Sources of Korean Effective Real Exchange Rate Fluctuations : The Relative Importance of Nominal Shocks.

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Ⅰ. Introduction

The main objective of this paper is to identify the sources of Korean effective real exchange rate fluctuations since 1974. Most of the research on real exchange rate is to investigate the behavior of bilateral real exchange rate. In our view,

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understanding the behavior of effective real exchange rate which is just the trade weighted thing of bilateral real exchange rate may be more important than understanding the bilateral real exchange behavior in eliciting some policy implications in continuously changing multilateral trade environment.

In an influential paper by Mussa (1986), he argued that sluggish price adjustment must play a central role in explaining the short-run movements of real and nominal exchange rates: the volatility of real exchange rates since the collapse of Bretton Woods has closely tracked the volatility of nominal exchange rate; the variance of real exchange rates since that time has been about 8 to 80 times higher than during Bretton Woods. Mussa's argument is consistent with Dornbush (1976)'s disequilibrium approach to real exchange rate determination. According to Dornbush, nominal shocks such as money supply shocks can overshoot the real exchange rate above the long-run level of real exchange rate when prices are sticky. On the contrary, Stockman (1987) pointed out that the real exchange rate behavior since the collapse of Bretton Woods reflects not the importance of sluggish adjustments of prices, but rather the influence of permanent real shocks. Modern empirical studies on real exchange rate has shown that since the collapse of Bretton Woods, real exchange rates appear to have a unit root, and that most of the variances of changes in real exchange rate is attributed to permanent shocks(Huizinga (1987)). These empirical findings might cast doubt on the relevance of Donbush's overshooting model of real exchange rate within sticky price framework.

These theoretical disputes and empirical findings of a unit root in the real exchange rate motivates the researchers to assess the relative importance of shocks that are driving forces of real exchange rates. In this sense, it is very interesting for us to assess the relative importance of nominal and real shocks in the movements of effective real exchange rates in continuously changing multilateral trade environment.

In the next section, we have done the univariate unit root test for effective real exchange rate, effective nominal exchange rate, foreign price level, and Korean price level. To preview our results, the effective real exchange rate was shown to have a unit root. In the third section of the paper, firstly we build up a stochastic rational expectations model of Mundell-Flemming's open economy. In the model, we have shown that the variables of effective real exchasnge rate and price level have a unit root, and that nominal shocks such as monetary shocks affect the effective real exchange rate in the short run, not in the long run. Using this long-run neutrality of nominal shocks, we have done the structural vector auto regressive(SVAR) analysis. Lastly, we conclude the paper.

Ⅱ. Unit Root Test

Before doing the unit root test, we will briefly describe the data. In what follows, we define the effective exchange rate(EER), foreign price index(FR), and effective real exchange rate(ERER). The sources for quarterly data of excahnge rates and the price indices are from Korean National Statistical Office. The quarterly data set spans from 1974 to 1998. The effective exchange rate is an import weighted average of 19 country exchange rates.1)

$$EER = \ln(E_t^*) = \Sigma_{j=1}^{19} w_{jt} \ln(E_{jt}^*)$$

where E_{jt}^* is the domestic price of foreign country j's currency at time t, and the weight for the country j is given by:

1) The list of 19 countries are : Australia, Belgium, Canada, Switzerland, Germany, France, England, Indonesia, India, Italy, Japan, Malaysia, Netherlands, New zealand, Philippines, Saudi Arabia, Sweden, Singapore, United States.

$$w_{jt} = M_{jt}/(\Sigma_{j=1}^{19} M_{jt})$$

and M_{jt} is the value of imports in millions of current US dollars to the Korea from country j at time t.

The foreign price index is an import weighted average of 19 country price indices:

$$FP = \ln(P_t^*) = \Sigma_{j=1}^{19} w_{jt} \ln(P_{jt}^*)$$

where P_{jt}^* is the foreign country j's consumer price index.

The effective real exchange rate is an import weighted average of 19 bilateral real exchange rates.

$$ERER = \Sigma_{j=1}^{19} w_{jt} \ln[(E_{jt} \times P_{jt}^*)/P_t]$$

where P_t is the Korean consumer price index.

To test for the nonstationarity of the variables such as effective real exchange rate, effective exchange rate, foreign price level, and Korean price level, we employ the traditional Augmented Dickey-Fuller(ADF) test and Phillips-Perron(PP) tests. Consider the following Dickey-Fuller(DF) test equation for the variable X.

$$\triangle X_t = a+bT+cX_{t-1}+Error$$

where a drift term and a linear time trend are included: Error is a white noise process.

The DF test statistic is the "t-ratio" of c in the above equation, known as a Dickey-Fuller regression. But that "t-ratio" does not have a standard normal distribution when the underlying stochastic process of the variable X has a unit root. Fortunately, Dickey and Fuller (1979,1981) derived the distribution of c and "t-ratio" of c under the hypothesis of c being 0, and they tabulated it.

Instead of using above DF test statistic, we employ the ADF test statistic to identify the unit root in the stochastic processes of the variables. One advantage of employing the augmented Dickey-Fuller strategy is that we control for the possible serial correlation in Error. The equation for Augmented Dickey-Fuller test of order p is written as follows.

$$\triangle X_t = a+bT+cX_{t-1}+ \lambda_1 \triangle X_{t-1}+ \ldots \lambda_p \triangle X_{t-p}+Error$$

Where Error is a white noise process.

Again, the ADF test statistic is the ratio of c in the above regression. The critical values for the Dickey-Fuller test statistics are given in Fuller(1976). Above equation can also be used to calculate Phillips-Perron (1988) Z test statistic, which controls for conditional heteroskedasticity of error.

Table 1: Unit Root Tests for Korea Exchange Rate, Domestic and Foreign Prices(sample period;1974 1/4-1998 2/4)

	ADF Test					PP Test				
Variable	τ_c	ρ	τ_{ct}	ρ	lags	τ_c	ρ	τ_{ct}	ρ	lags
ERER	-2.477	0.855	-1.535	0.886	4	-2.149	0.892	-1.933	0.895	4
EER	-0.221	0.994	-1.813	0.917	4	-0.978	0.976	-2.130	0.911	4
FR	-2.841	0.977	-3.986	0.885	5	-4.927	0.975	-4.923	0.995	5
KP	-2.429	0.992	-2.624	0.974	3	-4.876	0.980	-2.734	0.965	3

Notes:

1. τ_c indicates the test statistic in case constant(drift term) is only included in test equation.
2. τ_{ct} indicates the test statistic of including additionally time trend in test equation.
3. The lag length test was done to choose the lag lengths: for the variable EER, the appropriate lag length was not found (but reported as having 4 lags in the table) when only constant term was included in the test equation.
4. Significance at the 10% level is indicated in bold face. The critical values of 10% significance level for τ_c and τ_{ct} are -2.59 and -3.15 respectively.
5. KP represents the Korean consumer price index.

The coefficients of the lagged values of $\triangle X_{t-i}$ in the above equation is not generally important. Nonetheless, it is important to ensure that Error approximates white noise process.[2] To determine the lag lengths in the above equation, we start with a relatively long lag length and pare down the model by using the usual t-test.

The Unit Root Test results for Korean Effective Exchange Rate, Korean Effective Real Exchange Rate, Domestic and Foreign Prices during the period(1974 1/4-1998 4/4) are shown in table 1.

The effective real exchange rate(ERER) shows a random walk behavior which was usually found in the movement of the bilateral real exchange rate. The chosen lag length was 4 in the test for ADF and PP. We can't reject a null of unit root in ERER at the significance level of 10% regardless of whether a drift or linear time trend was included or not. We also found a unit root in the movement of

2) To ensure the white noise approximation of the Error process, Dickey and Fuller do a parametric correction for serial correction in the test equation. On the other hand, Phillips and Perron do a nonparametric correction.

effective exchange rate at the 10% significance level when both a drift and a linear time trend were included in the test equation. Unfortunately, the appropriate lag length in effective exchange rate was not found when we consider a drift term only in the test equation. We reject a null of a unit root in the trade weighted average of Foreign prices at 10% significance level regardless of whether a drift term or a linear time trend was included or not. The chosen lag lengths in the test equation was 5. On the contrary, Korean Price index was shown to be nonstationary no matter what we include a drift or a linear time trend in the test equation.

Ⅲ. Structural VAR Analysis

3.1 A Stochastic Rational Expectations Model of Mundell-Flemming's Open Economy

We now present a stochastic version of Mundell-Flemming's small open macro model developed by Obstfeld (1985), Clarida and Gali (1994), and Lee and Chin (1998). We define variables in logs, which represent home relative to weighted average of foreign levels, except for the interest rate. For example, $y_t \equiv y_t^h - \sum_{i=1}^N w_i y_t^i$, $i_t \equiv i_t^h - \sum_{i=1}^N w_i i_t^i$.

$$y_t^d = \eta (s_t - p_t) - \sigma (i_t - E_t(p_{t+1} - p_t)) \qquad (1)$$

$$p_t = (1-\theta) E_{t-1} p_t^e + \theta p_t^e \qquad (2)$$

$$m_t - p_t = y_t - \lambda i_t \qquad (3)$$

$$i_t = E_t(s_{t+1} - s_t) \qquad (4)$$

These equations constitute the basic open economy IS-LM model with sticky price adjustment. Equation (1) is an open economy IS equation in which the demand for output(y_t^d) is increasng in the effective real exchange rate(s_t-p_t) and decreasing in the real interest rate(i_t-$E_t(p_{t+1}$-p_t)). Equation (2) represents the price level(p_t) adjustment to the long-run equilibrium price level(p_t^e). When θ=1, actual price is a long-run equilibrium flexible price and output is determined in the supply side. Equation (3) is the standard LM equation. Equation (4) represents a trade weighted interest rate parity condition: s_t is the effective exchange rate. To solve our model, we specify the stochastic processes for y_t^s(the trade weighted average of relative supply of output), m_t^s(the trade weighted average of relative money supply), and b_t(trade balance) as follows.

$$y_t^s = y_{t-1}^s + z_t \tag{5}$$

$$m_t = m_{t-1} + v_t \tag{6}$$

$$b_t = \xi (s_t - p_t) + \rho z_t \tag{7}$$

In equations (5) and (6), we assume that both y_t^s and m_t are simple random walk processes. The positive relative supply shock(z_t) permanently increases the domestic output more than weighted average of foreign output. The positive relative money supply shock(v_t) brings about a permanent increase in the relative money supply, while it does not affect the movement of the real variables in the long run. The long-run money neutrality holds here. Equation (7) shows that the trade balance depends on the effective real exchange rate and the productivity shock.

To solve the flexible-price rational expectation equilibrium in which output is supply determined, we firstly derived the long-run effective real exchange rate $(s_t$-$p_t)^e$. Hereafter, we denote the effective real exchange rate as q_t. To derive q_t^e, we substitute y_t^s into equation (1) and solve for q_t^e by taking rational expectations on both sides of equation. Next, we derive the long-run relative price level from (3), (4) and the definition of the effective real exchange rate. Collecting these results, we see the following long-run flexible price equilibrium evolution of the variables(y_t^e, q_t^e, p_t^e).

$$y_t^e = y_t^e \tag{8}$$

$$q_t^e = y_t^e / \eta \tag{9}$$

$$p_t^e = m_t - y_t^l \tag{10}$$

Given the above characterization of flexible price equilibrium in the system, we derive the short-run behavior of the variables(p_t, q_t, y_t) when prices adjust slowly. Substituting (10) into price adjustment equation (2), we obtain the actual evolution of p_t as follows.

$$p_t = p_t^e - (1-\theta)(v_t-z_t) \tag{11}$$

In response to a positive money supply shock, short-run price level rises less than the long-run flexible price. The short-run price level falls but less than the long-run flexible price level responding to a positive supply shock. We derive the short-run effective real exchange rate(q_t) by solving the short-run IS-LM equilibrium. Substituting IS equation (1) and (4) into LM equation(3), we solve for q_t as follows.

$$q_t = q_t^e + \mu(1-\theta)(v_t-z_t) \tag{12}$$

where $\mu \equiv (1+\lambda)/(\lambda+\sigma+\eta)$.

Note that a positive monetary shock causes the effective real exchange rate to deviate temporarily from a flexible price equilibrium q_t^e in the short run. But, in the long run, it has no effect on the effective real exchange rate. Using (12) and the IS equation (1), we derive the demand determined level of output y_t as follows.

$$y_t = y_t^s + (\eta + \sigma)\upsilon(1-\theta)(v_t - z_t) \tag{13}$$

In the presence of sluggish price setting with θ being not 1, Both money and supply shocks affect the movements in the real output y_t. A positive money supply shock depreciates the effective real exchange rate, through which increases the real output y_t.

Within sticky price framework, a positive money supply shock depreciates the effective real exchange rate in the short run but has no effect on the effective real exchange rate in the long run. Obviously, the trade balance moves in the same direction as in the movement of effective real exchange rate. On the other hand, a positive supply shock has an ambiguous effect on the effective real exchange rate in the short run but appreciates it in the long run. These arguments are summarized as follows.

$$\begin{aligned} \partial q_t/\partial v_t &= \mu(1-\theta) > 0 \quad \text{for } \theta<1. \\ \partial q_t/\partial z_t &= 1/\eta - \mu(1-\theta) \\ \partial q_t^e/\partial z_t &= 1/\eta > 0 \end{aligned} \tag{14}$$

The above results imply that the effect of a positive supply shock on the trade balance is ambiguous in the short run and in the long run, and that the trade balance moves in the same direction as in the movement of effective real exchange rate:

$$\begin{aligned} \partial b_t/\partial v_t &= \xi\mu(1-\theta) > 0 \text{ for } \theta<1. \\ \partial b_t/\partial z_t &= \xi[1/\eta - \mu(1-\theta)] + \rho \end{aligned} \tag{15}$$

In terms of identification, as will be shown in the next section, we only require that nominal shocks such as monetary shocks should not affect the effective real exchange rate in the long run.. This restriction of money neutrality on the real exchange rate is also consistent with recent intertemporal models of open econom y.[3] In that sense, our key idetifiacation is reasonable.

3.2 The Empirical Implementation

Our theoretical model implies that q_t, y_t, and p_t are first order difference stationary. Suppose that $x_t \equiv [\triangle q_t, b_t]'$ is generated by the following Vector Moving Average Model:

$$x_t = C_0 \varepsilon_t + C_1 \varepsilon_{t-1} + C_2 \varepsilon_{t-2} + \ldots \qquad (16)$$

where $\varepsilon_t \equiv [z_t, v_t]$ denote the 2 by 1 vector of the system's 2 structural disturbances, and C_0 is the 2 by 2 matrix that defines the contemporaneous structural relationship between the system's 2 variables.

Our simple expository model implies that above structural moving average model would be a vector MA(1) process. But, here, we would expect further dynamics in the data. To identify the structural C_i matrices from the data, we first estimate the following Vector Moving Average model:

$$x_t = u_t + R_1 u_{t-1} + R_{t-2} + \ldots \qquad (17)$$

where u_t is a vector reduced-form disturbance.

3) In the model of Obstfeld and Rogoff (1996), the real exchange rate is constant with the assumption that purchasing power parity holds. In a model of Pricing-to-Market by Betts and Devereux (1996), the real exchange rate was shown to fluctuate in the short run, not in the long run.

We assume that there exists a nonsingular matirx S such that $u_t=S\varepsilon_t$. Matching above equations, we see that: $C_0=S$, $C_1=R_1S$, $C_2=R_2S$, i.e., $C(L)=R(L)S$. Thus, we note that:

$$u_t=C_0\varepsilon_t. \tag{18}$$

We obtain estaimates of the parameters R_i and the symmetric variance-covariance matrix $\Sigma(=Eu_tu_t')$ by estimating the reduced-form moving average representation (17). To recover C_i, we utilize the fact that:

$$\Sigma=C_0E(\varepsilon_t\varepsilon_t')C_0'=C_0C_0' \tag{19}$$

Where we assume that the structural shocks are mutually orthogonal and that each has unit variance. $\Sigma=C_0E(\varepsilon_t\varepsilon_t')$

Equation (19) represents a system of 4 equations with only 3 knowns, the 2 variances one covariance that define Σ. Thus, one additional restriction is needed to identify C_0 and to recover the time series of structural shocks ε_t as well as the structural system's dynamic parameter matrices $C_1, C_2, \ldots$

Recall that nominal shock v_t does not influence real exchange rate in the long run. This long-run neutrality of money is utilized in identifying C_0. Letting $C(1)\equiv C_0+C_1+C_2+\ldots$, the restricion of money neutrality on real exchange rate requires that:

$$C_{12}(1)=0. \tag{20}$$

Note that $x(t)=C(L)\varepsilon_t=R(L)C_0\varepsilon_t$, from which we obtain:

$$R(1)\Sigma R(1)'=C(1)C(1)' \tag{21}$$

Let H denote the lower triangular Choleski decomposition of $R(1)\Sigma R(1)'$:

$$HH'=R(1)\Sigma R(1)' \qquad (22)$$

Long-run restriction of equation (20) implies that C(1) is lower triangular. Since H is the unique lower triangular decomposition of $R(1)\Sigma R(1)'$, we have :

$$C(1)=H \qquad (23)$$

From the definition of $C(1)=R(1)C_0$, we deduce that:

$$C_0=R(1)^{-1}H \qquad (24)$$

Given an estimate C_0, we can also recover the structural-system dynamics $C_i=R_iC_0$, i=1, 2, ...

3.3 Empirical Results

In this paper, our main concern is to identify the sources of effective real exchange rate fluctuations, and to distinguish the relative importance of shocks since 1974 in Korea. Our structural stochastic version of Mundell-Flemming model suggests that nominal shocks such as monetary shocks have a short-run effect on the movement of effective real exchange rate, but have no long-run effect on that. Given the long-run neutrality of nominal shocks on effective real exchange rate, we estimated the structural VAR. We present here the empirical results: we calculate the variance decompositions for the change in effective real exchange rate, and we plot impulse responses of effective real exchange rate and trade balance to the structural supply and nominal shocks. The variance decompositions for the effective real exchange rate and for the trade balance are reported in table 1.

Table 1 shows that as the forecast horizon increases(after 10 quarters), 81.6 percent of the conditional variance of the change in the effective real exchange rate is attributed to monetary shocks, while 18.4 percent of that is attributed to the supply shocks. That is, relative to supply shocks, monetary shocks are dominant in the movements of the effective real exchange rate. For the trade balance, as the forecast horizon increases(after 10 quarters), about 54.3 percent of the conditional variance of the change in the trade balance is attributed to monetary shocks, on the other hand, about 54.3 percent is attributed to supply shocks: the nominal shocks are more important than the supply shocks in the movements of trade balance.

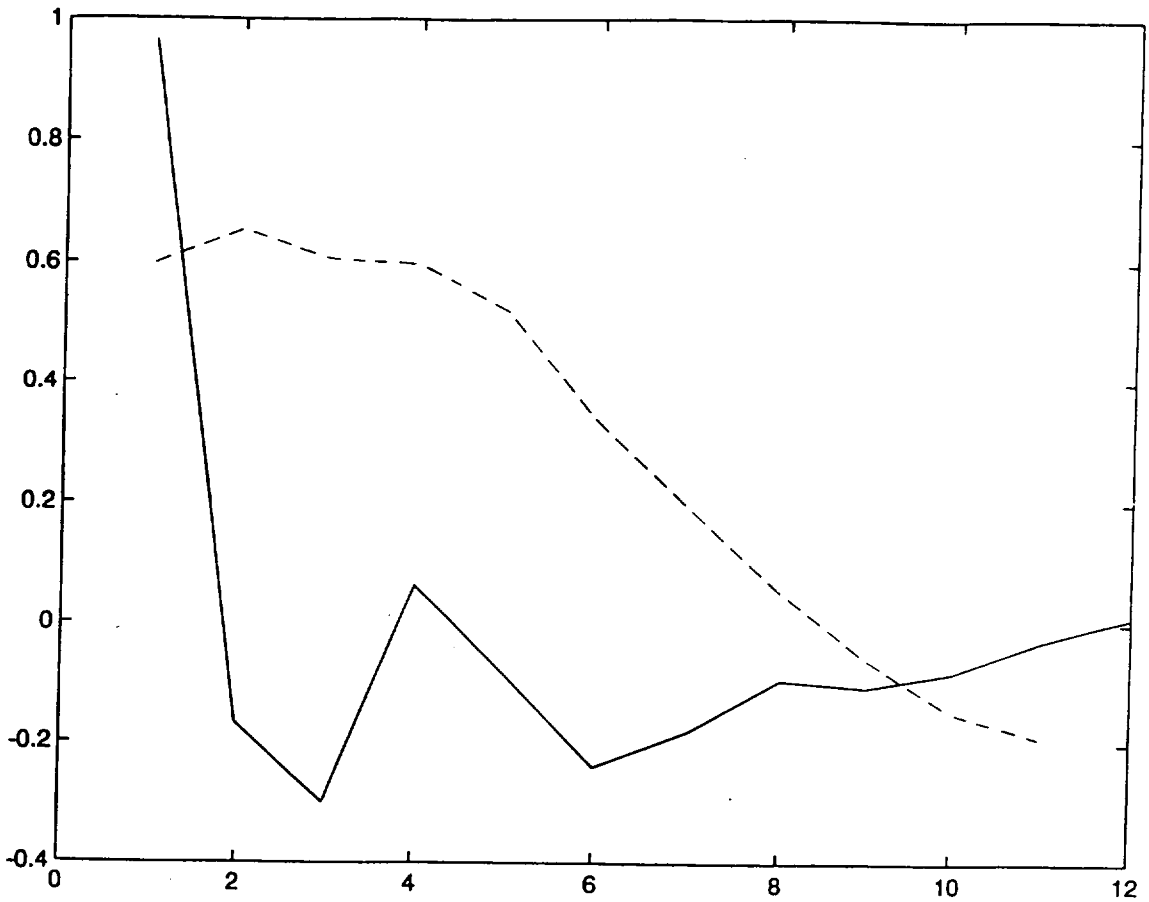
Impulse responses of the effective real exchange rate and the trade balance due to nominal shocks are reported in Figure 1. As the theory suggests, in response to a one-standard deviation nominal shock, the effective real exchange rate depreciates a lot, almost 100 percent immediately. But the depreciation of the effective real exchange rate immediately disappeared. the nominal shock to the trade balance increases the trade balance about 60 percent during 4 quarters, after which its effects diminishes rapidly. Impulse responses of the effective real exchange rate and the trade balance due to supply shocks are reported in Figure 2. One standard deviation supply shock depreciates the effective real exchange rate about 30 percent immediately. But its effect immediately disappears after which it reverts to depreciation until 6 quarters. One standard deviation supply shock worsens the trade balance very much, but eventually its negative effect disappears.

Table 1:

Variance decomposition: $\triangle q_t$ and b_t

Horizon	Effective real exchange rate fraction of variance due to		Trade balance fraction of variance due to	
	supply	money	supply	money
1	0.081	0.919	0.640	0.360
2	0.088	0.912	0.521	0.479
3	0.087	0.913	0.524	0.476
4	0.087	0.913	0.493	0.507
5	0.179	0.821	0.468	0.532
6	0.176	0.824	0.456	0.544
7	0.177	0.823	0.451	0.549
8	0.181	0.819	0.452	0.548
9	0.185	0.815	0.455	0.545
10	0.184	0.816	0.457	0.543
11	0.184	0.816	0.458	0.542
12	0.184	0.816	0.457	0.543

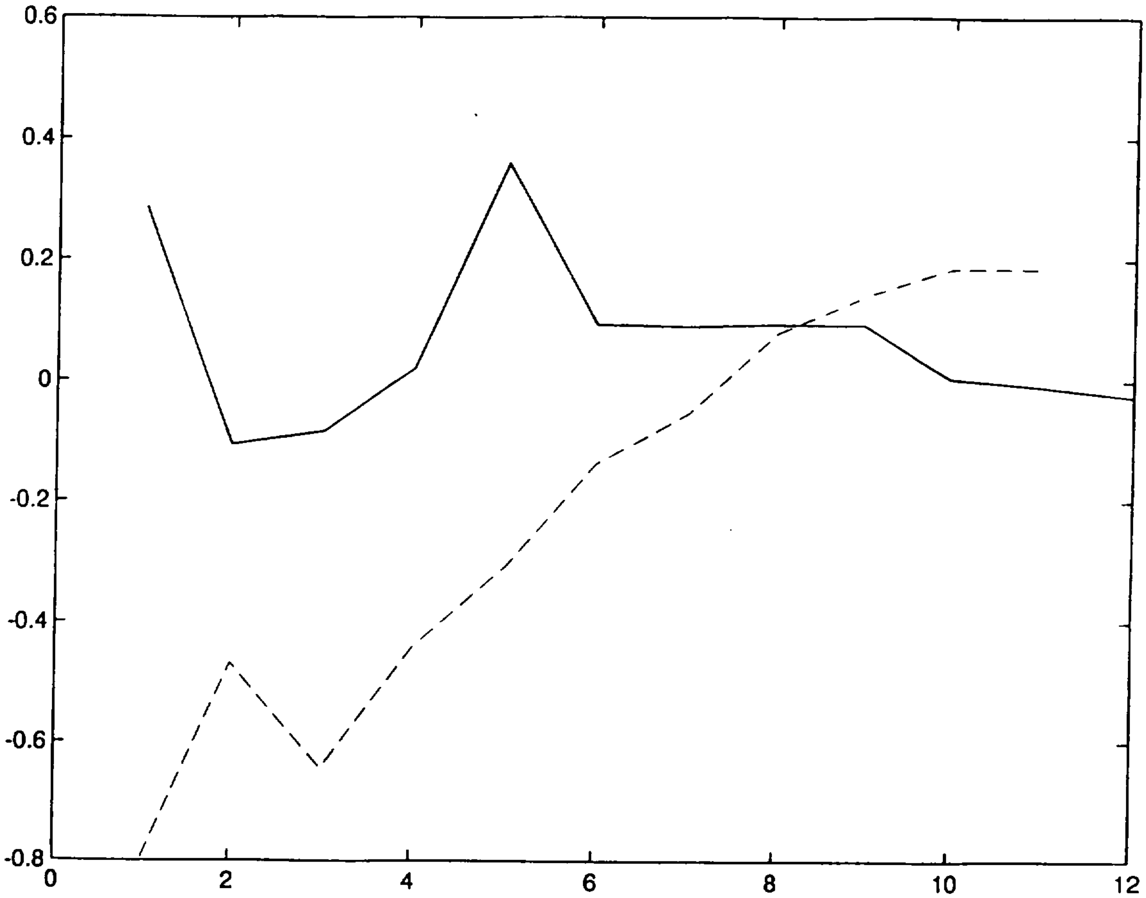
Figure 1. Impulse Responses of Effective Real Exchange Rate and Trade Balance to a Nominal Shock.



- ; Impulse responses of effective real exchange rate due to a nominal shock.

-- ; Impulse responses of trade balance due to a nominal shock.

Figure 2. Impulse responses of Effective Real Exchange Rate and Trade Balance to a Supply Shock.



- ; Impulse responses of effective real exchange rate due to a supply shock.

-- ; Impulse responses of trade balance due to a supply shock.

Ⅳ.Conclusion

Our main concern in this paper is to investigate the behavior of effective real exchange rate since 1974 in Korea. In our sense. the study of effective real exchange rate is more crucial than the study of bilateral real exchange rate under the changing multilateral trade environment. Using a unit root test, we have seen that the effective real exchange is nonstationary. The next step we do is assess the relative importance of driving forces in the movements in the effective real exchange rate. Under the restriction of money neutrality on the movement of effective real exchange rate, we employ the structural VAR estimation technique to identify the relative importance of shocks. As the theory suggests, the effective real exchange rate depreciates immediately in response to a one-standard deviation nominal shock. But the depreciation of effective real exchange rate immediately disappeared. The nominal shock also increases the trade balance during 4 quarters, after which its effects diminishes rapidly. One standard deviation supply shock depreciates the effective real exchange rate about 30 percent immediately. The surprising result of this empirical study is that the nominal shocks are much more dominant than the supply shocks in the movements in effective real exchange rate: as the forecast horizon increases, almost 82 percent of the conditional variance of the change in the effective real exchange rate is attributed to monetary shocks, while 18 percent of that is attributed to the supply shocks; for the trade balance, as the forecast horizon increases, about 54 percent of the conditional variance of the change in the trade balance is attributed to monetary shocks, on the other hand, about 46 percent is attributed to supply shocks. This empirical result implies that the fluctuations of real exchange rate are dominantly caused by the nominal shocks, which is inconsistent with the view of equilibrium approach of real exchange rate.

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