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ESTIMATING EQUILIBRIUM WON/DOLLAR REAL EXCHANGE RATE: A BEHAVIORAL APPROACH

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A BEER of won/dollar is estimated using the cointegration methods of Johansen(1995). Impulse response analysis shows that the responses of the real exchange rate to the various shocks differ. Variance decomposition analysis demonstrates that the net foreign asset and productivity differential plays a important role in explaining the behavior of real exchange rate. The long run equilibrium value of Won recovered from an estimated cointegrating equation reveals the periods of overvaluation in the 1990s until the 1997 financial crisis.

JEL Classification: F0, F4
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Ⅰ. INTRODUCTION

As the overvaluation of the real exchange rate has been pointed out to be one of the main factors contributing to the financial crisis (Sachs, Tornell and Velasco, 1996), interest in measuring the "equilibrium" exchange rate as a benchmark against which the actual development of the exchange rate can be gauged has been revived.

The starting point of the empirical studies on equilibrium exchange rate has been the purchasing power parity (PPP) doctrine, which claims that the exchange rate is determined by the relative developments of domestic and foreign prices, thereby suggesting that the equilibrium real exchange rate is a constant. However, it is well documented in the literature that the real exchange rate is

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either found to be non-stationary or, when found to be mean-reverting using a very long sample span or applying panel data analysis, its adjustment speed to the equilibrium path mapped out by relative prices is very slow, so that prolonged deviations from its equilibrium cannot be explained on the basis of this concept. Both the unit root test on the real won/dollar exchange rate and cointegration test between the nominal exchange rates and relative prices levels also do not support the PPP doctrine (Park 1995).

Real effective exchange rate based on the PPP also has been widely used in empirical analysis, but it is not without problems. It gives different implications depending on the base year selected (Williamson 1994), price levels chosen or trade weights entering the formula. Real effective won/dollar exchange rates with different base years not only give different results over the degree of overvaluation before 1997 financial crisis, but also raise the question whether the Won was ever overvalued (Park and Choi, 2000).

Owing to these limitations, a majority of recent studies use more sophisticated approaches. In particular, they explicitly model the equilibrium exchange rate as a function of real economic fundamentals, thereby allowing for a time-varying equilibrium path of the real exchange rate (Baffes et. Al. 1999, MacDonald and Stein 1999, Williamson 1994). When the discrepancies between the estimated equilibrium values and the actual exchange rate become extraordinarily large, such models may serve to suggest the direction of misalignment.

Two main approaches have been developed to assess the degree to which exchange rates are consistent with economic fundamentals. One is the macroeconomic balance approach, which calculates the real exchange rate that is consistent with internal and external balance. Internal balance is obtained when a country is operating at a level of output consistent with full employment and low inflation. External balance can be characterized by a sustainable current account position as reflected by the underlying and desired net capital flows, which depend on net savings that are, in turn, determined by factors such as consumption smoothing and demographic factors. This methodology has been popularized by Williamson (1994), who referred to the exchange rate computed in this manner as the Fundamental Equilibrium Exchange Rate (FEER). Barrell and Veld (1991) estimated FEER for European countries while Lee (1998) estimated FEER for Korean won/dollar exchange rate.

An alternative approach involves the direct econometric analysis of modeling the behavior of the real exchange rate, which can be called the Behavioral

Equilibrium Exchange Rate (BEER), proposed by Clark and MacDonald (1999, 2000). The BEER approach produces a measure of misalignment that is different from the FEER, as it relates to the deviation between the actual exchange rate and the value given by the estimated equilibrium relationship between the real exchange rate and economic fundamentals.

Clark and MacDonald (1999) used the multivariate cointegration methods of Johansen (1995) to construct estimates of the BEER for the real effective exchange rates of the U.S. dollar, the German mark, and the Japanese yen. Fernandez et al (2001) derives a BEER using synthetic quarterly data and found the undervaluation of the euro in 2000.

As it is generated from variables that are highly persistent and indeed often non-stationary, the measured BEER is itself likely to be a highly persistent series. Using the methods of Beveridge and Nelson (1981), a number of papers have in fact interpreted the persistent, or permanent, component of the real exchange rate as a measure of equilibrium (Huizinga 1987, Clarida and Gali 1994). Recently, Gonzalo and Granger (1995) have shown how the Johansen cointegration method can be used to extract the permanent component from a vector of variables which exhibit cointegration, thereby producing a measure of equilibrium which is close in spirit to the BEER.

This paper uses BEER approach in order to estimate equilibrium Korean won/dollar bilateral real exchange rate, thereby gauging the misalignment of Won. In contrast to the relative abundance of research on the currencies of industrialized countries, there are few studies on developing countries. Therefore, a thorough study of won/dollar exchange rate is likely to offer new insights into the behavior of exchange rate in these areas.

Several studies have measured the equilibrium won/dollar real exchange rate by looking at the relationship between exchange rate and fundamental variables, even though none of them explicitly used the BEER methodology. Among them, Kang and Ju (2004) estimated won/dollar equilibrium exchange rate using terms of trade and capital account as fundamental variables. Kim and Kim (1999) used the state-space model to estimate the equilibrium real won/dollar effective exchange rate.

Using the method of Johansen (1988, 1992), we report evidence of sensible and significant long-run relationships between won/dollar real exchange rate and a set of fundamental variables based on standard economic theory. The dynamic behavior of real exchange rate responding to the one of these fundamental variable shocks is also analyzed.

The outline of the remainder of this paper is as follows. In chapter Ⅱ, the BEER approach is explained. Chapter Ⅲ introduces estimation methodology briefly. Chapter Ⅳ explains data and Chapter Ⅴ presents the empirical estimation results of cointegration estimation. Finding out the long-run relationships exist, we additionally calculate the impulse responses and variance decomposition in chapter Ⅵ. Chapter Ⅶ compares the estimated equilibrium exchange rate, BEER with the actual exchange rate to measure the misalignment of the exchange rate. Chapter Ⅷ concludes.

Ⅱ. BEHAVIORAL EQUILIBRIUM EXCHANGE RATES (BEER)

The starting point of estimating BEER is the uncovered interest parity (UIP) condition, which ties up short-run with the longer run perspective (Meese and Rogoff 1988, MacDonald 1997, and Clark & MacDonald 2000):

$$E_t(\Delta s_{t+k}) = (i_t - i_t^*) \tag{1}$$

where s_t is the log of the domestic currency price of a unit of foreign currency with an increase in s_t corresponding to an depreciation in the home currency, i_t denotes a nominal interest rate, Δ is the first difference operator, E_t is the conditional expectations operator, $t+k$ defines the maturity horizon of the bonds, and a * denotes a foreign variable.

Equation (1) can be converted into a relationship between real variables by subtracting the expected inflation differential, $E_t = (\Delta p_{t+k} - \Delta p_{t+k}^*)$, from both sides of the equation. After rearrangement this gives:

$$q_t = E_t(q_{t+k}) + (r_t - r_t^*) \tag{2}$$

where $r_t = i_t - E_t(\Delta p_{t+k})$ is the ex ante real interest rate. Equation (2) describes the current equilibrium exchange rate as determined by two components, the expectation of the real exchange rate in period $t+k$ and the real interest differential with maturity $t+k$.

Assuming that the unobservable expectation of the exchange rate, $E_t(q_{t+k})$, represents the influence of fundamentals exclusive of interest rates on the equilibrium exchange rate, it can be labeled as "long-run" equilibrium exchange rate, $\overline{q_t}$.[1] The current equilibrium rate is defined as q_t as in equation (3)

$$q_t = \overline{q_t} + (r_t - r_t^*) \tag{3}$$

In our model, therefore, the actual equilibrium exchange rate by (3) comprises two components: the first component $\overline{q_t}$, driven by the fundamentals and the real interest differential.[2]

The factors which are likely to introduce systematic variability into $\overline{q_t}$ are discussed in elsewhere in detail (Faruqee 1995, MacDonald and Stein 1999). Therefore, it suffices to say that these are nonconstancy of the real exchange rate for traded goods and movements in the relative prices of traded to non-traded goods between the home and foreign country due to, say, productivity differentials in the traded goods sectors.

Nonconstancy of real exchange rate will arise if the kinds of goods entering international trade are imperfect substitutes. Also, factors such as fiscal balance may introduce systematic variability into the real exchange rate for traded goods. The best known source of systemic changes in the relative price of traded to non traded goods is the Balassa-Samuelson effect (Hsieh 1982, Marston 1990), which predicts the appreciation for fast growing countries even when the law of one price holds for traded goods.

We consider productivity differentials, government spending and the variables of commodity shock such as terms of trade and world real price of oil as the possible factors that could influence long-run real exchange rate movements. Measure of openness and housing price index as a proxy for the asset price have also been considered.

Ⅲ. A BRIEF REVIEW OF ECONOMETRIC METHODS

Since the fundamental variables affecting $\overline{q_t}$, interest rate differentials and q_t are potentially I(1) processes, and since there may exist cointegrating relationships among these variables, we use a cointegration framework to

[1] This assumption has been invoked by, for example, Meese and Rogoff (1988).

[2] Real interest differential is regarded to reflect the business fluctuations rather than economic fundamentals.

calculate the static relationship given by (3).

To test for cointegration in the multivariate case, we use Johansen (1988) and Johansen and Juselius (1992) likelihood ratio test. The procedure is well known and only the methodology is briefly reviewed.

Consider a vector X_t containing n variables, and then if X_t is cointegrated, it can be generated by a vector error correction model (VECM) of the following form:

$$\Delta X_t = \mu_0 + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-1} + \varepsilon_t \quad (4)$$

where μ_0 is an $n\times 1$ vector of drifts, Γ's and Π are $n\times n$ matrices of parameters, and ε_t is an $n\times 1$ vector of white-noise errors. The likelihood ratio test statistic for the hypothesis that there are at most r cointegrating vectors is:

$$\lambda_{trace} = T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \quad (5)$$

where $\hat{\lambda}$ contains the estimated values of the characteristic roots (or eigenvalues) obtained from the estimated Π matrix and T is the number of the usable observations. This is called the trace statistic and tests the null that the number of distinct cointegrating vectors is less than or equal to r against a general alternative. Another test is the so called the maximal eigenvalue or $\lambda_{\max}$ statistic,

$$\lambda_{\max} = -T \ln(1-\hat{\lambda}_{r+1}) \quad (6)$$

This tests the null that the number of cointegrating vectors is r against the alternative of $r+1$.

With the long-run relationships imposed, we additionally calculate the impulse responses in order to illustrate the short-run dynamic responses of exchange rate with respect to the fundamentals. Variance decomposition is conducted in order to measure the percent contribution of each innovation to the h-step ahead forecast error variance of the real exchange rate.

Ⅳ. DATA

Data and Definition

We consider productivity differentials, government spending and the variables of commodity shock such as terms of trade and world real price of oil as the possible factors that could influence long-run real exchange rate movements.

The real exchange rates (LQ1) used are bilateral rates against the U.S. Dollar adjusted by the domestic and U.S. consumer price indices. An increase in LQ1 means domestic currency depreciation. To explore the influence of productivity differentials on tradeables, we use the ratio of the domestic consumer price index to the wholesale price index relative to the equivalent foreign ratio, expressed in logarithms (RLPROD). This ratio is designed to proxy the ratio of traded to non-trade prices and was recommended by Kakkar and Ogaki (1993).

And since government spending on non-tradeables is not readily available, general government expenditure is used as a proxy, measured as the ratio of government expenditure to GDP (RGCEXP) relative to the equivalent U.S. ratio. In reality, it is plausible to assume that most of government spending is on service which is dominantly non-traded goods. Net foreign assets also captures the effect of fiscal policy on the real exchange rate as well as other factors more closely associated with private sector savings, such as demographics. The importance of net foreign assets as a determinant of real exchange rate has recently been highlighted by Lane and Milesi-Ferretti (2000), who approximate the change in net foreign assets with the current account balance and net of capital account transfer. We measure the accumulated current account position (INTCACUM) as a proxy for net foreign assets.

Two variables are used to capture the effect of commodity shocks. The terms of trade (RLTOT) is constructed as the ratio of domestic export price to import price as a proportion of the equivalent foreign ratio, expressed in logarithms. The real price of oil (ROIL) is defined as the ratio of the nominal price of oil to the U.S's wholesale price index.

Additionally, we have employed two variables, which can represent the measure of the openness of Korean economy, and the Korean housing price index, which are found to be important for the equilibrium value of the Singapore's real exchange rate (MacDonald 2004). The measure of openness (RLTTRADE) is the ratio of total trade to GDP expressed in logarithms. The measure of openness variable has bee used by both Edwards (1989) and Baffes, Elbadawi and O'Connel (1999). An increase in this variable is expected to depreciate the equilibrium value of a currency. In an internal-external balance setting, the increased openness would be represented by an upward movement of the external balance schedule, which requires a depreciation of the exchange rate. Housing price index (RLKOHOUIND) is the log of Korean housing price index and is expected to be positively related to the exchange rate since the index is included as a proxy for wealth. Finally, we use the real interest differential (RDIF) constructed using the domestic long term nominal bond yield minus a change in inflation rate minus the equivalent U.S rate. The definition of data are presented in Table 1.

[Table 1] Definition of Data

Variable	Definition
LQ1	Real won/dollar exchange rate in log
RLPROD	Productivity differentials on tradeables, ratio of domestic consumer price index to the whole sale price index relative to the equivalent foreign ratio
RLTOT	Terms of trade, ratio of domestic export price to import price as a proportion of the equivalent foreign ratio
ROIL	Real price of oil, ratio of the nominal price of oil to the U.S's wholesale price index
RDIF	Interest rate differential
RLTTRADE	Measure of openness, ratio of total trade to GDP in log
RGCEXP	Government expenditure, government expenditure to GDP relative to the equivalent foreign ratio
RLKOHOUIND	Housing price index, log of Korean housing price index
INTCACUM	Accumulated current account position

Sources: IFS, IMF

The sample period is from 1973:Q1 to 2003:Q4 comprising various foreign exchange rate regimes in order to capture the long run relationship between real exchange rate and fundamentals.[3] Due to the unavailability of some data, however, empirical analysis is conducted after the period of 1986. All the data are quarterly and are collected from IMF's International Financial Statistics (IFS).

[3] Foreign exchange rate system in Korea was fixed exchange rate system during 1970's and then managed floating exchange rate system in 1980's. Market based flexible exchange rate system was introduced in 1990's before adopting flexible exchange rate system after the 1997 financial crisis.

Summarizing the effect of all of these variables an operational version of the model can be expressed as in (7). Signs in ( ) below the equation represents the direction of effect predicted by the theory where +(-) implies the depreciating (appreciating) effect on the real exchange rate.

$$\begin{aligned} LQ1_t = C + & \underset{(-)}{\beta_1 * RLPROD_t} + \underset{(+)}{\beta_2 * RLTOT_t} + \underset{(+/-)}{\beta_3 * ROIL_t} + \underset{(-)}{\beta_4 RDIF_t} \\ & + \underset{(+)}{\beta_5 * RLTTRADE_t} + \underset{(+/-)}{\beta_6 * RGCEXP_t} + \underset{(-)}{\beta_7 * RLKOHOUING_t} \\ & + \underset{(-)}{\beta_8 * INTCACUM_t} + \nu_t \end{aligned} \tag{7}$$

Evolution of the variables

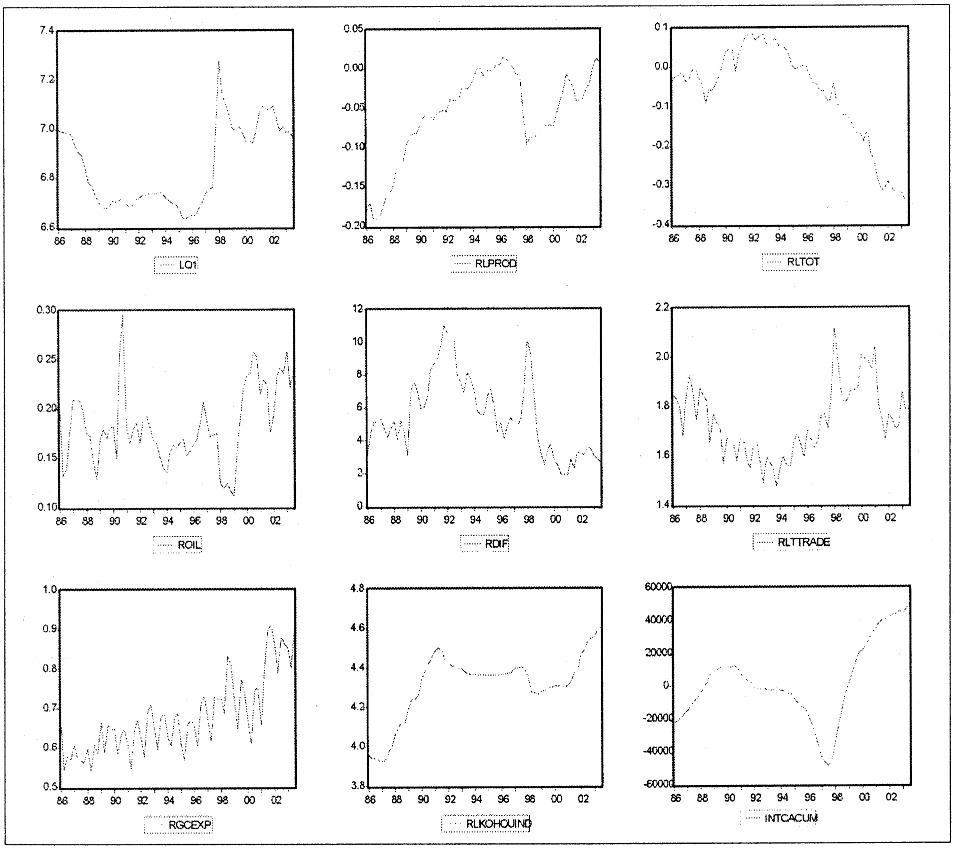
Figure 1 shows the evolution of the real won/dollar exchange rate and fundamentals considered in the paper. Korean won/dollar real exchange rate (LQ1) went over the periods of appreciation and depreciation alternatively. In late seventies, real exchange rate appreciated then depreciated in early 1980s, reversing its trend again and appreciating in late 1980s. After the long periods of appreciation in 1990s it depreciated sharply after the 1997 financial crisis. After the crisis, the Won showed a continuously appreciating trend.

Productivity proxy (RLPROD) followed a similar path with the real exchange rate, which supports the Balassa-Samuelson effect. It increased during the late seventies and then decreased during the early eighties and then increased thereafter continuously, before it sharply fell after 1997. Productivity proxy then increased in the early 2000s, following the trend of appreciation of real exchange rate.

The long-term real interest rate differential (RDIF) moves in the opposite direction with the real exchange rate in the eighties and early nineties, which is consistent with the theory of uncovered interest parity condition. After that, however, the interest differential displays co-movement with the real exchange rate. Appreciation of the real exchange rate in the nineties and in early 2000 is accompanied by the continuous decline in the real interest differential.

Relative government expenditure (RGCEXP) increases in late seventies and then decreases throughout the eighties reflecting the huge fiscal deficit in U.S. Relative government expenditure again shows the increasing trend in 1990s. The net foreign asset position shows smooth changes throughout the period. It shows the opposite movement with real exchange rate until the early eighties. However, it shows the declining trend through the nineties even though the real exchange rate is still appreciating, suggesting the possible misalignment of the real exchange rate. After falling sharply in 1997, it increases rapidly with the real exchange rate appreciating.

[Figure 1] Evolution of the Variables



Ⅴ. EMPIRICAL RESULTS: COINTEGRATING RELATIONSHIP

Unit root test

We start the empirical tests by examining the times series properties of each variables. Since the Phillips-Perron (PP) test is robust in that it allows for fairly mild assumptions concerning the distribution of the error, this method is applied to the level and the first difference of the variables with constant term or with constant and time trend. Table 2 indicates that the null hypothesis of a unit root cannot be rejected for all of the series in levels, with the exception of real price of oil (ROIL). Unit root test on the level of real price of oil without constant term however cannot reject the null of unit root. The PP test overwhelmingly rejects the null hypothesis of a unit root in every series in first difference. We continue our analysis assuming all the variables used are I(1) variables.

[Table 2] Phillips-Perron Unit Root Test

	Level		First difference	
	t_0	t_1	t_0	t_1
LQ1	-1.71	-2.28	-6.14***	-6.15***
RLPROD	-1.89	-1.79	-5.67***	-5.69***
RLTOT	0.82	-1.36	-8.16***	-8.93***
ROIL	-4.71***	-5.06***	-7.32***	-7.44***
RDIF	-1.92	-2.47	-6.86***	-6.91***
RLTTRADE	-2.79*	-2.87	-10.48***	-10.38***
RGCEXP	-2.47	-5.83***	-13.28***	-13.30***
RLKOHOUIND	-1.41	-1.62	-4.85***	-4.84***
INTCACUM	-0.66	-1.06	-2.61*	-2.52
1% critical value	-3.52	-4.10	-3.52	-4.09
5% critical value	-2.90	-3.47	-2.90	-3.47
10% critical value	-2.59	-3.16	-2.59	-3.16

Notes: The numbers denote Phillips-Perron t-ratio. t_0 and t_1 indicate that only a constant and constant plus a time trend are included in the model, respectively. Lag truncation parameter for Phillips-Perron test is set at 4.
*** (**, *) denotes rejection of the null of unit roots at 1%(5%, 10%) significance level

Johansen Cointegration Test

Test results of the long-run relationship among the variables that are considered to be fundamentals and interest rate differentials confirm the following equilibrium relationship:

$$q_t = x_t'\beta + z_t \tag{8}$$

where x_t is the vector of fundamentals, and z_t is the error term and should be stationary.

The trace statistics in Table 3 confirms that they share a common trend, supporting the claim that the real exchange rate was affected by permanent changes in real factors over the period.

[Table 3] Multivariate Cointegration Test

Hypothesized No. of CE(s)	Trace	Critical Value (5%)	Critical Value (1%)
$r=0$	306.0350	192.89	205.95
$R\leq 1$	226.5961	156	168.36
$r\leq 2$	164.4125	124.24	133.57
$r\leq 3$	110.2919	94.15	103.18
$r\leq 4$	64.22121	68.52	76.07
$r\leq 5$	42.02608	47.21	54.46
$r\leq 6$	24.21244	29.68	35.65
$r\leq 7$	11.99303	15.41	20.04
$r\leq 8$	2.294036	3.76	6.65

Under the assumption of one cointegrating vector and normalizing for the real exchange rate variable LQ1 to be 1, cointegrating relationship is represented in equation (9) with the asymptotic standard errors in ( ) below the coefficients. The signs of the coefficients are consistent with what the theory would predict. Increases in productivity and interest rate relative to the equivalent of U.S have the effect of appreciating the won/dollar real exchange rate. Increases in housing price and accumulation of current account also have the effect of appreciating real exchange rate. Increases in government spending relative to that of U.S and level of the openness of the Korean economy have the effect of depreciating real exchange rate.[4]

$$LQ1_t = 2.06 - \underset{(-0.37)}{1.35} * RLPROD + \underset{(0.68)}{4.45} * RLTOT + \underset{(0.68)}{5.42} * ROIL - \underset{(-0.01)}{0.08} * RDIF$$

[4] Since the foreign exchange rate regime in 1990s differs from 1980s, same estimation is conducted over the sample periods after 1990. The sign of the coefficient does not change even though the magnitude of the coefficient differs from those over the whole sample period.

$$\begin{aligned} LQ1_t = {} & 2.06 - \underset{(-0.30)}{1.94} * RLPROD + \underset{(0.17)}{0.28} * RLTOT + \underset{(0.19)}{0.21} * ROIL - \underset{(-0.00)}{0.01} * RDIF \\ & + \underset{(0.10)}{0.10} * RLTTRADE + \underset{(0.17)}{1.83} * RGCEXP - \underset{(-0.10)}{0.37} * RLKOHOUING \\ & - \underset{(-0.00)}{0.00} * INTCACUM \end{aligned} \quad (9')$$

$$+0.41*RLTTRADE+5.93*RGCEXP-0.06*RLKOHOUING$$
$$(0.16) \qquad (0.74) \qquad (-0.15)$$
$$-0.00*INTCACUM \qquad (9)$$
$$(-0.00)$$

Ⅵ. IMPULSE RESPONSE FUNCTION AND VARIANCE DECOMPOSITION

Impulse Response Function

We subject our cointegrated VAR system to impulse response analysis in order to consider the relative importance of the factors and persistence of their effects. In a cointegrating VAR system, the impact of shocks on the individual variables is expected not to die out in the long-run, which means that the variables will not return to their initial values if no further shocks occur.

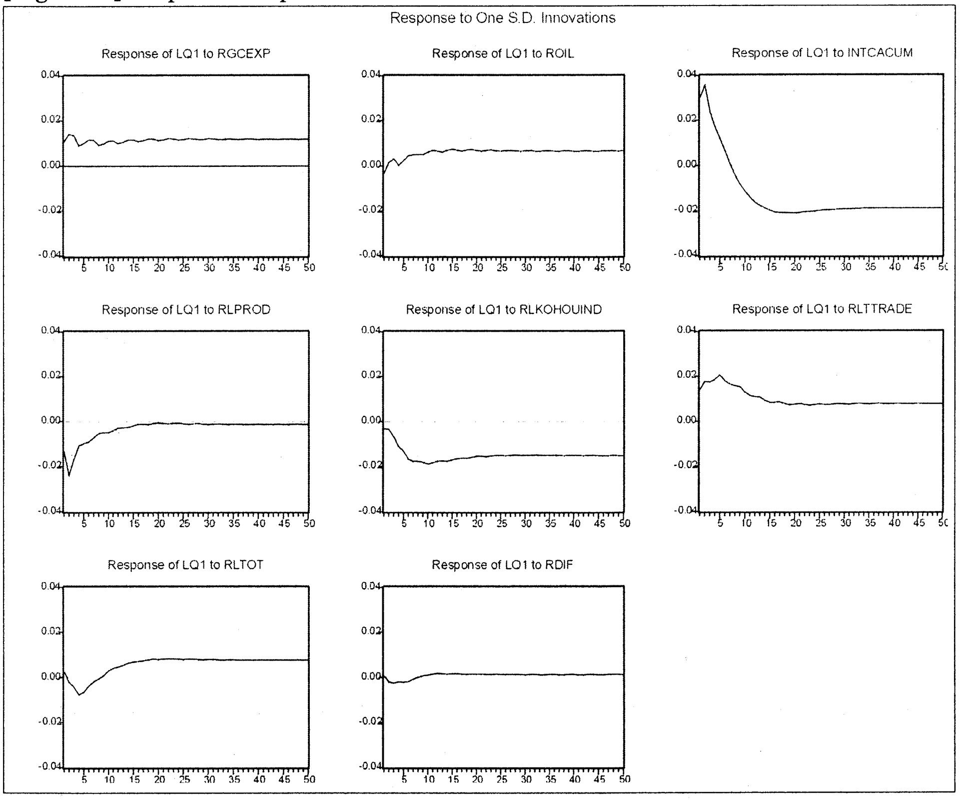
Figure 2 displays the dynamic response of the real exchange rate to various unitary shocks up to a limit of fifty periods. Several points are worthy of mention. First, the response of the real exchange rate to a real shock is clearly persistent and has a significant permanent effect on its level, which is to be expected for non-stationary variables. Second, the shape of dynamic responses of the real exchange rate to the various shocks differs.

From the variance decomposition analysis below, net foreign asset (INTCACUM) seems to be the most important factor in explaining the behavior of the real won/dollar exchange rate. The direction of effect is consistent with what we have expected, but the magnitude of the effect is small. On impact, net foreign asset shock depreciates the real exchange rate by 4%. This effect is soon reversed, appreciating the real exchange rate by 2% below its base line in the long term.

The reactions of real exchange rate to other important shocks such as productivity shock (RLPROD), openness (RLTTRADE) and housing price index (RLKOHOUIND) are as expected. The productivity shock immediately induces the real exchange rate to appreciate by more than 2% on impact and this effect persists over subsequent quarters. In the long run it appreciates the real exchange rate less than 1%. Openness shock leads to a depreciation of the real exchange rate by less than 2% on impact reaching a peak of over 2% after 5 quarters before it leads to permanent 1% depreciations. Housing price shock appreciates the real exchange rate slightly on impact leading to the long-run appreciation of real exchange rate by 2% from its baseline. Also, the relative increase in government spending depreciates the real exchange rate approximately by 1% over the long run.

The impulse response analysis of the effect of interest differential (RDIF), terms of trade (RLTOT) and oil shock (ROIL) shows that the direction of impact is consistent with what the theory would predict even though the magnitude of the impact is small. The long run effect of oil shock is to depreciate the real exchange rate, which is consistent with the fact that Korea is dependent on imported oil.

[Figure 2] Impulse Response Function



Variance Decomposition Analysis

Variance decomposition measures the percent contribution of each innovation to the h-step ahead forecast error variance of the real exchange rate, and provides a means for determining the relative importance of shocks in explaining the variation in the real exchange rate. Since the cointegration relationship between the real exchange rate and fundamentals is confirmed by the Johansen procedure, the empirical work is based on the VAR model augmented with error correction term, that is VECM.

Table 4 reports the variance decomposition for the real exchange rate and analyzes the relative importance of different real factors in influencing real exchange rate movements. The results for six forecasting horizons of 1, 4, 8, 12, 24 and 50 quarters are presented. The results of variance decomposition show that the won/dollar real exchange rate movement is dominated by the real factors. Approximately 70% of the one-step forecast error variance of the real exchange rate is accounted for by the fundamentals, even though the proportion explained by the fundamentals decreases to 60% in the longer term beginning 8 quarters.

The impacts of the real shocks show some variations by sources. The changes in net foreign assets proxied by cumulative current account balance (INTCACUM) is the most important factor accounting for 45% of the forecast error variance in real exchange rate, implying that the current account plays an important role as a determinant of the real won/dollar exchange rate.

Changes in productivity differential and openness of the economy also explain a substantial portion of the forecast error variance in real exchange rate, explaining 9% and 10% of forecast error variance in real exchange rate. The importance of these changes decreases over time. Korea was experiencing fast economic growth over the sample periods before 1997 and it is natural that the changes in the productivity differential account large portion of real exchange rate forecast error variance.

Even though relative government spending and housing price shocks account for less than 6% and 1% of the forecast error variance, the influence of these shocks increases, explaining more that 8% and 15% of the forecast error variance in 50 quarters.

[Table 4] Variance Decomposition

period	s.e	*RGCEXP*	*ROIL*	*INTCACUM*	*RLPROD*	*RLKOHOUIND*	*RLTTRADE*	*RLTOT*	*RDIF*	*LQ1*
1	0.02	5.69	0.56	45.06	8.92	0.54	9.65	0.31	0.03	29.22
4	0.05	5.73	0.23	30.50	11.64	1.97	11.57	0.90	0.16	37.30
8	0.07	5.80	0.55	18.46	8.07	7.25	13.76	0.87	0.15	45.09
12	0.09	6.09	1.01	16.30	6.24	10.93	12.84	0.84	0.13	45.64
24	0.12	7.18	1.88	20.78	3.58	13.57	9.09	2.04	0.13	41.75
50	0.16	8.33	2.39	22.87	1.95	14.54	6.75	3.02	0.11	40.04

Ⅶ. EXCHANGE RATE MISALIGNMENT

BEER is estimated using the fundamental variables at long run value with the estimated cointegrating vectors, as the current values of these determinants may depart from sustainable or long-run levels, as emphasized in the FEER approach.[5] The long run value of fundamental variables are extracted by the Hodrick-Prescott (H-P) filter.

The difference between the actual exchange rate and that given by the sustainable or long-run values of the economic fundamentals is called 'total misalignment' and this is represented Figure 3. We note periods of clear over and undervaluation of the currency. For example, for the period of 87-89, the Korean Won has slightly been undervalued. Beginning 1989 until the 1997:3Q, the Korean Won was consistently overvalued. Right after the 1997 currency crisis, the Won is found to be undervalued compared to the value which is predicted by economic fundamentals. Toward the end of year 2000, there is a close alignment between the actual and equilibrium rates. After that, the Won underwent some variation but was consistently overvalued.

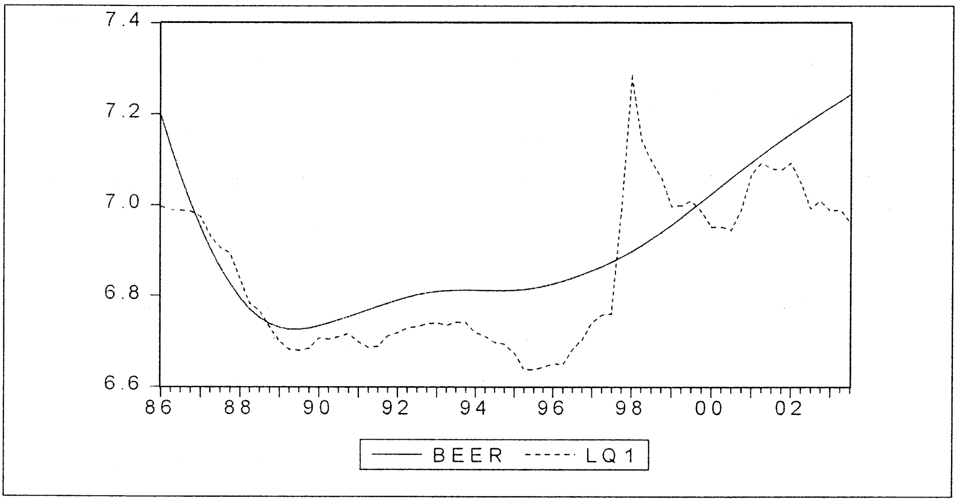
Figure 4 shows the misalignment of Korean Won calculated using the data after 1990s. Even though this gives different results of the misalignment before 1994 and after 2000 from the one using the whole sample periods, its estimation consistently shows the overvaluation of Korean Won before the 1997 financial crisis. It shows the slight undervaluation of the Won during 92-94 while showing overvaluation of the Won in the mid of 1990s up to the 1997 financial crisis. Also, after a close alignment between the actual and equilibrium rate toward 2000, the Won went over a period of overvaluation and undervaluation respectively.

The empirical results of misalignment are sensitive to factors such as the definition of real exchange rate, empirical methodology adopted and economic fundamental variables. However, studies on the overvaluation of Korean Won before the 1997 crisis gives the unanimous results. Kang and Ju (2004) estimated the misalignment of real exchange rate using the terms of trade and

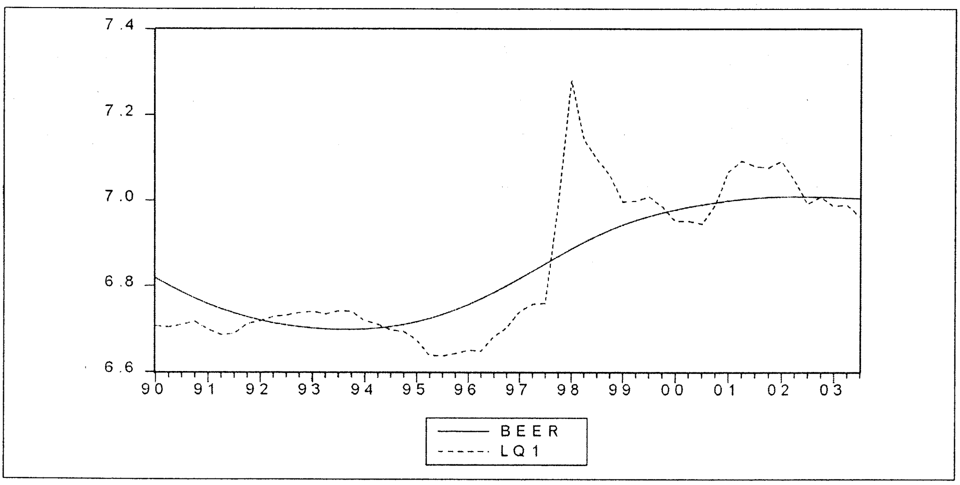
[5] BEER based on the current levels of the fundamental factors can be categorized as "current and cyclical equilibrium exchange rates". Comparison of BEER with the actual exchange rates produces namely a measure of 'current misalignment'(Driver and Westaway 2001). The estimated BEER, which is not presented in this paper, exhibits the higher volatility than the actual real exchange rate series reflecting the high volatility of fundamental variables used, especially relative government expenditure and measure of openness variables.

net foreign assets as fundamental variables. Kim and Kim (1999) extracted permanent trend of real effective exchange rate using a state-space model. All these studies confirm the overvaluation of the Won before the 1997 financial crisis, implying that overvaluation of the currency is one of major culprits of the financial crisis in Korea.

[Figure 3] Won/dollar real exchange rate and BEER(whole sample period)



[Figure 4] Won/dollar real exchange rate and BEER (after 1990s)



Ⅷ. CONCLUSION

In this paper we have estimated a BEER-based measure of the equilibrium Korean won/dollar real exchange rate over the sample periods of 1986:1Q to 2003:4Q. Using the multivariate cointegration methods of Johansen (1995), we were able to find a long-run equilibrium relationship of exchange rate with fundamental variables which comprises terms of trade, real oil price, net foreign asset, productivity differential, relative government expenditure, measure of openness and housing price index. All of the variables entered the cointegrating vector with the correct sign.

Impulse response analysis shows that the response of the real exchange rate to a real shock is clearly persistent and has a significant permanent effect on its level, which is to be expected for non-stationary variables. Also, the shape of dynamic responses of the real exchange rate to the various shocks differs. Variance decomposition analysis demonstrates that the net foreign asset, productivity differential, measure of openness and housing price index play important roles in explaining the behavior of real exchange rate.

Long run equilibrium value of Won is recovered from an estimated cointegrating equation and is used to assess the misalignment of Korean Won. We note periods of clear over and undervaluation of the currency: For example, for the period of 87-89, the Korean Won was slightly undervalued. Beginning 1989 until the 1997:3Q, 1997 financial crisis, the Korean Won was consistently overvalued. After the crisis, the Won is undervalued compared to the equilibrium value predicted by the economic fundamentals such as productivity differentials. Toward the end of year 2000, we found a close alignment between the actual and equilibrium rates. After that, the Won was found to be consistently overvalued.

REFERENCES

Allen P.R. and P.B. Kenen, (1980), *Asset markets, Exchange Rates and Economic Integration: A Synthesis*, Cambridge: Cambridge University Press.

Baffes, L., I.A. Elbadawi and S.A. O'Connell (1999), "Single-Equation Estimation of the Equilibrium Real Exchange Rate," Chapter 10 in *Estimating Equilibrium Exchange Rates in Developing Countries*, L.E. Hinkle and P.J. Montiel (eds.), Washington: World Bank.

Barrel, R., and J.W. I. Veld (1991), "FEERs and the Path to EMU," *National Institute Economic Review*, pp.51-58.

Beveridge, S. and Charles R. Nelson (1981), "A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the Business Cycle," *Journal of Monetary Economics*, Vol. 7, pp.151-174.

Chinn, M. C. (1999), "Productivity, Government Spending and the Real Exchange Rate: Evidence for OECD Countries," in R. MacDonald and J.L Stein (ed) *Equilibrium Exchange Rates*, Kluwer Academic Publisher, UK, pp.163-190.

Clarida, R. and J. Gali (1994), "Sources of Real Exchange Rate Fluctuations: How Important are Nominal Shocks?," In *Carnegie-Rochester Series on Public Policy*, Vol. 41, pp.1-56.

Clark, P. (1987), "The Cyclical Component of US Economic Activity," *Quarterly Journal of Economics*, 192, pp.797-814.

Clark, P.B. and Ro. MacDonald (2000), "Filtering the BEER: A Permanent and Transitory Decomposition," *IMF Working Paper*, 00/144.

Clark, P.B. and R. MacDonald (1999), "Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs," Chapter 10 in *Equilibrium Exchange Rates*, R. MacDonald, and J.L. Stein (eds.), Kluwer Academic Publishers, London, U.K.

Driver, R. and P.F. Westaway, (2001), "Concepts of Equilibrium Exchange Rates," Bank of England, mimeo.

Edison, H.J. and W.R. Melick, (1999), "Alternative Approaches to Real Exchange Rates: Three Up and One Down," *International Journal of Finance and Economics*, Vol. 4, pp.93-111.

Edward, S. (1989), *Real Exchange Rates, Devaluation and Adjustment: Exchange Rate Policy in Developing Countries*, Cambridge, Massachusetts: MIT Press.

Engle, Robert and Oliver Granger (1987), "Cointegration and Error Correction: Representation, Estimation and Testing," *Econometrica*, 55, pp.251-76.

Faruqee, Hamid (1995), "Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Equilibrium Approach," *Staff Papers*, IMF, Vol 42, pp.80-107

Fernandez, Francisco Maeso, Chiara Osbat and Bernd Schnatz, (2001), "Determinants of the Euro Real Effective Exchange Rate: A BEER/PEER Approach," *European Central Bank Working Paper Series*, No. 85, November.

Gonzalo, J., and C. Granger (1995), "Estimation of Common Long-Memory Components in Cointegrated Systems," *Journal of Business and Economic Statistics*, Vol. 13, pp.27-35.

Johansen, Soren (1995), Likelihood-Based Inference in Cointegrated Vector Autoregressive Models, Oxford: Oxford University press.

___________ and K. Juselius, (1992), "Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp.169-210.

____________, (1988), Statistical analysis of Cointegrating Vectors," *Journal of Economic Dynamic and Control*, Vol. 12, pp.231-254.

Hsieh, David (1982), "The Determination of the Real Exchange Rate: The Productivity Approach," *Journal of International Economics*, Vol. 12, pp.355-362.

Huizinga, John (1987), "An empirical Investigation of the Long-Run Behaviour of Real Exchange Rates," In *Carnegie-Rochester Conference Series on Public Policy,* Vol. 27, pp.149-214.

Isard, Peter (1983), "An Accounting Framework and Some Issues for Modeling How Exchange Rates Respond to the News," in J. Frenkel (ed.), *Exchange Rates and International Macroeconomics*, Chicago University Press.

Kakkari, Vikas and Masao Ogaki, (1993), "Real Exchange Rates and Nontradeables," University of Rochester, mimeo.

Kang, Sam Mo and Ju Sang Young (2004), "Analysis on the overvaluation of currencies in East Asia: Korea, Thailand, Singapore," *Korean Journal of Finance*, 18(2), Korea Institute of Finance, pp.1-28, (in Korean).

Kim, In Bae and Kim Jung Han (1999), "Estimation of Equilibrium Won/dollar Real Effective Exchange Rate," *Korean Journal of Public Finance and Economics*, Vol. 6., The Korean Association of Public Finance and Economics, pp.131-143, (in Korean).

Lane, Philip and Gaian Maria Milesi-Ferretti, (2000), "The Transfer Problem Revisited: Net Foreign Assets and Real Exchange Rates," unpublished paper, Trinity College Dublin and International Monetary Fund.

Lee, Choong Ryl (1998), "Estimation of FEER in Korea," *Korean Journal of Econometrics*, Vol. 8, The Korean Econometric Society, pp.159-189, (in Korean).

MacDonald, Ronald (2004), "The Long-Run Real Effective Exchange Rate of Singapore: A Behavioral Approach," mimeo, The Monetary Authority of Singapore.

MacDonald, Ronald and J.L. Stein (eds), (1999), *Equilibrium Exchange Rates*, Kluwer Academic Publishers, London, U.K.

MacDonald, Ronald (1997), "What Determines Real Exchange Rates: The Long and Short of It," *IMF Working Paper*, 97/21, Washington, International Monetary Fund.

Marston, Richard (1990), "Systematic Movements in Real Exchange Rates in the G5: Evidence on the Integration of Internal and External Markets," *Journal of Banking and Finance*, Vol. 14, pp.1023-1044.

Meese and Kenneth Rogoff (1988), "Was it Real? The Exchange Rate-Interest Differential Relation over the Modern Floating-Rate Period," *The Journal of Finance*, Vol LLIII, No. 4.

Mussa, Michael (1984), "The Theory of Exchange Rate Determination," in J.F.O. Bilson and R. Marston (eds.), Exchange Rate Theory and Practice, *NBER Conference Report*, Chicago, Chicago University Press.

Park, Dae Keun (1995), "Study on the Misalignment of Won/Dollar Exchange Rate from PPP," *Korean Journal of International Economics*, 1(1), Korea International Economic Association, pp.141-163 (in Korean).

Park, Dae Keun and Choi Jun Hyuk (2000), "Was Won Overvalued before the 1997 Financial Crisis?," *Korean Journal of Money and Finance*, 5(1), Korea Money and Finance Assoicaiton, pp.43-65, (in Korean).

Sachs, Jeffrey, Aaron Tornell and Andes Velasco (1996), "The Mexico Peso Crisis: Sudden Death or Death Foretold?," *Journal of International Economics,* 41, pp.265-283.

Stein, J.L. (1999), "The Evolution of the Real Value of the U.S. Dollar Relative to the G7 Currencies," Chapter 3 in Ronald MacDonald and J.L. Stein (eds.), *Equilibrium Exchange Rates*, Kluwer Academic Publishers, London, U.K.

Williamson, John (ed) (1994), *Estimating Equilibrium Exchange Rates*, Washington, Institute for International Economics.