

## **Exchange Rate Volatility, Trade, Export Price and Exchange Rate Pass-Through in Korea<sup>\*</sup>**

Won Joong Kim<sup>\*\*</sup>

This paper analyzes the exchange rate pass-through on Korean *export* price and introduces two different measures of exchange rate pass-through: the structural exchange rate pass-through and the shock-specific exchange rate pass-through. It shows that the structural exchange rate pass-through on the Korean export price is very small and that the shock-specific exchange rate pass-through on the Korean export price is always positive, irrespective of the source of the shocks. Also shown is that an increase in the exchange rate volatility will decrease the Korean export volume. The sign of the shock-specific exchange rate volatility pass-through on Korean export volume depends on the source of the shocks.

JEL Classification: E52, F30

Keywords: exchange rate pass-through, vector autoregressions (VAR), exchange rate volatility, liquidity effect.

---

<sup>\*</sup> Received March 1, 2007. Accepted April 20, 2007.

The author thanks William Lastrapes and two anonymous referees for their valuable comments and suggestions.

<sup>\*\*</sup> Economist, Economic Research Division, POSCO Research Institute, POSRI Bldg., 147, Samseong-dong, Gangnam-gu, Seoul, 135-878, Korea, E-mail: wjkim@posri.re.kr

## 1. INTRODUCTION

No study has simultaneously analyzed the relationship between exchange rate volatility, trade volume, export price, and exchange rate pass-through. Also, earlier studies on exchange rate pass-through measured it in a reduced form regression of import (export) price on the exchange rate which presumed that the latter is exogenous (see for example, Matsuura and Takeda, 2003). This paper allows the exchange rate to be endogenous and uses a VAR to estimate the impulse responses of both import (export) prices and the exchange rate to different shocks. The main advantage of this VAR approach is that the exogeneity assumption of the exchange rate can be relaxed. The VAR is also better than the reduced form regression at capturing general dynamic relations, and focuses on how import (export) prices and the exchange rate respond to exogenous shocks.

This paper considers two different measures of exchange rate pass-through: the structural exchange rate pass-through and the shock-specific exchange rate pass-through, respectively. The usual notion of exchange rate pass-through is the coefficient on the exchange rate in the import (or export) price equation, which is typically based on the optimal pricing by imperfectly competitive firms. The structural exchange rate pass-through coefficients that this paper reports are comparable with the conventional notion of exchange rate pass-through, except that the endogeneity of the exchange rate is controlled for. The structural exchange rate pass-through coefficient is calculated by measuring the contemporaneous effect of a change in the exchange rate on the import (export) price from the import (export) price equation in the structural VAR.

The shock-specific exchange rate pass-through coefficients are calculated using the impulse response functions of the import (export) price and the exchange rate to different shocks. The difference between the structural exchange rate pass-through and the shock-specific exchange rate pass-through is as follows. First, the structural exchange rate pass-through measures the effect of contemporaneous and direct change in the exchange

rate on the import (export) price; in effect, it measures the optimal price elasticity of imperfectly competitive firms with respect to a change in the exchange rate. On the other hand, certain shocks will have effects both on the import (export) price and on the exchange rate. The shock-specific exchange rate pass-through measures the indirect effect of a particular macroeconomic shock on the relationship between the import (export) price and the exchange rate.

This paper includes exchange rate volatility, export price, and export quantity along with other macro variables to analyze the dynamic effects of different shocks on exchange rate pass-through in Korea. The study measures the structural exchange rate pass-through coefficient and the shock-specific exchange rate pass-through coefficient. By assuming that U.S. macro variables are not affected by Korean macro shocks at any lags and by imposing the long-run identifying restrictions on within-country macro variables, the paper shows how exchange rate pass-through of Korean export price is affected by Korean macro shocks as well as by U.S. macro shocks.

Even though the import price of the Korean exports in the import countries are not observed, the exchange rate pass-through can be inferred from the change in the Korean export price with respect to a change in the exchange rate. It is noted that the U.S. is one of the biggest markets for Korean exporters. In 1971, Korean exports to the U.S. were about 50% of total Korean exports, and by 2005, the share was about 15%.<sup>1)</sup> As of 2005, the U.S. was the second largest market for Korean exports. In 1980, Korean exports to China were about 0.09%, and by 2005, the share was about 22%. In 2003, about 85% of total Korean export prices were set in U.S. dollars.<sup>2)</sup> In other words, Korea exporters set their prices of goods exported to overseas mostly in dollars. The analysis of exchange rate pass-through using Korean export prices and the U.S.-Korea bilateral exchange rate would, therefore, reveal the pricing behavior of Korean firms.

---

<sup>1)</sup> Source: Korea National Statistics Office (KNSO).

<sup>2)</sup> Source: Bank of Korea.

Few studies have focused on the relationship between exchange rate volatility and exchange rate pass-through. Devereux *et al.* (2004) theoretically show that a unique equilibrium rate of pass-through exists under the condition that exchange rate volatility rises as the degree of pass-through falls. They also show that the exchange rate pass-through and the exchange rate volatility are unlikely to move in the same direction. Finally, they show that countries with low volatility of money growth have relatively low rates of exchange rate pass-through. Campa and Goldberg (2005) empirically find that exchange rate volatility is highly noisy and does not have any clear effect on pass-through rates.

The remainder of this paper is organized as follows. Section 2 discusses the model and identification strategy. Section 3 presents our estimation results. Concluding remarks are contained in section 4.

## 2. EMPIRICAL MODEL AND IDENTIFICATION

A vector autoregression (VAR) representation of the U.S. and the Korean economy is estimated. Since Korea is small, account for external effects is dealt with by including U.S. macroeconomic variables. Since the U.S. is one of the largest trading partners to Korea, the paper estimates a two-country system. As in Cushman and Zha (1997) and Halabi and Lastrapes (2003), the paper imposes the restriction that shocks in the small economy (Korea) have no effects on the large economy (the U.S.). For example, Halabi and Lastrapes (2003) measured the effect of a U.S. monetary shock on the U.S. interest rate and the effect of a Chilean monetary shock on the Chilean interest rate after considering the block exogeneity of U.S. variables to Chilean shocks.

Lastrapes (2005) theoretically shows how to estimate the VAR with block exogeneity and diagonality assumptions.<sup>3)</sup> The next section closely follows

---

<sup>3)</sup> In footnote 3 of Lastrapes (2005) suggested how to estimate the VAR when the diagonality assumption is relaxed.

Lastrapes (2005) to discuss the empirical model and identification strategies.

## 2.1. Empirical Model

Let  $z_t = \begin{pmatrix} z_{1t} \\ z_{2t} \end{pmatrix}$  be an  $n$ -dimensional vector stochastic process, where  $z_{1t}$  is  $n_1 \times 1$  vector of foreign (U.S.) variables,  $z_{2t}$  is  $n_2 \times 1$  vector of domestic (Korea) variables and  $n = n_1 + n_2$ .  $z_{1t}$  includes U.S. output, nominal interest rate, real money balances, and nominal money supply ( $n_1 = 4$ ), and  $z_{2t}$  contains Korean output, nominal interest rate, real money balances, real exchange rate, a measure of exchange rate volatility, real export price, real exports, and nominal money supply ( $n_2 = 8$ ).

Assume that this process is generated by the linear dynamic model

$$A_0 z_t = A_1 z_{t-1} + L + A_p z_{t-p} + u_t, \quad (1)$$

where  $u_t = \begin{pmatrix} u_{1t} \\ u_{2t} \end{pmatrix}$  is a white noise vector process normalized so that

$$E u_t u_t' = I \text{ and } A_i, \quad i=0, 1, \dots, p \text{ is } n \times n.$$

The corresponding reduced form of this structure model is

$$z_t = A_0^{-1} A_1 z_{t-1} + L + A_0^{-1} A_p z_{t-p} + A_0^{-1} u_t = B_1 z_{t-1} + L + B_p z_{t-p} + \varepsilon_t, \quad (2)$$

$$E \varepsilon_t \varepsilon_t' \equiv \Omega.$$

The system in (2) is the VAR representation of the structural model in (1). The moving average representation of the structural model is

$$z_t = (A_0 - A_1 L - L - A_p L^p)^{-1} u_t = (D_0 + D_1 L + D_2 L^2 + \dots + L^p) u_t = D(L) u_t. \quad (3)$$

Likewise, the reduced form moving average is

$$z_t = (I_0 - B_1L - L - B_p L^p)^{-1} \varepsilon_t = (I_0 + C_1L + C_2L^2 + L) \varepsilon_t = C(L) \varepsilon_t. \quad (4)$$

The objective is to identify the economic structure in (3) from the moving average in (4), which is directly determined by the coefficients in (2).

The study now partitions the coefficient matrices in equations (1) through (4) according to

$$X_h = \begin{pmatrix} X_{11}^h & X_{12}^h \\ X_{21}^h & X_{22}^h \end{pmatrix}, \quad (5)$$

for  $X = A, B, C,$  and  $D,$  where  $X_{i,j}^h$  has dimension  $n_i \times n_j$  for all  $h$  and  $i, j = 1, 2.$  Partition the reduced form covariance matrix  $\Omega$  conformably

$$\Omega = E \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \begin{pmatrix} \varepsilon_{1t}' & \varepsilon_{2t}' \end{pmatrix} = \begin{pmatrix} \Omega_{11} & \Omega_{21}' \\ \Omega_{21} & \Omega_{22} \end{pmatrix}. \quad (6)$$

Korea is small with respect to the U.S., so the paper assumes that Korean shocks ( $z_{2t}$ ) have no effect on U.S. variables ( $z_{1t}$ ) at any lags. This block exogeneity assumption of  $z_{1t}$  with respect to  $z_{2t}$  restricts the  $n_1 \times n_2$  matrix  $A_{12}^h$  to be 0, for  $h = 0, 1, K, p.$  Inverting  $A_0$  implies

$$A_0^{-1} = \begin{pmatrix} (A_{11}^0)^{-1} & 0 \\ -(A_{11}^0)^{-1} A_{21}^0 (A_{22}^0)^{-1} & (A_{22}^0)^{-1} \end{pmatrix}, \quad (7)$$

so that block exogeneity assumption carries over to the inverse. Furthermore, from (2),

$$\begin{aligned}
B_{22}^i &= (A_{22}^0)^{-1} A_{22}^i, \quad i = 1, K, p, \\
B_{12}^i &= 0, \quad i = 1, K, p,
\end{aligned} \tag{8}$$

the VAR coefficient matrices are similarly restricted.

The block exogeneity restriction implies that the VAR in (2) can be expressed as

$$\begin{pmatrix} z_{1t} \\ z_{2t} \end{pmatrix} = \sum_{i=1}^p \begin{pmatrix} B_{11}^i & 0 \\ B_{21}^i & B_{22}^i \end{pmatrix} \begin{pmatrix} z_{1t-i} \\ z_{2t-i} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}. \tag{9}$$

Due to block exogeneity, it is possible to re-parameterize and separate eq. (9) into independent parts

$$z_{1t} = \sum_{i=1}^p B_{11}^i z_{1t-i} + \varepsilon_{1t}, \tag{10a}$$

$$z_{2t} = \sum_{i=1}^p G_i z_{1t-i} + \sum_{i=1}^p B_{22}^i z_{2t-i} + v_t, \tag{10b}$$

where

$$G_0 = \Omega_{21} \Omega_{11}^{-1}, \tag{11a}$$

$$G_i = B_{21}^i - G_0 B_{11}^i, \quad i = 1, K, p, \tag{11b}$$

$$E v_t v_t' = H = \Omega_{22} - \Omega_{21} \Omega_{11}^{-1} \Omega_{21}'. \tag{11c}$$

Note from (2) and the normalization of  $E u_t u_t' = I$  that

$$\varepsilon_t = A_0^{-1} u_t, \tag{12}$$

$$\Omega = A_0^{-1} A_0^{-\prime}. \quad (13)$$

Then from (6) and (7) has

$$\begin{aligned} \Omega_{11} &= (A_{11}^0)^{-1} (A_{11}^0)^{-\prime}, \\ \Omega_{21} &= -(A_{11}^0)^{-1} A_{21}^0 (A_{22}^0)^{-1} (A_{11}^0)^{-\prime}, \\ \Omega_{11} &= -(A_{22}^0)^{-1} (A_{22}^0)^{-1} + (A_{11}^0)^{-1} A_{21}^0 (A_{22}^0)^{-1} (A_{22}^0)^{-\prime} (A_{21}^0)^{-1} (A_{11}^0)^{-\prime}. \end{aligned} \quad (14)$$

From (14) and (11c) has

$$H = (A_{22}^0)^{-1} (A_{22}^0)^{-\prime}.$$

## 2.2. Identification

The study now considers identifying the structure from the reduced form estimates obtained in the previous section. Using (12) in (4), and comparing to (3), it follows that

$$D_0 = A_0^{-1}, \quad (15)$$

$$D_i = C_i D_0, \quad i = 1, 2, K. \quad (16)$$

Partition  $D_0$  as in (5), and use the partitioned expression of  $A_0^{-1}$  in (7) to get

$$D_{22}^0 = (A_{22}^0)^{-1}, \quad (17)$$

$$D_{12}^0 = 0. \quad (18)$$

The solution to the inverted lag polynomial in (4a) is



$$\begin{aligned}
C_0 &= I, \\
C_i &= B_1 C_{i-1} + L + B_p C_{i-p}, \quad i=1, 2, K.
\end{aligned} \tag{19}$$

All  $C_i$  will have the same restrictions as the VAR coefficient matrices, as will all  $D_i$  from (16).

Now substitute (15) into (13) to get  $\Omega = D_0 D_0'$ , then partition the right-hand-side of this expression using (18)

$$\begin{pmatrix} \Omega_{11} & \Omega_{21}' \\ \Omega_{21} & \Omega_{22} \end{pmatrix} = \begin{pmatrix} D_{11}^0 D_{11}^{0'} & D_{11}^0 D_{21}^{0'} \\ D_{21}^0 D_{11}^{0'} & D_{21}^0 D_{21}^{0'} + D_{22}^0 D_{22}^{0'} \end{pmatrix}. \tag{20}$$

Because of the block exogeneity of  $z_1$ ,  $D_{11}^0$  can be identified solely from the upper-left block of (20). For example, if  $D_{11}^0$  is assumed to be lower triangular, then it is just-identified as the Cholesky factor of  $\Omega_{11}$ , which is estimated directly from the  $z_1$  sub-system and independently of  $z_2$ .

Once  $D_{11}^0$  is identified, the lower-left matrix in (20) implies

$$\begin{aligned}
\Omega_{21} &= D_{21}^0 D_{11}^{0'}, \\
D_{21}^0 &= \Omega_{21} (D_{11}^{0'})^{-1}.
\end{aligned} \tag{21}$$

From the lower-right matrix in (20),

$$D_{22}^0 D_{22}^{0'} = \Omega_{22} - D_{21}^0 D_{21}^{0'}. \tag{22}$$

$\Omega_{22}$  is directly estimated from eqs. (10a), (10b) and (11a-11c), while  $D_{21}^0$  is identified from eq. (21). But, to identify  $D_{22}^0$ , some restrictions are required. For example, if  $D_{22}^0$  is assumed to be lower triangular, then it is just-identified as the Cholesky factor of  $(\Omega_{22} - D_{21}^0 D_{21}^{0'})$ .  $D_0$  is now fully identified. No restrictions on  $D_{21}^0$  are necessary to identify how the system

responds to the entire set of shocks.

It is noted that, following Blanchard and Quah (1989), infinite-horizon restrictions both from the  $z_1$  sub-system and from the  $z_2$  system are also sufficient to identify the dynamics of the full system. Suppose that  $z_1 = \Delta a_t$ , then the long-run multipliers of the levels are

$$\lim_{k \rightarrow \infty} \frac{\partial a_{t+k}}{\partial a_t} = D(1) = \begin{pmatrix} \sum_{i=0}^{\infty} D_{11}^i & 0 \\ \sum_{i=0}^{\infty} D_{21}^i & \sum_{i=0}^{\infty} D_{22}^i \end{pmatrix} = \begin{pmatrix} \mathcal{D}_{11}^c & 0 \\ \mathcal{D}_{21}^c & \mathcal{D}_{22}^c \end{pmatrix}, \quad (23)$$

where  $\mathcal{D}_{11}^c$  contains the long-run multipliers from the  $z_1$  sub-system, and  $\mathcal{D}_{22}^c$  contains the long-run multipliers from the  $z_2$  sub-system. From eq. (16) and the mapping from  $D_0$  to  $\Omega$

$$D(1) = C(1)D_0, \quad (24)$$

$$D(1)D(1)' = C(1)D_0D_0'C(1)' \quad (25)$$

$$= C(1)\Omega C(1)'. \quad (26)$$

Expanding eq. (26) to express partitions and noting the restrictions on  $C(1)$ , gives

$$\begin{pmatrix} \mathcal{D}_{11}^c \mathcal{D}_{11}^{c'} & D_{11}D_{21}' \\ D_{21}D_{11}' & D_{21}D_{21}' + D_{22}D_{22}' \end{pmatrix} = \begin{pmatrix} \mathcal{C}_{11}^c & 0 \\ \mathcal{C}_{21}^c & \mathcal{C}_{22}^c \end{pmatrix} \begin{pmatrix} \Omega_{21} & \Omega_{21}' \\ \Omega_{21} & \Omega_{22} \end{pmatrix} \begin{pmatrix} \mathcal{C}_{11}^{c'} & \mathcal{C}_{21}^{c'} \\ 0 & \mathcal{C}_{22}^{c'} \end{pmatrix}, \quad (27)$$

which implies

$$\mathcal{D}_{11}^c \mathcal{D}_{11}^{c'} = \mathcal{C}_{11}^c \Omega_{21} \mathcal{C}_{11}^{c'}. \quad (28)$$

If sufficient conditions are imposed on  $\mathcal{D}_{11}^c$ , such as lower triangularity, it

can be identified from the long-run covariance matrix of the reduced form in eq. (28). Once  $\tilde{D}_{11}^0$  is known, from eqs. (28) and (20),

$$\Omega_{11} = \mathcal{C}_{11}^{0'} \tilde{D}_{11}^0 \tilde{D}_{11}^{0'} (\mathcal{C}_{11}^0)^{-1} = D_{11}^0 D_{11}^{0'}. \quad (29)$$

Since  $\Omega_{11}$  is known from estimation,

$$D_{11}^0 = \mathcal{C}_{11}^{0'} \tilde{D}_{11}^0. \quad (30)$$

Also to impose sufficient conditions on  $\tilde{D}_{22}^0$ , such as lower triangularity,  $D_{21}^0$  and  $D_{22}^0$  can be identified from eqs. (21) and (22), and eq. (16) yields the entire set of structural parameters.

The paper now assumes that the ordering of macro variables is given as

$$z_t = \Delta a_t = \begin{pmatrix} z_{1t} \\ z_{2t} \end{pmatrix} = \begin{pmatrix} \Delta a_{1t} \\ \Delta a_{2t} \end{pmatrix}, \quad (31a)$$

$$z_{1t} = \Delta a_{1t} = \begin{pmatrix} \Delta y_t^{us} \\ \Delta i_t^{us} \\ \Delta m_t^{us} - \Delta p_t^{us} \\ \Delta m_t^{us} \end{pmatrix}, \quad (31b)$$

$$z_{2t} = \Delta a_{2t} = \begin{pmatrix} \Delta y_t^{kor} \\ \Delta i_t^{kor} \\ \Delta m_t^{kor} - \Delta p_t^{kor} \\ \Delta s_t + \Delta p_t^{us} - \Delta p_t^{kor} \\ \Delta v_t \\ \Delta p x_t^{kor} - \Delta p_t^{kor} \\ \Delta y x_t^{kor} \\ \Delta m_t^{kor} \end{pmatrix}, \quad (31c)$$

where  $z_{1t}$  denotes the U.S. macro system, and  $z_{2t}$  denotes the Korean macro system.  $y_t^{us}$  ( $y_t^{kor}$ ) denotes U.S. (Korean) output,  $i_t^{us}$  ( $i_t^{kor}$ ) denotes U.S. (Korean) nominal interest rate,  $m_t^{us} - p_t^{us}$  ( $m_t^{kor} - p_t^{kor}$ ) denotes U.S. (Korean) real money balances, and  $m_t^{us}$  ( $m_t^{kor}$ ) denotes U.S. (Korean) nominal money supply. Also,  $(s_t + p_t^{us} - p_t^{kor})$  denotes real exchange rate,  $v_t$  denotes exchange rate volatility,  $(px_t^{kor} - p_t^{kor})$  denotes real Korean export price, and  $yx_t^{kor}$  denotes Korean export volume.

Money supply shocks are assumed to be neutral, in the long-run, within each economy. Long-run neutrality of the nominal money supply is a standard assumption in most macro models, and is generally considered to be a stylized fact (see, for example, Lucas 1996).

The paper also assumes that the long-run impulse response matrix for each system is assumed to be fully lower-triangular. Finally, following Halabi and Lastrapes (2003), the paper assumes that the U.S. economy is block-exogenous to Korean macro shocks at any lags, i.e.,  $D_{12}^k = 0$ ,  $\forall k = 0, \dots, \infty$ . These assumptions fully identify the entire system. Specifically identify the responses of Korean variables to Korean shocks, the responses of U.S. variables to U.S. shocks, and the responses of Korean variables to U.S. shocks. If the entire long-run impulse matrix  $[D^{\infty}(1)]$  as in eq. (23) is identified, the paper can identify the entire  $D_0$  matrix from eq. (24) and  $A_0$  matrix from eq. (15).

Note finally that, while the study imposes restrictions on  $D_{11}^c$  and  $D_{22}^c$  as in eq. (23) with the assumptions above, no restrictions are imposed on  $D_{21}^c$ .

### 3. ESTIMATION RESULTS

#### 3.1. Data and Model Specification

Data was obtained from the Bank of Korea and from the Korea National Statistics Office (KNSO). The U.S. data are obtained from the FRED

(Federal Reserve Economic Data Base). The study uses monthly data, and the sample period is from 1988:1 to 2005:12 (216 observations) because Korean export price and volume indices were not available earlier. All variables are in logs except for the interest rates. U.S. variables include output proxied by industrial production, nominal interest rate (federal funds rate) real money balances (M2 deflated by U.S. PPI), and nominal money ( $n_1 = 4$ ). Korean variables include output (proxied by industrial production), nominal interest rate (one-year monetary stability bond rate), real money balances (M2 deflated by Korean PPI), the real exchange rate as the nominal exchange rate plus U.S. PPI minus Korean PPI, the real export price as the nominal export price deflated by Korean PPI, real exports as the export volume index, and nominal money as M2 ( $n_2 = 8$ ).<sup>4)</sup> To control for the Korean currency crisis effect the study includes a dummy (=1 if 1997 or 1998; 0 otherwise).

There are many different measures of exchange rate volatility (see, for example, a survey paper on exchange rate volatility by McKenzie 1999). Among those the study follows De Grauwe (1987), and measures the monthly exchange rate volatility as

$$v_t = 100 \times \left( \frac{1}{m} \sum_{i=1}^m (s_i - \bar{s}_t)^2 \right)^{\frac{1}{2}}, \quad (32)$$

where  $s_i$  is the log of daily exchange rate denoted as the domestic currencies per foreign currency,  $\bar{s}_t$  is the monthly average of the log of daily exchange rates,  $m$  is the number of days in a certain month.<sup>5)</sup> Given the irregularity of the working days in a month, measuring the volatility as the standard deviation seems reasonable. The study included in the VAR a deterministic component consisting of a constant, Korean currency crisis

---

<sup>4)</sup> One-year monetary stability bond rate as the Korean nominal interest rate based upon the availability of data is used.

<sup>5)</sup> Daily exchange rate is defined as “noon buying rates in New York City for cable transfers payable in foreign currencies (Korean Won/U.S. Dollar),” and is obtained from the FRED.

dummy and 11 seasonal dummies and uses a lag length of 4 months (i.e.,  $p = 4$ ).<sup>6)</sup>

Note from eq. (1) that  $A_0$  measures the contemporaneous relationship from the structural equations. The structural Korean export price equation is written as

$$\begin{aligned} (\Delta px_t^{kor} - \Delta p_t^{kor}) = & -\gamma_1 \Delta y_t^{us} - \gamma_2 \Delta i_t^{us} - \gamma_3 (\Delta m_t^{us} - \Delta p_t^{us}) - \gamma_4 \Delta m_t^{us} - \gamma_5 \Delta y_t^{kor} \\ & - \gamma_6 \Delta i_t^{kor} - \gamma_7 (\Delta m_t^{kor} - \Delta p_t^{kor}) - \gamma_8 (\Delta s_t + \Delta p_t^{us} - \Delta p_t^{kor}) \\ & - \gamma_9 \Delta v_t - \gamma_{11} \Delta yx_t^{kor} - \gamma_{12} \Delta m_t^{kor}, \end{aligned} \quad (33)$$

$$\frac{\partial \Delta px_t^{kor}}{\partial \Delta s_t} = -\gamma_8.$$

The structural exchange rate pass-through on the Korean export price, which measures contemporaneous effect of a change in the exchange rate on the export price in the structural export price equation, is calculated from the fully-identified  $A_0$  matrix.

Analogously the structural exchange rate volatility effect is measured on the Korean export volume. The structural Korean export volume equation can be written as

$$\begin{aligned} \Delta yx_t^{kor} = & -\phi_1 \Delta y_t^{us} - \phi_2 \Delta i_t^{us} - \phi_3 (\Delta m_t^{us} - \Delta p_t^{us}) - \phi_4 \Delta m_t^{us} - \phi_5 \Delta y_t^{kor} \\ & - \phi_6 \Delta i_t^{kor} - \phi_7 (\Delta m_t^{kor} - \Delta p_t^{kor}) - \phi_8 (\Delta s_t + \Delta p_t^{us} - \Delta p_t^{kor}) \\ & - \phi_9 \Delta v_t - \phi_{10} \Delta (px_t^{kor} - p_t^{kor}) - \phi_{12} \Delta m_t^{kor} \end{aligned} \quad (34)$$

$$\frac{\partial \Delta yx_t}{\partial \Delta v_t} = -\phi_9.$$

<sup>6)</sup> The estimated reduced form residuals from the VAR are generally well-behaved. In only a few of the equations the  $q$ -statistics significantly different from zero, but even in these cases the estimated autocorrelations are small. Alternatively used is the lag length of 12 to find no advantage of it over 4 lags. Also, the use of 4 lags instead of 12 lags greatly increases the degrees of freedom. Especially for the Korean equations, there are 42 degrees of freedom with 12 lags and 146 degrees of freedom with 4 lags.

Therefore, the structural exchange rate volatility effect on Korean export volume can also be calculated from the fully-identified  $A_0$  matrix.

The shock-specific exchange rate pass-through on the Korean export price is calculated by dividing the contemporaneous covariance between the nominal export price and the nominal exchange rate responses – the sum of the product of the nominal export price response and the nominal exchange rate response – by the variance of the nominal exchange rate response to different shocks for all forecasting horizons. The shock-specific exchange rate volatility effects on Korean export volume are analogously calculated.

Before running the VAR it is necessary to perform unit-root tests using both the augmented Dickey-Fuller and the Phillips-Perron methods.<sup>7)</sup> The test results confirm that all the variables are stationary in first-differences. Also tested is the vector  $z_t$  for the presence of cointegration using the FIML techniques of Johansen with the small sample correction suggested by Reimers (1992). In running the tests, the estimated model allows for seasonal dummy variables to account for deterministic seasonality, and the lag length is four. The tests revealed no strong evidence for the existence of cointegrating vectors in the system; the model specification in which the variables are first differenced and no error-correction terms are included is reasonable.<sup>8)</sup>

### 3.2. Impulse Responses

Twelve different shocks are identified. The 12 different responses can be directly estimated from the VAR, and 8 other responses are inferred from the combination of other responses.<sup>9)</sup> Therefore, there are  $12 \times 20 = 240$

<sup>7)</sup> Detailed unit-root test results will be provided from the author by request.

<sup>8)</sup> The trace test statistic for the largest root is 350.01 (using 4 lags and no constraint on the constant terms), marginally higher than 5% critical value of 336.22 as reported by MacKinnon (1999, table 4); the analogous maximum eigen value test statistic is 57.63, less than 5% critical value of 76.61. This suggests only a weak rejection of the null hypothesis of no cointegration. There appears to be no serious misspecification by first-differencing.

<sup>9)</sup> Those include the Korean price level, Korean export price level, nominal exchange rate, Korean inflation rate, Korean real interest rate, U.S. price level, U.S. inflation rate, and U.S. real interest rate responses. Korean price level response, for example, can be inferred from

relationships among the different shocks and different responses. Analysis is limited to the responses of export price, export volume, exchange rate, and exchange rate volatility. The accumulated responses are reported, which are to be interpreted as the response of the levels of the variables. The figure includes a standard error band for each response, generated from a Monte Carlo integration simulation with 1000 replications. Because of lags ( $p=4$ ) and differencing, the estimation period is 1988:6-2005:12, which includes 211 monthly observations. There are 182 degrees of freedom in each equation of the U.S. sub-VAR, and 147 degrees of freedom in each equation of Korean sub-VAR. The forecasting horizon at 24 months is truncated because most of the impulse responses are stabilized before 24 months after the shocks.

### 3.2.1. Responses of Korean variables to Korean shocks

Figures 1 and 2 report the responses of Korean variables to Korean shocks. First noted is that there is little evidence of a *within-Korea* liquidity effect, the negative response of Korean nominal interest rate to a positive Korean money supply shock. The Korean nominal interest rate falls at the instant of the shock, but it is not statistically different from zero (figure 1, second row and eighth column). For the entire forecasting horizon, only the responses 2 through 6 months after the shock are significant and *positive*. The Korean real interest rate shows little evidence of a liquidity effect (figure 2, fifth row and eighth column). The real interest rate falls to a statistically significant degree only at the instant of the shock. In response to a money supply shock real money balances fall in the short run. A fall in real money balances to a money supply shock is mainly due to an over-reaction of the

---

the real money and nominal money responses:  $\frac{\partial p_{t+k}^{kor}}{\partial u_t} = \frac{\partial m_{t+k}^{kor}}{\partial u_t} - \frac{\partial (m_{t+k}^{kor} - p_{t+k}^{kor})}{\partial u_t}$ . Note that the real exchange rate ( $q_t$ ) is defined as  $q_t = s_t + p_t^{us} - p_t^{kor}$ . Then, the nominal exchange rate is inferred as  $s_t = q_t - p_t^{us} + p_t^{kor}$ . Therefore, the nominal exchange rate response to a certain shock can be derived as

$$\frac{\partial s_{t+k}}{\partial u_t} = \frac{\partial q_{t+k}}{\partial u_t} - \left[ \frac{\partial m_{t+k}^{us}}{\partial u_t} - \frac{\partial (m_{t+k}^{us} - p_{t+k}^{us})}{\partial u_t} \right] + \left[ \frac{\partial m_{t+k}^{kor}}{\partial u_t} - \frac{\partial (m_{t+k}^{kor} - p_{t+k}^{kor})}{\partial u_t} \right].$$



domestic price level. When the domestic price level rises by more than the increase in money supply real money balances fall. As a result the real interest rate, defined as the difference between the nominal interest rate and the price level, may fall in response to a money supply shock. The findings, that unexpected Korean monetary shocks have a positive impact on interest rates and a negative impact on real money balances, seem puzzling.<sup>10)</sup> Most studies on liquidity effects employ one country model where the important foreign economic variables are ignored, and found strong liquidity effects (see, for example, Christiano *et al.*, 1996; Strongin, 1995; Bernanke and Mihov, 1998). Also tested is whether there are liquidity effects when the paper adopts one country model by ignoring foreign effects. Even though not reported, the paper *does* find strong liquidity effects both in Korea and in the U.S. in one-country model. One implication of a no within-Korea liquidity effect with two-country model used in this paper is that the exogenous Korean monetary policy shock from one country model control that was thought to be determined independently is in effect closely related to the U.S. monetary policy. No within-Korea liquidity effects from an exogenous Korean monetary shock after controlling for the U.S. effects may be attributable either to inflationary expectations or to the lack of credibility in Korean monetary policy.<sup>11)</sup>

Interest exists in how the Korean nominal export price and the nominal exchange rate responds to common Korean shocks. Generally, in response to common Korean shocks, the nominal exchange rate and the Korean export price moves in the same direction (figure 2).<sup>12)</sup> In response to Korean output shocks, Korean export price falls in the short run as well as in the long

<sup>10)</sup> Results are generally robust to alternative model specification and identifying restrictions.

<sup>11)</sup> Using a two-country model, Halabi and Lastrapes (2003) find that a Chilean money supply shock has a positive impact on interest rate and a negative impact on real money balances.

<sup>12)</sup> Recall that the real exchange rate ( $q_t$ ) is defined as  $q_t = s_t + p_t^{us} - p_t^{kor}$ . Therefore, the nominal exchange rate ( $s_t$ ) is derived as  $s_t = q_t - p_t^{us} + p_t^{kor}$ . Note also that, given that Korea is a small country; a Korean shock has no effect on U.S. variables at any lags. Therefore, the response of nominal exchange rate to a Korean shock is calculated as

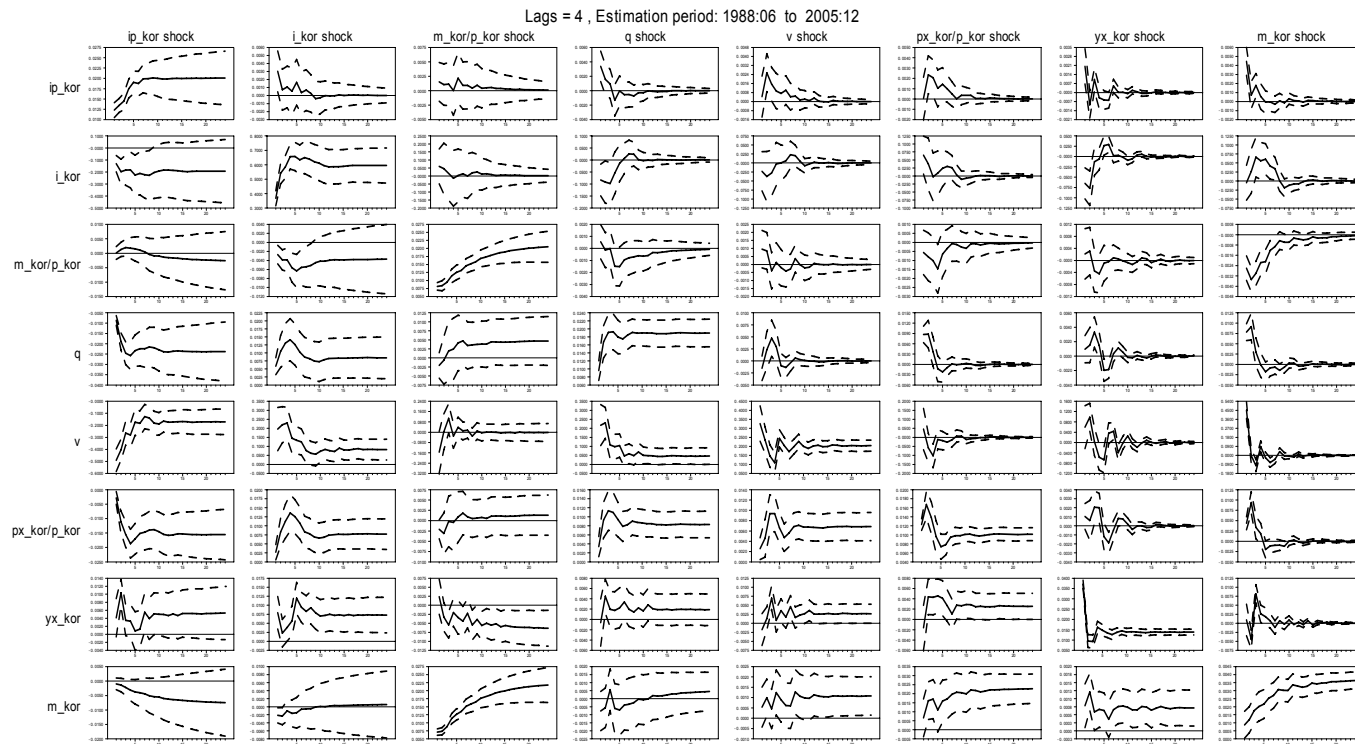
$$\frac{\partial s_{t+k}}{\partial u_t^{kor}} = \frac{\partial q_{t+k}}{\partial u_t^{kor}} - \frac{\partial p_{t+k}^{kor}}{\partial u_t^{kor}}, \text{ where } u_t^{kor} \text{ denotes a Korean shock.}$$

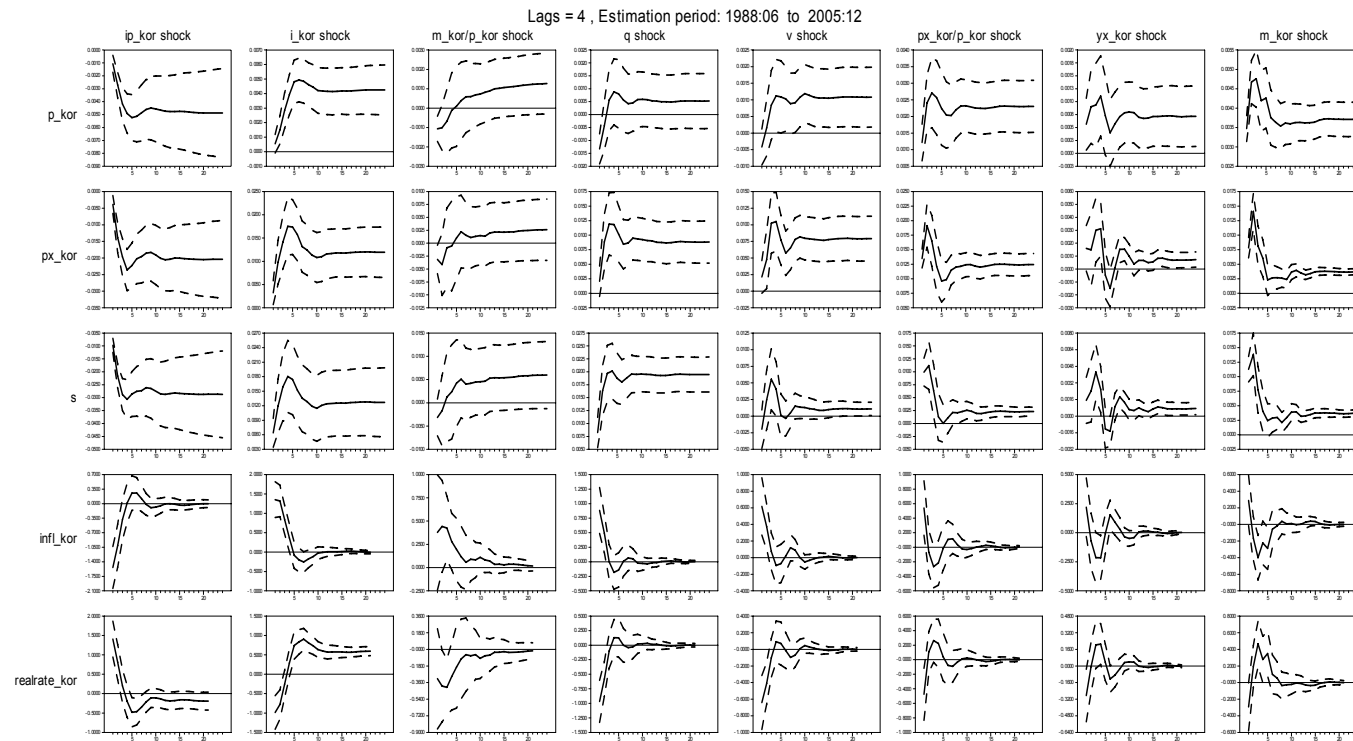
run. The nominal exchange rate also falls (appreciates) both in the short run and in the long run. In response to Korean nominal interest rate shocks, both the Korean export price and the nominal exchange rate rise both in the short run and in the long run. In response to Korean real money balance shocks, the Korean export price and the nominal exchange rate fall in the short run and become positive in the long run, even though the responses are generally not statistically different from zero. Both the Korean export price and the nominal exchange rate show positive responses to real exchange rate shocks at all forecasting horizons.

In response to exchange rate volatility shocks, the Korean export price response and the nominal exchange rate response generally move in the same direction. The Korean export price always shows positive responses to a volatility shock, and the nominal exchange rate generally shows positive responses. The nominal exchange rate falls only at the instant of the shock and 5 months after the shock. At any forecasting horizon, both the Korean nominal export price and the nominal exchange rate show positive responses to Korean real export price shocks. The Korean nominal export price and the nominal exchange rate show similar responses to Korean export volume shocks. Only at 4 and months after the shock, the nominal export price shows negative responses, and for other forecasting horizons, it shows positive responses. The nominal exchange rate also appreciates only at 4 and 5 months after the shock, and for other forecasting horizons, it depreciates. Finally, in response to Korean money supply shocks, both the nominal export price and the nominal exchange rate show positive responses at all forecasting horizons.

Interest also exists in seeing how the exchange rate volatility and the Korean export volume respond to common Korean shocks (figure 1). In response to Korean output shocks, the exchange rate volatility and the Korean export volume move in opposite directions. While the nominal exchange rate volatility falls, the Korean export volume rises at all forecasting horizons. In response to Korean nominal interest rate shocks, both the exchange rate volatility and the Korean export volume rise at all

**Figure 1 Responses of Korean Variables to Korean Shocks**



**Figure 2 Responses of Korean Variables to Korean Shocks**

forecasting horizons. In response to real Korean money balance shocks, the exchange rate volatility and the Korean nominal export volume seem to move in opposite direction. The Korean export volume rises only at the instant of the shock, and falls for all other forecasting horizons. The exchange rate volatility, on the other hand, falls not only at the instant of the shock but also for the most of the forecasting horizons. In response to real exchange rate shocks, the exchange rate volatility and the Korean export volume seem to move in the same direction. The exchange rate volatility rises over all forecasting horizons. The Korean export volume, even though statistically insignificant, falls only at the instant of the shock, and rises for the rest of the forecasting horizons.

In response to exchange rate volatility shocks, the exchange rate volatility and the Korean export volume move in the same direction. The exchange rate volatility rises at all forecasting horizons, and Korean export volume, except at the instant of the shock, also rises. This is what is typically estimated by many other studies (for example, Koray and Lastrapes, 1992) that find a positive effect of volatility on volume.

The exchange rate volatility and the Korean export volume move in opposite directions in response to real export price shocks. Korean export volume falls only at the instant of the shock, and rises for the rest of the forecasting horizons. The exchange rate volatility oscillates over the forecasting horizon. Specifically, the exchange rate volatility rises at the instant of the shock, but falls one through 6 months after the shock. In response to Korean export volume shocks, the exchange rate volatility and the Korean export volume show different patterns. While Korean export volume rises over all forecasting horizons, exchange rate volatility oscillates over the forecasting horizons. Specifically, exchange rate volatility rises until 2 months after the shock then falls until 4 months after the shock. Finally, in response to Korean money supply shocks the exchange rate volatility and the Korean export volume move differently. While Korean export volume rises in response to Korean money supply shocks, the exchange rate volatility oscillates in response to the same shocks.

### 3.2.2. Response of Korean variables to U.S. shocks

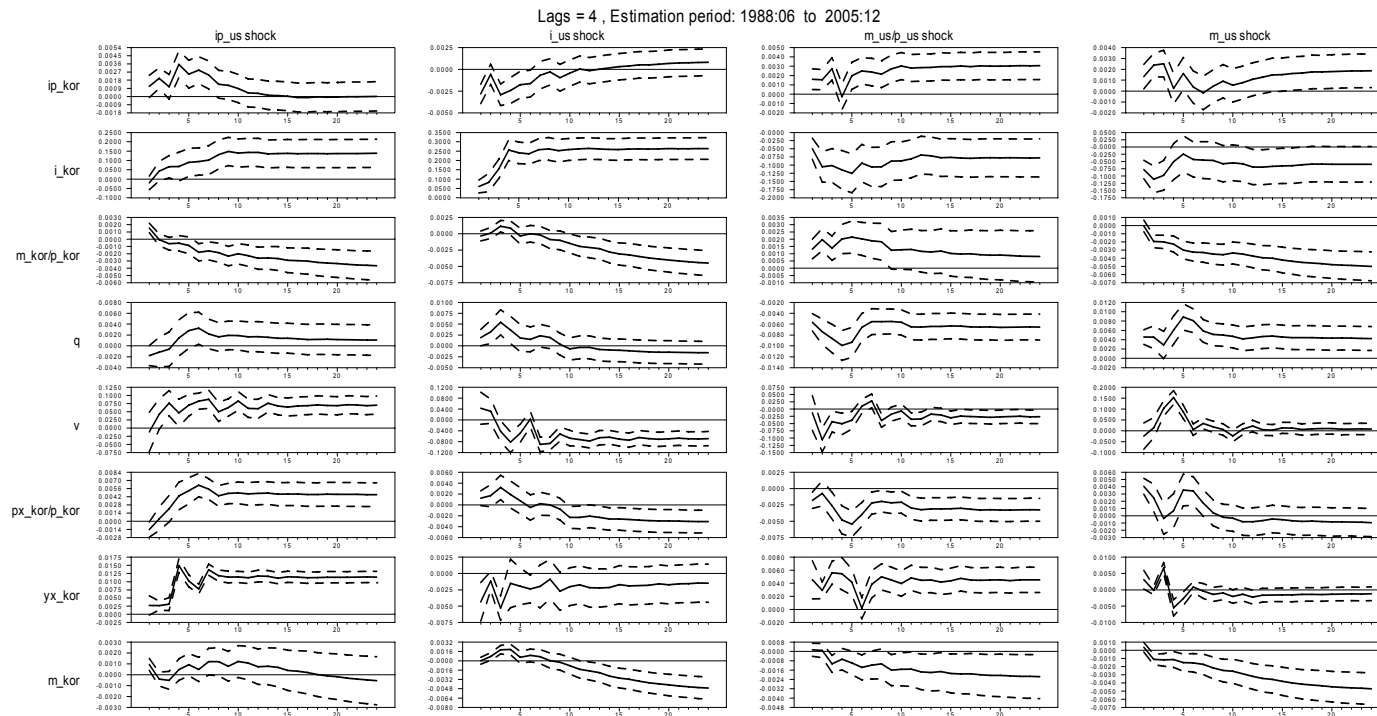
The study now analyzes how the U.S. shocks affect Korean variables. Figure 4 reports the responses of Korean variables to U.S. shocks. Note from section 2.1 that the responses of Korean variables to U.S. shocks are not directly estimated but derived from the two different blocks of conditional VARs in eqs. (10a) and (10b). To generate the standard error bands for the responses of Korean variables to U.S. shocks a SUR was run.

The most surprising finding is that there is a *cross-country liquidity effect* defined as the negative response of Korean nominal interest rate to U.S. money supply shock. In response to a U.S. money supply shock, the Korean nominal interest rate falls at *all* forecasting horizons. Especially, the negative response of the nominal interest rate is statistically significant until two months after the shock, and 11 through 16 months after the shock, respectively. Also, there appears to be a cross-country liquidity effect, at least in the short run, when the Korean interest rates are measured in *real* terms. In response to a U.S. money supply shock, the Korean real interest rate falls until 3 months after the shock.

The Korean nominal export price and the nominal exchange rate move in the same direction in response to U.S. shocks. Both the Korean nominal export price and the nominal exchange rate show negative responses only at the instant of the U.S. output shocks. In response to a U.S. nominal interest shock, the Korean nominal export price rises until 8 months after the shock, and then it falls. The nominal exchange rate also falls until 3 months after the shock, and then it rises. In response to U.S. real money balance shocks, both the export price and the nominal exchange rate fall at all forecasting horizons. Finally, in response to U.S. money supply shocks, both the export price and the nominal exchange rate rise at all forecasting horizons.

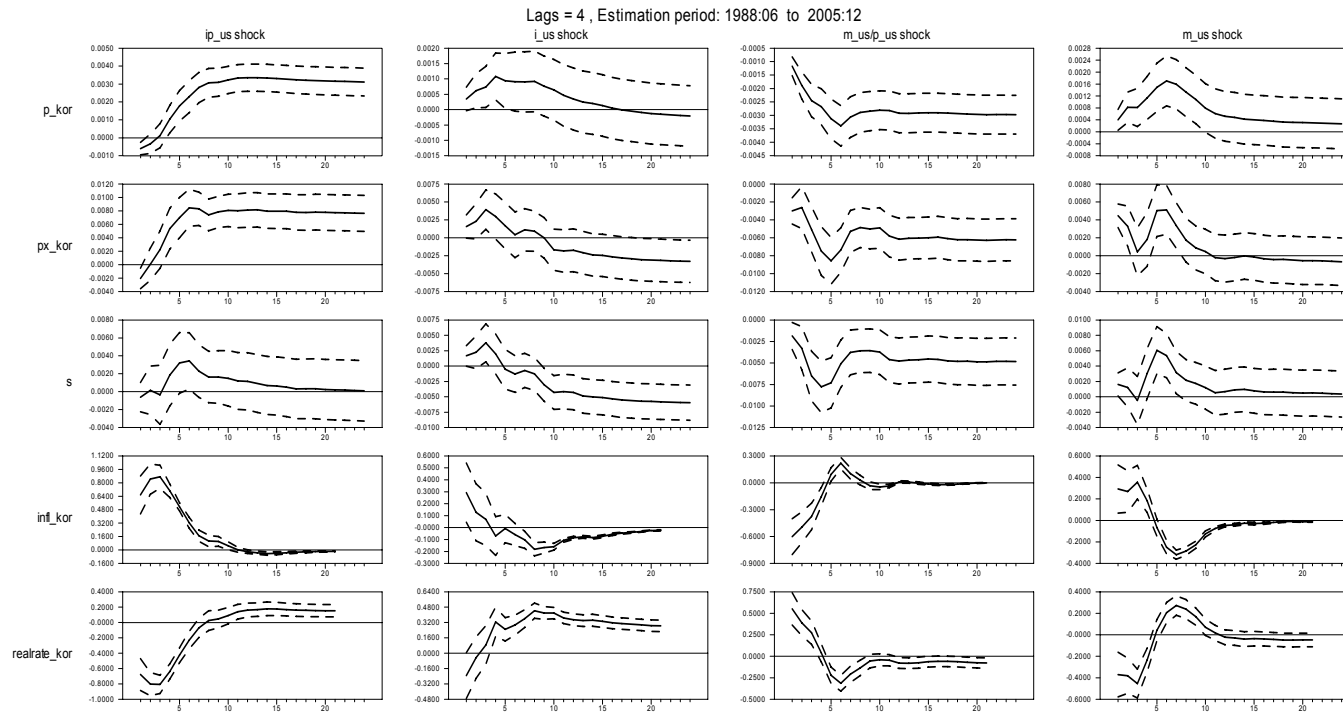
The impulse responses of the exchange rate volatility and the Korean export volume are reported in figure 3. The exchange rate volatility initially shows no response to a U.S. output shock, and it rises after. The Korean export volume rises over all forecasting horizons in response to the same shock. In response to a U.S. nominal interest rate shock, the exchange rate

**Figure 3 Responses of Korean Variables U.S. Shocks**



Actual responses (solid lines) are obtained from the OLS; the standard error bands (dashed lines) are obtained from the SUR

Figure 4 Responses of Korean Variables U.S. Shocks



Actual responses (solid lines) are obtained from the OLS; the standard error bands (dashed lines) are obtained from the SUR



volatility rises until one month after the shock, and then it falls. The Korean export volume always shows negative responses to a U.S. nominal interest rate shock. In response to U.S. real money balance shock, the Korean export volume rises at all horizons. The exchange rate volatility generally shows a negative response to the shock. Finally, in response to a U.S. money supply shock, the exchange rate volatility generally rises. The Korean export volume, on the other hand, generally falls in response to the same shock.

### 3.3. The Structural and the Shock-specific Pass-through

#### 3.3.1. The structural and the shock-specific exchange rate pass-through on the Korean export price

Table 1 reports the shock-specific exchange rate pass-through on the Korean export price. It shows that, irrespective of different shocks, the signs of the shock-specific exchange rate pass-through coefficients are all positive. It was also found that the shock-specific exchange rate pass-through differs by different shocks. In many cases, the shock-specific

**Table 1 Shock-specific ERPT on the Korean Export Price**

|                                    | Exchange rate pass-through on the Korean export price |
|------------------------------------|-------------------------------------------------------|
| Output shock (Korea)               | 0.71                                                  |
| Interest rate shock (Korea)        | 0.90                                                  |
| Real money balance shock (Korea)   | 0.84                                                  |
| Real exchange rate shock           | 0.58                                                  |
| Exchange rate volatility shock     | 0.71                                                  |
| Real export price shock (Korea)    | 1.18                                                  |
| Export volume shock (Korea)        | 0.78                                                  |
| Nominal money supply shock (Korea) | 0.82                                                  |
| Output shock (U.S.)                | 1.21                                                  |
| Interest rate shock (U.S.)         | 0.75                                                  |
| Real money balance shock (U.S.)    | 0.86                                                  |
| Nominal money supply shock (U.S.)  | 0.97                                                  |

**Table 2 Structural ERPT on the Korean Export Price**

|                                                   |       |
|---------------------------------------------------|-------|
| Structural exchange rate pass-through coefficient | 0.089 |
|---------------------------------------------------|-------|

exchange rate pass-through coefficients exist between zero and one, and in some cases, the coefficients are greater than 1. The shock-specific exchange rate pass-through is the highest from the U.S. output shock, and is the lowest from the real exchange rate shock.

The study now addresses the following question: Does the exchange rate volatility raise exchange rate pass-through? Compared with no exchange rate volatility shock, exchange rate pass-through on the Korean export price from an exchange rate volatility shock *rises* by 71%. Alternatively, exchange rate pass-through on the implicit import price in the import country, assuming all Korean exports are sold in the United States, falls in response to an exchange rate volatility shock. A fall in the exchange rate pass-through on the implicit import price in the import country in response to positive exchange rate volatility shocks is consistent with Devereux *et al.* (2004)

Table 2 reports the structural exchange rate pass-through on the Korean export price that is identified by the  $A_0$  matrix in eqs. (34) and (35). The structural exchange rate pass-through coefficient measures the *contemporaneous* effect of a change in exchange rate on the Korean export price. The structural exchange rate pass-through coefficient is found to be 0.089. When the nominal exchange rate (defined as Korean won per U.S. dollar) depreciates by 10%, the Korean nominal export price rises by 0.89%.<sup>13)</sup>

Table 2 found the export price exchange rate pass-through to be 0.089. The implicit import price exchange rate pass-through is 0.911, assuming that

<sup>13)</sup> Although not reported here, the paper also ran a regression of real export price on a constant, a Korean currency crisis dummy, seasonal dummies, the lags of real export price, the contemporaneous and the lagged values of the explanatory variables, and the lags of the real import price equation. It found that the contemporaneous exchange rate pass-through was 0.855 and was statistically significant. As discussed in the introduction, the exchange rate pass-through from a reduced-form regression is biased unless all the explanatory variables are strictly exogenous.

**Table 3 Shock-specific Exchange Rate Volatility Effects on Export Volume**

|                                    | Exchange Rate Volatility Effects<br>on Korean Export Volume |
|------------------------------------|-------------------------------------------------------------|
| Output shock (Korea)               | 0.0088                                                      |
| Interest rate shock (Korea)        | 0.0256                                                      |
| Real money balance shock (Korea)   | 0.0202                                                      |
| Real exchange rate shock           | 0.0029                                                      |
| Exchange rate volatility shock     | 0.0059                                                      |
| Real export price shock (Korea)    | 0.0266                                                      |
| Export volume shock (Korea)        | 0.0135                                                      |
| Nominal money supply shock (Korea) | 0.0018                                                      |
| Output shock (U.S.)                | 0.0459                                                      |
| Interest rate shock (U.S.)         | 0.0093                                                      |
| Real money balance shock (U.S.)    | 0.0002                                                      |
| Nominal money supply shock (U.S.)  | 0.0247                                                      |

all Korean exports are sold in the United States.

### 3.3.2. The Structural and the Shock-Specific Exchange Rate Volatility Effects on Korean Export Volume

Table 3 reports a shock-specific exchange rate volatility effects on Korean export volume. It shows that the sign of shock-specific exchange rate volatility effects on the Korean export volume depends on the source of the shock. Specifically, the shock-specific exchange rate volatility effects on the Korean export volumes are positive from the Korean nominal interest rate shocks, the real exchange rate shocks, the Korean nominal money supply shocks, and the U.S. real money balance shocks.

Table 4 reports the structural exchange rate volatility effect on Korean export volume. The structural exchange rate volatility effect on Korean export volume is found to be  $-0.17\%$ , i.e., 1% increase in the exchange rate volatility decreases Korean export volume by 0.17%.

**Table 4 Structural Exchange Rate Volatility Effect on Export Volume**

|                                                             |        |
|-------------------------------------------------------------|--------|
| Structural exchange rate volatility effect on export volume | 0.0017 |
|-------------------------------------------------------------|--------|

#### 4. CONCLUSION

This paper shows how different economies of the U.S. and Korea respond to different shocks. It also shows what the shock-specific and the structural exchange rate pass-through coefficients are. Specifically, the sign of the shock-specific exchange rate pass-through on the Korean export price is always positive, irrespective of the source of the shocks. The structural exchange rate pass-through on the Korean export price is very low (less than 10%). Evidence that the exchange rate volatility increases exchange rate pass-through on the Korean export price is found. The paper shows that the sign of shock-specific exchange rate volatility effects on Korean export volume varies by different shocks. It is also found from the structural VAR that the exchange rate volatility *decreases* the volume of Korean exports. Finally, using a two-country model, the paper finds a strong evidence of a *cross-country* liquidity effect, a negative response of Korean interest rate to a U.S. money supply shock, but no strong evidence of *within-country* liquidity effects.

#### REFERENCES

- Bernanke, B. and I. Mihov, "The Liquidity Effect and Long-run Neutrality," *Carnegie-Rochester Conference Series on Public Policy*, 49, 1998, pp. 149-194.
- Blanchard, O. and D. Quah, "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review*, 79, 1989, pp. 655-673.

- Campa, J. and L. Goldberg, "Exchange Rate Pass-Through into Import Prices," *The Review of Economics and Statistics*, 87, 2005, pp. 679-690.
- Christiano, L., "Resolving the Liquidity Effect: Comment," *Review of Federal Reserve Bank of St. Louis*, 1995, pp. 55-62.
- Christiano, L. J., M. Eichenbaum, and C. Evans, "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," *Review of Economics and Statistics*, 78, 1996, pp. 16-34.
- Cushman, D. O., "The Effects of Real Exchange Rate Risk on International Trade," *Journal of International Economics*, 15, 1983, pp. 5-63.
- Cushman, D.O. and T. Zha, "Identifying Monetary Policy in a Small Open Economy under Flexible Exchange Rates," *Journal of Monetary Economics*, 39, 1997, pp. 433-448.
- De Grauwe, "International Trade and Economic Growth in the European Monetary System," *European Economic Review*, 31, 1987, pp. 781-793.
- Devereux, M., C. Engel, and P. Storgaard, "Endogenous Exchange Rate Pass-Through when Nominal Prices are Set in Advance," *Journal of International Economics*, 63, 2004, pp. 263-291.
- Halabi, C. E. and W. D. Lastrapes, "Estimating the Liquidity Effect in Post-Reform Chile: Do Inflationary Expectations Matter?," *Journal of International Money and Finance*, 22, 2003, pp. 813-833.
- Koray, F. and W. D. Lastrapes, "Real Exchange Rate Volatility and U.S. Bilateral Trade: A VAR Approach," *Review of Economics and Statistics*, 71, 1989, pp. 708-712.
- \_\_\_\_\_, "Exchange Rate Volatility and U.S. Multilateral Trade Flows," *Journal of Macroeconomics*, 12, 1990, pp. 341-362.
- Kroner, K. F. and W. D. Lastrapes, "The Impact of Exchange Rate Volatility on International Trade: Reduced Form Estimates Using the GARCH-in-Mean Model," *Journal of International Money and Finance*, 12, 1993, pp. 298-318.
- Lastrapes, W. D., "Sources of Fluctuations in Real and Nominal Exchange

- Rates,” *Review of Economics and Statistics*, 74, 1992, pp. 530-539.
- \_\_\_\_\_, “Estimating and Identifying Vector Autoregressions under Diagonality and Block Exogeneity Restrictions,” *Economic Letters*, 87, 2005, pp. 75-81.
- Leeper, E. and D. Gordon, “In Search of the Liquidity Effect,” *Journal of Monetary Economics*, 17, 1992, pp. 341-369.
- Lucas, Jr. R. E., “Nobel Lecture: Monetary Neutrality,” *Journal of Political Economy*, 104, 1996, pp. 661-682.
- Matsuura, K. and F. Takeda, “Exchange Rate Pass-through and Strategic Behavior in Japanese Imports of DRAMs,” *The Journal of the Korean Economy*, 4, 2003, pp. 345-369.
- McKenzie, M. D., “The Impact of Exchange Rate Volatility on International Flows,” *Journal of Economic Surveys*, 13, 1999, pp. 71-106.
- Pagan, A. and J. Robertson, “Resolving the Liquidity Effect,” *Review of Federal Reserve Bank of St. Louis*, 1995, pp. 33-54.
- Reimers, H. E., “Comparisons of Tests for Multivariate Cointegration,” *Statistical Papers*, 1992, pp. 335-359.
- Strongin, S., “The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle,” *Journal of Monetary Economics*, 35, 1995, pp. 463-497.