Exchange Rates and the Inflation Rate

Keivan Deravi
Auburn University at Montgomery

Philip Gregorowicz
Auburn University at Montgomery

Charles E. Hegji
Auburn University at Montgomery

The paper estimates the effects of exchange rate depreciation on the price level using a vector autoregressive model of exchange rates, the price level, and money. The study estimates the model over the January 1975 to February 1990 horizon and uses variance decomposition and impulse analysis to trace the links between the above three variables. We find that exchange rates and prices are monetary phenomena, with the money supply Granger causing both variables. We also find an independent causal link from exchange rates to prices. Innovations accounting finds that the marginal contributions of money and exchange rates to the inflation rate forecast error variance are approximately equal over a period of 48 months. The contributions of both variables increase dramatically, however, when the shocks to the system are reordered. This finding suggests that some of the explanatory power of exchange rates to inflation may be due to contemporaneous monetary policy feedback. The results generally are confirmed by the impulse analysis, which indicates that a depreciated dollar leads to a higher rate of inflation over a two year period.

INTRODUCTION

A reading of the financial press suggests a belief that the underlying inflation rate is related significantly to the movement in the foreign exchange value of the dollar. (See Boyd, 1989; Passell, 1989; and Uchtelle, 1989a, 1989b.) This view has been supported by exchange rate and domestic inflation rate trends in the 1980s. The first part of the decade was associated with declining inflation and a strong dollar, while the latter part of the decade was characterized by a weaker dollar and a higher U.S. inflation rate.

While the simple statistical connection between inflation and exchange rates cannot be denied, recent research has questioned the causal nature of this relationship. For instance, Hooper and Lowrey (1979), Hafer (1989), and others argue that once the influence of domestic money supply growth has been accounted for, changes in exchange rates provide no additional explanatory power for inflation. Using a time series model, Whitt, Koch, and Rosensweig (1986) find the exchange rate to Granger cause the price level. Using a single equation approach, however, Woo (1984) finds that after adjusting for energy price increases a 10 percent depreciation in the dollar leads to only a 0.02 percent increase in the price level after one year.

Structural models that allow for the endogeneity of exchange rates also exhibit mixed results. These models generally find that allowing feedback from the price level to exchange rates increases the inflationary impact of a dollar depreciation. The magnitude of the inflationary impact of a dollar depreciation in such models, however, can differ widely. While Sachs (1985) finds that a 10 percent depreciation of the dollar may lead to only a

0747-5535/95/1600-0042 $01.00

1.67 percent permanent increase in the price level, Kahn (1987) finds the long-run impact of a 10 percent depreciation in the dollar to be a 4 percent increase in the price level.

The present paper further considers the effects of exchange rate depreciation on the price level. The paper extends the results of other studies by examining these effects using a vector autoregressive (VAR) model of exchange rates and the price level based on a monetary version of exchange rate determination. In particular, the paper develops a simple 3×3 vector autoregressive model in which the inflation rate, the exchange rate, and a monetary aggregate are modeled as depending on their own lagged past and the lagged past of all other variables. We perform the conventional VAR analysis consisting of F-tests, variance decomposition, and impulse analysis to trace the links between money, exchange rates, and inflation.

Many of the existing studies of the inflationary impact of exchange rate movements, such as Whitt, Koch, and Rosensweig (1986) and Kahn (1987), base their analysis on dynamic models that link only exchange rates and prices. The approach used in this paper is a simple theoretical extension of this analysis which acknowledges that there are underlying dynamic relationships between exchange rates and prices that operate through other variables. We have chosen money as an additional variable in the link between exchange rates and the price level because of its central role as a policy variable throughout the 1970s and 1980s.

As Hafer (1989) points out, the literature is not clear as to the precise nature in which prices, exchange rates, and money interact. Therefore, while there is consensus that excess monetary growth is inflationary, there is uncertainty, as suggested by Dornbusch (1987), about the links between exchange rates and the price level. Moreover, the work of Driskell and Sheffrin (1981), Frankel (1981), Haynes and Stone (1981), Meese and Rogoff (1983a, 1983b), Boothe and Glassman (1987a, 1987b), Wolf (1987), and Meese (1990) points to considerable uncertainty regarding the proper dynamic specification of exchange rate equations, particularly for forecasting purposes.

We therefore begin with the following premise: exchange rates and prices are at least in part monetary phenomena, but exchange rates, money, and prices interact in an unknown way as part of the same transmission mechanism. We have selected a vector autoregressive model as the estimating procedure to convey this uncertainty because VAR models impose minimal *a priori* restrictions on the system to be estimated. In most applications this amounts to the choice of the variables to be included in the system of equations and possibly their lag structure. The simultaneous equation structure of a vector autoregressive model captures the possibility that money may affect prices and exchange rates and that prices and exchange rates, in turn, may affect money, possibly through central bank intervention to stabilize the exchange rate or some other policy response.

In modeling the monetary approach to exchange rates, we purposely have chosen not to expand the system to include short- and long-term interest rates and other monetary or financial variables that might impact the behavior of exchange rates. Estimation of a small three variable vector autoregressive model based only on money, exchange rates, and prices preserves degrees of freedom. The choice of system has been based in part on a trade-off between theoretical completeness and practicality.

The system will be used to trace the dynamic links between money, exchange rates, and prices. By reordering the variables, these links will be examined both under the assumption that money is exogenous and under the assumption that money is endogenous (possibly due to contemporaneous policy response). Given these orderings, the inflationary impact of an assumed depreciation of the dollar will be examined and compared to the inflationary impact of a money supply shock. Allowing for the impact of money, its possible endogeneity, and its feedback to exchange rates and prices is a natural extension of the existing literature which only concerns the direct effects of exchange rates on the price level.

We discuss the alternative linkages between exchange rates, money, and the price level. Then we present a discussion of the vector autoregressive model to be estimated and report the estimates, variance decompositions, and impulse analyses.

In general, we find that exchange rates and prices are monetary phenomena, with the money supply Granger causing both variables. We also find an independent causal link from exchange rates to prices. The innovations accounting of the VAR finds that the marginal contributions of money and exchange rates to the inflation rate forecast error variance are approximately equal over a period of 48 months. The contributions of both variables increase dramatically when the shocks to the system are reordered. This finding suggests that some of the explanatory power of exchange rates to inflation may be due to contemporaneous monetary policy feedback. These results are also confirmed by the impulse analysis, which indicates that a depreciated dollar leads to a higher rate of inflation over a two year period.

EXCHANGE RATES, THE MONEY SUPPLY, AND INFLATION

The link between the money stock and inflation is well reported (Bresciani-Turroni, 1937; Cagan, 1956; Friedman, 1956; Friedman and Schwartz, 1963; Barro, 1978; Lucas, 1980; Attfield, Demery, and Duck, 1981). It generally is believed that money growth influences the inflation rate primarily through its effect on aggregate demand. Increases in the money stock lower interest rates and stimulate interest-sensitive spending, putting upward pressure on domestic prices. Alternatively, money may stimulate domestic demand directly through its liquidity or expectations effects. Similar portfolio effects will work in an open economy to alter the relative price of domestic currency. These exchange rate movements, in turn, may reinforce the links from money to inflation.

Exchange rate movements can influence domestic prices through their effects on aggregate supply and demand. From the supply side, exchange rates should affect prices paid by domestic buyers of imported goods directly. In general, a dollar depreciation results in higher import prices, while lower import prices result from a dollar appreciation. The strength and timing of this direct effect on domestic prices is not clear, however, given the nature of long-term contracts, the possible short-run nonprice responses of foreign firms to sizable exchange rate changes, and the relatively small proportion of imports to the overall economy.

Exchange rate fluctuations also could induce indirect supply effects on domestic prices. The potentially higher dollar cost of imported inputs associated with an exchange rate depreciation increases marginal costs and leads to higher prices on domestically produced goods. Further, import-competing firms might increase prices in response to foreign competitor price increases to improve profit margins. The extent of such price adjustments depends on a variety of factors such as market structure, the relative number of domestic and foreign firms in the market, and product substitutability. (See Dornbusch, 1987.)

The exchange rate also may affect inflation through its influence on aggregate demand. To the extent that a real exchange rate depreciation increases foreign demand for U.S. goods and services, domestic producers may increase output prices as they expand production. Further, the expansion in domestic demand and gross national product may bid up input prices and accelerate wage demands by workers seeking to maintain real wages. This wage inflation may result in further price increases by firms. The initial demand-induced rise in prices following a dollar depreciation will be augmented as these wage-price dynamics work through the economy. A more complete analysis of the possible linkages between exchange rate movements and domestic inflation is provided by Kahn (1987) and Hafer (1989).

To analyze the relative strengths of the above forces on domestic inflation, this study does not focus on the specific direct or indirect channels through which an increase in the money supply or a change in the value of the dollar may affect domestic prices. We estimate a VAR model based on the simplifying assumption that both exchange rates and prices are monetary phenomenon or, alternatively, that exchange rates, money and prices interact in an unknown way as part of the same transmission mechanism. The dynamic simulations are conducted under the assumption that, given sufficient time, all the above effects from money and or exchange rates to inflation will occur.

A VECTOR AUTOREGRESSIVE MODEL OF MONEY, THE EXCHANGE RATE AND THE PRICE LEVEL

We use a three variable VAR model, in which the variables are the nominal level of the broad money supply (M2), an exchange rate measure (R), and the Consumer Price Index (CPI). For the exchange rate we use three different prices: the trade-weighted dollar exchange rate (RAVE), the deutschemark price of a dollar (RDM), and the yen price of the dollar (RYEN). Given the above definition of the exchange rate, an increase in value indicates dollar appreciation.

The broad measure of the money supply is included in the model as representing one current Federal Reserve policy variable. The price level of output is measured by the CPI. The analysis uses a trade-weighted average of the dollar, as well as two major bilateral exchange rates, the German mark and Japanese yen. We select these two exchange rates because they are the dominant world currencies next to the dollar and because West Germany and Japan were major trading partners of the United States during the 1980s. All data were obtained from the Citibase database.

A VAR model using the above variables can be written as:

$$(1) \begin{bmatrix} M2 \\ R \\ CPI \end{bmatrix} = \begin{bmatrix} a_{11}(L) & a_{12}(L) & a_{13}(L) \\ a_{21}(L) & a_{22}(L) & a_{23}(L) \\ a_{31}(L) & a_{32}(L) & a_{33}(L) \end{bmatrix} \begin{bmatrix} M2 \\ R \\ CPI \end{bmatrix} + \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix}$$

Except for a constant a_i and disturbance term e_{jt}, equation (1) models the M2 money stock, exchange rate, and CPI as functions of their own lagged past and the lagged past of all other variables. In the present model, the degree of lag $a_{ij}(L)$ of all variables entering each equation is equal. Although zero restrictions on the lag coefficients $a_{ij}(L)$ are possible, no such restrictions are assumed in the above model. We proceed in this manner in order to impose the minimum theoretical structure on the model, yet retain the assumption that both exchange rates and the CPI are monetary phenomena. We estimate the M2 money stock in the above form to allow for monetary policy feedback from both the CPI and the exchange rate.

We estimate the model using monthly data from January 1975 to February 1990. The sample includes most of the period of floating exchange rates since the Bretton Woods Agreement.

Standard vector autoregressive procedures require that the underlying stochastic processes are stationary (that is, invariant with respect to time). If they are not stationary, the F-statistics on which the significance of the regression estimates are based will be biased. A standard procedure used to test for stationarity is an augmented Dickey-Fuller test (Fuller, 1976; Dickey and Fuller, 1979). The procedure consists of regressing a variable against its own value lagged one period. If the coefficient on the lagged value is not significantly different than one, the model requires differencing to achieve stationarity. Based on these tests, we estimate the model in first difference form over the entire sample period.[1]

Variables are expressed in logs, so that first differences represent percentage changes. This form is particularly useful because the price variable in the estimated model directly measures the inflation rate.

The model empirically determines the lag structure, using Akaike's (1973) criterion for an optimal length lag. We estimate the model under assumptions of alternative length lags and construct the final prediction error (FPE) test statistic

$$(2)\ FPE(k) = \frac{(T+k)\sigma^2}{(T-k)}$$

from the sample size T and residual variance σ^2 for each estimated lag k. We estimate the VAR model using the value of k that minimizes this final prediction error criterion. This procedure results in a lag structure of 13 months.[2]

Because a vector autoregressive model is estimated under the assumption that each variable depends on all other variables, the reduced form coefficients cannot be interpreted as multipliers, as would be the case with a structural econometric model. Due to the difficulty in interpreting estimated reduced form VAR coefficients, these coefficients will not

---

[1] As suggested by Granger (1986), Engle and Granger (1987), and Engle and Yoo (1987), for the estimated system to be able to make independent predictions from each variable, there must be no underlying stochastic trends between variables. To check for such cointegration, we test the residuals obtained from regressing each variable (expressed in levels) against each other variable, pair by pair, using an augmented Dickey-Fuller test (Fuller, 1976; Dickey and Fuller, 1979). We find no cointegration, suggesting the model can be estimated in first difference form without including the lagged level of any variable in any of the equations.

[2] To check for robustness of the lag structure, we also determine the optimal length lag using the procedure of Schwarz (1978). This approach again indicates a 13 month lag in all variables.

be reported. The analysis will concentrate instead on three standard types of experiments in the VAR framework.

First, we consider F-tests for block exogeneity. These are tests of Granger causality (Granger, 1969). By definition, the series X is said to Granger cause Y if the addition of X to a regression of Y on its own lagged past adds to the explanatory power of Y. To apply this definition in our model, the group of lag coefficients for a variable in any one of the equations is constrained to zero. An F-statistic can be computed to test whether the residual variance of the equation estimated with the variable excluded is large relative to the residual variance of the equation in its full form. If so, the lag structure of the excluded variable adds to the explanatory power of the equation.

The limitation of the F-tests for exogeneity are that they require the entire lag structure of a variable to be omitted from an equation to test for the variable's significance. They are static, therefore, in sense that they give the same weight to all lagged observations of the omitted variables.

As Sims (1980) suggests, a more robust test of the dynamic contribution of a variable is variance decomposition. This involves transforming the system into its moving-average representation and then decomposing the system's estimated variance-covariance matrix to obtain a similar covariance matrix for a vector of orthogonal innovations or shocks estimated from the data. Our analysis considers two such decompositions. Given these decompositions, the dynamics of the innovations in the variables can be traced over time to account for the total amount of system variation attributable to each of the shocks.

Finally, the paper traces the responses of the system to the innovations using impulse analysis. This analysis involves shocking the system's disturbances and tracing the sign and magnitude of the system's response to the shocks over time. If the assumed theory is correct, a correctly constructed vector autoregressive model of the link between exchange rates and the price level should demonstrate that an assumed depreciation in the exchange rate leads to inflation.

EMPIRICAL RESULTS

The results of the F-tests and variance decompositions are reported in Tables 1 and 2. The F-tests are aimed at addressing two questions. First, are exchange rates and prices monetary phenomena? Second, are there independent causal links from exchange rates to the inflation rate? The variance decompositions compute the percentage of forecast error variance in the inflation rate to each of the system's variables. This computation gauges the relative importance of the variables in the system for predicting inflation.

Table 1 reports the results of the F-tests. The hypothesis to be tested is that the stock of M2 money Granger causes both the exchange rate and the CPI. These tests are reported for all three exchange rate measures. The bottom two equations in the table are of particular interest, because they report the results when exchange rates and the CPI are the dependent variables. For the exchange rate equations, the results show a significant temporal ordering from money to the exchange rate for all three foreign exchange measures. The M2 regressor is significant at the 5 percent level in all three equations, suggesting exchange rates are a monetary phenomenon. For the CPI equation, similar, but somewhat

Table 1—F-Tests For Exogeneity of Variables

Dependent Variable	Independent Variables	Coefficients	RAVE	RDM	RYEN
M2	M2	a11(L)	6.23***	6.44***	6.42***
	R	a12(L)	1.88**	1.85**	2.28***
	CPI	a13(L)	1.47	1.38	1.59*
R	M2	a21(L)	1.78**	2.02**	2.12**
	R	a22(L)	1.22	0.87	3.39***
	CPI	a23(L)	1.16	1.12	1.12
CPI	M2	a31(L)	1.59*	1.52*	1.51*
	R	a32(L)	2.04**	1.83**	2.24**
	CPI	a33(L)	17.91***	17.40***	17.75***

M2 = Broad monetary aggregate measure
R = Exchange rate measure for estimated equation
CPI = Consumer Price Index
RAVE = Trade-Weighted Average of U.S. dollar
RDM = Deutschemark price of U.S. dollar
RYEN = Yen price of U.S. dollar

Source: All data are obtained from Citibase Data Base. Sample Period January 1975 to February 1990.

*** Significant at 1 percent
** Significant at 5 percent
* Significant at 10 percent

weaker, results are obtained. The money supply is significant at the 10 percent level in the CPI equation across all three foreign exchange measures.

The table also shows a significant temporal ordering from exchange rates to prices. The exchange rate (R) is significant at the 5 percent level in the CPI equation across all three foreign exchange measures. Moreover, the explanatory power of the exchange rate in the price equations is approximately equal to that of the money stock. These findings are consistent with the popular notion that fluctuations in the value of the dollar contribute to changes in the price level.

A more precise measure of the extent to which the price level depends on the money stock and exchange rate can be established through variance decomposition and dynamic simulation. Accordingly, we disturb the estimated system by one standard deviation of each variable. Given these disturbances, we decompose the forecast error variance (FEV) of the inflation rate into the proportion attributable to each of the random shocks. The results of this innovations accounting are reported in Table 2. The table displays the inflation rate's forecast error variance for five alternative time horizons, ranging from three to 48 months in the future, and for all three exchange rate measures. The forecast error variances also are reported for the variance decompositions for two alternative orderings of the system's variables. The use of these decompositions allows for a more clear cut examination of the contribution of a dollar depreciation to inflation.

For both methods, we estimate the system with the money supply equation stacked over the exchange rate equation stacked over the price level equation. To obtain the variance decompositions from this system, the first method assumes that the money supply is the primary driving variable in the system and is exogenous. Under this assumption,

Table 2—Proportion of Variance of CPI Attributable to Each Shock (Reported For Alternative Time Horizons)

	Ordering 1				Ordering 2		
Time Horizon	M2	R	CPI		M2	R	CPI
3 Months	1.1	5.8	93.1	RAVE	7.0	16.6	76.4
12 Months	6.3	8.2	85.5		25.3	34.2	40.4
24 Months	7.8	9.4	82.8		27.8	37.0	35.2
36 Months	8.5	10.6	80.9		28.0	39.7	32.2
48 Months	9.0	11.1	79.9		28.1	41.1	30.8
3 Months	1.3	5.9	92.8	RDM	27.3	37.3	35.3
12 Months	5.9	7.7	86.4		42.7	47.1	10.2
24 Months	6.9	9.1	83.9		43.7	47.9	8.3
36 Months	7.5	10.1	82.4		43.5	49.1	7.4
48 Months	7.8	10.5	81.6		43.4	49.6	6.9
3 Months	.7	6.5	92.8	RYEN	15.5	30.5	53.9
12 Months	4.4	11.4	84.2		39.4	45.9	14.7
24 Months	5.8	11.3	82.8		42.1	46.9	11.0
36 Months	7.2	11.5	81.3		40.9	48.6	8.5
48 Months	8.2	11.3	80.5		43.4	49.3	7.3

M2 = Broad monetary aggregate measure
R = Exchange rate measure for estimated equation
CPI = Consumer Price Index
RAVE = Trade-Weighted Average of U.S. dollar
RDM = Deutschemark price of U.S. dollar
RYEN = Yen price of U.S. dollar

Source: All data are obtained from Citibase Data Base. Sample Period January 1975 to February 1990

*** Significant at 1 percent
** Significant at 5 percent
* Significant at 10 percent

the money supply is shocked first to obtain the forecast errors generated by the money supply equation. Given this monetary impulse, the forecast error variances generated by the remaining equations are computed by disturbing the money supply first and sequentially disturbing the other variables to obtain the residual variance due to their innovations. By this procedure, the money supply equation becomes only a function of its own shock, while the price equation depends on shocks to money, exchange rates, and prices. These results are reported in Table 2 under the heading Ordering 1.

The alternative ordering is consistent with the view of an endogenous money supply, possibly due to a contemporary policy-induced response to exchange rates and prices. For this alternative ordering, we shock the price level first and calculate its forecast error variance. Given this impulse, we generate the forecast error variances in the remaining equations by disturbing the price level first and sequentially disturbing the other variables to obtain the residual variance due to their innovations. In this decomposition, the price level becomes only a function of its own shock, while the money supply equation contemporaneously depends on all three disturbance terms. The forecast error variances for the CPI equation for this decomposition are reported under the heading Ordering 2 in Table 2.[3]

[3] Both variance decompositions are obtained using subroutines contained in the *Regression Analysis of Time Series* (RATS) statistical package.

The table indicates a number of sources of variation in the inflation rate. First, assuming the money supply is exogenous as in Ordering 1, inflation is only weakly a monetary phenomenon. Although the contribution of M2 to the CPI's forecast error variance increases over the 48 month horizon for all three exchange rates, it explains no more than 9.0 percent of this variation. Second, under Ordering 1 there are independent, although weak, effects of exchange rates on inflation. Similar to M2, the contribution of all three exchange rates to the CPI's forecast error variance increases over the 48 month horizon, but explains about 11 percent of this variation which supports the idea of independent exchange rate effects on inflation. These results are consistent with the F-test results in the price equation reported in Table 1.

The results of Ordering 2 suggest that allowing for an endogenous money supply through the joint contemporaneous interaction of the money and exchange rates dramatically increases the power of both variables in explaining inflation's forecast error variance. The percent of the forecast error variance of the CPI explained by its own past decreases over time under Ordering 1, but remains in the vicinity of 80 percent after 48 months. For Ordering 2, this decrease in forecast error variance is much more dramatic, declining to 30.8 percent for the RAVE equation and declining to approximately 7 percent after 48 months in the other two exchange rate equations. The explanatory power of M2 is correspondingly increased. After 48 months M2 explains 28.1 percent of inflation's forecast error variance for the RAVE equation and 43.4 percent of the forecast error variance in the other two exchange rate equations. A similar increase in explanatory power is obtained for the exchange rates. RAVE explains 41.1 percent of CPI's forecast error variance after 4 years, compared with 11.1 percent for Ordering 1. For the other two exchange rate equations these percentages reach a maximum of 49 percent under Ordering 2.

Although tentative, the variance decompositions of the price equation point to two broad conclusions. First, if inflation is a monetary phenomenon, independent foreign exchange effects play a much larger role for predicting inflation than previously was thought. Moreover, allowing for the contemporaneous correlation between money and exchange rate innovations increases the influence of both exchange rates and money on prices. The source of this interaction is not clear, but it is consistent with the view that endogenous monetary responses in the foreign exchange market play some role in inflation dynamics.

For the final experiment we measure the direction and magnitude of the impact of the innovations on the CPI using impulse analysis. In performing this exercise, we restrict the analysis to innovations in the exchange rate because this variable has received the most attention in the literature. Along these lines, we shock the exchange rate variable by one standard deviation and calculate the CPI's response to this impulse over a period of 48 months. We perform this exercise for both alternative variance decompositions and for all three exchange rates. The results are presented in Figures 1 to 3. The impulse responses represent deviations about the estimated mean inflation rate over the 48 month horizon for each approach. The responses are scaled in terms of percentages of one standard deviation of the first period's CPI response for Ordering 2. Using this scaling allows a comparison of the relative magnitudes of the impulse responses between the two approaches.

As expected, in all three cases the graphs show an overall increase in the inflation rate in response to an assumed dollar depreciation. The results confirm the conclusion

Figure 1—Inflation's Dynamic Response to a Shock to the Weighted Average Exchange Rate (RAVE) (January 1975 to February 1990)

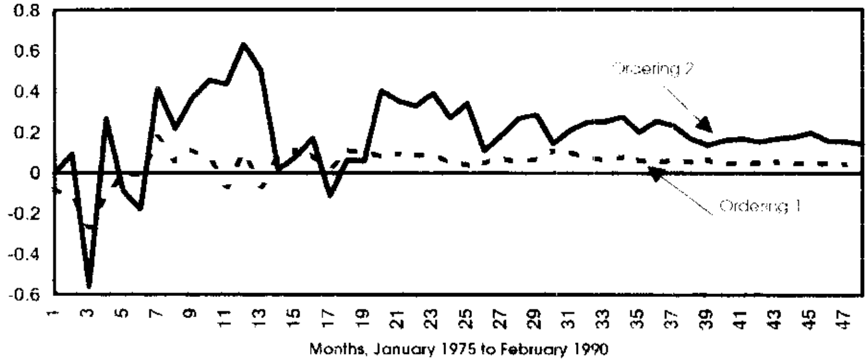


Figure 2—Inflation's Dynamic Response to a Shock to the Deutschemark (RDM) (January 1975 to February 1990)

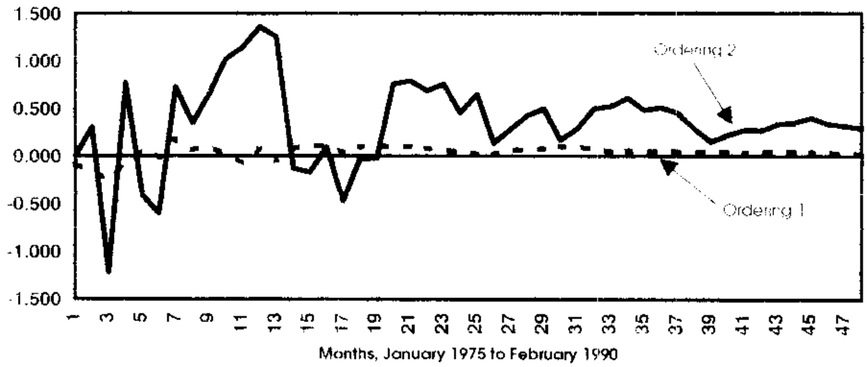
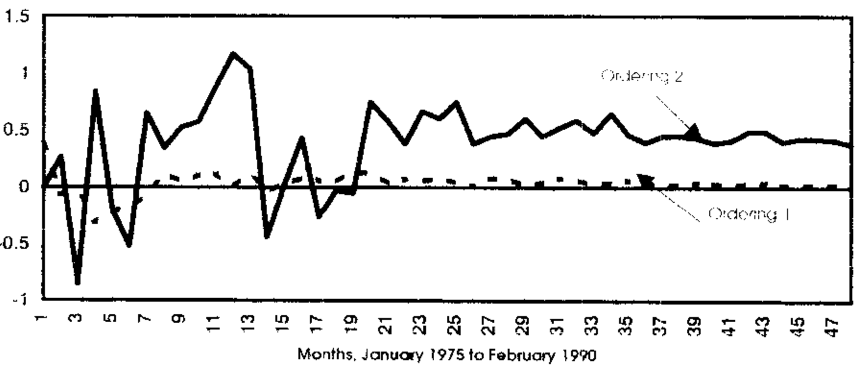


Figure 3—Inflation's Dynamic Response to a Shock to the Japanese Yen (RYEN) (January 1975 to February 1990)



obtained from the variance decomposition. In all the three cases Ordering 2 results in stronger price responses to an innovation in the exchange rate. In the case of RAVE, the mean CPI response for Ordering 2 is 4.4 times greater than the price response for Ordering 1. For RDM and RYEN, the mean CPI responses are 8.3 and 11.5 times larger for Ordering 2.[4]

Not only are the impulse responses in Ordering 2 stronger, but they also persist longer than the responses under Ordering 1. For Ordering 1, the CPI response reaches a maximum at about the 8th month and fades to zero quickly afterward. For Ordering 2, the price response peaks out at the 12th month, stabilizes at a positive level after 20 months, and continues through the 48th month. This horizon is also somewhat longer than that obtained by Kahn (1987), who finds that an exogenous exchange rate depreciation results in a CPI inflation rate that converges to zero within the third year after the shock.

One possible explanation for these results is policy-related, and based on the assumption that the Federal Reserve has the stability of the dollar as a policy objective.[5] Under these conditions, a depreciation in the dollar may lead to an immediate decrease in the money supply to raise interest rates and appreciate the dollar to its former levels. If the Federal Reserve offsets these short-term money supply decreases with future monetary injections, one result could be persistent inflation over the longer run.

CONCLUSIONS

The above tests lead to three general conclusions. First, changes in exchange rates lead to changes in the general price level and inflation, even when one accounts for the effects of the money supply on the price level. Second, the explanatory power of these exchange rate effects on the inflation rate are comparable in size to the predictive power of monetary shocks. This somewhat surprising finding is robust across alternative variance decompositions. A final conclusion is that the dynamic response to shocks is relatively responsive to alternative variance decompositions. Assuming a temporal ordering in the impulse vector consistent with a monetary approach to exchange rates while simultaneously allowing for contemporaneous correlation between the monetary and exchange rate impulses increases the predictive power of both responses. Moreover, it increases both the magnitude and length of the impulse response of the inflation rate to a dollar depreciation.

The results are limited by the VAR framework chosen. The use of a simple monetary model of exchange rates and prices is based on consistency with previous empirical work and on tractability. Future research should test for the robustness of these results within a larger VAR system that would allow for the possibility of examining monetary-fiscal policy interaction and its effects on exchange rates and prices, as well as for real sector effects on exchange rates and inflation. Enlarging the system complicates the identification procedure, however, and is beyond the scope of the current paper. Until such research

---

[4] The smaller CPI response for RAVE is expected. By construction, RAVE is a weighted average and more stable than the other two alternatives. Consequently, its innovations are smaller and should produce smaller inflation responses.

[5] The performance of the dollar occasionally has been mentioned as a policy objective in the Federal Open Market Committee Minutes throughout the sample period and consistently since 1986.

is undertaken, the popular notion that an exchange rate depreciation has inflationary consequences retains some empirical validity.

REFERENCES

1. Akaike, H., "Information Theory and the Extension of the Maximum Likelihood Principle," in B.N. Petrov and F. Csaki (eds.), *2nd International Symposium on Information Theory* (Budapest: need publisher, 1973).

2. Attfield, C.L.F., D. Demery, and N.W. Duck, "A Quarterly Model of Unanticipated Monetary Growth, Output and the Price Level in the U. K.," *Journal of Monetary Economics*, 8 (November 1981), pp. 331-350.

3. Barro, Robert J. "Unanticipated Money, Output and the Price Level in the United States," *Journal of Political Economy*, 86 (August 1978), pp. 548-580.

4. Boothe, P. and D. Glassman, "Comparing Exchange Rate Forecasting Models," *International Journal of Forecasting*, 3 (1987a), pp. 65-79.

5. Boothe, P. and D. Glassman, "Off the Mark: Lessons for Exchange Rate Modeling," *Oxford Economic Papers*, 30 (1987b), pp. 443-457.

6. Boyd, John, "Economic Beat," *New York Journal of Commerce* (February 24, 1989).

7. Bresciani-Turroni, Costantino, *The Economics of Inflation* (London: Allen & Unwin, 1937).

8. Dickey, David A. and Wayne A. Fuller, "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association* (1979), pp. 427-431.

9. Cagan, Phillip D., "The Monetary Dynamics of Hyperinflation," in Milton Friedman (ed.), *Studies in the Quantity Theory of Money* (Chicago: University of Chicago Press, 1956).

10. Dornbusch, Rudiger, "Exchange Rates and Prices," *American Economic Review*, 77 (March 1987), pp. 93-106.

11. Driskill, R. and S. Sheffrin, "On the Mark: Comment," *American Economic Review*, 71 (1981), pp. 1068-74.

12. Engle, Robert F., and C.W.J. Granger, "Co-Integration and Error Correction Representation, Estimation, and Testing," *Econometrica* (March 1987), pp. 255-276.

13. Engle, Robert F., C.W.J. Granger, and Byung Sam Yoo, "Forecasting and Testing in Co-Integrated Systems," *Journal of Econometrics* (1987), pp. 143-159.

14. Frankel, Jeffrey A., "On the Mark: Comment," *American Economic Review*, 71 (1981), pp. 1075-1082.

15. Friedman, Milton, "The Quantity Theory of Money—A Restatement," in Milton Friedman (ed.), *Studies in the Quantity Theory of Money* (Chicago: University of Chicago Press, 1956).

16. Friedman, Milton, and Anna J. Schwartz. *A Monetary History of the United States, 1867 - 1960* (Princeton, NJ: Princeton University Press, 1963).

17. Fuller, W.A., *Introduction to Statistical Time Series* (New York: John Wiley and Sons, 1976).

18. Granger, C.W.J., "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica*, 37 (July 1969), pp. 424-438.

19. ______, "Developments in the Study of Co-Integrated Economic Variables," *Oxford Bulletin of Economics and Statistics* (1986), pp. 213-228.

20. Hafer, Richard W., "Does Dollar Depreciation Cause Inflation?" *Federal Reserve Bank of St. Louis Review*, 71 (July/August 1989), pp. 16-28.

21. Haynes, S.E., and J.A. Stone, "On the Mark: Comment," *American Economic Review*, 71 (1981), pp. 1060-1067.

22. Hooper, Peter, and Barbara R. Lowrey, "Impact of the Dollar Depreciation on the U.S. Price Level: An Analytic Survey of Empirical Estimates," *Staff Study 103*, Board of Governors of the Federal Reserve System (April 1979).

23. Kahn, George A., "Dollar Depreciation and Inflation," *Federal Reserve Bank of Kansas City Economic Review* (November 1987), pp. 32-49.

24. Lucas, Robert E., Jr., "Two Illustrations of the Quantity Theory of Money," *American Economic Review*, 70 (December 1980), pp. 1005-1014.

25. Meese, Richard, "Currency Fluctuations in the Post-Bretton Woods Era," *Journal of Economic Perspectives*, 4 (Winter 1990), pp. 117-134.

26. Meese, Richard, and Kenneth Rogoff, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out-Of-Sample?" *Journal of International Economics*, 14 (February 1983a). Need page numbers.

27. Meese, Richard, and Kenneth Rogoff, "The Out-Of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" in Jacob Frenkel (ed.), *Exchange Rates and International Macroeconomics* (Chicago: University of Chicago Press, 1983b), pp. 67-105.

28. Passell, Peter, "Inflation is Looking Like It's Going to Cost," *New York Times* (March 5, 1989).

29. Sachs, Jeffrey A., "The Dollar and the Policy Mix: 1985," *Brookings Papers on Economic Activity*, (1: 1985), pp. 117-185.

30. Schwarz, G., "Estimating the Dimension of a Model," *Annals of Statistics* (1978), pp. 461-464.

31. Sims, Christopher A., "Macroeconomics and Reality," *Econometrica*, 48 (January 1980), pp. 1-48.

32. Uchtelle, Louis, "Dollar Weakness a Crucial Factor in Inflation's Rise," *New York Times* (March 1, 1989a).

33. ________, "A Shaky Lid on an Inflation Threat," *New York Times* (March 12, 1989b).

34. Whitt, Joseph A., Jr., Paul D. Koch, and Jeffrey A. Rosensweig, "The Dollar and Prices: An Empirical Analysis," *Federal Reserve Bank of Atlanta Economic Review*, (October 1986), pp. 4-18.

35. Wolff, Christian P., "Time Varying Parameters and the Out-Of-Sample Forecasting Performance of Structural Exchange Rate Models," *Journal of Business and Economic Statistics*, 5 (1987), pp. 87-97.

36. Woo, Wing T., "Exchange Rates and the Prices of Nonfood, Nonfuel Products," *Brookings Papers on Economic Activity*, 2 (1984), pp. 511-530.