the positive(+) correlation appear more evident, which can be considered due to the increased influence of yen/dollar exchange rate shocks over the ERER in a situation of heated competition between South Korea and Japan in third markets since the mid 1980s.

Fifth, in the period of 1995Q3 to 1997Q3, which precedes the Korean foreign exchange crisis, overvaluation of the RER appears to be at the highest level no

21) The major positive(+) monetary shocks that could affect the RER in the corresponding periods are 10.1% per quarter during 1975Q2-1976Q4, 15.3% in 1978Q4, 17.8% in 1980Q3, 9.2% in 1980Q4, 17.2% in 1988Q4, 10,5% in 1989Q3, 20.6% in 1989Q4 and lastly 7.6% in 1990Q4.

matter which equilibrium period is chosen, as shown in [Figure 2] to [Figure 6]. Such pronounced overvaluation appear due to sluggish adjustment of the RER to the sharply depreciated ERER because of yen/dollar exchange rate shocks, and also monetary shocks that cause its temporary appreciation. Since the actual RER rises in the period of 1995Q3 to 1997Q3, however, the effects of monetary shocks on the RER is not so influential as to offset the equilibrium adjustments of the RER due to yen/dollar exchange rate shocks.

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