FOREIGN OUTPUT AND PRICE SHOCKS AND MACROECONOMIC ACTIVITY IN KOREA

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ABSTRACT

This paper examines the effects of foreign output and price shocks on output and the price level in Korea. The framework is a nine variable VAR model which includes output, price level, interest rate, real exchange rate, money supply, government expenditures, government debt, and foreign output and price variables. Foreign output and price effects are evaluated through computation of variance decompositions and impulse response functions. The variance decompositions indicate significant effects of foreign output on domestic output and significant effects of foreign prices on domestic output and the price level. The impulse response functions indicate positive short-run effects of foreign output on domestic output but insignificant effects on the price level while foreign price shocks have significant negative effects on output and significant positive effects on the price level for approximately two years. The results indicate the importance of including foreign shock variables when modeling the Korean economy.

I. INTRODUCTION

That foreign output and price shocks can importantly influence the domestic economy regardless of exchange rate regime is now widely recognized. The extent to which foreign

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shocks affect the pace of economic activity is, however, an empirical question. Furthermore, recent empirical studies indicate that estimates of the effects of foreign shocks on one economy often cannot be generalized even to other economies of a similar nature. For example, Lastrapes and Koray (1990) find that shocks emanating from the U.S. economy have different effects on the economies of West Germany, the United Kingdom, and France, even though these economies are importantly linked to each other. Lastrapes and Koray attribute their results to differences in institutions and the conduct of policy.

It thus appears that the impact of foreign shocks must be studied on a country-by-country basis. Most of the recent studies have focused upon the transmission of foreign shocks among developed countries; however, it is also important to understand the impact of foreign shocks on developing countries where foreign trade is often of more importance to the economy than in the case of developed countries. Accordingly, this study analyzes empirically the effects of foreign output and price shocks on macroeconomic activity in Korea. Korea is selected because of its rapid growth in recent decades and because of the critical importance of foreign trade to the Korean economy. Furthermore, despite the importance of the Korean economy, there are almost no studies of the impact of foreign shocks on the Korean economy. Kim (1987) estimated the effects of U.S. monetary and fiscal shocks within a structural model estimated over the 1973–1983 period and found substantial effects of these shocks on Korean output and prices.

The aim of this paper is to examine empirically the effect of foreign output and price shocks on output and the price level within a nine variable vector autoregressive (VAR) model of the Korean economy. Monthly data for the period May, 1973 to November, 1989 are used in the analysis. The variables included in the model are consistent with the reduced form of an aggregate demand-aggregate supply framework, where the IS-LM-BP model underlies the aggregate demand side. The model comprises output, the price level, the interest rate, the money supply, two fiscal policy variables, government spending and the stock of government debt, the real exchange rate, and two external shock variables. The latter two variables measure output and price shocks emanating from Korea's major trading partners, the United States and Japan. The sensitivity of the results to the inclusion of a proxy for oil price shocks and to the inclusion of a foreign interest rate is also examined. The impact of the foreign shocks is examined by computing variance decompositions (VDCs) and cumulative impulse response functions (CIRFs) for which standard errors are calculated using a Monte Carlo simulation approach. This study differs importantly from that of Kim (1987) by examining output and price shocks from both of Korea's major trading partners and by employing a less restrictive empirical framework.

The VAR modeling approach is employed since there is little agreement on the appropriate structural model and since few restrictions are placed on the way in which the system's variables interact in the estimation of the system. In the specification and estimation of the model, all variables are treated as jointly determined; no a priori assumptions are made about the exogeneity of any of the variables in the system at this stage of analysis. However, in the computation of the VDCs and CIRFs, some decisions about structure must be made. These decisions are discussed in Section III.

Section II discusses the data and the specification of the model while the empirical results are presented and analyzed Section III. Our conclusions are summarized in Section IV.

II. DATA DESCRIPTION AND MODEL SPECIFICATION

As noted earlier, the macroeconomic effects of foreign output and price shocks are examined within the context of a 9-variable VAR model. The model is specified and estimated using monthly data for May, 1973 to November, 1989. The period May, 1973 to August, 1975 is used as presample data to allow for lags in the stationarity tests and to generate the lags in the VAR, and the model is estimated over the period September, 1975 to November, 1989.[1] Monthly data are used based on a desire to minimize any problems with temporal aggregation (see Christiano & Eichenbaum, 1987) that might arise with the use of quarterly or annual data. Our sample begins in May, 1973 since this is the earliest date for which we can obtain our interest rate series. The end of our sample coincides with the latest data available to us at the inception of the study.

The model variables include:

1. industrial production (y) which is employed as a proxy for output;
2. the consumer price index (P) which is our measure of the domestic price level;
3. the yield on national housing bonds (r) which is used as a proxy for the long-term interest rate;
4. the narrowly defined money supply (M1) which is the monetary policy variable;
5. real government expenditures (g);
6. the par value of privately held government debt (D);
7. the real exchange rate (e);
8. a foreign output shock measure (y^*); and
9. a foreign price shock measure (P^*).

All data with the exception of that discussed below were taken from the March 1990 International Finance Statistics tape produced by the International Monetary Fund. All data except for e and r are seasonally adjusted. The use of seasonally adjusted data was required since industrial production data were available only in seasonally adjusted form.

The foreign output shock variable is measured as a weighted average of industrial production in the U.S. and Japan, and the foreign price variable is a weighted average of the wholesale price indices in the U.S. and Japan. The measures are defined as: $y^* = w_{US}y_{US} + w_{JP}y_{JP}$, $P^* = w_{US}P_{US} + w_{JP}P_{JP}$, $w_{US} = s_x(X_{US}/\Sigma X_i) + s_m(M_{US}/\Sigma M_i), w_{JP} = s_x(X_{JP}/\Sigma X_i) + s_m(M_{JP}/\Sigma M_i)$, i = U.S. and Japan. The w_{US} and w_{JP} are, respectively, Korea's trade weights with the U.S. and Japan; y_{US} and y_{JP} are, respectively, industrial production indices for the U.S. and Japan; and P_{US} and P_{JP} are, respectively, wholesale price indices for the U.S. and Japan. Weighted average output and price shock measures are employed rather than separate series for U.S. and Japanese output and price since use of separate series would have substantially reduced the degrees of freedom available for estimation. Our procedure is similar to that of Genberg, Salemi, and Swoboda (1987) who use an index of European industrial production to measure foreign output shocks in their study of the effects of foreign shocks in the Swiss economy.

The real exchange rate is a multilateral trade-weighted measure constructed in the manner outlined by Rhomberg (1976). The countries used in the construction of the exchange rate are the U.S. and Japan.[2] Since the nominal exchange rates used in the construction of this measure are the number of Korean won per unit of foreign currency and the weighted average of these nominal rates is multiplied by the ratio of the foreign price level to the Korean price level, an increase (decrease) in the real exchange rate represents depreciation (appreciation). We note that the estimation period includes the 1975–1979 period in which the nominal exchange rate was fixed and the subsequent period in which a managed float applied. We combine data from these periods for two reasons. One is that not enough data are available to estimate the model over just the fixed rate subperiod of our sample. Second, a formal stability test yielded no evidence of a structural shift after 1979.[3]

The yield on national housing bonds was selected as the proxy for the long-term rate since no other consistent series for a long-term rate is available over our sample. Our focus is upon the long-term rate rather than a short-term rate since it is generally thought that investment decisions depend more closely upon the long-term rate than the short-term rate. Measures of both monetary and fiscal policy are included in the model. As noted earlier, M1 is the monetary policy variable. Fiscal policy is captured by including real government expenditures and the par value of privately held government debt. Real government expenditures are measured as the total expenditures of the consolidated central government and are deflated by the consumer price index. This measure includes transfer payments; ideally, a series that excludes transfer payments would be preferred, but no series of this type is available monthly. The series for the par value of privately held government debt is constructed by subtracting the central bank's holdings of debt from total government debt outstanding. Total outstanding debt is from the IFS tape while central bank holdings of debt are calculated from information in the *Monthly Statistical Bulletin*, Bank of Korea.[4]

Prior to specification and estimation of the VAR, augmented Dickey-Fuller tests were employed to check for first order unit roots. These tests suggested that first differences of the logs of y, P, $M1$, g, D, e, and P^* and the first difference of the level of r should be used in specifying and estimating the model. The evidence was more ambiguous for y^*; a unit root could be rejected at the five percent level but not at the one percent level. Based upon the arguments of Engle and Granger (1987), cointegration tests were also performed for the eight variables that required differencing to achieve stationarity and then for all nine variables.[5] Since no evidence of cointegration was found, the system was estimated with the differences of y, P, $M1$, g, D, e, r, and P^* and the log level of y^*. However, since a unit root in the log level of y^* could not be rejected at the one percent level, the robustness of the results was checked by estimating a system that included the first difference of the log of y^*. The results were robust to the use of the log difference of y^* in place of the log level of y^*.

Akaike's AIC criterion was used to determine the lag length of the VAR model. Use of this criterion suggested an optimal lag of 12 months. The Q statistics indicated the absence of any serial correlation in the residuals of the model.[6]

III. EMPIRICAL RESULTS

An indicated in Section I, the effects of foreign output and price shocks on domestic output and the price level are analyzed through computation of VDCs and CIRFs which, in turn, are based on the moving average representation of the VAR model and reflect both direct and indirect effects. The VDCs show the percent of the forecast error variance for each variable that may be attributed to its own innovations and to fluctuations in the other variables in the system. Therefore, the VDC for y indicates the percent of the forecast error variance in y accounted for by y^* and P^* and the other variables in the system. This suggests that if y^* and P^* are important determinants of movements in y, they should explain a significant portion of the forecast error variance in y. Moreover, Sims (1982) has suggested that VDCs give an indication of the strength of Granger-causal relations that may exist between variables. Therefore, if y^* and P^* explain a large and significant portion of the forecast error variance of y, this could be interpreted as a strong Granger-causal relation.

The CIRFs indicate the size and direction of effect of a one-standard deviation shock to one of the system's variables on the other variables in the system. By computing CIRFs, we can examine the direction of effect of a shock to y^* and P^* on the levels of y and P. The value of the CIRF in any period is the sum of the effect of the shocks to a variable on another variable in the current and prior periods.

Since Runkle (1987) has argued that reporting VDCs and IRFs without standard errors is similar to reporting regression coefficients without t-statistics, a Monte Carlo integration procedure like that described in Doan (1990) is employed to estimate standard errors for the VDCs and CIRFs. One thousand draws are employed in the Monte Carlo procedure. For the VDCs, the estimates of the proportion of forecast error variance explained by each variable are judged to be significant if the estimate is at least twice the estimated standard error. For the CIRFs, a two-standard deviation band is constructed around the point estimates. If this band includes zero, the effect is considered insignificant.

Since the equations of the VAR contain only lagged values of the system's variables, it is assumed that the residuals of the VAR model are purged of the effects of past economic activity. Any contemporaneous relations among the variables are reflected in the correlation of residuals across equations. In this paper, the Choleski decomposition is used to orthogonalize the variance-covariance matrix. In this approach, the variables are ordered in a particular fashion, and, in this way, some structure is imposed in the computation of the VDCs and CIRFs. When a variable higher in the order changes, variables lower in the order are assumed to change. The extent of the change depends upon the covariance of the variables higher in the order with those lower in the order.

The order chosen is: y^*, P^*, M1, g, D, e, r, y, P; and is selected for the following reasons. Placement of y^* and P^* first is based on the assumption that any contemporaneous effects flow from the large economies of the U.S. and Japan to the Korean economy. Placement of the policy variables next is consistent with the familiar textbook (IS-LM-BP) treatment of aggregate demand in which current period shocks to the policy variables contemporaneously affect e, r, y, and P. We assume in this ordering that current period shocks to e, r, y, and P have no contemporaneous effect on the policy variables; this is consistent with typical policy reaction functions in which the current values of the policy variables depend only upon lagged values of domestic macro variables. Placement of e and r next is consistent with the transmission mechanism embedded in the typical formulation of aggregate demand. Finally, placement of y and P last allows these variables to respond directly and indirectly to contemporaneous shocks to all other model variables. Thus the ordering is designed to be consistent with a model in which the IS-LM-BP model underlies aggregate demand and where output and the price level respond to current innovations in domestic policy variables as well as foreign shocks.[7]

For the purposes of this paper, the critical element of this ordering is the placement of y^* and P^* first. As long as these variables are placed first, rearrangement of the other variables will not alter the estimates of the effects of y^* and P^* on these variables. The results are essentially unchanged when P^* is placed first and y^* second. All results for this ordering are well within one standard deviation of those reported in Table 1. Little is gained in the analysis of the effects of y^* and P^* by adopting the "structural" VAR approach of Bernanke (1986) if the assumption that y^* and P^* are not contemporaneously affected by the other model variables is maintained in specifying a "structural" model of the residuals of the VAR. If this assumption is maintained, any contemporaneous relations between y^* and P^* and the other variables will be due to the effects of y^* and P^* on these variables and not vice versa. This is essentially the same as in the Choleski decomposition used here. For this reason, a "structural" VAR is not estimated.[8]

The VDCs are reported in Table 1. Column (1) reports results for y^* while Column (2) reports results for P^*. The estimated standard errors are in parentheses beside the point estimates. A * indicates the point estimate is at least twice the standard error. VDCs at horizons of six, 12, 24, 36, and 48 months are shown in order to convey a sense of the dynamics of the system. Only the effects of y^* and P^* on y and P are shown in order to focus upon the variables of central interest to the paper and to conserve space. We observe that shocks to y^* have significant effects on y but small and, with only one exception, insignificant effects on P. However, shocks to P^* have significant effects on y and P.

It thus appears that foreign output and price shocks had important effects on the Korean economy over our sample. It is of interest to examine the magnitude of the effects of foreign shocks relative to the magnitude of the effects of shocks to the domestic policy variables (M1, g, and D). The relative importance is measured by the ratio $RATIOF = [FEVF/(FEVF+FEVD)]*100$. $FEVF$ and $FEVD$ are the proportions of the forecast error variance of the Korean variable explained, respectively, by the sum of the foreign shock variables (y^* and P^*) and the sum of the domestic policy variables (M1, g, and D). $RATIOF$ values are reported in column (3) of Table 1. We observe that the magnitude of the joint

Table 1. Variance Decompositions[1]

Variable	*Horizon*	*Explained by Shocks to* y^*	P^*	*RATIOF*
y	6	17.0 (4.8)*	4.7 (2.2)*	53.8
	12	15.9 (3.8)*	6.8 (2.6)*	50.2
	24	16.4 (3.9)*	9.9 (3.0)*	53.1
	36	15.1 (3.8)*	10.2 (3.4)*	50.9
	48	14.5 (4.1)*	11.3 (4.1)*	51.3
P	6	4.3 (2.4)	15.7 (5.3)*	48.9
	12	5.5 (2.5)*	19.6 (6.4)*	47.9
	24	5.4 (3.1)	20.4 (7.2)*	45.0
	36	5.6 (3.6)	18.6 (6.4)*	42.2
	48	5.6 (3.8)	18.3 (6.5)*	41.7

Notes: [1]Standard errors are in parentheses next to the point estimates. A * indicates the point estimate is at least twice the standard error. RATIOF is the ratio of the forecast error variance explained by foreign output and price shocks to the sum of the forecast error variance explained by foreign shocks and the forecast error variance explained by domestic policy variables.

effects of y^* and P^* are greater than those for the domestic policy variables for y and are quite close in magnitude for P, especially at the shorter horizons.

The VDCs indicate significant effects of y^* and P^* on the macroeconomy but give no indication of the direction of effect. This information is obtained from the CIRFs which are presented in Figure 1. In this figure, point estimates of the CIRFs are plotted with a dotted line while the solid lines represent a two standard deviation band around the point estimates. The top two diagrams present the results for shocks to y^*. Significant positive effects on the level of y are observed at horizons of one and 6–8 months, but there are no significant effects after this. No significant effects are found on the level of P. Since the VAR approach is a reduced form approach, it is difficult to make a structural interpretation of the results. The short-lived positive effects on y are consistent with an aggregate demand channel in which shocks to y^* raise exports and hence aggregate demand. Tempering this interpretation is the absence of any significant effects on P even in the short-run. This may reflect a relatively flat short-run aggregate supply curve which would allow short-run effects of demand shocks on y with little effect on P.[9]

The bottom two diagrams present the effects of shocks to P^* on the levels of y and P. The effects on y and P stand in contrast to those for y^* shocks, however. There are negative and significant effects on y and positive and significant effects on P up to the 27th month; thereafter, the effects are not significant. A shock to P^* may have effects on aggregate demand by lowering import demand and thereby raising net exports; this type of effect would tend to raise price and output. However, shocks to P^* may also reduce aggregate supply by

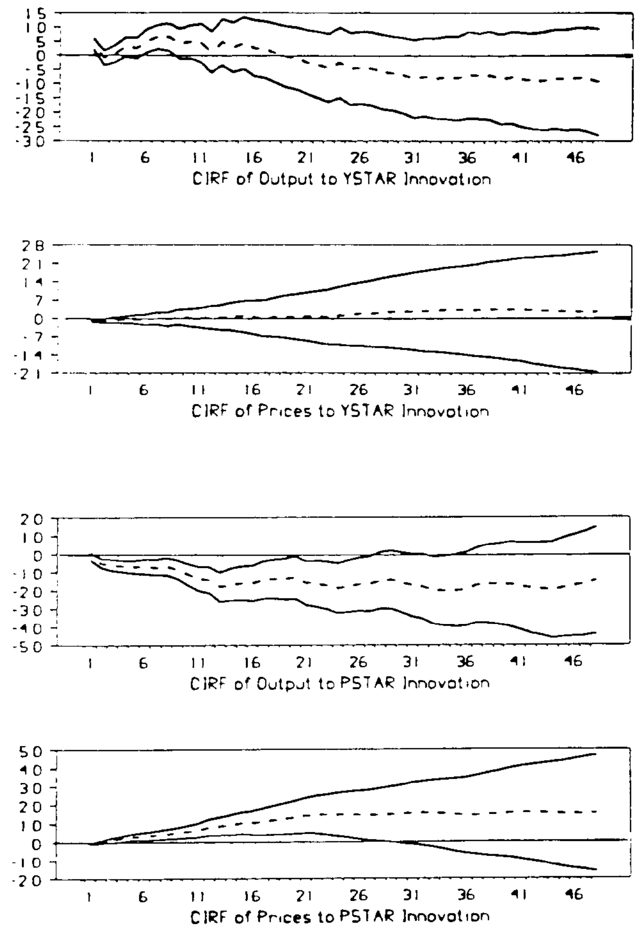

Figure 1.

raising the price of inputs to the production process. Other things equal, this would tend to reduce output and raise price. The pattern of effect on y and P suggests that, for our sample, aggregate supply effects outweigh any aggregate demand effects of shocks to P^*.

Since our sample spans a period of several substantial changes in the relative price of oil, one might argue that the external shocks (especially to P^*) may merely be proxying for the effects of shocks to the relative price of oil. The sensitivity of the results to the inclusion of a proxy for the relative price of oil was checked. An oil shock variable measured as the difference in the rate of change in the price of oil in Korea and the rate of change in the Korean CPI was added to the model.[10] The AIC criterion again suggested an optimal lag of 12 months, and VDCs and CIRFs were computed. The oil shock variable was ordered prior to y^* and P^* in the computation of the VDCs and CIRFs; this allows y^* and P^* to respond to contemporaneous shocks to the oil shock variable. The VDC results for shocks to y^* and P^*

are all well within one standard deviation of those in Table 1. Furthermore, the CIRFs for y^* and P^* display a very similar pattern and magnitude to those in Figure 1. Thus, it does not appear that the effects of y^* and P^* are merely proxying for the effects of shocks to the relative price of oil.[11]

Since Genberg, Salemi, and Swoboda (1987) found that the foreign interest rate (measured by the three-month U.S. Treasury bill rate) was important in explaining output and price in Switzerland, we checked the robustness of our results for y^* and P^* to inclusion of a foreign interest rate. In addition to the three-month U.S. Treasury bill rate used by Genberg et al., we also considered the long-term U.S. Treasury bond rate.[12] Two orderings were employed: one in which the foreign interest rate followed y^* and P^* but preceded the domestic variables and one in which the foreign interest rate preceded y^* and P^* . As before, 12 lags were employed in the model. All VDC results were within two standard deviations of those in Table 1, and all but a few were within one standard deviation. Thus inclusion of a foreign interest rate does not alter the conclusions about the effects of y^* and P^*.

The VAR as specified allows feedback with a lag from the Korean variables to y^* and P^*. It does not seem unreasonable to allow for some effect of events in the Korean economy on price and output in Japan, although one would expect such effects on the U.S. economy to be trivial. As long as there is some feedback from the Korean economy to the Japanese economy, then lagged values of the Korean variables should enter the equations for y^* and P^*. However, it is of interest to examine the effects of restricting the feedback from the Korean variables to y^* and P^* to be zero.[13] Accordingly, we specified the equations for y^* and P^* to be functions only of 12 lagged values each of y^* and P^*. The remaining equations were specified in the usual way. VDCs were computed with the same ordering as before. The effects of a shock to y^* on y (P) at horizons of six, 12, 24, 36, and 48 months were 16.5 (4.8), 18.8 (8.7), 21.6 (8.1), 20.0 (8.9), and 19.3 (9.1). All of these effects are within two standard deviations of those in Table 1, and most are within one standard deviation. The effects of a shock to P^* on y (P) at the same horizons as before are 12.2 (27.9), 16.2 (37.6), 18.5 (44.8), 17.3 (43.4), and 18.3 (42.7). With only one exception, these effects are all greater than two standard deviations from those in Table 1. Thus this specification suggests stronger effects of P^* on the Korean economy than does our basic specification. The effects of y^* are of approximately the same magnitude in both specifications although the point estimates are generally higher in the specification without lagged feedback from the Korean variables to y^* and P^*. While there may be some dispute as to which specification is preferred, VDCs for both specifications indicate important effects of y^* and P^* on the Korean economy.

IV. CONCLUSION

This paper has examined the effects of shocks to foreign output and prices on output and the price level in Korea. Unlike most studies of the effects of foreign output and prices shocks on the macroeconomy which concentrate on developed economies, this study focuses upon a rapidly growing developing economy which is heavily dependent upon foreign trade. The framework of analysis is a nine variable vector autoregressive model which includes measures of output, the price level, the interest rate, the real exchange rate, the money supply, government expenditures, government debt, and foreign output and price variables. The results are essentially unchanged when a relative oil price shock proxy or a foreign interest rate is added to the model.

The effects of foreign output and price shocks are evaluated through the computation of variance decompositions and cumulative impulse response functions. The variance decompositions indicate significant effects of foreign output on domestic output and significant effects of foreign prices on both domestic output and the price level. In fact, the joint effects of foreign shocks are of comparable magnitude to the effects of domestic policy shocks for both variables. The impulse response functions indicate positive short-run effects of foreign output shocks on the level of Korean output but insignificant effects on the price level. These effects are broadly consistent with an aggregate demand channel of influence for foreign output shocks. The impulse response functions also reveal that shocks to foreign prices have significant negative effects on the level of Korean output and significant positive effects on the Korean price level for a period of approximately two years. Thereafter the effects are insignificant. The pattern of effects of foreign price shocks on domestic price and output seem most consistent with a dominant aggregate supply channel of transmission of these effects. Finally, we stress that these results indicate the importance of including foreign shock variables when modeling the Korean economy.

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NOTES

1. In testing for stationarity, a maximum of 15 lags was considered. Since one observation is lost due to first differencing, the tests for stationarity begins in September, 1979. Data from September, 1974 to August, 1975 were then used to generate the lags for the VAR, and estimation began in September, 1975.
2. The real exchange rate is defined as:

$$e = [s_m EXCH_m + s_x(1/EXCH_x)](P^*/P)*100$$

where $s_m =$ $M^T/(M^T + X^T)$,

$s_x =$ $X^T/(M^T + X^T)$,

$EXCH_m =$ $\Sigma(M_i/\Sigma M_i)(E_{it}/E_{i0})$,

$EXCH_x =$ $\Sigma(X_i/\Sigma X_i)(E_{i0}/E_{it})$,

$M^T =$ Korea's total imports from the world market as an annual average over the periods 1973–1987, measured in U.S. dollars,

$X^T =$ Korea's total exports to the world market as an annual average, measured in U.S. dollars,

M_i = Korea's imports from country i (the U.S. and Japan) as an annual average, measured in U.S. dollars,
X_i = Korea's exports to country i (the U.S. and Japan) as an annual average, measured in U.S. dollars,
E_{it} = the nominal exchange rate as the ratio of the Korean won to currency i at time t,
E_{i0} = the nominal exchange rate as the ratio of the Korean won to currency i in the base period,
P = price index in Korea, and
P^* = foreign price level.

The first term of the equation is an import weighted index ($EXCH_m$), while the second term is the reciprocal of an export weighted index ($EXCH_x$). These two indices are weighted, respectively, by import shares (s_m) and export shares (s_x). A more detailed discussion of this measure is provided in Jin (1991).

We note that although only data from Korea's two major trading partners are used in constructing e, our measure moves over the common sample of 1973–1982 in a similar fashion to the exchange rate of Edwards (1989) who focuses upon Korea's 10 largest trade partners in 1975.

3. The test is a multivariate extension of the procedure suggested by Dufour (1980; 1982). The system was first estimated with 12 lags on each variable over the period September, 1975 to November, 1989. Dummy variables for each observation in the fixed nominal/0–1 rate period September, 1975 to December, 1979 were then added to each equation in the system, and this system was estimated over the sample September, 1975 to November, 1989. The joint significance of the coefficients on the dummy variables was tested by computing the likelihood ratio statistic

$$(T - C) \cdot \log |DR| - \log |DUR|)$$

where $|DR|$ = determinant of the variance-covariance matrix of the restricted system, $|DUR|$ = determinant of the variance-covariance matrix of the unrestricted system (the system with the dummy variables), T = number of observations from September, 1975 to November, 1989, and C = number of parameters in each unrestricted equation (161). The difference (T – C) is the small sample correction suggested by Sims (1980). The statistic is distributed as χ^2 with degrees of freedom equal to the number of restrictions (number of dummy variables in the system, 468 in this study). The marginal significance of the calculated χ^2 was 0.99. The hypothesis that the coefficients on the dummy variables jointly equalled zero could not be rejected, and hence no instability was indicated.

4. It would also be desirable to include a measure(s) of the marginal tax rate(s) since changes in distortionary taxes can affect output even if Ricardian equivalence holds. This was not done since no reliable marginal tax rate series was available.

5. The lag length for the unit root and cointegration tests was determined using the criterion suggested by Schwert (1987). Cointegration tests of the sort suggested by Engle and Yoo (1987) were performed. However, since Hansen (1990) pointed out that the power of this test, as well as the test proposed by Johansen (1988), falls substantially as the size of the system increases, Hansen's two-stage test was also employed. The power of Hansen's test is unaffected by the size of the system. Neither the Engle and Yoo nor the Hansen tests yielded any evidence of cointegration.

6. Because the optimal lag chosen was also the maximum considered, the robustness of the results was checked by estimating a 13 lag model. The results were essentially the same as for the 12 lag model. A desire to conserve degrees of freedom prevented us from checking longer lags.

7. The estimated variance-covariance matrix for the basic model is:

	y^*	P^*	*M1*	*g*	*D*	*e*	*r*	*y*	*P*
y^*	.206								
P^*	.012	.025							
M1	−.059	.007	4.05						
g	.001	−.198	2.72	76.3					
D	.244	−.085	.786	3.82	6.32				
e	−.005	−.002	.054	−.612	.156	.653			
r	3.22	−.354	24.8	42.3	−10.9	−8.09	4723		
y	.184	−.006	.816	2.56	.832	.074	13.1	1.59	
P	−.035	−.004	−.012	−.260	−.010	−.044	−2.43	−.071	.067

Each entry in the table should be multiplied by 10^{-4}.

8. Another alternative to the Choleski decomposition is recommended by Blanchard and Quah (1989). In this procedure, long-run constraints that are, in principal, consistent with alternative structural models are imposed in order to obtain estimates of the fundamental shocks. Implementation of this procedure in a model the size of ours is a formidable task and is beyond the scope of this paper.

9. As mentioned in the text, the VDC results can be interpreted as indicating the strength of any Granger-causal relations while the CIRFs can be thought of as a type of dynamic multiplier indicating how a shock today affects the path of another variable over some horizon. The VDC results for y for shocks to y^* indicate Granger-causality from y^* to y while the CIRF indicates that a shock to y^* has only a transitory positive effect on the level of y with no lasting effect. These are not inconsistent since Granger-causality does not require a non-zero long-run effect.

10. We were unable to obtain the Korean price of oil from Korean data sources. We constructed a series by multiplying the $/barrel refiner acquisition cost of imported oil in the U.S. (from Citibase) times the won/$ nominal exchange rate. The rate of change in the Korean CPI was then subtracted from the rate of change in this proxy for the Korean price of oil to obtain our measure of the relative price of oil in Korea.

11. The VDCs indicate the supply shock variable has significant effects on y but much weaker effects on P. Only at two horizons (24 and 36 months) are the effects even marginally significant for P. The point estimates of the CIRFs indicate negative effects on y and positive effects on P. The negative effects on y are significant for about six months and insignificant thereafter. For P, the CIRFs indicate only one marginally significant positive effect at a horizon of three months.

12. The interest rates were taken from Citibase. The three-month Treasury bill rate is series FYGM3 and the long-term Treasury bond rate is series FYGL.

13. We thank a referee for suggesting this specification. The model with the zero restrictions was estimated using ordinary least squares and seemingly unrelated regression, but the results were essentially identical. Only the least squares results are reported in the text.

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