Impacts of monetary and real factors on the US dollar in identifiable VAR models*

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The importance of monetary forces is compared with that of real factors in the determination of the value of the US dollar exchange rate. Impulse response analysis and forecast variance decomposition are carried out within an identifiable vector autoregression model. Identification is obtained through the use of an eclectic asset model of exchange rate determination. Real factors (related to current account) and monetary forces (operating through the money/financial markets) were both quite relevant to explain the US dollar exchange rate behavior during the last two decades.

1. Introdution

There have been major changes in the international economy over the last 20 to 25 years. Two of these were of major importance in terms of the effectiveness of macroeconomic policies of individual countries. The first was the emergence of a well integrated international capital market starting in the mid-1960's. The second major change was the breakdown of the Bretton Woods fixed exchange rate system and the shift to a system of bloc-floating exchange rates in 1973.

Since the exchange rate is the relative price of one country's currency in terms of other countries' currencies, the changes in the international capital markets and in the exchange rate system brought about substantial interdependence among macroeconomic policies of the major developed

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countries. The failure to create the necessary institutional arrangement based on that interdependence may explain, at least in part, the wide oscillations of exchange rates and interest rates, and also the patterns of the worldwide economic cycles, in the last 20 years. For instance, from 1976 to 1980, the US dollar exchange rate depreciated by about 20%; from 1980 to 1985 it appreciated by 60% and then depreciated again by more than 30% until 1987. At the same time, the US dollar short-term yearly interest rates increased from 5% in 1976 to 12% in 1980 (and to 14% in 1981) and decreased again to 6% in 1987. The economic cycles also became interrelated, as the worldwide inflation of 1973/74 and 1979/80 and recession of 1975/76 and 1981/83 clearly indicate.

During the seventies and eighties the exchange rate has exhibited a rather unstable pattern as it moves to equilibrate worldwide demand for and supply of stocks of assets within the well integrated capital market. Large current account deficits and surpluses have been evidence of its slow adjustment, while capital account rapidly adjusts to accomodate available assets to desired holdings through exchange rate movements.

In this paper we intend to compare the importance of monetary or financial forces with that of real forces to explain the behavior of the US dollar exchange rate. Special emphasis is given to the role of exchange rate as the price of an asset; as such its value is hypothesized to be associated with the ratios of money supplies, outputs, expected inflation rates, and accumulated trade balances in addition to interest rate differentials between the US and the other countries' average.

Thus we estimate the proportion of the exchange rate forecast error variance atributable to monetary and real shocks and the response of exchange rate to these shocks over a given period of time. Vector autoregression techniques are used as the estimation procedure. Contrary to what has been done previously in the literature (see Meese & Rogoff, 1983, for a collection of estimation procedures), special efforts are made in order to obtain identifying restrictions based on economic theory so as to circumvent the criticisms that have been associated with the use of these techniques.

In the next section we present a theoretical model and the empirical procedures. The results of our analyses are presented in the third section. The paper ends with the conclusions and some final remarks.

2. The theoretical model and empirical approach

2.1 The empirical approach

The role of monetary and real factors in exchange rate markets will be empirically analyzed within the multivariate time series model known as

Vector Autoregression (VAR). As forescasting tools, VAR models are recommended for allowing "complete flexibility and generality (except for the linearity assumption) in specifying the correlations between future, present and past realizations of the system variables" (Cooley & LeRoy, 1985, p. 286). However, VAR models have been used also for other types of analyses which have been under serious criticism recently (Cooley & LeRoy, 1985). One of these analyses is the so-called Innovation Accounting by which the proportion of each variable's forecast error is attributed to innovations in each variable. Another application considered incorrect is the Impulse Response Analysis designed to determine the response of each variable to innovation in the others. A third invalid application is Policy Analysis based on forecasts conditional on different values of policy variables taken as exogenous by using the Granger and Sims causality tests.

Innovation Accounting and Impulse Response Analysis have been criticized because these are techniques which have been employed under very restrictive identifying assumptions. More specifically, the system of variables is assumed to be structurally recursive, the ordering of the recursiveness being unknown. Policy Analyses by VAR models, on the other hand, are considered invalid because the procedure to test the exogeneity of the policy variables does not correspond to the conventional concept of predeterminedness of these variables. The latter is the relevant concept for policy analysis and has to be established by assumption and not by empirical testing. Again this is a problem of establishing meaningful identifying restrictions for the multivariate system. Such meaningful restrictions have to be sought in the relevant economic theory (Leamer, 1985; Sims, 1986).

Several alternative procedures to identify VAR models have been recently devised (Blanchard & Watson, 1984; Bernanke, 1986; Sims, 1986; Mason, 1985; Fackler, 1988). The choice of the appropriate procedure largely depends on the specific hypotheses made about the structural model to be estimated.

In order to identify our VAR models we follow Orden and Fackler (1989) and concentrate all the identifying restrictions on the matrices of contemporaneous interactions for which theories provide clear guidance; no restrictions are imposed on lagged values of the variables under the assumption that these past values are known to economic agents and, therefore, may be used to form expectations. So in the general representation:

$$A(0)\,Y(t) = \sum_{s=1}^{n} A(s)Y(t-s) + B_0 v(t) \tag{1}$$

we make $B_o = I$ and assume $v(t)$ to be a vector of orthogonal shocks. The matrix $A(O)$, needed to obtain the reduced form, is specified according to economic theory. First we estimate the reduced form:

$$Y(t) = \sum_{s=1}^{n} A\,(0)^{-1} A\,(s)\, Y(t-s) + A\,(0)^{-1} v\,(t) \tag{2}$$

by ordinary least squares (OLS) and obtain the reduced form residuals:

$$u(t) = A(0)^{-1} v(t) \tag{3}$$

and the covariance matrix estimated by $\mathrm{Cov}[u(t)] = \Omega$, which in the second stage is used to estimate $A(0)$. Since in Ω there are $k(k+1)/2$ free parameters, this is the number of free parameters that can be estimated in $A(0)$ and B_o. These two matrices are jointly formed by $2k^2$ parameters, so that we must place

$2k^2 - \dfrac{k(k+1)}{2} = \dfrac{3k^2 - k}{2}$ restrictions in the two matrices. Since we make B a unitary matrix and A is assumed to have a unitary diagonal, there remains $k(k-1)/2$ restrictions to be imposed on $A(0)$. This, of course, is the minimum number of restrictions to assure identification. A model with a higher number of restrictions will be overidentified.

We use the Bernanke (1986) procedure of the RATS program which starts from (3) where $A(0)$ is assumed to have only 1's in the diagonal. Therefore, in the second stage, the log of the likelihood function to be maximized is:

$$\begin{gathered} lnL = -(T.k/2)\, ln(2\pi + T.ln|A(0)| - (1/2).ln\,|D| - \\ (T/2) tr(D\,A(0)\,\Omega\,A(0)') \end{gathered}$$

since we assume that $v(t)$ is multinormally distributed with $D = \mathrm{Cov}[v(t)]$ being the diagonal covariance matrix of the model's disturbances. The reduced form covariance matrix Ω has been substituted for T times the matrix of cross residual products. The first order conditions are quadratic and are solved using Newton's method. Fackler (1988) presents a detailed discussion of the steps involved in the maximization process for a more general framework.[1]

[1] "One main advantage of the VAR model is that the identifying restrictions allow the reduced form parameters to be estimated separately from the contemporaneous coefficient matrices, A and B. The reduced form coefficients can be estimated efficiently using OLS. Maximum likelihood estimates of A and B conditional on the values of the reduced form coefficients then can be estimated. This two-stage estimation approach yields FIML coefficient estimates even if the model is overidentified because the identifying restrictions

Having estimated the matrices A and D we proceed to obtain the analysis of (a) the impulse responses and (b) the decomposition of the variance of the forecast errors. The vector autoregressive model may be solved so that:

$$Y(t) = \sum_{s=0}^{\infty} C(s)\, u(t-s)$$

Using (3) we have:

$$Y(t) = \sum_{s=0}^{\infty} C(s)\, A(0)^{-1} D^{\frac{1}{2}} e(t) \tag{4}$$

which can be used to obtain effects of the unitary shocks in $e(t)$, which once multiplied by D as in (4) are equivalent to one-standard-deviation shocks in the disturbances.

The variance decomposition procedure is based on (4) ignoring the effects of the sampling errors with the coefficient estimates.

The theoretical model presented bellow will help in establishing meaningful contemporaneous restrictions in our empirical model.

2.2 The theoretical model

Following the breakdown of the Bretton Woods system in 1973, international economics theorists have concentrated efforts towards the development of models of exchange rate determination under the new flexible system involving the major developed countries. Basically, the exchange rate has since then been taken as an asset price and as such moves to equilibrate international supply of and demand for stocks of assets in a world where financial capital flows became increasingly important when compared to the flows of goods and services traded among countries. A model synthesizing the several developments which have taken place recently is presented in this section.

Three major empirical questions related to the exchange rate markets have concerned economists during the 1970's. The first was the observed tendency of rising nominal interest rate to be associated with an increasing value of the currency. The second question was the strong empirical rejection, observed at that time, of the short run purchase power parity

on A and B are implicitly covariance restrictions and have no implications for the reduced form coefficients ..." (Fackler, 1988, p. 125).

principle (Frankel, 1981). The third concern was the substantial fluctuation in real exchange rate observed during that period.

The first two concerns gave rise to the so-called Sticky-Price Monetary Model. Its essencial assumption is that prices of goods and services adjust slowly when the equilibrium is disturbed by, say, monetary policy. Therefore the parity principle would not hold in the short run. As a result real money supply may increase when money stock is increased bringing about a reduction in real interest rate. If that is the case, exchange rate will have to jump toward a depreciated value. This is really an exchange rate overshooting, in the sense that it has to depreciate more than proportionally to the increase in money supply. The overshooting creates the necessary expectation of an appreciation towards the new equilibrium capable of inducing economic agents to hold the additional domestic currency and bonds at a lower real interest rate. During the period of adjustment to the new equilibrium, prices increase, real money supply reduces, nominal and real rates of interest increase and exchange rate appreciates.

The third concern associated with the fluctuations in real exchange rates had the important effect of reintroducing the current account as a variable in exchange rate models. "Unexpected changes in the current account are assumed to provide information about shifts in the real exchange rate in order to maintain current account in equilibrium in the long run. Current account equilibrium is defined as the rate at which domestic and foreign asset holders wish to accumulate (or decumulate) domestic assets net of foreign assets in the long run..." (Hooper & Morton, 1982, p. 40).

Now we summarize an eclectic model of exchange rate determination. It is eclectic because it encompasses the Flexible Price and the Sticky-Price Monetary Models as well as the so called Portfolio-Balance Model. The final semi-reduced form was formulated by Meese and Rogoff (1983) based on models developed by Frankel (1979) and Hooper and Morton (1982). Frankel (1979) extends Dornbusch's small country model (Dornbusch, 1976) to a two-country model.

We begin by summarizing Frankel's Real Interest Differential Theory. First, assume conventional money demands for, say, the US and a foreign country:

$$m = p + \Phi y - \alpha r \tag{5}$$

$$m^* = p^* + \Phi y^* - \alpha r^* \tag{6}$$

where m, p and y are logs of money supply, price level and output; r is short-term nominal interest rate. Asteriscs are used for variables pertaining to the foreign country.

Second, assume that in the long run equilibrium purchasing power parity holds:

$$\bar{e} = \bar{p} - \bar{p} - \bar{p}^{*} \qquad (7)$$

where $\bar{e}$, $\bar{p}$ and $\bar{p}^{*}$ are logs of long run equilibrium levels of the exchange rate (dollar price of foreign currency), domestic price level and foreign price level.

Third, if the domestic and foreign assets are perfect substitutes and the capital mobility is perfect, the expected rate of depreciation of exchange rate (*d*) is given by:

$$d = r - r^{*} \qquad (8)$$

Fourth, assume that expected rate of depreciation is a function of current gap between spot and equilibrium exchange rate ($e - \bar{e}$) plus the equilibrium inflation differential between countries ($\pi - \pi_{*}$):

$$d = -\Theta(e - \bar{e}) + (\pi - \pi^{*}) \qquad (9)$$

which Frankel shows to be the rational expected depreciation rate if prices are sticky and adjust according to the expression:

$$\dot{p} = \Theta(e - p + p^{*}) + \pi$$

where $\dot{p}$ is differential of p (log of price level) and the expression in parentheses is the real spot exchange rate. The first term on the right-hand side indicates that prices adjust to excess demand which is a function of real exchange rate.

From these four assumptions, Frankel (1979) develops an empirical equation that is a quasi-reduced form model, since some right-hand side variables are not probably independent of each other.

$$e = (\bar{m} - \bar{m}^{*}) - \Phi(\bar{y} - \bar{y}^{*}) - (1/\Theta)(\bar{r} - \bar{r}^{*}) + ((1/\Theta) + \alpha)(\pi - \pi^{*}) \qquad (10)$$

To better understand its meaning, (10) may be rewritten as

$$e = (\bar{m} - \bar{m}^{*}) - \Phi(\bar{y} - \bar{y}^{*}) - (1/\Theta)[(\bar{r} - \pi) - (\bar{r}^{*} - \pi^{*})] + \alpha(\pi - \pi^{*}) \qquad (10')$$

In (10') we see that a permanent and once for all (with no effect on expected inflation) rise in money supply will result in a proportional

increase (devaluation) in the exchange rate. If that money supply increase also reduces real interest rate due to price stickiness, an additional devaluation (overshooting) will occur in the amount of $(1/\Theta)$ times the nominal interest rate change.

If the increase in money supply signals a new growth rate of money supply, then two additional sources of overshooting will come into play due to the increased expected rate of inflation (π). One is related to the further reduction in real rate of interest as π increases and is represented by $(1/\Theta)$ times the increase in π; the second is due to reduction in money demand in favor of foreign money demand and domestic bond and is represented by $\overline{\alpha}$ times the increase in π.

Of course the size of the overshooting may be reduced if the monetary policy exerts any effect on output rate and thus on money demand.

Equation (10) is general enough to encompass the flexible price and the sticky-price hypotheses. The hypothesis that prices are flexible implies that Θ goes to infinity so that the coefficient of $(r\text{-}r^*)$ goes to zero and the coefficient of $(\pi-\pi^*)$ goes to α (the interest semi-elasticity of money demand). In this case no overshooting is possible.

Following Hooper and Morton (1982), Meese and Rogoff (1983) extended equation (10) to include accumulated trade balance's (TB) effects on exchange rate so as to obtain:

$$e = (\overline{m} - \overline{m}^*) - \Phi(\overline{y} - \overline{y}^*) - (1/\Theta)(\overline{r} - \overline{r}^*) + ((1/\Theta) + \alpha)(\pi - \pi^*) + \beta(\overline{TB} - \overline{TB}^*) \tag{11}$$

It is assumed that unanticipated current account accumulated balances — represented in (11) by the proxy trade balances — can affect long run real exchange rate. "In the especial case where current account is expected to return to equilibrium in the next period... and the equilibrium current account is zero, the equilibrium real exchange rate becomes a linear function of the cumulative current account" (Hooper & Morton, 1982, p. 44). Among the real factors that may affect long run equilibrium current account and real exchange rate, Dornbusch and Fischer (1980) consider changes in the world demand for domestic goods, and changes in imports arising from a reduction in saving patterns.

Frankel (1981) presents a model similar to (11) on the assumption that current account affects money demand through a wealth effect.

3. Empirical results

In this section we present an analysis of the behavior of the US dollar exchange rate from 1973 to 1987, based on monthly data. As discussed in

the previous section, our analysis is based on a monetary approach to the asset market model of exchange rate determination. Therefore we explain the behavior of the nominal exchange rate in the terms of money supply, short term interest rate, expected inflation rate, income and accumulated trade balance, all expressed in relative terms, involving the US and its major trade partners.

The US dollar exchange rate may be defined as the geometric trade-weighted average of the foreign currency price of the dollar. Following the approach used by the Federal Reserve Board (FED), the weights are given by the share of each country in the total trade (exports plus imports) among the countries considered. Seven foreign countries were included in the analysis. These countries and respective weights were: Germany (.2424), Japan (.1585), France (.1527), United Kingdom (.1327), Canada (.1061), Italy (.1049) and Netherlands (.0947). Three countries — Sweden, Switzerland and Belgium — included in the FED's index were not considered in this analysis due to the lack of the necessary monthly informations. As far as trade is concerned, these are the three least important countries in the block of ten countries considered by the FED.

Similar trade-weighted indexes were computed for the money supplies, short - term interest rates, long-term interest rates, incomes and accumulated trade balances for the seven countries. All the data were obtained from the International Monetary Fund (IMF) as published in *International Financial Statistics* and collected by the USDA. It is supposed that the long-term interest rate differential can represent the expected inflation rate differential. This would be the case if current long run real rates of interest were equal. The short-term interest rates used were the three-month Treasury Bill rates for the United States, United Kingdom and Canada; and the equivalent money market rates for the remaining countries. The long-term interest rates were those for long-term government bonds. The industrial output was used as proxy to the monthly income variable.

4. The structural model

The first step in our analysis consists of defining the structural form of the contemporaneous interactions among the variables in the vector autoregressive model. The theoretical model discussed previously is used to justify the behavioral equations to be defined. To be compatible with the model formulation, the exchange rate is expressed in terms of the dollar value of the foreign currencies.

The exchange rate (twer) equation is of course the one we are most interested in. However, in order to properly interpret the results we need to specify how the explanatory variables relate with each other in the model.

The first variable in the structural model is the log of the money supply ratio (m-m^*), that is assumed not to depend contemporaneously on any of the other variables, as our theoretical model assumes.

The second equation relates the log of the income ratio (y-y^*) to the log of the money supply ratio, as we intend to detect any possible positive effect of liquidity on output, which can affect—through the money demand—the interest rate and, therefore, the exchange rate.

In the third equation, the accumulated trade deficit ratio (TB/TB*) is associated with the log of the income ratio and log of the exchange rate. We expect the income ratio to affect positively the deficit ratio, since a larger output level is commonly presumed to increase imports. It is also expected that an increase in (that is, a depreciation of) the US dollar exchange rate will result in a reduction in the deficit ratio due to its effects on exports and imports.

The fourth equation in the structural model relates the long-term interest rate differential ($\pi - \pi^*$) to the log of the money supply ratio, the log of the income ratio and log of the exchange rate. As far as that variable reflects the expected inflation differential, we expect that it will be affected positively by both the money supply ratio and the income ratio. We have also hypothesized that an exchange rate devaluation may lead to an increase in the expected inflation ratio differential, either due to increased costs or to possible future increases in the money supply ratio.

In the fifth equation the short-term interest rate differential (r-r^*) is related to all the previous variable. We expect this differential to be negatively associated to the money supply ratio and positively related to the income ratio (due to money demand effects) and positively related to the long-term interest rate differential, that may reflect the expected inflation differential and might affect the short-term rate. Regarding the accumulated trade deficit ratio, an increase in its value may lead to a reduction in the short-term interest rate differential, since it would indicate an increased supply of dollars in the exchange rate market.

The last contemporaneous equation has the log of the exchange rate as the dependent variable and is formulated as discussed in the previous section.

This set of assumptions made regarding the $A(0)$ matrix resulted in a just identified model.

In order to take into account the lagged effects of the variables, we need to establish the lag structure of the model. Here we followed most of previous works and used a lag-length of 12 months. We applied a log likelihood test to verify the possibility of reducing this length to six months, but that hypothesis was rejected at the 1% level.

The results of the estimation of the $A(0)$ matrix are presented in table 1. We should remember that the complete structural model is given by:

$$A(0)\ Y(t) = \sum A(s)\ Y(t - s) + e(t)$$

The figures in table 1 represent the estimates of the coefficients in matrix $A(0)$. Therefore the numbers outside the diagonal must have their signs changed to correctly interpret the partial immediate (contemporaneous) effects of the variable in each column upon the dependent variable in each row.

Table 1

Coefficient estimates of the A(O) matrix the exchange rate model

	Explanatory variables					
Dep. var.	(m-m*)	(y-y*)	(TB-TB*)	$(\pi - \pi^*)$	(r-r*)	twer
(m-m*)	1	0	0	0	0	0
(y-y*)	-.07478	1	0	0	0	0
	(.1044)					
(TB-TB*)	0	-.0855	1	0	0	1.6466
		(.1969)				(.2703)
$(\pi - \pi^*)$	1.1434	-3.4071	0	1	0	-1.7982
	(2.6978)	(2.0129)				(na)
(r-r*)	6.0023	-3.6361	6.0008	-.8949	1	0
	(4.6230)	(3.4250)	(1.5527)	(.0584)		
twer	3.3996	-1.9468	-5.3140	-.2653	.3698	1
	(1.8104)	(1.3310)	(.7783)	(.0123)	(na)	

Note: figures in parentheses are estimated standard errors.

The results in table 1 are relatively good. Although the estimated standard deviation are high in several cases, only three coefficients out of fifteen presented unexpected signs. These were the coefficients for the money supply ratio in the long-term interest rate differential equation and the exchange rate equation, and for the income ratio in the exchange rate equation. The remaining coefficient presented the expected sign, and pro-

Figure 1
Impulse elasticities of money supply ratio on exchange rate

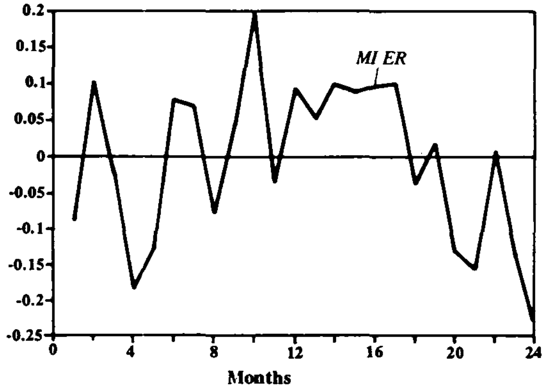
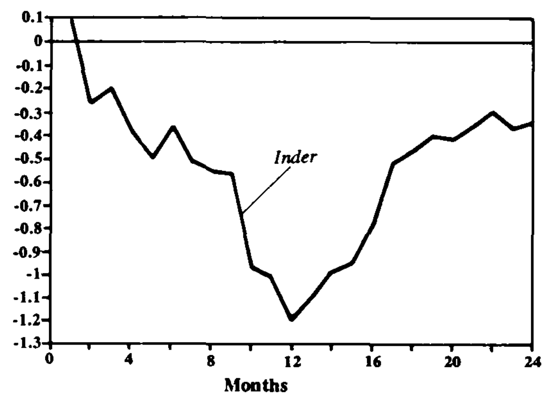


Figure 2
Impulse elasticities of the income ratio on exchange rate



vide us with a reasonably clear theoretical interpretation of the effects of the economic shocks to be analysed through the impulse analysis.

5. Impulse responses and forecast variance decomposition

In this section we present the estimates of the impulse response analysis and the decomposition of the variance of the forecast errors. These two questions have to be dealt with jointly, since the real importance to be attributed to an

Figure 3
Impulse elasticities of accumulated trade deficit ratio on exchange rate

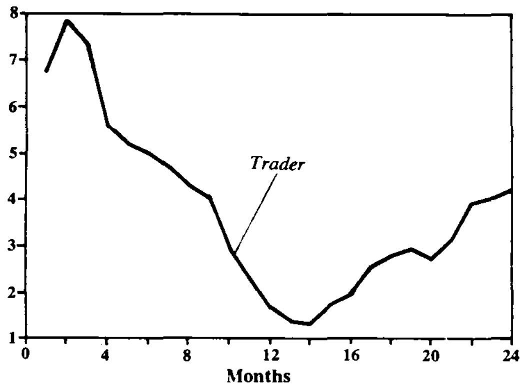
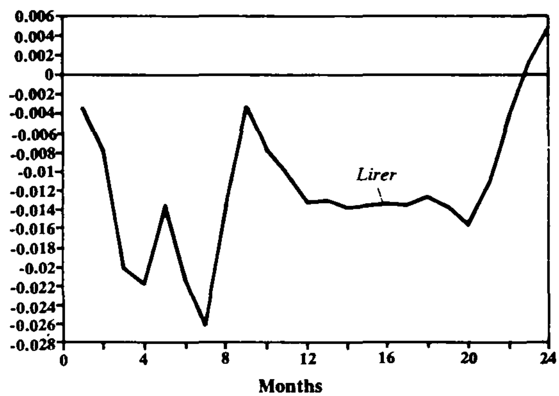


Figure 4
Impulse elasticities of expected inflation rate differential on exchange rate



impulse response pattern is associated with its power to explain the variance of the forecast errors.

Table 2 contains the responses of the dollar exchange rate — measured as the dollar price of foreign currencies — to shocks in each of the variables included in the model. Instead of expressing our results in terms of responses to a standard deviation shock in each variable, as usual, we present them as elasticities, a concept more easily visualized by economists. The same results are presented in a graphical fashion in figures 1 to 6.

Notice that, unless a variable is not contemporaneously related to any other in the model, the partial immediate effect — given in $A(0)$ — differs from the complete contemporaneous effect (which takes account of the contemporaneous relations with other variables). The impulse elasticities relates the complete contemporaneous effect of all the variables to complete

Figure 5
Impulse elasticities of short-term interest rate differential on exchange rate

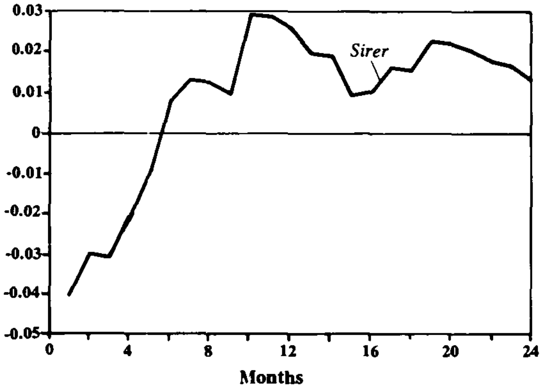


Figure 6
Exchange rate impulse elasticities

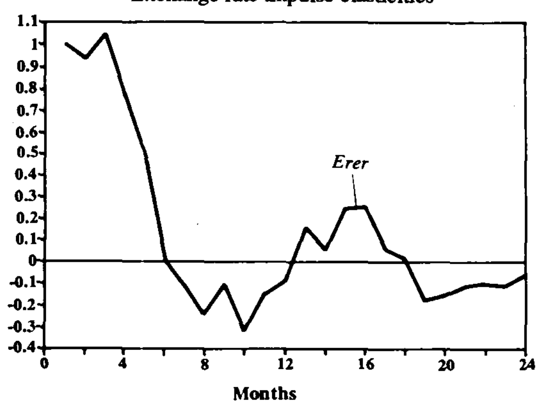


Table 2

Exchange rate impulse elasticities

month	(m-m*)	(y-y*)	(TB-TB*)	($\pi - \pi$*)	(r-r*)	twer
1	-.087	.081	6.723	-.0034	-.0423	1.000
2	.102	-.264	7.883	-.0078	-.0293	.935
3	-.021	-.198	7.346	-.0201	-.0303	1.044
6	.078	-.366	5.020	-.0213	.00806	.0011
12	.096	-1.200	1.701	-.0132	.0256	-.084
18	-.034	-.463	2.809	-.0127	.0161	.0184
24	-.233	-.341	4.249	.0047	.0136	-.0555

Table 3

Decomposition of the variance of exchange rate forecast errors (percentages)

month	(m-m*)	(y-y*)	(TB-TB*)	($\pi - \pi$ *)	(r-r*)	twer
1	.07	.12	37.07	.14	29.47	33.13
2	.09	.68	.44.33	.43	22.92	31.55
3	.06	.68	43.82	1.88	20.69	32.87
6	.17	2.67	46.56	4.39	16.92	29.30
12	.21	13.62	40.80	5.20	19.38	20.79
18	.22	20.71	36.04	5.88	19.42	17.73
24	.31	19.31	37.79	5.83	21.21	15.53

contemporaneous effect on the variable which experienced the unexpected shock. Therefore, the first period impulse elasticity of a variable to shocks in itself is equal to unity.

In table 3 we present the decomposition of the variance of the exchange rate forecast errors associated with the same variables for which the impulse responses were presented in table 2.

Now we proceed to the joint analysis of the results in tables 2 and 3.

The impulse elasticity for the money supply ratio suggests that unexpected changes in the US money suply relative to its trade partners' money supply have an oscillatory effect on the value of the dollar. These effects are quite small and explain only a negligible portion of the variance of the exchange rate forecast errors, as we can see in table 3.

The elasticities of shocks in the income ratio variable indicate that following an unexpected 10% increase in the US industrial output relative to its trade partners, the US currency will appreciate continuously until the twelfth month, when a 12% appreciation would be reached. After that, the currency begins to depreciate, but its original value is not restored after 24 months. The effect of the income ratio variable is relatively important to explain the exchange rate forecast error especially after six months. Almost 21% of that variance may be atributed to the income ratio shocks around the eighteenth month of projection.

An unexpected 10% increase in the accumulated trade deficit ratio between the US and its partners tends to depreciate the American currency by about 68% in the first month and by 79% in the second month. This effect decreases thereafter until the fourteenth month, but after that a new sequence of devaluations is observed. The importance of this variable in terms of the forecasting errors' variance is very large (more than 35% in any month).

The impulse elasticities for the long-term interest rate differential indicate that following an unexpected increase in this variable, the US dollar

will appreciate. The reason for this effect seems to be the impact that changes in it exert upon the short-term interest rate variable. Our estimates (not presented here) indicate that an increase in the long-term rate differential may result in more than proportional increases in the short-term rate differential during the first three months following the shock, with positive effects remaining until the sixteenth month. The impulse semi-elasticities indicate that for each additional percentage point of increase in the long run rate differential the exchange rate would appreciate by .34% in the first month and by 2.0% by the third month. After the seventh month the appreciation reduces but the currency value is restored only by the twenty third month. From the sixth month on, the long run rate differential explains between 4% and 6% of the forecast errors' variance of the exchange rate.

The effects of shocks in the short-term interest rate differential were very important in terms of its explanatory power of the forecast errors' variance, second only to the accumulated deficit ratio (more than 15% in any month). The impulse elasticities indicate that for each initial increase in the interest rate of one percentage point the exchange rate would appreciate by 4% in the first month. The appreciation trend would reduce until the fifth month. After that the currency would begin to depreciate. The highest depreciation would be observed by the tenth month (almost 3%). The reason for the sign reversion (from appreciation to depreciation) apparently is that the interest rate differential itself changes sign (from positive to negative) after the fifth month following the initial one percentage point increase. The reduction in the interest rate differential seems to be related to the effects that an appreciation of the dollar has on the expected inflation differential rate (that is reduced) and on the accumulated deficit (that is increased).

Finally we comment on the impulse elasticities related to the exchange rate itself. Given an unexpected 10% increase (that is, depreciation) in the exchange rate, the dollar would remain depreciated for most of the first six-month period. In the first two months following the initial change the dollar would experience a little additional devaluation and, then, the depreciation would diminish until the original value is restored by the sixth month. After that, however, a small appreciation is observed and is followed by an oscilatory pattern of relatively small amplitude.

In table 3 we notice that most of the forecast errors' variance of the exchange rate is explained by shocks in other variables, that is, the exchange rate variable itself explains one third or less of that variance.

6. Conclusions and final remarks

The effects of monetary or financial variables were identified and measured and can be potentially important. Unexpected shocks in the trade deficit

ratio, in the short-term interest rate differential and in the income ratio played major roles when compared to unexpected shocks in the exchange rate itself. These results indicate that both monetary forces (represented by factors related to money demand and supply) and real factors (represented by the cumulative trade balance) were roughly equally relevant to explain the behavior of the US dollar exchange rate during the period of analysis.

The effects of real factors were represented by unexpected changes in the ratio between US and its trade partners' accumulated trade deficits. Real effects are, therefore, those associated with changes in tastes—including saving pattern—technology, etc. that lead to changes in exports and imports demand of the country. Changes in the deficit ratio explain between 35% and 48% of the forecast variance of the US exchange rate.

Regarding the effects of factors operating through changes in money supply and demand, our results pointed out as particularly relevant those arising from unexpected changes in the short-term interest rate differential and in the income ratio between the countries. Unexpected changes in the interest rate differential and in the relative income ratio explain between 20% and 40% of the variance of the forecast of the US exchange rate.

Finally, between 15% and 30% of the exchange rate forecast variance are due to autonomous changes in this rate itself. However, these effects tend to vanish after five or six months, suggesting the operation of a mechanism of correction of the deviations not related to market fundamentals.

It is clear from our results that the US exchange rate is highly sensitive to both real and monetary forces. In general the exchange rate seems to overreact to changes in its underlying determinants and a stable trend is only restored during the second year following the initial shock. Although the effect of real factors is substantial, the results stress that a more coordinated action by the US and its trade partners in the design of their short run macroeconomic policies could contribute significantly to a more stable exchange rate market.

Appendix
Variables used in the VAR analysis

Nº*	Twer	M1	Ind	Lir	Sir	Trade
1	4.406073	0.305346	-0.02998	-1.32748	-0.15088	1.114434
2	4.453901	0.277394	-0.02635	-1.15996	1.42396	1.120471
3	4.493334	0.252891	-0.03446	-1.16487	0.60768	1.05524
4	4.487183	0.251568	-0.03188	-1.3153	0.03922	1.064074
5	4.498075	0.231965	-0.03854	-1.38068	0.00354	1.033509

(cont.)

(continuation)

Appendix
Variables used in the VAR analysis

Nº*	Twer	M1	Ind	Lir	Sir	Trade
6	4.532794	0.247	-0.03572	-1.532	-0.01002	1.050635
7	4.570691	0.247805	-0.02643	-1.40967	-1.05933	1.097315
8	4.547449	0.249302	-0.04678	-1.33879	-0.25027	1.043459
9	4.547958	0.241205	-0.03133	-1.66023	-0.71397	0.956928
10	4.554886	0.25491	-0.02934	-1.95119	-2.47605	0.908576
11	4.511197	0.251552	-0.03369	-2.04273	-1.82597	0.897435
12	4.485868	0.238733	-0.04283	-2.24839	-3.4067	0.836179
13	4.431208	0.277522	-0.06252	-2.3181	-2.7801	0.762735
14	4.453927	0.251448	-0.06759	-2.59339	-3.0432	0.699628
15	4.480884	0.230455	-0.05789	-2.6023	-2.8073	0.608984
16	4.497994	0.228769	-0.06593	-2.6075	-0.95554	0.547582
17	4.508761	0.194612	-0.05886	-2.722	-2.16	0.505925
18	4.492413	0.209994	-0.04936	-3.113	-2.9307	0.507734
19	4.490048	0.217002	-0.05417	-2.9683	-3.7566	0.525689
20	4.47175	0.217903	-0.05111	-2.8623	-2.6033	0.541396
21	4.463115	0.216497	-0.03184	-2.9655	-2.4322	0.555291
22	4.474063	0.224706	-0.02259	-3.0556	-3.7238	0.541989
23	4.484511	0.205172	-0.04103	-3.1296	-2.5215	0.534747
24	4.497788	0.186245	-0.05299	-3.2934	-3.2917	0.553104
25	4.520434	0.210825	-0.06715	-2.8615	-3.20664	0.564319
26	4.535346	0.186098	-0.08206	-2.60731	-2.59913	0.558848
27	4.545902	0.177354	-0.09323	-2.01306	-2.37878	0.524546
28	4.531307	0.182976	-0.07881	-1.67779	-1.6771	0.514991
29	4.537437	0.146978	-0.07379	-1.68897	-1.64421	0.494211
30	4.536335	0.146845	-0.069	-1.64362	-1.51498	0.483214
31	4.498138	0.140312	-0.05804	-1.65559	-0.23326	0.490499
32	4.469853	0.130556	-0.03542	-1.33104	1.02359	0.488065
33	4.457958	0.125854	-0.04103	-1.33802	0.1798	0.484895
34	4.460879	0.12619	-0.04365	-1.63061	-0.40761	0.464052
35	4.461338	0.110092	-0.04494	-1.73668	-0.8145	0.44747
36	4.450485	0.091661	-0.04375	-1.73751	-1.0433	0.433743
37	4.45118	0.115558	-0.05025	-1.77315	-1.12758	0.438567
38	4.449252	0.092176	-0.04177	-1.55549	-1.07785	0.445195
39	4.431108	0.085597	-0.0497	-1.64656	-1.08064	0.437528
40	4.419413	0.094214	-0.05286	-1.87292	-1.20159	0.431149
41	4.415228	0.05853	-0.05506	-1.63047	-1.68651	0.420837
42	4.409686	0.059169	-0.05594	-1.90026	-2.06136	0.433163
43	4.412667	0.068761	-0.05083	-1.92854	-2.55854	0.459013
44	4.415782	0.076985	-0.04645	-2.07024	-3.34798	0.473668
45	4.421217	0.070616	-0.06104	-2.26202	-3.3446	0.480485
46	4.417057	0.072916	-0.0499	-2.54942	-3.09755	0.47807

(cont.)

(continuation)

Appendix
Variables used in the VAR analysis

№*	Twer	M1	Ind	Lir	Sir	Trade
47	4.414459	0.07125	-0.04219	-2.45516	-3.4304	0.481141
48	4.418309	0.073298	-0.03549	-2.71649	-4.06015	0.480705
49	4.422107	0.090541	-0.05133	-2.20029	-3.30114	0.485981
50	4.420909	0.072166	-0.2941	-1.98048	-2.92181	0.518676
51	4.423024	0.067527	-0.02625	-1.80745	-2.90266	0.527445
52	4.429504	0.089115	-0.01024	-1.72824	-2.28655	0.540137
53	4.430847	0.04332	0.000474	-1.4358	-0.69791	0.539879
54	4.432739	0.044333	0.003794	-1.568	-0.38992	0.57061
55	4.449381	0.040371	0.017995	-1.42386	-0.33906	0.601271
56	4.443272	0.048421	0.068434	-1.00947	-0.42562	0.628094
57	4.441123	0.050443	0.004678	-0.904907	0.11208	0.654035
58	4.456268	0.054622	0.016398	-0.75994	0.53292	0.692306
59	4.470569	0.037773	0.020199	-0.73754	0.39216	0.714104
60	4.492226	0.004635	0.020633	-0.58572	0.19668	0.744684
61	4.507272	0.050277	0.002454	-0.14313	0.75687	0.765514
62	4.511425	0.017246	0.014678	-0.05886	0.57377	0.804695
63	4.525537	0.009545	0.024102	0.03568	0.36013	0.831029
64	4.529645	0.026482	0.028147	0.18922	0.55095	0.859688
65	4.511261	0.000857	0.042495	0.28592	0.54803	0.873122
66	4.52807	0.002999	0.051309	0.3509	0.85555	0.907872
67	4.553954	0.00275	0.043666	0.40782	1.18808	0.956038
68	4.578431	0.003536	0.0454458	0.12895	1.37752	0.96752
69	4.580692	0.004581	0.036888	0.18063	1.82423	0.991879
70	4.617636	0.012139	0.04752	0.31248	1.6891	1.016673
71	4.590695	-0.00993	0.047516	0.04334	2.73636	1.029514
72	4.591958	-0.03682	0.034206	0.54062	2.38818	1.038598
73	4.601746	0.006382	0.056986	0.6415	3.0331	1.05235
74	4.595467	-0.02136	0.04972	0.40993	2.55303	1.055816
75	4.594161	-0.02634	0.042486	0.45236	2.59808	1.053387
76	4.583057	0.001351	0.027504	0.41031	2.2467	1.072061
77	4.573236	-0.03749	0.024279	0.10702	2.25798	1.069725
78	4.480624	-0.02388	0.020805	-0.53098	1.25202	1.093856
79	4.610695	-0.00542	0.006768	-0.62178	0.91663	1.111642
80	4.606723	-0.00133	0.00701	-0.45151	0.52146	1.107176
81	4.610469	-0.00068	0.008908	-0.27527	1.01727	1.116783
82	4.599526	0.006552	0.016386	0.47761	1.59526	1.107042
83	4.591899	-0.01318	0.005514	0.4068	1.3398	1.092523
84	4.614029	-0.03582	0.006942	-0.0409	0.348	1.109737
85	4.624403	0.022579	1.95E-05	0.248	0.9339	1.089897
86	4.615501	-0.00155	0.002195	1.4497	1.5223	1.084754
87	4.572606	-0.01083	0.002528	0.9793	3.5747	1.055124

(cont.)

(continuation)

Appendix
Variables used in the VAR analysis

Nº*	Twer	M1	Ind	Lir	Sir	Trade
88	4.562628	-0.00466	-0.00946	-0.1303	1.6638	1.042051
89	4.60939	-0.03814	-0.02526	-1.067	-3.2192	1.013711
90	4.629321	-0.02247	-0.03592	-0.9981	-5.2484	1.011562
91	4.635955	0.002425	-0.03772	-0.4278	-3.7512	0.998037
92	4.619288	0.008328	0.002167	0.3313	-2.2175	0.982243
93	4.627104	0.022986	0.015874	0.4795	-1.1467	0.968413
94	4.616718	0.032777	0.014407	0.5214	0.1765	0.950499
95	4.585475	0.009458	0.032706	1.346	2.8224	0.935357
96	4.567431	-0.02192	0.0421	1.3391	4.3621	0.931.708
97	4.567123	0.024078	0.044136	0.9514	3.5754	0.925588
98	4.516875	0.00529	0.033545	1.2839	3.5235	0.921747
99	4.514251	0.016424	0.042061	0.9885	1.6636	0.89851
100	4.489327	0.04867	0.034048	1.449	2.0035	0.901336
101	4.441267	-0.01045	0.038444	1.2674	3.8674	0.894704
102	4.409751	-0.0037	0.041543	0.3667	1.4071	0.896782
103	4.381075	0.01285	0.052236	0.91	1.271	0.894607
104	4.359107	0.017756	0.059709	1.4064	2.2021	0.90824
105	4.397132	0.020788	0.039331	1.5172	1.601	0.89288
106	4.414302	0.024332	0.020944	1.7729	0.6626	0.895171
107	4.430654	0.012787	0.01716	-1.1092	-1.1092	0.893726
108	4.425343	-0.0211	0.008772	1.1148	-1.1745	0.878108
109	4.409538	0.031294	-0.011	1.9598	0.614	0.874074
110	4.378258	-0.00459	0.008754	2.0512	2.137	0862454
111	4.363597	-0.00458	-0.00579	1.7649	1.1509	0.85053
112	4.349443	0.013298	-0.01557	2.0153	1.1968	0.830958
113	4.378911	-0.02192	-0.01896	1.8855	0.6279	0.831036
114	4.325185	-0.04428	-0.0172	2.2136	0.7165	0.815816
115	4.308791	-0.02176	-0.00791	1.7854	0.718	0.811488
116	4.304007	-0.0109	-0.01728	1.3694	-1.7094	0.815497
117	4.29414	-0.01363	-0.02538	0.9406	-1.8474	0.802207
118	4.280756	-0.0063	-0.02185	-0.1131	-1.82886	0.804741
119	4.27219	-0.00458	-0.01673	-0.2816	-1.08051	0.797605
120	4.314802	-0.03738	-0.02276	-0.1047	-0.71085	0.792154
121	4.326221	-0.01161	0.011875	0.0963	-0.79434	0.783119
122	4.310488	-0.02833	0.02111	0.3762	-0.3713	0.777728
123	4.302292	-0.03615	0.023319	0.4763	-0.03275	0.771842
124	4.292859	-0.01137	0.032679	0.44722	0.22441	0.780161
125	4.290593	-0.02957	0.041664	0.3161	0.18785	0.7843
126	4.266557	-0.03855	0.040967	0.5999	0.86009	0.791553
127	4.255493	-0.02564	0.067554	1.0676	1.10035	0.804722

(cont.)

(continuation)

Appendix
Variables used in the VAR analysis

№*	Twer	M1	Ind	Lir	Sir	Trade
128	4.230639	-0.01197	0.075579	1.4583	1.30565	0.81685
129	4.230783	-0.01784	0.08395	1.3746	0.83009	0.824893
130	4.248832	-0.00478	0.093617	1.4277	0.52081	0.844873
131	4.227666	-0.01576	0.07991	1.6262	0.59558	0.8548
132	4.208618	-0.03345	0.07404	1.7497	0.69093	0.866204
133	4.192643	0.00674	0.099687	1.71799	0.75099	0.874447
134	4.215137	-0.00765	0.108065	1.93867	0.86454	0.885549
135	4.244194	-0.02059	0.113034	2.47014	1.15128	0.899085
136	4.231361	-0.01439	0.127614	2.81456	1.61119	0.920934
137	4.199079	-0.02408	0.116943	3.44559	1.76897	0.938614
138	4.197521	-0.03195	0.148285	3.3881	1.70283	0.951058
139	4.161042	-0.01639	0.124453	3.2495	1.59995	0.986044
140	4.153655	-0.01618	0.120841	2.84101	2.11097	1.00593
141	4.117437	-0.03423	0.118989	2.90853	1.98673	1.025553
142	4.102482	-0.02854	0.113858	2.80484	1.64312	1.039925
143	4.122559	-0.03757	0.116116	2.42923	0.68848	1.058624
144	4.092203	-0.07925	0.114974	3.45747	-0.04736	1.074948
145	4.068601	-0.01935	0.116514	2.47424	-.3307	1.075565
146	4.035021	-0.03365	0.10976	2.37727	-0.41737	1.08075
147	4.031494	-0.04608	0.104275	2.55875	-0.15154	1.095704
148	4.092598	-0.02754	0.110582	2.3591	-0.37873	1.113585
149	4.087681	-0.04124	0.10378	1.92944	-0.76207	1.13464
150	4.103026	-0.04282	0.101716	1.36892	-1.22704	1.164894
151	4.145545	-0.02272	0.098702	1.67542	-0.89588	1.183057
152	4.172745	-0.01887	0.10851	1.82771	-0.46045	1.203038
153	4.15953	-0.02734	0.109497	1.94226	-0.46575	1.226433
154	4.222803	-0.01467	0.097909	1.84441	-0.3859	1.25019
155	4.244124	-0.02943	0.092027	1.20735	-0.47083	1.273113
156	4.26056	-0.05124	0.125683	0.80162	-0.78625	1.303927
157	4.276413	-0.01733	0.116582	0.90581	-0.76411	1.327948
158	4.317386	-0.03017	0.106835	0.61225	-0.75262	1.34751
159	4.343629	-0.04451	0.096766	0.28779	-1.03364	1.371315
160	4.342914	-0.02242	0.088327	0.28309	-0.93994	1.386328
161	4.365083	-0.03239	0.112463	0.66625	-0.46527	1.410397
162	4.359803	-0.03186	0.098338	0.5997	-0.30665	1.437709
163	4.39072	-0.01336	0.092754	0.18107	-0.75532	1.477779
164	4.415691	-0.01423	0.107127	0.16853	-0.88735	1.509224
165	4.419479	-0.00653	0.09348	0.41002	-1.22664	1.523578
166	4.424383	-0.00337	0.102928	0.13985	-1.30059	1.549269
167	4.410928	-0.01125	0.109853	-0.09225	-1.00178	1.585567
168	4.422299	-0.00435	0.112399	-0.13158	-1.29416	1.616328

(cont.)

(continuation)

Appendix
Variables used in the VAR analysis

Nº*	Twer	M1	Ind	Lir	Sir	Trade
169	4.475415	0.023193	0.119064	0.0041	-1.0928	1.620346
170	4.490111	-0.00222	0.111299	0.30221	-0.63851	1.63857
171	4.496773	-0.00898	0.107448	0.5159	-0.44435	1.65112
172	4.516436	0.010745	0.111927	1.31705	-0.16329	1.664953
173	4.52696	-0.02078	0.111489	1.99392	0.04166	1.676692
174	4.509051	-0.03521	0.115533	1.64734	-0.03179	1.690673
175	4.493316	-0.03018	0.123807	1.36015	0.00303	1.71599
176	4.491145	-0.02523	0.120042	1.24904	0.12804	1.746017
177	4.515896	-0.03379	0.118287	1.67887	0.37217	1.754389
178	4.520581	-0.02511	0.121739	1.50107	0.49091	1.775455
179	4.575631	-0.04402	0.122942	1.36933	0.00421	1.792327
180	4.605985	-0.05866	0.163514	1.53916	0.15923	1.810619

* Number of months from Jan. 1973 to Dec. 1987.

Abstract

A importância de forças monetárias é comparada àquela de fatores reais na determinação do valor da taxa de câmbio do dólar norte-americano. Análises de impulsos e a decomposição de variância de previsão são realizadas dentro de um modelo de auto-regressão vetorial identificável. A identificação é obtida mediante uso de um modelo de ativo eclético de determinação de taxa de câmbio. Tanto fatores reais (relacionados à conta corrente) como monetários (que operam via mercados monetários/financeiros) mostraram-se muito relevantes para explicar o comportamento da taxa de câmbio do dólar norte-americano nas duas últimas décadas.

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