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The Effects of Macroeconomics Shocks on Exchange Rate and Trade Balances in Korea*

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This study analyzes the effects of various macroeconomic shocks on exchange rate and trade balance in South Korea using a structural vector error correction (SVEC) model. Conventional theories such as exchange rate overshooting and J-curve effects are re-examined by allowing for the endogeneity among relevant macroeconomic variables. The study identifies the structural relationship among different macroeconomic variables by imposing the short-run and the long-run identifying restrictions based on the various macroeconomic theories.

The impulse responses analysis results conform to our expectations. An interest rate shock (or contractionary monetary policy shock) causes exchange rate (KRW/foreign) to fall (or Korean Won to appreciate) and trade balance to worsen. Money supply shocks lead to a depreciation of Korean Won and an improvement of trade balance. Price level shocks cause Korean Won to depreciate and trade balance to improve. The output shocks lead to an appreciation of Korean Won, worsening the trade balance. In addition, the exchange rate depreciation shock of Korean Won leads to an improvement in trade balance. The results show that exchange rate overshooting is found only from its own exchange rate shock. We find no evidence of J-curve effect. Instead, we find that the exchange rate shock causes an instant and small improvement in the trade balance and the magnitude of improvement in trade balance gets bigger in the long run.

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Keywords: exchange rate overshooting, trade balance, J-curve effects, structural vector error-correction (SVEC) model, impulse response, variance decomposition

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1. INTRODUCTION

In 1973, a largely flexible, market-based pricing mechanism for currencies was introduced due to the breakdown of exchange rate controls imposed by the Bretton-Woods System. Since then, many researchers have investigated on topics related to the effects of macroeconomics shocks on exchange rate and trade balances. They have come up with different results, given the different coverage of countries, periods and different econometric methods.

A classical explanation of exchange rate overshooting comes from price rigidity. According to the model, when a change in monetary policy occurs, the market will adjust to a new equilibrium between prices and quantities. Initially, because of the “stickiness” of prices of goods, the new short run equilibrium level will first be achieved through shifts in financial market prices. Then, gradually, as prices of goods “unstick” and shift to the new equilibrium, the foreign exchange market continuously re-prices, approaching its new long-term equilibrium level. Only after this process has run its course will a new long-run equilibrium be attained in the domestic money market, the currency exchange market, and the goods market. As a result, the foreign exchange market will initially overreact to a monetary change, achieving new short run equilibrium. Over time, goods prices will eventually respond, allowing the foreign exchange market to dissipate its overreaction, and the economy to reach the new long run equilibrium in all markets. So the main focus of the exchange rate overshooting was on the effect of monetary policy on exchange rate.

J-curve effects state that a country’s current account worsens immediately after real currency depreciation of domestic currency and improves with some lags. The theoretical basis of the J-curve effect comes in part from Alfred Marshall and Abba Lerner, whose “Marshall-Lerner Condition” states that if initially the balance of trade is zero, and if supply elasticities are infinite, then the absolute values of export and import demand elasticities have to be at least large enough to add up to unity to have an exchange rate devaluation bring about the surplus in balance of payments. This theory can be proven by looking at the changes in elasticity over time. In the short run, elasticities are small, making the Marshall-Lerner Condition less likely to be satisfied. However, as time goes by, elasticities become larger, ultimately crossing the threshold point described by Marshall and Lerner, thus creating the condition for an improvement in the balance of payment.

After careful examinations of the births of exchange rate overshooting and J-curve effects, we can infer what researchers have done for these issues. Regarding the exchange rate overshooting, the main focus was how monetary policy affects the exchange rate both in the short run and in the long run. However, the findings on exchange overshooting differ by estimation strategy (reduced-form approach such as OLS or structural-form approach), by country and by estimation periods. Regarding the J-curve effects, researchers' focus was either on measuring the effects of exchange rates on the trade balances, the elasticities of import and export with respect to exchange rates. Again, the findings on J-curve effects differ by estimation strategy, by country and by estimation periods.

Exchange rate overshooting and J-curve effects may be found from different macroeconomic activities in addition to variables specified in each theory. Therefore, the paper is to investigate the effects of not only the monetary policy shock but also other macroeconomic shocks, such as exchange rate shock, price level shock, output shock, on exchange rate and trade balance. To identify the structural macroeconomic shocks, the paper employs the structural vector error correction (hereafter, SVEC) model with non-recursive short-run and long-run identifying restrictions. The estimation results from conventional structural VAR (hereafter SVAR) may be biased if there is any cointegration relationship among relevant macroeconomic variables. Also, the main advantage of SVEC over SVAR is that SVEC greatly reduces the number of identifying restrictions by imposing cointegrating relationship in the long-run matrix.

The paper is organized as follows. In section 2, we review the literature on exchange rate overshooting and the J-curve effects and surveys the studies that analyze either exchange rate overshooting or J-curve effects in Korea. In section 3, we introduce the SVEC we employed to analyze how different macroeconomic shocks affect the exchange rate and trade balance. The empirical analysis and the results are discussed in sections 4 and 5. Finally, section 6 concludes the paper.

2. LITERATURE REVIEW

There are number of theoretical hypotheses on how macroeconomic shocks effect on exchange rate, trade balance. The paper deals with the two general hypotheses: (i) exchange rate overshooting and (ii) J-curve effects.

2.1. Exchange Rate Overshooting Hypothesis and J-Curve Effects

Exchange rate overshooting hypothesis was first developed and exemplified by Rudi Dornbusch (1976) with sticky price model. It was shown that an increase in the (exogenous) money supplies would cause exchange rate, first, to depreciate beyond its long run equilibrium value, and then appreciate back to the steady state. Apart from this, some other congruent results were found by Frankel (1979) with two country model. The prevalent works from the body of theory related to Dornbusch's hypothesis and exchange rate dynamics include Frenkel and Rodriguez (1982), Mussa (1982) and Eaton and Turnovsky (1983), Sims (1992), Eichenbaum and Evans (1995), Alvarez *et al*. (2001), Chari *et al*. (1996), Gourinchas and Tornell (1996), McGrattan (1998), Kollmann (1998).

When it was confronted with the data, however, few empirical studies that analyzed the effects of monetary policy supported Dornbusch's exchange rate overshooting hypothesis (see, for example, Kim and Roubini (2000) for G7 countries, Peersman and Smets (2003) and Favero and Marcellino (2001) for the aggregate Euro area, Mojon and Peersman (2003) for individual Euro area countries and Lindé (2003) for Sweden). Instead, they found that following a contractionary monetary policy shock, the domestic currencies generally and gradually appreciate. Regarding the U.S., Jang and Ogaki (2004) found the evidence of the exchange rate overshooting to a contractionary monetary policy shock. On the other hand, Eichenbaum and Evans (1995) found no exchange rate overshooting to a contractionary monetary policy shock.

The J-curve hypothesis suggests that if domestic currency depreciates, it causes exports price to fall (in terms of the buyer's currency). Exports are, therefore, expected to rise. Likewise, imports are expected to fall as the rest of the world's goods and services become more expensive for domestic residents. Thus, a country attains a trade surplus in the long-run. However, the J-curve hypothesis articulated the aforementioned process is not an immediate phenomenon. It emphasized that the trade balance may worsen when the quantities of export and imports did not adjust immediately to the depreciation of domestic currency. Trade balance deteriorates in the short run because of the depreciation of domestic currency. However, as time progresses, the quantity of imports goes down and exports goes up. It implies that the trade balance improves due to depreciation of the domestic currency in the long-run. In sum, an expansionary monetary policy will have J-shaped effects on trade balance: it initially causes a trade deficit and then leads to a trade surplus. [1)]

Some research claims that the phenomenon of J-curve does not apply to every country. Rose and Yellen (1989) found that the J-curve effects do not apply to G-7 countries. Rose (1990) also found no J-curve effects for 30 developing countries over 18 years. Koray and McMillin (1999), for example, investigated the response of the exchange rate and the trade balance to monetary policy shocks for the U.S. economy during the period 1973:01-1993:12 using SVAR model. Their results showed that contractionary monetary policy shocks lead to transitory appreciations of the real and the nominal exchange rate. Causes of this shock to monetary policy led to a

[1)] Kim (2007a, 2007b) also measured the effect of exchange rate on export. However, his focus was only on the exchange rate pass-through and had limitation in analyzing J-curve effect.

short-lived improvement in the trade balance which was then followed by deterioration in the trade balance, giving support to the J-curve hypothesis. Hakcer and Hatemi-J (2003) also found the J-curve effects for five small northern European economies. Kim (2001), however, found that, for France, Italy and the United Kingdom, the effects of monetary policy shocks on trade balance are consistent with expenditure-switching effect, but there is a little evidence of J-curve effect. Jannsen and Klein (2011) used a structural VAR model of the euro area and found that a monetary policy shock in the euro area leads to a largely similar change in the interest rate and GDP in other western European countries. They also found that the effects of monetary policy shock on exchange rates are limited and trade balances are usually unaffected.

2.2. The Case of Korea

Kwack (1988) showed that a change in the external currency value of a country has direct effects on the trade via changes in relative prices and indirect effects via induced changes in income and monetary conditions. He found that an exchange rate appreciation is shown to worsen the trade balance, lower price levels and overall economic growth.

For the periods of 1973-1980, Bahmani-Oskooee (1985) found an evidence of an inverse J-curve effect in Korea. Bahmani-Oskooee and Malixi (1992) also found evidence of J-curve effect in Korea. Lal and Lowinger (2002) also confirmed the existence of J-curve effects in Korea. Hsing and Savvides (1996), on the other hands, found no J-curve phenomenon in Korea. Hsing (2003), unlike what the traditional J-curve theory predicts, found a rise in initial trade ratio (export/import) of Taiwan and Korea was observed during the currency depreciation period. Hsing emphasized that "the finding is consistent with the hypothesis for small open economics (with original trade surplus), which assumes both export and import are dominated in foreign currency". Bahmani-Oskooee and Ratha (2004) showed that long-run effects of depreciation of Korean Won are advantageous in case of Korea-US trade.

Recently, Kim (2011) examined the sources of fluctuations in real exchange rate and trade balance in Korea using key macroeconomic variables such as cross-country output differential, real exchange rate and trade balance using structural VAR with long-run and recursive identifying restrictions. He found that all three shocks (supply shocks identified from output differential equation, demand shocks from real exchange rate equation and nominal shock identified from trade balance equation) have non-negligible impacts in explaining fluctuations in real exchange rate. He found that real exchange rate depreciation (demand) shock of Korean Won led to a deterioration of trade balance and that trade balance improvement (nominal) shock of Korea lead to a depreciation of Korean Won. Regarding the worsening of trade balance in response to a real exchange rate depreciation shock, which is contradictory to theoretical expectations as implied by the expenditure switching effect, Kim (2011) argued that it is possible if the demand shock is interpreted either as home-country government spending shock or taste shocks toward domestic goods. Those shocks will cause the real exchange appreciation of Korean Won and the increase the relative demands for domestic goods hence the improvement of trade balance. Regarding the real depreciation of Korean Won in response to trade balance improvement (nominal) shock of Korea, he argued that this relationship may hold if the nominal shock is considered as monetary shock. A monetary expansion depreciates the real exchange rate and improves the trade balance by expenditure switching effect. Based on the impulse responses of exchange rate and trade balance, Kim (2011) generally seemed to find neither exchange rate overshooting nor J-curve effects.

3. METHODOLOGY

The structural vector error correction (SVEC) model and the structural vector autoregression (SVAR) model are similar in that they are trying to identify the structural shocks by imposing identifying restrictions. The only difference between SVEC and SVAR is that SVEC accounts for cointegrating relationship. The SVAR approach is biased when there is any cointegrating relationship among endogenous variables.

The study adopts the structural vector error correction (SVEC) model with contemporaneous and long run restrictions. The approach was initially developed by King *et al*. (1991), refined by Breitung *et al*. (2007) and implemented by Ivrendi and Guloglu (2010).

3.1. SVECM Technique

We start with the reduced form VAR and identify macroeconomic innovations through specification about variable ordering. Specifically, the reduced form VAR of order p is given as

$$B(L)y_t = c + \mu_t, \tag{1}$$

where $B(L)$ is a matrix polynomial in the lag operator L, of order p, is a k-dimensional vector of observable variables, μ_t is an $n \times 1$ white noise process with zero mean and nonsingular covariance matrix $\sum\mu$, $\mu_t \sim (0, \sum\mu)$. Moreover, $y_{t-p+1}, \ldots, y_0$ are assumed to be fixed initial conditions.

It is possible to apply the same reasoning of SVAR models to SVEC models, in particular when the equivalent level-VAR representation of the VECM is used (Pfaff, 2008). Suppose that all variables are at most $I(1)^*$, the VAR (p) has the following vector error correction representation:

$$\Delta y_t = \alpha\beta' y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ \ldots \ + \Gamma_{p-1}\Delta y_{t-p+1} + \mu_t. \tag{2}$$

The dimensions of both α and β matrices are $n \times r$ and $r < n$. More precisely, α and β contain the loading coefficients and the cointegration vectors, respectively. $\alpha\beta'$ has reduced rank and the term $\alpha\beta' y_{t-1}$ stands for error correction term. The $\Gamma_i (i=1, 2, \ldots, p-1)$ indicates $n \times n$ reduced-form short-run coefficient matrices.

The structural form of equation (2) is given by

$$A\Delta y_t = \Pi y_{t-1} + \Phi_1 \Delta y_{t-1} + \ \ldots \ + \Phi_{p-1} \Delta y_{t-p+1} + \varepsilon_t, \tag{3}$$

where A represents the contemporaneous coefficients matrix, the Φ_i 's are structural form short run coefficient matrices, the term ε_t stands for structural innovations.

In the SVEC model, the reduced form disturbances (μ_t) are linearly related to the structural innovations (ε_t) such that

$$\mu_t = A^{-1}\varepsilon_t. \tag{4}$$

Now assume that the structural innovations ε_t have zero mean and identify covariance matrix. Under this assumption, one can obtain $\sum \mu = A^{-1}(A^{-1})'$. This relation imposes $n(n+1)/2$ restrictions on the n^2 elements of A^{-1}. Thus for just-identification of the structural shocks, one needs to impose at least $n(n-1)/2$ additional restrictions on the elements of A^{-1} to exactly identify the system, which defines the contemporaneous relations among the variables in the system. The way to impose these restrictions and the identification of shocks are discussed below.

Assume that the process y_t is affected by two types of structural disturbances: disturbances that have a transitory effect and disturbances that have a permanent effect. From Johansen (1995) version of the Granger's representation theorem, it follows that the process y_t has the following Vector Moving Average (VMA) representation:

$$y_t = \rho(1)\textstyle\sum_{i=1}^{t} \mu_t + \rho(L)\mu_t + y_0. \tag{5}$$

Notice that y_t comprises the permanent and transitory shocks, and initial conditions. The initial conditions are taken into account by y_0. The absolute summability of the term $\rho(L)=\sum_{i=1}^{\alpha}\rho_i L^j$ indicates that these matrices converge to zero as j approaches to ∞. This, in turn, implies that the transitory shocks have no long run effects. The term $\rho(1)$ which represents the long run effects of permanent shocks is given by the following equation.

$$\rho(1)=\beta_{\perp}\left[\alpha_{\perp}'(I_n-\sum_{i=1}^{r-1}\Gamma_i)\beta_{\perp}\right]^{-1}\alpha_{\perp}'. \tag{6}$$

This matrix has rank $n-r$ implying that there are $n-r$ independent common trends in the system.

Replacing μ_i by $A^{-1}\varepsilon_i$ the common stochastic trends in equation (4) can be rephrased as:

$$\rho(1)\sum_{i=1}^{t}\mu_i=\rho(1)A^{-1}\sum_{i=1}^{t}\varepsilon_t. \tag{7}$$

Since the structural innovations have a nonsingular covariance matrix, the matrix A^{-1} has to be nonsingular. This implies that the rank of $\rho(1)A^{-1}$ is $n-r$ and there can at most be r zero columns in the matrix $\rho(1)A^{-1}$. In other terms, in a system with r cointegration relations, at most r of the structural shocks can have transitory effects and at least $n-r$ of them must have permanent effect. Thus r columns in the matrix $\rho(1)A^{-1}$ can be restricted to zero while $n-r$ columns are left unrestricted. Note that each zero column, representing one transitory shock, stands for $n-r$ independent restrictions because the reduced rank of $\rho(1)A^{-1}$ is $n-r$. Therefore, the r transitory shocks require $r(n-r)$ independent restrictions on the cointegrating relationships in the system. For just identification of the transitory shocks we need $r(r-1)/2$ additional restrictions. To exactly identify permanent shocks we need $(n-r)((n-r)-1)/2$ further restrictions. Thus the identification of transitory and permanent shocks require a total of $r(n-r)+r(r-1)/2+(n-r)((n-r)-1)/2=n(n-1)/2$ restrictions. The transitory shocks can be identified by replacing zero restrictions on A^{-1}

matrix. These zero restrictions imply that some shocks have no instantaneous impact on some of the variables in the system. Therefore the restrictions on the A^{-1} matrix cannot be arbitrary; they have to be consistent with economic theories. They also need to be specified in such a way that the permanent and transitory shocks can be identified. As a general rule, the form of identifying restrictions is given as

$$S^l vec(\rho(1)A^{-1}) = s_l, \quad S^s vec(A^{-1}) = s_s, \tag{8}$$

where S^l and S^s are choice matrices to specify the long run and contemporaneous restrictions, respectively. The vectors s_l and s_s are zero vectors of suitable dimensions. Using the properties of vec operator these restrictions can be reformulated as follows

$$S^l (I_n \otimes \rho(1)) vec(A^{-1}) = S^* vec(A^{-1}) = s_l, \tag{9}$$

where $\otimes$ stands for Kronecker product and $S^* = S^l (I_n \otimes \rho(1))$ represents a matrix of long-run restrictions on A^{-1}.

4. EMPIRICAL ANALYSIS

4.1. Data

The study uses monthly series of the selected variables from 1991:1 to 2011:12. Most of datasets are from the Bank of Korea (BOK) and nominal and real exchange rate data are from Bank for International Settlement (BIS). The choice of this period is based on the availability of credible interest rate data. To control for the structural change arisen from Asian financial crisis, we include Asian financial crisis dummy (=1 for the periods 1997:10-2011:12; 0 otherwise).

Our study includes eight macroeconomic variables in Korea. The interest rate (*r*) is measured by the log of money market rate (i) $(r = \ln(1 + (i/100)))$, the monetary aggregate (*m*2) is measured by log of *m*2; the price level (*p*) is measured by the log of consumer price index, the real output (*y*) is measured by the log of industrial production index; the nominal effective exchange rate (*neer*) is measured by the log of the relative value of the Korean Won against foreign currency, the real effective exchange rate (*reer*) is measured by the log of the weighted average of a domestic relative to an index or basket of other major currencies adjusted for the effects of inflation. The trade balance (*tbl*) is conventionally measured as the ratio of total value of exports less total value of imports to GDP. Nevertheless, this study uses the log of the ratio of exports to imports values $(tbl = \ln(export / import))$ given that we utilize the monthly data.[2)] Also the real trade balance (*rtbl*) is measured as the log of the ratio of real export to real import. To control for the exogenous shocks, we include world interest and world oil price. The world interest rate (*wsr*) is log of simple arithmetic average of G-7 countries' short term interest rate and the world oil price (*oil*) is the log of the average dollar price of Brent, Dubai and WTI.

4.2. Unit Root and Cointegration Analysis

We employ the DF-GLS test developed by Elliott *et al*. (1996). The test overcomes the problems that Dickey-Fuller (DF) and Phillips-Perron (PP) tests have: both DF and PP tests suffer from size distortions. Table 1 shows result of unit root tests.

All the variables are shown to be non-stationary in levels and stationary in first differences. To test for cointegration among variables, we use Johansen's (1988, 1995) maximum eigen value and trace tests for cointegration among the eight variables. As Johansen approach is sensitive to the autocorrelation of residuals, we select the lag lengths so that the estimated

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[2)] See, for example, Koray and McMillin (1999), Bahmani-Oskooee and Brooks (1999), Gupta-Kapoor and Ramakrishnan (1999), Lal and Lowinger (2001), and Ivrendi and Guloglu (2010).

Table 1 Unit Root Tests for Level and First Differenced Variables

Variables	Difference	DF-GLS Test
r	Level	–0.965
	First Difference	–5.072***
*m*2	Level	1.889
	First Difference	–3.095***
p	Level	4.450
	First Difference	–3.066***
y	Level	1.526
	First Difference	–2.765***
neer	Level	–0.172
	First Difference	–7.945***
reer	Level	–1.971
	First Difference	–9.283***
tbl	Level	–1.091
	First Difference	–5.666***
rtbl	Level	0.771
	First Difference	–3.986***

Notes: 1) *r*, *m*2, *p*, *y*, *neer*, *reer*, *tbl*, *rtbl* are the log of Korea market interest rate, money supply, consumer price index, industrial production index, nominal effective exchange rate, real effective exchange rate, export/import ratio, respectively. 2) *** denotes significance at 1% level, ** 5% level and * at 10% level.

models do not suffer from the autocorrelation problem. To be more precise, we first use Akaike information criterion to select lag lengths, then we tested for autocorrelation at the selected lag lengths. Two lags were sufficient to obtain residuals with no autocorrelation in all cases. The maximum eigenvalue and the trace tests for each model suggest one or two cointegration relations among six variables depending on the different specification of the models.

4.3. Estimating Unconditional Error-correction Model

The study proposes two different models to measure the effects of different macroeconomic shocks on the exchange rate and trade balances. The first model is specified as the data vector $\gamma_1 = [r,\ m2,\ p,\ y,\ neer,\ tbl]$ and includes two exogenous variables *oil* and *wsr*. The second model is specified as the data vector $\gamma_2 = [r,\ m2,\ p,\ y,\ reer,\ rtbl]$ and also includes two exogenous variables. The difference between the first model and the second model is that we replace nominal effective exchange rate with real effective exchange rate and nominal trade balance with real trade balance in the second model. It is to distinguish how patterns of responses of nominal exchange rate and nominal trade balance are different from those of real exchange rate and real trade balance.

Before we apply the SVEC model, we need to estimate the unconditional error-correction model. The standard reduced-form error correction model is estimated using standard Johansen procedure (restrictions on beta are ignored).

4.4. Identifying Restrictions

To identify the orthogonalized macroeconomic shocks, we need to impose the identifying restrictions. Following Ivrendi and Guloglu (2010), we impose both short run and long run identifying restrictions in the structural vector error correction model.

First, the cointegration test reveals the existence of relationships among the variables and we impose restriction on the long-run matrix: monetary policy shock does not have permanent effects on real variables in the long-run which is consistent with both Keynesian and Monetarist approaches. So, the long-run impact matrix is given as:

$$\rho(1)A^{-1} = \begin{pmatrix} 0 & * & * & * & * & * \\ 0 & * & * & * & * & * \\ 0 & * & * & * & * & * \\ 0 & * & * & * & * & * \\ 0 & * & * & * & * & * \\ 0 & * & * & * & * & * \end{pmatrix}, \tag{10}$$

where * denotes free parameters. Since $r=1$, the transitory shock is identified without the additional restrictions $(r(r-1)/2=0)$. However, identification of permanent shocks requires at least $((n-r)((n-r)-1/2=10)$ further restrictions which can be obtained by imposing contemporaneous restrictions on the A^{-1} matrix.

With slight modifications of Kim and Roubini (2000), Kim (2001) and Ivrendi and Guloglu (2010), this study imposes a total of eleven short-run identifying restrictions. In this study, the contemporaneous restrictions are imposed in the following manner:

$$\mu_t = A^{-1}\varepsilon_t = \begin{pmatrix} * & * & 0 & 0 & 0 & 0 \\ * & * & * & * & 0 & * \\ * & * & * & 0 & 0 & 0 \\ * & * & * & * & 0 & 0 \\ * & * & * & * & * & 0 \\ * & * & * & * & * & * \end{pmatrix} \begin{pmatrix} u_r \\ u_{m2} \\ u_p \\ u_y \\ u_{e\text{var}1} \\ u_{e\text{var}2} \end{pmatrix}. \tag{11}$$

The first row represents the monetary policy reaction function. The Bank of Korea is assumed to set the interest rate after observing the current value of money (*m*2) and two exogenous variables: the world oil price index (*oil*) and the world interest rate (*wsr*). The exogenous variables do not appear in $A^{-1}\varepsilon_t$ matrix since they are exogenous to the system. It is clear that there is no information delay in (*m*2), (*oil*) and (*wsr*). They are available daily. However, there is information delay in the price level (*p*), real output (*y*) as well as the (*evar*1) and (*evar*2) variables because they are not available to policy makers within a month. They are released monthly or quarterly. Therefore, the Bank of Korea is assumed not to contemporaneously react to (*y*), (*p*), (*evar*1) and (*evar*2) variables but they are assumed to react to the lags of all variables in the SVEC models. The second row of A^{-1} matrix represents a conventional real money demand function. The demand for real money contemporaneously reacts to interest rate (*r*), price level (*p*) and real output (*y*). Because trade balance is one of the components in the output, we also assume that money supply contemporaneously reacts to trade balance (*evar*2). It does not contemporaneously react to the exchange rate (*evar*1). The third row stands for price level (*p*) equation. It is assumed that the price level (*p*) is contemporaneously affected by interest rate (*r*), money (*m*2), exchange rate (*evar*1) and the exogenous variables. The fourth row describes the real output (*y*) equation. The output level is assumed to contemporaneously response to (*r*), (*m*2), (*p*), (*evar*2) and the exogenous variables. The other variables are assumed to affect the output level (*y*) with lags. The fifth row represents the nominal effective exchange rate (*neer*) in the first model; real effective exchange rate (*reer*) in the second model. The sixth row stands for the nominal trade balance (*tb*) in the first and the real trade balance (*rtbl*) in second models. In the evar1 equation the study imposes one of the following restrictions in turn: in model 1, we assume that the nominal effective exchange rate (*neer*) is not contemporaneously influenced by the trade balance (*tbl*); in model 2, we assume that the real effective exchange rate (*reer*) is not contemporaneously affected by the real trade balance (*rtbl*). The study does not impose any restrictions on the evar2 equation.

5. EMPIRICAL RESULTS

5.1. Impulse Responses to Macroeconomic Policy Shock

Figure 1 and 2 report the responses of macroeconomic variables to different macroeconomic shocks. Especially, when the exchange rate and trade balance respond to various shocks, those responses can be interpreted as how these two variables change over time, compared with the cases when there are no shocks. Each graph includes a point estimation of IRFs as well as lower and upper bounds for a 95% confidence interval (95% Hall Percentile (B=1000, horizons=25 (or 2 years)). The solid line portrays the actual responses of macroeconomic variables in response to a one standard deviation whereas the dotted lines represent the 95% confidence error bands.

Figure 1 Impulse Responses to a Macroeconomic Policy Shock in SVEC Model 1

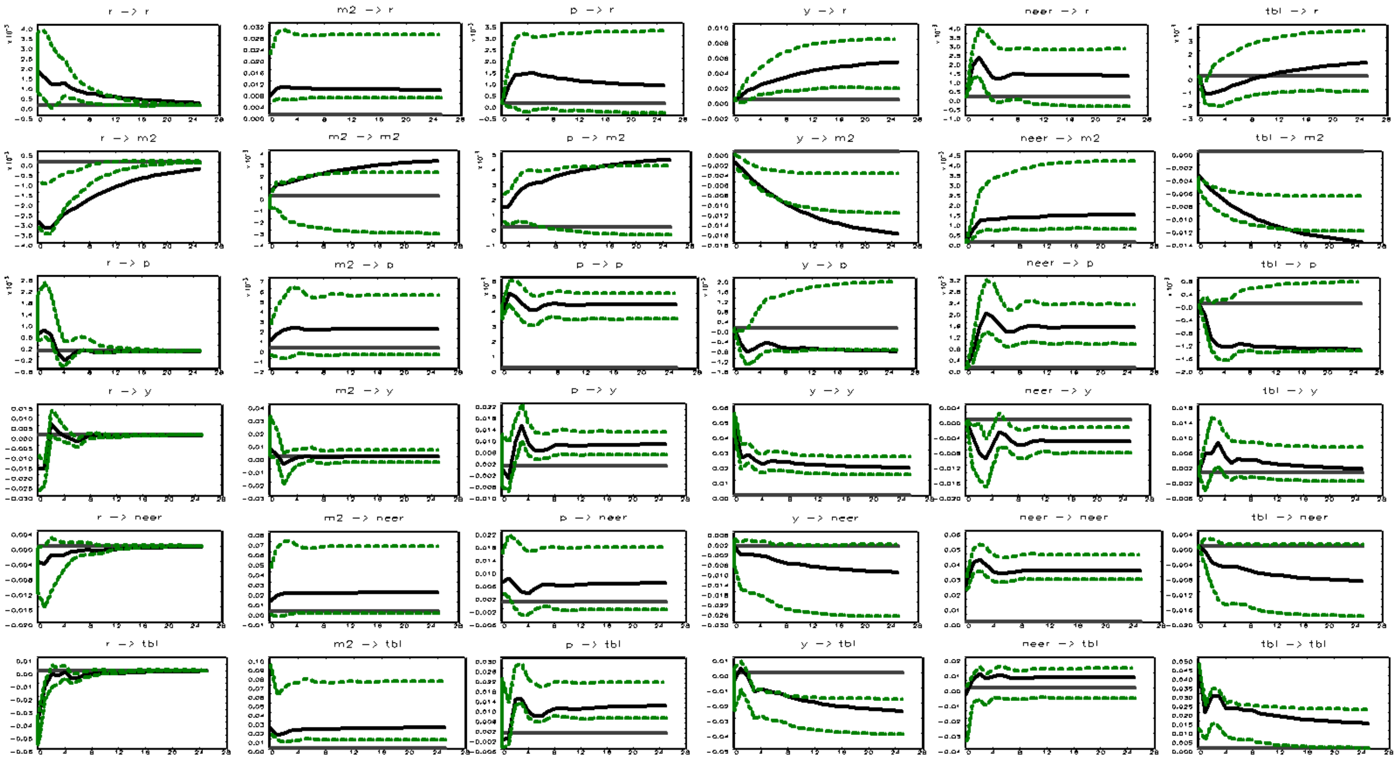
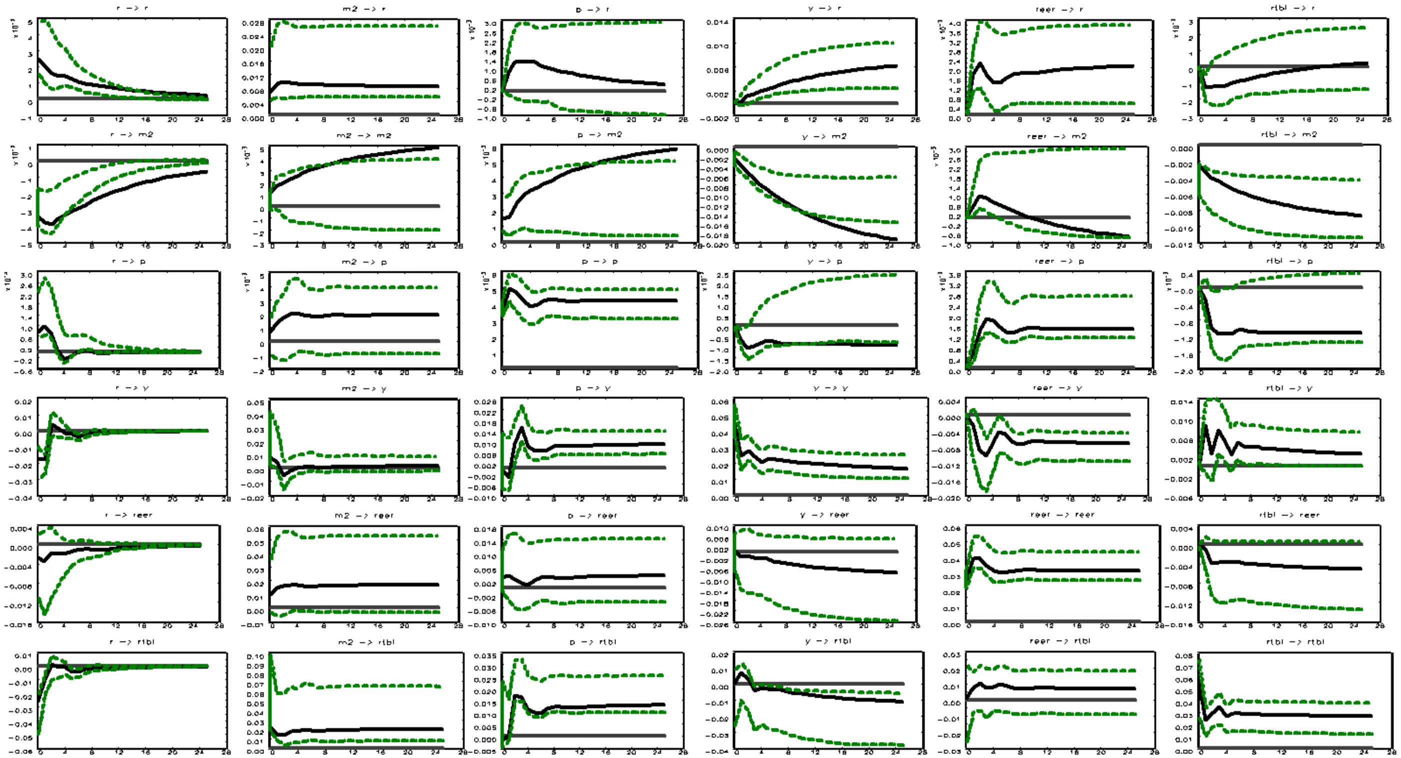


Figure 2 Impulse Responses to a Macroeconomic Policy Shock in SVEC Model 2



5.1.1. Interest rate shock (or contractionary monetary policy shock)

The first columns of figures 1 and 2 show the responses of macroeconomic variables to the contractionary monetary (or interest rate) shocks. The signs of the responses of macroeconomic variables to interest rate shocks generally conform to our expectations. In response to interest rate shock, the interest rate (r) initially rise in the short-run and approaches to zero in the long run. In response to interest rate shock, money supply falls sharply in the short run and approaches to zero in the long run. At the instant of the shock, price rises. However, price response becomes negative 4 months after the shock. The output falls in the short run and both nominal and real Korean Won appreciate (KRW/foreign falls) in response to the interest rate shock. The appreciation of Korean Won to interest rate shock is consistent with Dornbusch (1976) and Kim and Roubini (2000) who find that Contractionary monetary policy shock (interest rate shock) will appreciate the nominal effective exchange rate of domestic currency (*neer*) to appreciate, due to a rise in capital inflows and then a gradually depreciate domestic currency toward the equilibrium level.

The interest rate shock significantly worsens both nominal and real trade balances. The reaction of the trade balance to a contractionary monetary policy depends on the magnitude of the “expenditure switching effect” and the “income absorption effect”. These two effects move the trade balance in opposite direction: on the one hand, a contractionary monetary policy leads to an appreciation in the nominal exchange rate due to capital inflows. The appreciation of exchange rate makes foreign goods and services cheaper than domestic goods and services, which leads to an increase in import and a decrease in export. This effect is called “the expenditure switching effect” and it results in deterioration of the trade balance. On the other hand, a monetary contraction causes a fall in real income and reduces imports, which leads to an improvement in the trade balance. This effect is called “the income absorption effect”. A contractionary monetary policy causes an initial appreciation of domestic currency in the real effective exchange rate (*reer*) due to capital inflows. This expectation is based on the assumption of price rigidity in the economy. A contractionary monetary policy causes the nominal effective exchange rate to appreciate. Under assumption of price rigidity, this leads to a short-run appreciation of the real effective exchange rate. Following the real appreciation, a reverse movement of reer toward the equilibrium level is expected. Our results seem to support that expenditure switching effects dominate the income absorption effects at least in the short run, and trade balance worsens in response to a contractionary monetary policy shock (interest rate shock). We found little evidences of exchange rate overshooting and J-curve effect to interest rate shock.

5.1.2. Money supply shock

The second columns of figures 1 and 2 show that expansionary money supply shocks lead to both nominal and real depreciations of Korean Won and the improvement of both nominal and real trade balances. Even though the money supply shocks have statistically significant effects both on exchange rate and trade balances, we don't find any evidence of exchange rate overshooting and J-curve effects.

5.1.3. Price level shock

The third columns of figures 1 and 2 report the responses of macroeconomic variables to price level shocks. Although not statistically significant, the price shock raises interest rate and money supply both in the short run and in the long run. The price shock significantly increases the output.

The price level shocks conduce to a nominal and real depreciation of Korean Won and an improvement in trade balance. However, the responses of exchange rates to price level shocks are not statistically significant. We found little evidence of exchange rate overshooting. However, we do find an evidence of J-curve effect from price shock.

5.1.4. Output shock

The forth column of figure 1 resports the responses of macroeconomic variables to output shocks. Regarding the effects of output shock on the exchange rate, there are two opposite driving forces that affect the exchange rate. The first force is the rise in the price level to output shock. A rise in the price level would cause a domestic currency to depreciate. The second force is the rise in the interest rate to output shock. In other words, if the real interest rate rises to output shock, domestic currency will appreciate and trade balance will be worsen in the long run. Our results show that the positive output shocks leads to nominal and real appreciations of Korean Won and worsening of both nominal and real trade balance. However, the responses of exchange rates to output shocks are not statistically significant. We find little evidences of exchange rate overshooting and J-curve effects from output shocks.

5.1.5. Exchange rate shock

The fifth columns of figures 1 and 2 show the responses of the variables to KRW depreciation shocks. Exchange rate shock (shock that causes either a nominal depreciation of domestic currency in figure 1 or real depreciation of domestic currency in figure 2) would improve trade balance in the short run only if income absorption effect is less than expenditure switching effect. In the long run, however, depreciation of domestic currency will improve the trade balance. Out results show that in response to the exchange rate depreciation shock of Korean Won, the exchange rate (KRW/foreign) rises and we found some evidence of exchange rate overshooting: in response to exchange rate shock, exchange rate rise more in the short run than in the long run. The exchange rate shock is thought as the shock that is not correlated with other Korean macroeconomic shocks. So exchange rate shock identified in this study can be thought as the foreign financial shock.

There is little evidence of J-curve effects. Instead, we find that exchange rate depreciation shock leads to a small improvement in trade balance in the short run, and the magnitude of improvement gets bigger in the long run.

5.2. The Variance Decompositions

Table 2 report the variance decomposition results with nominal effective exchange rate and nominal trade balance. The results show that the exchange rate volatility is mostly explained by its own shock at the instant of the shock (77% at *k*=1). The real money supply (*m*2) shocks explain an important portion (16% at the instant of the shock) of the variance in nominal effective exchange rate (*neer*) and it becomes more significant *k* increases. In long-run, the major source of fluctuation in the in nominal effective exchange rate

Table 2 SVEC Forecast error Variance Decomposition of Model 1 Variables at Different Forecasting Horizons

Impulses \ Shocks	*K*	*R*	*M*2	*P*	*Y*	*NEER*	*TBL*
Interest Rate (*R*)	1	0.06	0.94	0.00	0.00	0.00	0.00
	13	0.01	0.88	0.01	0.07	0.02	0.01
	25	0.00	0.82	0.01	0.14	0.02	0.01
Money Supply (*M*2)	1	0.31	0.01	0.0	0.15	0.00	0.48
	13	0.03	0.02	0.05	0.45	0.01	0.44
	25	0.01	0.02	0.04	0.51	0.00	0.42
Price Level (*P*)	1	0.02	0.04	0.93	0.00	0.00	0.00
	13	0.00	0.13	0.71	0.02	0.08	0.06
	25	0.00	0.13	0.70	0.03	0.08	0.07
Real Output (*Y*)	1	0.12	0.01	0.00	0.87	0.00	0.00
	13	0.06	0.01	0.07	0.78	0.05	0.02
	25	0.04	0.01	0.09	0.79	0.06	0.01
Nominal Effective Exchange Rate (*NEER*)	1	0.02	0.16	0.05	0.00	0.77	0.00
	13	0.00	0.20	0.02	0.02	0.74	0.02
	25	0.00	0.21	0.02	0.04	0.70	0.03
Trade Balance (*TBL*)	1	0.36	0.13	0.00	0.01	0.01	0.49
	13	0.09	0.28	0.06	0.13	0.03	0.41
	25	0.05	0.31	0.07	0.25	0.03	0.29

Notes: Variance decomposition is read horizontally for each endogenous variable to sum up to 100%. *K*=1 denotes instant response and *k*=13 denotes responses 12 months after the shock.

(*neer*) is greatly affected by the money supply (*m*2) shock (21%), in addition to its own shock (70%).

Regarding nominal trade balance (*tbl*), the fluctuation of the variable is greatly explained by its own shock (49% at *k*=1, 29% at *k*=25). At the instant of the shocks (*k*=1), the trade balance fluctuation is also explained by the interest rate (*r*) (36%) and money supply (*m*2) (13%). On the other hand, the volatility in the trade balance is explained by the money supply (*m*2) (31%), output (*y*) (25%), price level (7%) and interest rate (5%) in the long run (*k*=25). However, the nominal effective exchange rate (*neer*) is not a major source of fluctuation in the trade balance (3% in the long run).

Table 3 SVEC Forecast Error Variance Decomposition of Model 2 Variables at Different Forecasting Horizons

Shocks / Impulses	*K*	*R*	*M*2	*P*	*Y*	*REER*	*RTBL*
Interest Rate (*R*)	1	0.12	0.88	0.00	0.00	0.00	0.00
	13	0.02	0.84	0.01	0.09	0.03	0.01
	25	0.01	0.76	0.01	0.19	0.03	0.00
Money Supply (*M*2)	1	0.42	0.04	0.08	0.24	0.00	0.22
	13	0.05	0.05	0.08	0.63	0.00	0.19
	25	0.02	0.05	0.07	0.70	0.00	0.16
Price Level (*P*)	1	0.04	0.03	0.93	0.00	0.00	0.00
	13	0.01	0.13	0.72	0.03	0.08	0.04
	25	0.00	0.13	0.71	0.03	0.08	0.04
Real Output (*Y*)	1	0.14	0.03	0.00	0.83	0.00	0.00
	13	0.07	0.01	0.08	0.76	0.06	0.03
	25	0.04	0.01	0.11	0.74	0.07	0.02
Real Effective Exchange Rate (*REER*)	1	0.01	0.13	0.01	0.00	0.84	0.00
	13	0.00	0.18	0.01	0.01	0.79	0.01
	25	0.00	0.20	0.01	0.02	0.76	0.01
Real Trade Balance (*RTBL*)	1	0.16	0.13	0.00	0.00	0.00	0.72
	13	0.04	0.21	0.08	0.02	0.04	0.61
	25	0.02	0.24	0.10	0.04	0.04	0.57

Note: Variance decomposition is read horizontally for each endogenous variable to sum up to 100%.

Table 3 reports the variance decomposition results with real effective exchange rate and real trade balance. Most of results are similar to those with nominal exchange rate and nominal trade balance. Real exchange rate is mostly explained by money supply in addition to its own shock. While real trade balance is mostly explained by interest rate and money supply in addition to its own shock in the short run, it also affected by price level, output, real exchange rate in the long run.

6. CONCLUSION

This study analyzes the effects of various macroeconomic shocks on exchange rate and trade balance and identified responses of the exchange rate and the trade balance to those shocks in Korea. The noble feature of the study is that conventional theories such as exchange rate overshooting and J-curve effects are re-examined by allowing for the endogeneity among relevant macroeconomic variables. The study identifies the structural relationship among different macroeconomic variables by imposing the short-run and the long-run identifying restrictions with SVEC model based on the various macroeconomic theories.

The impulse responses analysis results generally conform to our expectations. An interest rate shock (or contractionary monetary policy shock) causes exchange rate (KRW/foreign) to fall (or an appreciation of Korean Won) and trade balance to worsen. This is consistent with Chung (2001) who found that a contractionary shock to monetary policy leads to the persistent appreciation of the Korean Won against dollar for both nominal and real exchange rates. This result is also consistent with the evidence by Eichenbaum and Evans (1995) who found no exchange rate overshooting from a contractionary monetary policy shock.

The results show that exchange rate overshooting is found only from its own exchange rate shock. J-curve effect is not found. Instead, exchange rate shock leads to an instant and small improvement in trade balance and the magnitude of improvement gets bigger the long run. Our finding is consistent with Sim and Chang (2006) who found that the evidence of J-curve effect is weak in Korea's bilateral trade with the UK, Germany and China.

REFERENCES

Alvarez, F., A. Atkeson, and F. J. Kehoe, "Money, Interest Rates, And Exchange Rates With Endogenously Segmented Markets," *Journal of Political Economy*, 110(1), 2001, pp. 73-112.

Backus, D., S. Foresi, and C. Telmer, "Affine Models of Currency Pricing," NBER Working Paper, No. 5623, 1996.

Bahmani-Oskooee, M., "Devaluation and J-Curve: Some Evidence from LDCs," *Review of Economics and Statistics*, 67, 1985, pp. 500-504.

Bahmani-Oskooee, M. and A. Ratha, "The J-Curve Dynamics of U.S. Bilateral Trade," *Journal of Economics and Finance*, 28(1), 2004, pp. 32-38.

Bahmani-Oskooee, M. and T. J. Brooks, "Bilateral J-Curve between U.S. and Her Trading Partners," *Weltwirtschaftliches Archiv*, 135(1), 1999, pp. 156-165.

Bahmani-Oskooee, M. and M. Malixi, "More Evidence on the J-Curve from LDCs," *Journal of Policy Modeling*, 14, 1992, pp. 641-653.

Bjornland, H. C., "Monetary Policy and Exchange Rate Overshooting: Dornbusch Was Right after All," *Journal of International Economics*, 79(1), 2009, pp. 64-77.

Breitung, J., R. Brüggemann, and H. Lutkepohl, "Structural Vector Autoregressive Modeling and Impulse Responses," in Lutkepohl, H. and M. Kratzig, eds., *Applied Time Series Econometrics*, Cambridge University Press, USA, 2007, pp. 159-196.

Chari, V. V., P. J. Kehoe, and E. R. McGrattan, "The Poverty of Nations: A Quantitative Exploration," NBER Working Paper, No. 5414, 1996.

Christiano, L. J., M. Eichenbaum, and C. L. Evans, “The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds,” *Review of Economics and Statistics*, 78, 1996, pp. 16-34.

Chung, J. H., “Capital Liberalization, Capital Flows, and Monetary Policy Responses on Exchange Market: the Case of Korea,” University of Missouri-Columbia, 2001, pp. 242-374.

Dornbusch, R., “Exchange Expectations and Monetary Policy,” *Journal of International Economics*, 6, 1976, pp. 231-244.

Eaton, J. and S. J. Turnovsky, “Covered Interest Parity, Uncovered Interest Parity and Exchange Rate Dynamics,” *Economic Journal*, *The Economic Journal*, 93(371), 1983, pp. 555-575.

Eichenbaum, M. and C. Evans, “Some Empirical Evidence on the Effect of Monetary Policy Shocks on Exchange Rates,” *Quarterly Journal of Economics*, 110, 1995, pp. 975-1009.

Elliott, G., T. J. Rothenberg, and J. H. Stock, “Efficient Tests for an Autoregressive Unit Root,” *Econometrica*, 64, 1996, pp. 813-836.

Favero, C. A. and M. Marcellino, “Large Datasets, Small Models and Monetary Policy in Europe,” CEPR Discussion Paper, No. 3098, 2001.

Frenkel, J. A. and C. A. Rodriguez, “Exchange Rate Dynamics and the Overshooting Hypothesis,” IMF Staff Papers, 29, March 1982, pp. 1-30.

Gourinchas, P. O. and A. Tornell, “Exchange Rate Dynamics and Learning,” NBER Working Paper, No. w5530, 1996.

Gupta-Kapoor A. and U. Ramakrishnan, “Is There a J-Curve? A New Estimation for Japan,” *International Economic Journal*, 13(4), 1999, pp. 71-79.

Hacker, R. S. and A. Hatemi-J, “Is the J-Curve Effect Observable for Small North European Economies?,” *Open Economies Review*, 14(2), 2003, pp. 119-134.

Hsing, H. M., “Re-examination of J-curve Effect for Japan, Korea and Taiwan,” *Journal of Japan and the World Economy*, 17(1), 2003, pp.

43-58.

Hsing, H. M. and A. Savvides, "Does a J-Curve Exist for Korea and Taiwan?," *Open Economies Review*, 7(2), 1996, pp. 127-145.

Ivrendi, M. and B. Guloglu, "Monetary Shocks, Exchange Rates and Trade Balances: Evidence from Inflation Targeting Countries," *Journal of Economic Modelling*, 27, 2010, pp. 1144-1155.

Jang, K. and M. Ogaki, "The Effects of Monetary Policy Shocks on Exchange Rates: A Structural Vector Error Correction Model Approach," *Journal of Japanese International Economies*, 18, 2004, pp. 99-114.

Jannsen, N. and M. Klein, "The International Transmission of Euro Area Monetary Policy Shocks," Kiel Working Paper, No. 1718, Kiel Institute for the World Economy, Kiel, 2011.

Johansen, S., *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press, Oxford, 1995.

__________, "Statistical Analysis of Cointegrating Vectors," *Journal of Economics and Dynamic Control*, 12, 1988, pp. 231-254.

Kim, S., "Effects of Monetary Policy Shocks on the Trade Balance in Small Open European Countries," *Journal of Economics Letters*, 71(2), 2001, pp. 197-203.

__________, "International Macroeconomic Fluctuations in Korea," *Seoul Journal of Economics*, 24(1), 2011, pp. 1-20.

Kim, S. and N. Roubini, "Exchange Rate Anomalies in the Industrial Countries: A Solution with a Structural VAR Approach," *Journal of Monetary Economics*, 45, 2000, pp. 561-586.

Kim, W. J., "Exchange Rate Volatility, Trade, Export Price and Exchange Rate Pass-Through in Korea," *The Journal of the Korean Economy*, 8(1), 2007a, pp. 39-68.

__________, "Exchange Rate Pass-through on Disaggregated Korean Export Prices: A Structural VAR Approach," *The Journal of the Korean Economy*, 8(2), 2007b, pp. 357-376.

King, R., C. Plosser, J. Stock, and M. Watson, "Stochastic Trends and

Economic Fluctuations," *The American Economic Review*, 81(4), 1991, pp. 819-840.

Kollmann, R., "U.S. Trade Balance Dynamics: The Role of Fiscal Policy and Productivity Shocks and of Financial Market Linkages," *Journal of International Money and Finance*, 17, 1998, pp. 637-669.

Koray, F. and W. D. McMillin, "Monetary Shocks, Exchange Rate, and the Trade Balance," *Journal of International Money and Finance*, 18(6), 1999, pp. 925-940.

Kwack, S. Y., "Exchange Rate Effects on Korea's Economy," *Journal of International Economics*, 2(2), 1988, pp. 101-109.

Lal, A. K. and T. C. Lowinger, "The J-curve Evidence from East Asia," *Journal of Economic Integration*, 17, 2002, pp. 397-415.

Levin, J. H., "The Dornbusch Model Trade Flow Lags, and Exchange Overshootings," *Journal of International Economic Integration*, 2(1), 1987, pp. 71-82.

Lindé, J., "Monetary Policy Shocks and Business Cycle Fluctuations in a Small Open Economy: Sweden 1986-2002," Sveriges Riksbank Working Paper Series, No.153, 2003.

Lutkepohl, H., "Structural Vector Autoregressive Analysis for Cointegrated Variables," EUI Working Paper ECO No. 2005/2, 2005.

McGrattan, E. R., "Trends in Velocity and Policy Expectations: A Comment," Carnegie-Rochester Conference Series on Public Policy, 49(1), 1998, pp. 305-316.

Mojon, B. and G. Peersman, "A VAR Description of the Effects of Monetary Policy in the Individual Countries of the Euro Area, Monetary Policy Transmission in the Euro Area," in Angeloni, A. Kashyap and B. Mojon, eds., Cambridge University Press, Part 1, Chap. 1, 2003, pp 56-74.

Mussa, M., "A Model of Exchange Rate Dynamics," *Journal of Political Economy*, 90, 1982, pp. 74-104.

Papell, D. H., "Activist Monetary Policy and Exchange Rate Overshooting: The Deutsche Mark/Dollar Rate," NBER Working Paper, No. 1195, 1983.

Peersman, G. and F. Smets, “The Industry Effects of Monetary Policy in the Euro Area,” *Economic Journal*, 115(503), 2003, pp. 319-342.

Pfaff, B., “VAR, SVAR and SVEC Models: Implementation within R Package Vars,” *Journal of Statistical Software*, 27(4), 2008.

Rogoff, K., “Dornbusch’s Overshooting Model after Twenty-Five Years,” IMP Working Paper 49, WP/02/39, 2002, pp. 1-35.

Romer, C. D. and D. H. Romer, “A New Measure of Monetary Shocks: Derivation and Implications,” *The American Economic Review*, 94, 2004, pp. 1055-1084.

Rose, A. K., “Exchange Rates and the Trade Balance: Some evidence from Developing Countries,” *Economics Letters*, 34, 1990, pp. 271-275.

Rose, A. K. and J. L. Yellen, “Is There a J-Curve?,” *Journal of Monetary Economics*, 24, 1989, pp. 53-68.

Scholl, A. and H. Uhlig, “New Evidence on the Puzzles: Results from Agnostic Identification on Monetary Policy and Exchange Rates,” *Journal of International Economics*, 76, 2008, pp. 1-13.

Sim, S. H. and B. K. Chang, “Bilateral Trade Balance between Korea and Her Trading Partners: The J-Curve Effect,” *Journal of Korea Trade*, 10(3), 2006, pp. 76-93.

Sims, C. A., “Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy,” *European Economic Review*, 36(5), 1992, pp. 975-1000.

Web site of the Bank of Korea (BOK): http://ecos.bok.or.kr

Web site of Bank for International Settlement (BIS): http://www.bis.org