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EFFECTS OF U.S. MONETARY RESTRAINT ON THE DM-$ EXCHANGE RATE AND THE GERMAN ECONOMY

Jacques R. Artus

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ABSTRACT

This paper assesses the quantitative effects of a shift to monetary restraint in the United States on the DM-$ exchange rate and the German economy. The results indicate that such effects are large. If Germany keeps its money growth unchanged, it will tend to experience a sharp and sustained depreciation of the deutsche mark and a significant increase in inflation and in unemployment. If it adopts an equivalent policy of monetary restraint, it will tend to benefit from a marked decline in inflation, but the cost in terms of lost output is extremely large.

Jacques R. Artus
International Monetary Fund
Research Department
700 19th Street, N.W.
Washington, D.C. 20431

(202) 477-7159

Introduction

This paper assesses the quantitative importance of the effects of a shift to a policy of monetary restraint in the United States on the DM-$ exchange rate and the German economy. The paper was motivated by events in 1979-81, when a shift toward monetary restraint in the United States was accompanied by a sharp rise in U.S. interest rates and in the exchange rate of the U.S. dollar. This sharp rise is widely viewed as having placed pressures on other industrial countries, in particular Germany, to boost their interest rates in order to limit the depreciation of their currencies. However, there is much uncertainty as to exactly how much U.S. monetary restraint contributed to the appreciation of the U.S. dollar. There is also much uncertainty as to the magnitude of the effects of the depreciation of the other currencies on their corresponding economies, and, therefore, on the degree of constraint imposed on other national authorities by the U.S. policy of monetary restraint. Finally, there is much uncertainty as to the costs and advantages of the decision made by other countries to largely match the rise in U.S. interest rates by a rise in their own interest rates. The present paper aims at clarifying these issues, at least with respect to Germany.

Beyond these specific policy issues, the paper also aims at casting some light on a number of theoretical and empirical issues concerning the functioning and the interdependence of industrial countries under floating exchange rates. In the area of wage and price formation, the main issues considered in the paper concern the formation of price expectations, the effect of wage and price long-term contracts, and the effect of variations in import prices. More specifically, the paper addresses itself to the following questions. Do private market participants form their price expectations on the basis of past price developments or do they directly take into account information that they have on the monetary policy stance of the authorities? How fast can changes in price expectations be reflected in actual wages and prices, given the existence of long-term wage and price contracts? Are changes in import prices reflected in wages and prices of domestically produced goods, either because of wage indexation or because of the effect of import prices on price expectations?

In the area of interest rate and output determination, the main issue concerns the effect of monetary policy on interest rates. The crucial question here is whether a reduction in money growth rapidly leads to a decrease in interest rates because of reduced inflationary expectations, or whether it may in fact lead to an increase in interest rates for a sustained period of time because of a liquidity squeeze. The liquidity squeeze could result from the persistence of inflation either because monetary restraint has no effect on price expectations or because long-term contracts prevent wages and prices from adjusting rapidly. Thus, the interest rate issue is closely related to the price formation issue. It also has direct implications as far as output is concerned, because an increase in interest rates at a time when inflationary expectations are constant or declining will lead to a reduction in the demand for investment goods and consumer durables and, ultimately, to a decline in overall output.

These various theoretical and empirical issues have further implications as far as the exchange rate determination process is concerned. If interest rates rise in real terms, and a fortiori in nominal terms, as a result of a reduction in money growth, the exchange rate may initially shoot upward as a result of the rise in the uncovered interest-rate differentials. If output declines, the current account surplus may gradually increase, possibly causing a further appreciation of the exchange rate. The first overshooting effect depends on how persistent the rise in interest rates is expected to be. The second overshooting effect depends both on whether the substitution among assets denominated in different currencies is small and on whether private market participants view new data on the current account balance as containing new information on where the real exchange rate will have to be in the longer run to yield a "reasonable" current balance outturn. The paper examines how large these overshooting effects are and how they may affect domestic inflation.

To deal with these issues, the paper uses a model of a monetary economy developed in Artus (1981). Section I briefly reviews the main characteristics of this model. Section II presents the results of the estimation of the parameters of this model for Germany from data through the second quarter of 1981. One of the main findings, consistent with results of a number of previous studies, is that the DM/$ exchange rate is quite sensitive to changes in uncovered interest-rate differentials and to inflation rate differentials and current balance developments. A shift to monetary restraint in the United States will influence all these variables and, therefore, the DM-$ exchange rate. Nevertheless, only a small part of the depreciation of the deutsche mark vis-à-vis the U.S. dollar in the course of 1980 and the first two quarters of 1981 can be explained by the effects of U.S. monetary restraint. A large residual remains that is called the "Reagan effect" in the present paper, for lack of a better name.

Section III presents the results of five simulations made with the model. The first three simulations concern the effects of U.S. monetary restraint on Germany. The first simulation assumes that neither the German monetary authorities nor the monetary authorities of other industrial countries change their policies to counter the tendency toward a depreciation of their exchange rates vis-à-vis the U.S. dollar. The second simulation assumes that the German monetary authorities do not change their policies, while the monetary authorities of other industrial countries change their policies to offset the effect of U.S. monetary restraint on their exchange rates vis-à-vis the U.S. dollar. The third simulation assumes that both the German monetary authorities and the monetary authorities of other industrial countries change their monetary policies. In the next two simulations, the consequences of the Reagan effect on Germany are simulated under the assumption that neither Germany nor other industrial countries change their monetary policies, then under the assumption that they all shift to a policy of monetary restraint to offset the consequences of the Reagan effect on their exchange rates.

Finally, Section IV summarizes some of the conclusions that can be drawn from this study with respect to international economic interdependence under floating exchange rates.

I. The Model

The model developed in Artus (1981) and used in this paper with a few modifications is composed of three blocks of equations: a price block, an output block, and an exchange rate block. The equations are reproduced in Table 1 and described briefly below.

The price block differentiates between short-run inflationary expectations (for the next quarter) and long-run inflationary expectations (for the next year and a half). Short-run inflationary expectations are assumed to be formed on the basis of recent inflationary developments, while long-run inflationary expectations are assumed to reflect the long-run expected rate of growth of money (for the next year and a half). The assumption underlying this specification is that, in the short run, the relation between money and prices is too tenuous to yield efficient forecasts; private market participants can do better by extrapolating recent inflationary developments. However, in the long run, the amount of money and the overall price level are clearly related and it makes sense to accept the view that inflationary expectations reflect the monetary policy stance of the authorities, as it is perceived by private market participants.[1]

It is the long-run expected rate of inflation that enters the Phillips curve equation. Furthermore, it does so in the form of a distributed lag. The assumption is that participants in labor markets enter into long-run contractual wage arrangements that specify the rate of increase of money wage rates. In each quarter, the arrangements being entered into reflect the expected long-run rate of inflation prevailing

Table 1. Model of a Monetary Economy [a]

Equations

Price block [b]

(1) $\dot{m}^{e\ell} = \sum_j \alpha_{1,j}\, \dot{m}_{-j} - \alpha_2\, (y-\bar{y})_{-1} - \alpha_3\, z_2$

(2) $\dot{p}^{e\ell} = \alpha_5 + \dot{m}^{e\ell} - \dot{\bar{y}}$

(3) $\dot{p}^{es} = \sum_j \alpha_{6,j}\, \dot{p}_{-j+1}$

(4) $\dot{p}^{es}_{d} = \sum_j \alpha_{7,j}\, \dot{p}_{d,-j+1}$

(5) $\dot{p}_d = \alpha_8 + \sum_j \alpha_{9,j}\, \dot{p}^{e\ell}_{-j} + \sum_j \alpha_{10,j}\, (y-\bar{y})_{-j}$

(6) $\dot{p} = \alpha_{11}\, \dot{p}_d + (1-\alpha_{11})(\dot{p}_m - \dot{e})$

Output block

(7) $i^{\ell} = \alpha_{12} - \alpha_{13}(m-p) + \alpha_{14}\, y + \alpha_{15}\, \dot{p}^{e\ell} + \alpha_{16}\, t + \alpha_{17}(\dot{p}^{es} - \dot{p}^{e\ell})$

(8) $y = \bar{y} + \alpha_{18} + \sum_j \alpha_{19,j}(i^{\ell} - \dot{p}^{e\ell})_{-j}$

$\qquad + \sum_j \alpha_{20,j}(\alpha_{21}\tilde{g} + (1-\alpha_{21})\tilde{x})_{-j}$

(9) $\tilde{g} = g - \sum_j \alpha_{22,j}\, g_{-j}$

(10) $\tilde{x} = x - \sum_j \alpha_{23,j}\, x_{-j}$

Exchange rate block

(11) $\dot{e} = -(\dot{p}^{es}_{d} - \dot{p}^{es}_{d,U.S.}) + \alpha_{24} + \alpha_{25}(\Delta i^{s} - \Delta i^{s}_{U.S.}) + \alpha_{26}((b - b_{U.S.})$

$\qquad + (b - b_{U.S.})_{-1})/2$

(12) $i^{s} = i^{\ell} - \alpha_{27} - \alpha_{28}(m-p) + \alpha_{29} y + \alpha_{30}(\dot{p}^{es} - \dot{p}^{e\ell})$

(13) $x = \alpha_{31} - \alpha_{32}(y-\bar{y}) + \alpha_{33}(y^{*} - \bar{y}^{*}) - \sum_j \alpha_{34,j}(p_d - p_d^{*} + e)_{-j}$

(14) $b = x + p_d - p_m - e$

(continued on p. 7)

Table 1 (continued). Model of a Monetary Economy [a]

List of Variables

Endogenous variables: b, e, $\tilde{g}$, i^{ℓ}, i^{s}, $m^{e\ell}$, p_d, p, $p^{e\ell}$, p^{es}, p_d^{es}, x, $\tilde{x}$, y.

Exogenous variables: $b_{U.S.}$, g, $i^{s}_{U.S.}$, m, p_d^{*}, $p^{es}_{d,U.S.}$, p_m, t, $\bar{y}$, $\bar{y}^{*}$, y^{*}, z_2.

Notation

b = current balance defined as the ratio of exports of goods and services over imports of goods and services

e = nominal exchange rate (value of one deutsche mark in terms of U.S. cents)

g = real government expenditures

i^{ℓ} = long-term interest rate (yield on industrial bonds outstanding)

i^{s} = short-term interest rate (3-month deposits in local money market)

m = base money adjusted for changes in reserve requirements

p = domestic demand deflator

p_d = GDP deflator

p_m = deflator of import of goods and services (in U.S. dollars)

$\dot{r}$ = change in net foreign assets component of base money scaled by the proportion of base money accounted for by the net foreign asset component in the previous period

t = time trend.

x = ratio of the volume of exports of goods and services to the volume of imports of goods and services.

y = GDP (real terms)

(continued on p. 8)

Table 1 (concluded). Model of a Monetary Economy [a]

$\bar{y}$ = potential GDP (real terms)

z_1, z_2 = dummy variables for announced changes in the stance of monetary policy (see text)

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[a] All variables denoted by small letters are in logs, except for the interest rates (i^s and i^ℓ), the change in foreign assets ($\dot{r}$), and the dummy variables (z_1 and z_2).

The various signs must be interpreted as follows: a dot (·) denotes the rate of change of the variable (i.e., $\dot{m} = m - m_{-1}$, with m and m_{-1} in logs); a delta (Δ) signifies that the variable is considered in first-difference terms (i.e., $\Delta\dot{m} = \dot{m} - \dot{m}_{-1}$); a superscript (eℓ) denotes the long-run expected value of the variable (i.e., $\dot{m}^{e\ell}$ = the rate of growth of money expected to prevail on average from period t to period t + 6 at the time of period t); a superscript (es) denotes the short-run expected values of the variable (i.e., $\dot{p}^{es}$ = rate of increase of domestic demand deflator expected to prevail from period t to period t + 1 at the time of period t; a tilde (~) signifies that the variable is expressed in terms of deviation from an average of past values; and, finally, an asterisk (*) signifies that the variable refers to the industrial world, minus the Federal Republic of Germany, while a subscript U.S. signifies that the variable refers to the United States. All variables are expressed in deutsche mark, except for the deflator of imports (p_m) and the variables referring to the rest of the industrial world or to the United States that are expressed in U.S. dollars.

[b] The coefficents of equation (1) are to be derived by estimating the coefficients of

$$(1')\quad \sum_{k=1}^{k=6} \dot{m}_k/6 = \sum_{j=1}^{j=n} \alpha_{1,j}\,\dot{m}_{-j} - \alpha_2(y-\bar{y})_{-1} - \alpha_3\, z_1 - \alpha_4 \sum_{k=1}^{k=6} \dot{r}_k$$

while the coefficients of equations (3) and (4) are to be derived, respectively, from the estimation of the coefficients of

$$(3')\quad \dot{p} = \sum_{j=1}^{i=n} \alpha_{6,j}\,\dot{p}_{-j}$$

and

$$(4')\quad \dot{p}_d = \sum_{j=1}^{j=n} \alpha_{7,j}\,\dot{p}_{d,-j}$$

at the time.[2] Therefore, in any given quarter, the increase in the average money wage rate for the whole economy reflects an average of the expected long-run rates of inflation prevailing in a number of past quarters. The behavior of the GDP deflator is assumed to follow the behavior of the average money wage rate. The important consequence of that specification is that, even if an unexpected policy change is immediately reflected in a change in money growth expectations, it will only lead to a gradual change in the actual rate of inflation.

From an empirical standpoint, the difficulty is to find a proxy for the long-run expected rate of growth of money. The standard procedure to derive estimates for the expected rate of growth of money is to assume that the monetary authorities react with a lag to values taken by certain target variables, such as the GDP gap. In each period, the parameters of the policy reaction function can be estimated from the use of past observations on the relevant target variables. The estimates are then used to calculate a proxy for the expected rate of growth of money for the next period on the basis of past and present values of the target variables.[3] This method is employed in the present model with two important modifications. The first modification is that the policy reaction function (equation (1') in footnote a of Table 1) aims at explaining the average rate of growth of money over overlapping six-quarter periods. This modification is needed because the proxy that is sought is for the long-run rate of growth of money (over the next year and a half).

The second modification is that two variables that are concurrent with the money growth being explained are introduced in the policy reaction function. The first variable (z_1) is a dummy that identifies the change in the rate of growth of money that tends to follow the announcement of a major discretionary policy change. [4] The effect of the announcement on money growth expectations in equation (1) of Table 1 is then related to the magnitude of the actual change in the rate of money growth that tended to follow similar announcements in the past. The second concurrent variable introduced in the policy reaction function is the amount of foreign exchange market intervention. In calculating the expected rate of growth of money, it is then assumed that private market participants do not anticipate the money growth that results from foreign exchange market intervention because of the erratic nature of this intervention so that this latter variable can be ignored. In brief, variations in money growth related to exchange market intervention are considered to be unanticipated. The introduction of these two concurrent variables into the policy reaction function allows for a better identification of the unanticipated component of money growth and helps to alleviate some of the identification problems that arise in the estimation of the model. [5]

The output block assumes that, given a certain level of potential output, the long-term real interest rate and the impulse coming from real government expenditures and foreign trade determine actual output. The interest-rate effect on output is expected to take place with a substantial lag because investment reacts slowly. It takes time to decide upon and plan capital projects, and it is costly to stop them before completion. The effect of the impulse coming from real government expenditures and foreign trade is expected to take place more rapidly because no similar lags are involved. At the same time, the model assumes that the effect of this impulse is temporary. Both real government expenditures and the ratio of exports over imports (in volume terms) are introduced in the form of deviations from past tendencies, so that any increase in the rate of growth of these variables has first a positive impulse effect on output growth, and then a negative effect of equal magnitude spread over time.

The long-run expected rate of inflation having already been determined, the determination of the long-term real interest rate requires only the specification of an equation for the long-term nominal interest rate. This is done by inverting a demand for money equation in which the long-term rate of interest represents the opportunity cost of holding money. In the resulting equation (7), it is expected that a lower real money stock leads, by itself, to a higher nominal interest rate, while the sign of the coefficient of the expected long-run inflation term is indeterminate.[6] The last term in equation (7) represents an expected liquidity squeeze or glut, which should have a positive coefficient. As explained in Artus (1981), when a shift to monetary restraint leads to a downward shift in the long-run expected rate of growth of money, the slow speed of price adjustment will lead private market participants to expect that the real money stock is going to decline. The excess of the short-run over the long-run expected inflation rate will indicate how severe the liquidity squeeze is likely to become in forthcoming quarters. If this excess is large, private market participants will bid up the interest rate in anticipation of the forthcoming squeeze.

The exchange rate block is based on the asset-market theory of exchange rate determination. In the equation that explains the change in the DM-$ exchange rate, the three explanatory variables are the expected inflation rate differential, the change in the uncovered short-term interest rate differential, and the relative current balance position of Germany and the United States.[7] A derivation of this equation was presented in Artus (1981, Appendix I). One of the results of the derivation was that the introduction of the relative current balance position could be justified on two grounds. First, the substitutability of domestic and foreign securities may be limited. For example, if Germany has a large current balance deficit, the spot value of the deutsche mark vis-à-vis foreign currencies may have to decline in comparison with its expected future value in order to induce private market participants abroad to increase the share of the deutsche-mark denominated securities in their portfolios. Second, private market participants may view new data on the current balance as containing new information as to where the exchange rate should be in the future and, therefore, because of interest-rate arbitrage, where it should be in the present.[8]

To complete the exchange rate block, it remains to determine the short-term interest rate and the current balance. The short-term interest rate is determined by specifying an equation for the term structure of interest rate. In this equation, the excess of the short-term interest rate over the long-term interest rate is related to a constant, the real money stock, the real GDP, and the excess of the short-run expected rate of inflation over the long-run expected rate of inflation. The constant measures the liquidity premium and is expected to be negative. The current balance is determined by relating the ratio of exports over imports (in volume terms) to relative real GDP levels and relative GDP deflators in Germany and in the rest of industrial countries. For simplification purposes, the German GDP deflator is taken as a proxy for the deflator of German exports expressed in deutsche mark, while the deflator of German imports expressed in U.S. dollars is taken as exogenous.

II. Econometric Results

Table 2 presents the regression results obtained by using quarterly observations and two-stage-least-squares regression methods to estimate the parameters of the model. [9] The estimation period extends from the third quarter of 1964 to the second quarter of 1981. Two exceptions are equations (1'), (3') and (4'), which were estimated for each quarter _t_ using observations on the period extending from the first quarter of 1955 to _t_, [10] and equations (7), (11), and (12), which were estimated from observations on the floating rate period extending from the fourth quarter of 1973 to the second quarter of 1981. On the whole, the results were similar to those obtained in Artus (1981) for periods with identical starting points, but ending in the fourth quarter of 1979. However, there were important differences that will be stressed below.

In the price block, the results obtained for the equations that are used to estimate proxies for inflationary expectations remained similar to those obtained previously. In brief, long-run money growth expectations, and therefore long-run inflationary expectations, are deemed to adjust slowly to actual changes in the rate of growth of money, but they also

Table 2. Empirical Results[a]

Price block

(1') $\sum_{j=1}^{j=6} \dot{m}_j/6 = \sum_j \alpha_{1,j}\, \dot{m}_{-j} - \underset{(0.0163)}{0.0360}\,(y-\bar{y})_{-1} - \underset{(0.0011)}{0.0072}\, z_1 + \underset{(0.0164)}{0.1116} \sum_{j=0}^{j=5} \dot{r}_j$

$\alpha_{1,1} = 0.055$ $\alpha_{1,5} = 0.139$
$\alpha_{1,2} = 0.154$ $\alpha_{1,6} = 0.163$
$\alpha_{1,3} = 0.104$ $\alpha_{1,7} = 0.143$
$\alpha_{1,4} = 0.103$ $\alpha_{1,8} = 0.072$

Total = 0.933 (0.037) $\bar{R}^2 = 0.959$
Mean lag = 4.648 (0.782) SEE = 0.0047
D-W = 0.392

(1) $\dot{m}^{e\ell} = \sum_j \alpha_{1,j}\, \dot{m}_{-j} - 0.0360\,(y-\bar{y})_{-1} - 0.0072\, z_2$

(2) $\dot{p}^{e\ell} = 0.00^{b} + \dot{m}^{e\ell} - \dot{\bar{y}}$

(3') $\dot{p} = \sum_j \alpha_{6,j}\, \dot{p}_{-j}$

$\alpha_{6,1} = 0.123$ $\alpha_{5,4} = 0.360$
$\alpha_{6,2} = 0.166$ $\alpha_{6,5} = 0.163$
$\alpha_{6,3} = 0.255$ $\alpha_{6,6} = -0.048$
$\alpha_{6,7} = -0.062$

Total = 0.957 (0.104) $\bar{R}^2 = 0.399$
Mean lag = 2.877 (0.721) SEE = 0.0069
D-W = 1.999

(3) $\dot{p}^{es} = \sum_j \alpha_{6,j}\, \dot{p}_{-j+1}$

(4') $\dot{p}_d = \sum_j \alpha_{7,j}\, \dot{p}_{d,-j}$

$\alpha_{7,1} = 0.258$ $\alpha_{7,4} = 0.298$
$\alpha_{7,2} = 0.174$ $\alpha_{7,5} = 0.103$
$\alpha_{7,3} = 0.051$ $\alpha_{7,6} = -0.012$
$\alpha_{7,7} = 0.052$

Total = 0.948 (0.106) $\bar{R}^2 = 0.326$
Mean lag = 3.061 (0.641) SEE = 0.0070
D-W = 1.989

(continued on p. 15)

Table 2 (continued). Empirical Results[a]

(4) $\dot{p}_d^{es} = \sum_j \alpha_{6,j}\, \dot{p}_{d,-j+1}$

(5) $\dot{p}_d = \underset{(0.0030)}{0.0036} + \sum_j \alpha_{9,j}\, \dot{p}^{e\ell}_{-j} + \sum_j \alpha_{10,j}(y-\bar{y})_{-j} + \underset{(0.0021)}{0.0092}\, d_1$

$+ \underset{(0.065)}{0.245} \sum_{j=0}^{j=-6} (\dot{p}_m - \dot{e})_j/6$

$\alpha_{9,0}$	= 0.422[c]	$\alpha_{10,0}$	= 0.017[d]		
$\alpha_{9,1}$	= 0.039	$\alpha_{10,1}$	= 0.029		
$\alpha_{9,2}$	= 0.025	$\alpha_{10,2}$	= 0.034		
$\alpha_{9,3}$	= 0.212	$\alpha_{10,3}$	= 0.033		
$\alpha_{9,4}$	= 0.421	$\alpha_{10,4}$	= 0.027		
$\alpha_{9,5}$	= 0.349	$\alpha_{10,5}$	= 0.019		
$\alpha_{9,6}$	= −0.255	$\alpha_{10,6}$	= 0.009	$\bar{R}^2$	= 0.435
Total	= 1.085 (0.372)		0.168 (0.051)	SEE	= 0.0054
Mean lag	= 2.253 (1.246)		2.698 (1.186)	D-W	= 1.950

(6) $\dot{p} = 0.726\, \dot{p}_d + 0.274\, (\dot{p}_m - \dot{e})$

Output block

(7) $i^{\ell} = \underset{(0.0696)}{-0.0025} - \underset{(0.0163)}{0.0654}\, (m-p) + \underset{(0.0203)}{0.0569}\, y - \underset{(0.124)}{0.084}\, \dot{p}^{e\ell} - \underset{(0.00013)}{0.00006}\, t$

$+ \underset{(0.127)}{0.190}\, (\dot{p}^{es} - \dot{p}^{e\ell})$

$\bar{R}^2 = 0.879$ SEE = 0.0014 D-W = 0.992

(8) $y = \bar{y} - \underset{(0.0136)}{0.0083} + \sum_j \alpha_{19,j}\, (i^{\ell} - \dot{p}^{e\ell})_{-j} + \sum_j \alpha_{20,j}\, (0.41\tilde{g} + 0.59\tilde{x})_{-j}$

$+ \sum_j \beta_{1,j}(0.0092\, d_1 + 0.245 \sum_{j=0}^{j=-6} (\dot{p}_m - \dot{e})_j/6)_{-j}$

(continued on p. 16)

Table 2 (continued). Empirical Results[a]

$\alpha_{19,0}$	= -0.093^{e}	$\beta_{1,0}$	= 0.015^{d}	$\alpha_{20,0}$	= 0.294
$\alpha_{19,1}$	= −0.354	$\beta_{1,1}$	= 0.251	$\alpha_{20,1}$	= 0.040
$\alpha_{19,2}$	= −0.546	$\beta_{1,2}$	= 0.429		
$\alpha_{19,3}$	= −0.676	$\beta_{1,3}$	= 0.555		
$\alpha_{19,4}$	= −0.753	$\beta_{1,4}$	= 0.635	Total	= 0.334 (0.052)
$\alpha_{19,5}$	= −0.782	$\beta_{1,5}$	= 0.674	Mean lag	= 0.120 (0.041)
$\alpha_{19,6}$	= −0.771	$\beta_{1,6}$	= 0.677		
$\alpha_{19,7}$	= −0.726	$\beta_{1,7}$	= 0.649		
$\alpha_{19,8}$	= −0.655	$\beta_{1,8}$	= 0.597		
$\alpha_{19,9}$	= −0.564	$\beta_{1,9}$	= 0.526		
$\alpha_{19,10}$	= −0.461	$\beta_{1,10}$	= 0.441		
$\alpha_{19,11}$	= −0.352	$\beta_{1,11}$	= 0.348		
$\alpha_{19,12}$	= −0.245	$\beta_{1,12}$	= 0.251		
$\alpha_{19,13}$	= −0.146	$\beta_{1,13}$	= 0.158		
$\alpha_{19,14}$	= −0.062	$\beta_{1,14}$	= 0.072	$\bar{R}^2$	= 0.886
				SEE	= 0.0079
Total	= −7.187 (1.207)		6.279 (1.029)	D-W	= 1.889
Mean lag	= 6.208 (1.263)		6.548 (1.643)	RHO	= 0.593

(9) $$\tilde{g} = g - \left(\sum_{j=1}^{j=12} 0.9^{j} g_{-j} \Big/ \sum_{j=1}^{j=12} 0.9^{j}\right)$$

(10) $$\tilde{x} = x - \left(\sum_{j=1}^{j=12} 0.9^{j} x_{-j} \Big/ \sum_{j=1}^{j=12} 0.9^{j}\right)$$

Exchange rate block

(11) $$\dot{e} = -(\dot{p}_d^{es} - \dot{p}^{es}_{d,U.S.}) - \underset{(0.0103)}{0.0395} + \underset{(0.822)}{1.371} (\Delta i^s - \Delta i^s_{U.S.})$$

$$+ \underset{(0.797)}{2.406} (\Delta i^s - \Delta i^s_{U.S.})_{-1} + \underset{(0.054)}{0.243} ((b - b_{U.S.}) + (b - b_{U.S.})_{-1})/2$$

$$- \underset{(0.010)}{0.027} d_3 - \underset{(0.022)}{0.062} d_4 - \underset{(0.019)}{0.065} d_5$$

$\bar{R}^2$ = 0.728 SEE = 0.0250 D-W = 2.022

(continued on p. 17)

Table 2 (concluded). Empirical Results [a]

(12) $i^s = i^\ell - \underset{(0.0491)}{0.3641} - \underset{(0.0158)}{0.0188}(m-p) + \underset{(0.0204)}{0.0826}\,y + \underset{(0.084)}{0.258}(\dot{p}^{es} - \dot{p}^{e\ell})$

$\bar{R}^2 = 0.815$ SEE = 0.0012 D-W = 1.714 RHO = 0.498

(13) $x = \underset{(0.1024)}{0.6166} - \underset{(0.308)}{1.585}(y-\bar{y}) + \underset{(0.163)}{0.952}(y^*-\bar{y}^*) - \sum_j \alpha_{34,j}(p_d - p_d^* + e)_{-j} + \underset{(0.0112)}{0.0598}\,\dot{d}_4$

$\alpha_{34,0}$	= -0.222 [c]	$\alpha_{34,9}$	= -0.066
$\alpha_{34,1}$	= -0.144	$\alpha_{34,10}$	= -0.081
$\alpha_{34,2}$	= -0.087	$\alpha_{34,11}$	= -0.093
$\alpha_{34,3}$	= -0.050	$\alpha_{34,12}$	= -0.098
$\alpha_{34,4}$	= -0.029	$\alpha_{34,13}$	= -0.093
$\alpha_{34,5}$	= -0.021	$\alpha_{34,14}$	= -0.075
$\alpha_{34,6}$	= -0.024	$\alpha_{34,15}$	= -0.042
$\alpha_{34,7}$	= -0.034	$\alpha_{34,16}$	= -0.010
$\alpha_{34,8}$	= -0.049		
		Total	= -1.198 (0.258)
		Mean lag	= 6.509 (2.095)

$\bar{R}^2 = 0.634$
SEE = 0.0351
D-W = 1.331

(14) $b = x + p_d - p_m^* + e$

[a] The period covered by the left-hand-side variables extends from the third quarter of 1964 to the second quarter of 1981, except for equations (1'), (3'), (4'), (7), (11) and (12). As explained in the text, the parameters of equations (1'), (3'), and (4'), are estimated for each period t on the basis of observations for the period extending from the first quarter of 1955 to t. To save space, the results are presented here only for the regression equations covering the period extending from the first quarter of 1955 to the second quarter of 1981. The parameters of equations (7), (11) and (12) are estimates from observations on the flexible exchange rate period extending from the fourth quarter of 1973 to the second quarter of 1981. Standard errors of the estimated values of the parameters are shown in parentheses below the coefficients. SEE denotes standard error of the estimate. D.W. denotes the Durbin-Watson statistic. Columns may not add to totals shown because of rounding.

[b] -0.05 from 1976 to 1979.

[c] Almon constraint: polynomial of degree 3, without zero-constraint.

[d] Almon constraint: polynomial of degree 3, zero-constraint at the end.

[e] Almon constraint: polynomial of degree 3, zero-contraints at the beginning and end.

are deemed to be directly influenced by announcements of major policy changes. Short-run inflationary expectations are deemed to adjust slowly to actual changes in inflation rates.

The results for the Phillips curve equations are also similar to those obtained previously. In particular, the sum of the coefficients on the expectation term is not significantly different from one, but a large part of the effect comes with a significant lag. It takes about five quarters for the total effect to take place, which is consistent with the a priori knowledge that most labor contracts in Germany cover a period of one year. Similarly, it takes a long time for the output gap to affect the rate of inflation. Furthermore, in this case, even the final effect is not large. Ultimately, an increase of 1 percentage point in the gap between actual and potential GDP reduces the quarterly rate of inflation by a 0.17 (0.05) [11] percentage point, or the annual rate by about a 0.68 (0.20) percentage point. As in Artus (1981), variables outside the monetary field had to be introduced into the regression equation to account for certain developments. The surge of inflation in 1968-71 is still explained by introducing a dummy variable of the zero-one type. However, contrary to that previous study, the surge of inflation in 1973-75 is not explained anymore by the introduction of a dummy variable. Instead, a variable measuring the average change in import prices during the preceding six quarters performs that function. The introduction of import prices had not been successful previously, possibly because, except for 1973-75, import prices in deutsche marks were not increasing rapidly during the sample period. It is only when introducing 1980 and the first half of 1981, which was characterized by rapidly increasing import prices in deutsche marks, that the coefficient of the import price variable became relatively large and statistically significant. [12]

These results suggest that German real wage rates are somewhat rigid. [13] For example, a 10 per cent deterioration in the terms of trade due to an increase in import prices will lead to a 2.5 per cent increase in the GDP deflator, presumably because of an increase in nominal wage rates. Given a constant money growth rate, the growth of real GDP will start to decline. But, for many years, the resulting rise in the output gap will fail to bring about the decline in real wage rates necessary to restore domestic equilibrium at full employment.

In the output block, the addition of observations for 1980 and the first half of 1981 allows a better identification of the effects of changes in the real money stock on the long-term rate of interest. The coefficient of the real money stock, contrary to previous results, is now statistically significant and is large in magnitude. A 1 per cent reduction in the real money stock is found to lead to an increase of a 0.065 percentage point in the long-term interest rate at a quarterly rate, or a 0.26 percentage point at an annual rate. [14] The other results in the long-term interest rate equation remained unchanged. In particular, the coefficient of the long-run expected rate of inflation is small and not statistically significant. The coefficient of the expected liquidity-squeeze variable is positive as expected, but also not statistically significant. Together, the two latter coefficients imply that a

1 percentage point decrease in the long-run expected inflation rate initially leads to a 0.27 percentage point increase in the long-term nominal interest rate and, therefore, to a 1.27 percentage point increase in the long-term real interest rate.

The results for the output equation were not affected by the updating. The long-term real interest rate is still found to have a gradual, but ultimately large, effect on output. After three and one-half years, an increase in the interest rate of 1 percentage point at a quarterly rate (or 4 percentage points at an annual rate) is found to result in a 7.2 per cent decline in real GDP. By contrast, the impulse effect of an additional 1 per cent increase in real government expenditures and in the ratio of exports over imports in volume terms leads to a 0.33 (0.05) per cent increase in real GDP after two quarters, while government expenditures and exports per se account for about 45 per cent of GDP.

In the exchange rate block, the coefficients of the exchange rate equation were first estimated without making any attempt to isolate the effects of major disturbances such as the oil embargo. The results were as follows:

$$\dot{e} = -(\dot{pes}_d - \dot{pes}_{d,U.S.}) - \underset{(0.0129)}{0.0506} + \underset{(1.016)}{2.799}\,(\Delta is - \Delta is_{U.S.})$$

$$+ \underset{(1.026)}{3.209}\,(\Delta i^s - \Delta i^s_{U.S.})_{-1} + \underset{(0.069)}{0.294}\,((b - b_{U.S.}) + (b - b_{U.S.})_{-1})/2$$

$\overline{R}2 = 0.509$ SEE = 0.0336 D.W. = 1.670.

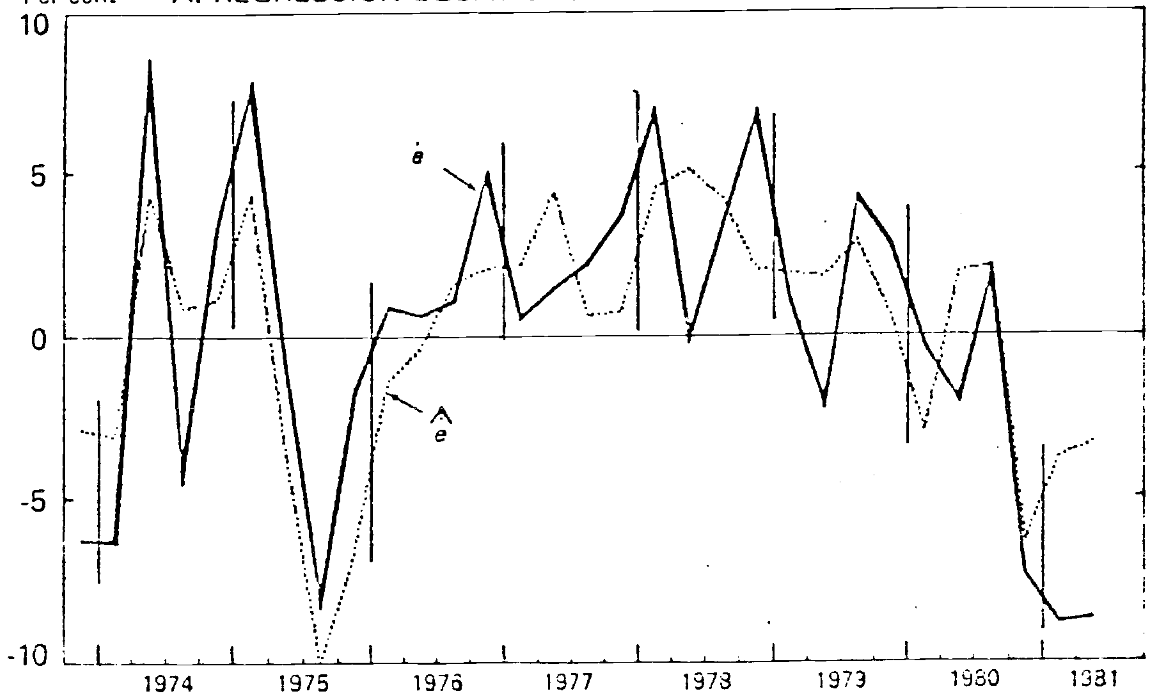
While the estimates of the coefficients have the expected signs and are statistically significant, the regression equation explains only 51 per cent of the variations in the exchange rate. The plot of actual and estimated values presented in Chart 1.A clearly shows that the large residuals are to be found in three periods, which follow the oil embargo in late 1973, the collapse of the Herstatt bank in mid-1974, and the election of Ronald Reagan in late 1980. [15] When dummy variables were included for these factors, [16] Table 2 show that the estimates of the coefficients were not significantly affected, but that their standard errors were greatly reduced. The explanatory power of the equation increased sharply, with 73 per cent of the variations in the exchange rate now accounted for. (See Chart 1.B for the residuals in the new regression equation.) The results of this latter equation will be used in the rest of this study; they are roughly similar to those obtained in Artus (1981) as far as interest rate and current balance effects are concerned.

The interesting implication of these results is that about half of the 29 per cent depreciation of the deutsche mark against the U.S. dollar from the fourth quarter of 1979 to the second quarter of 1981 is due to what we have called the "Reagan effect" (see Chart 2). The other significant factor during this period is the worsening of the German current balance relative to the U.S. current balance. Contrary to what is commonly thought, changes in interest rates do not account for much of the net change in the exchange rate from the fourth quarter of 1979 to the second quarter of 1981, mainly because the rise in U.S. real interest rates was soon offset by an equivalent rise in German interest rates. But the pattern of quarterly changes in the DM-$ exchange rate was strongly influenced by changes in interest rates.

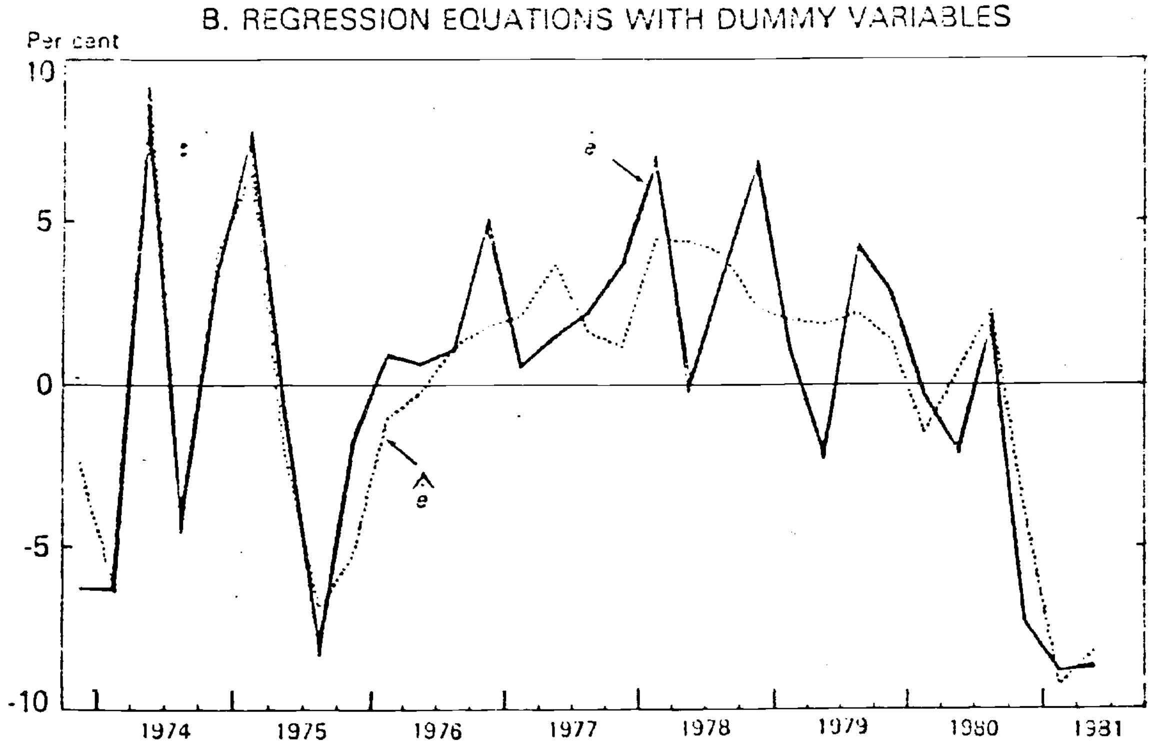
CHART 1

ACTUAL AND ESTIMATED VALUES OF THE CHANGE IN THE DM-$ EXCHANGE RATE

A. REGRESSION EQUATIONS WITHOUT DUMMY VARIABLES[1]



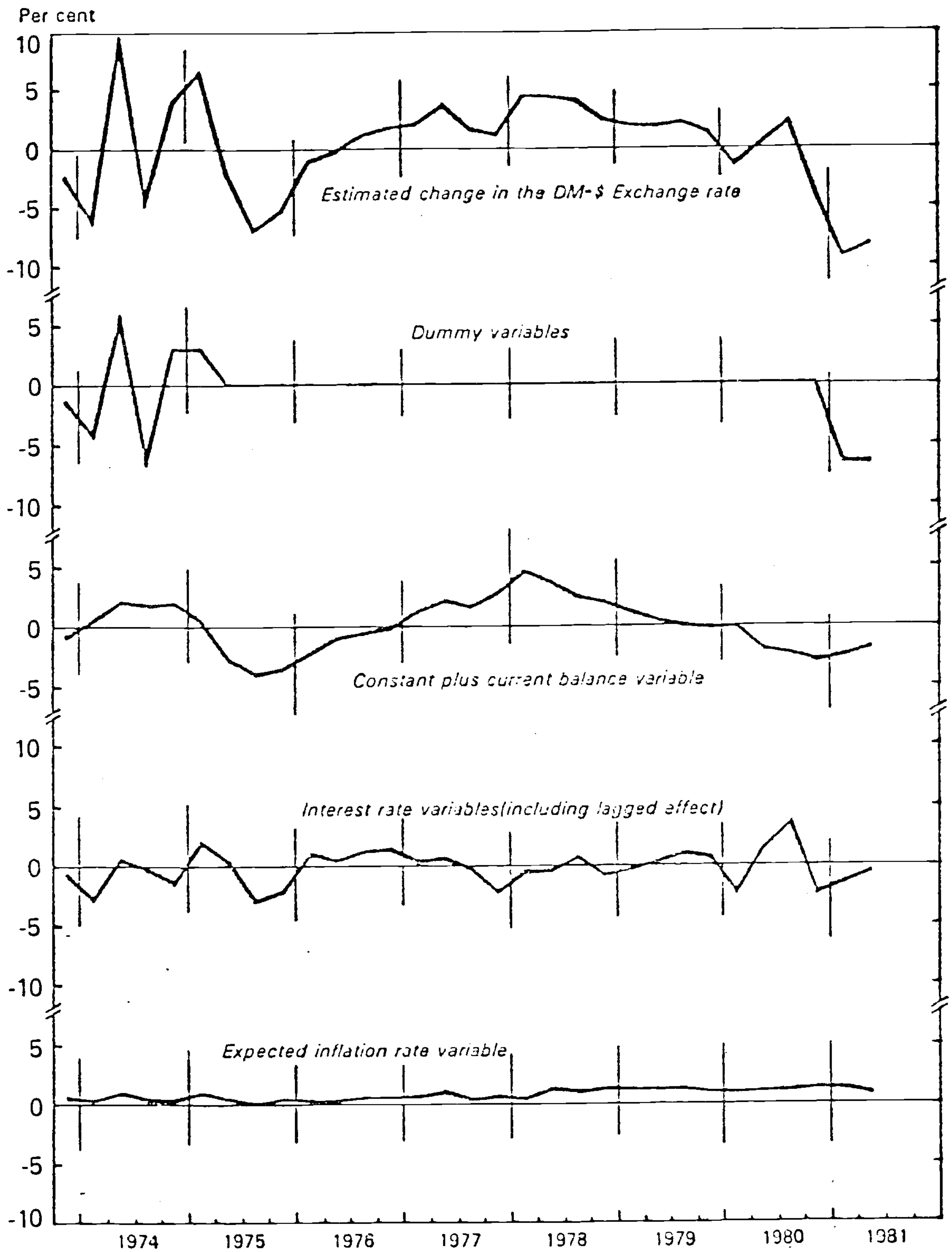
B. REGRESSION EQUATIONS WITH DUMMY VARIABLES



[1] $\dot{e}$ is the rate of change of the value of one deutsche mark in terms of U.S. cents.
$\hat{e}$ is the estimated value of $\dot{e}$.

CHART 2

CONTRIBUTIONS TO THE ESTIMATED VALUE OF THE CHANGE IN THE DM-$ EXCHANGE RATE[1]



[1] These results refer to the regression equation with dummy variables.

The results for the two remaining regression equations in the exchange rate block call for only brief comments. The results of the equation for the short-term interest rate are reasonable. There is a significant liquidity premium indicated by the negative constant. As expected, an increase in the real money stock decreases the short-term rate by comparison with the long-term rate, while an increase in economic activity increases the short-term rate by comparison with the long-term rate. An excess of the short-run expected rate of inflation over the long-run expected rate of inflation is reflected by an excess of the short-term interest rate over the long-term interest rate. Finally, the trade equation remains characterized, as previously, by a sum of the export and import price elasticities that exceeds one only after a lag of about three years.

III. Policy Simulations

The model estimated above can be used to investigate various policy issues. Here, I focus on issues of international interdependence. First, I investigate the normal effects of a shift to monetary restraint in the United States on the DM-$ exchange rate and the German economy, and the policy alternatives available to the German monetary authorities. Then, I consider the different case of an "exogenous" change in the DM-$ exchange rate, taking as an example the Reagan effect, and again I investigate the effects on the German economy and the policy alternatives available to the German monetary authorities.

1. Effects of monetary restraint in the United States

The purpose of the first set of simulations is to estimate the effects of a shift to monetary restraint in the United States on the DM-$

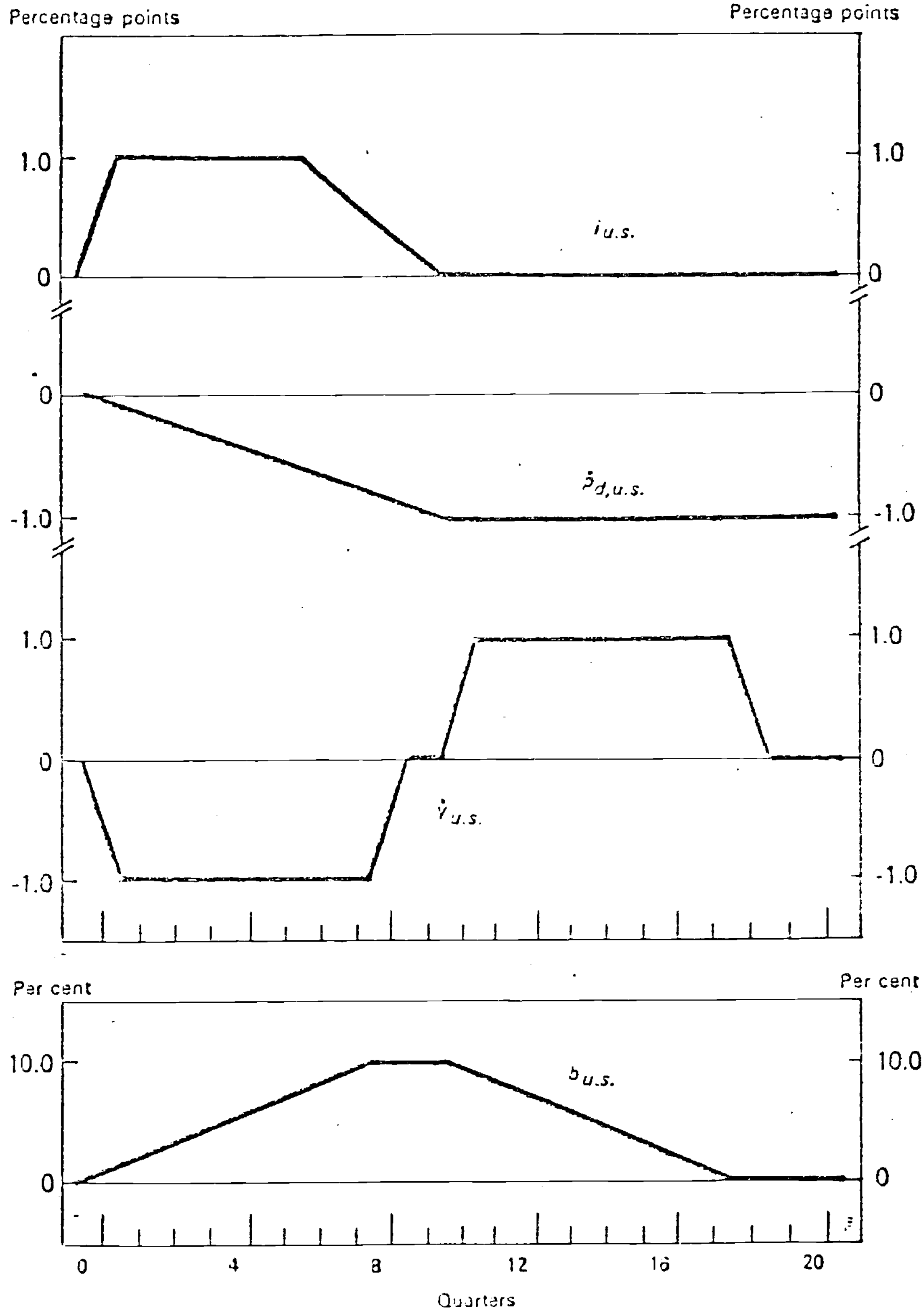
exchange rate and the German economy, when the German monetary authorities do not change their rate of money growth in response to the change in U.S. policy. The estimation is made under two polar assumptions as to the policy response in other industrial countries. Under assumption A, the other industrial countries keep their real exchange rates vis-à-vis the deutsche mark constant and, therefore, follow the German monetary policy. Under assumption B, the other industrial countries keep their real exchange rates vis-à-vis the U.S. dollar constant and, therefore, follow the U.S. monetary policy. To make the estimation, I generate a control solution for the period 1980 to 1984 which, although somewhat arbitrary, is intended to provide a plausible picture of what would have taken place during this period if there had not been a shift in U.S. monetary policy and a Reagan effect. Then, I "shock" the model by changing the exogenous variables and I calculate the effect of the given shock by subtracting the new simulation results from those obtained in the control solution.

The shock that depicts the shift to monetary restraint in the United States is represented in Chart 3. The short-term interest rate (at a quarterly rate) is increased by one percentage point in the first quarter, stays at its new level for one and a half year, and then declines back to its initial level in four quarters. The U.S. inflation rate (at a quarterly rate) declines gradually, with a total decline of one percentage point after two and a half years. The rate of growth of real GNP (at a quarterly rate) is reduced by one percentage point in the first quarter, stays at its new level for two years, goes back to its initial level for two quarters, and then increases by one percentage point for two years,

CHART 3

THE U.S. SHIFT TO MONETARY RESTRAINT

(Values of variables in terms of deviations from control solution)



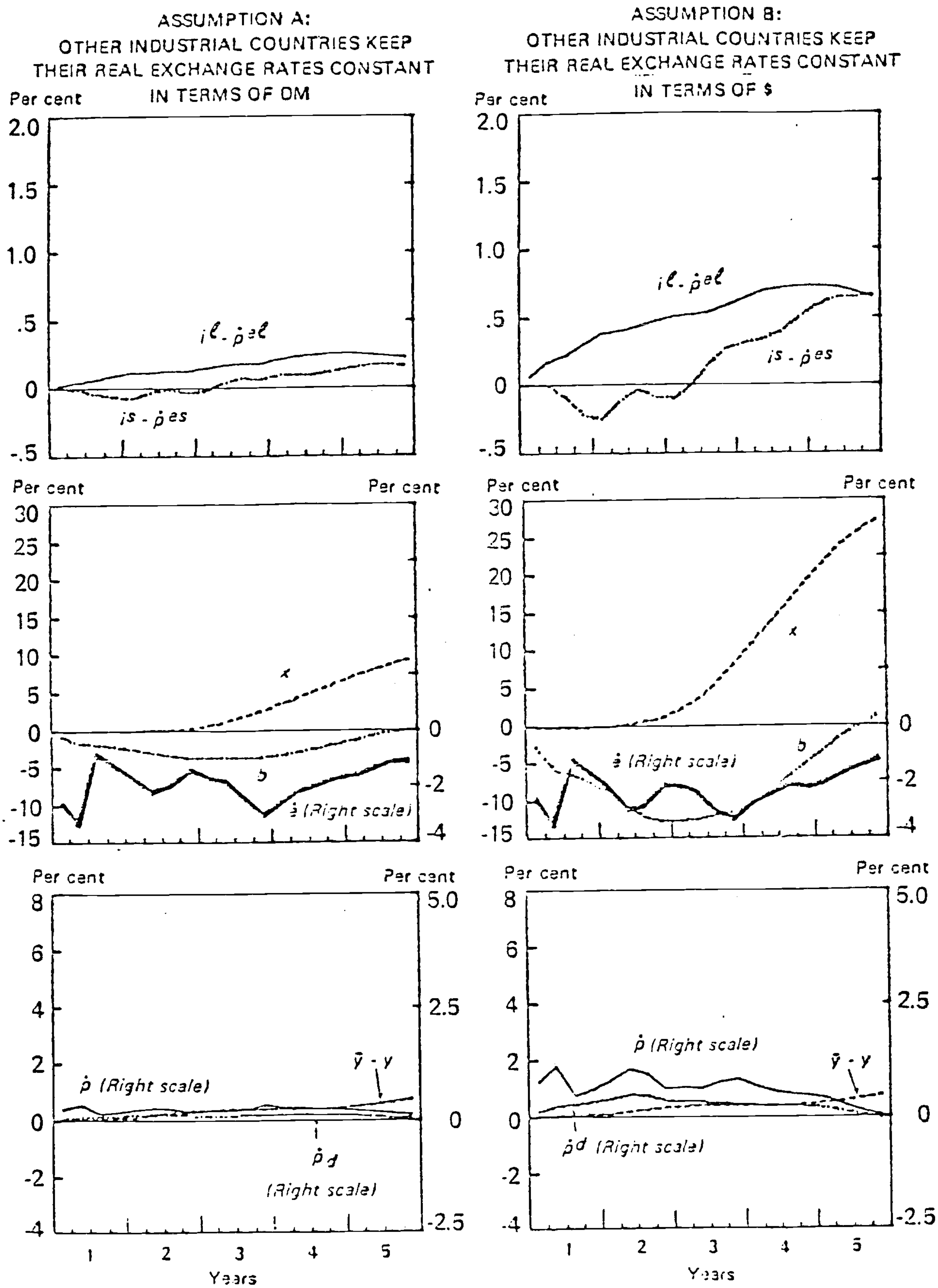
before finally settling back to its initial level. The U.S. current balance (expressed by the ratio of exports of goods and services over imports of goods and services) increases gradually during the first two years for a total gain of 10 per cent, stays at its new level for two quarters, then gradually goes back to its initial level during the next two years. The choice of these adjustment paths is arbitrary, but it would not be unrealistic to view them as representing the effects of the shift of monetary restraint in the United States in late 1979 in a schematic form. At least this is true if one neglects the sharp quarterly movements in U.S. money growth and U.S. interest rates during 1980.

Chart 4 depicts the estimates of the effects of the shift in U.S. monetary policy on the DM-$ exchange rate and the German economy, when the German monetary authorities do not change their rate of money growth. The estimates on the left-hand side assume that the rest of the industrial countries keep their real exchange rates vis-à-vis the deutsche mark constant (assumption A), while the estimates on the right-hand side assume that the rest of the industrial countries keep their real exchange vis-à-vis the U.S. dollar constant (assumption B).

Considering assumption A first, the effects on the DM-$ exchange rate and the German economy are quite pronounced. Three main factors cause the deutsche mark to depreciate sharply in real terms against the U.S. dollar for a sustained period. First, the increase in short-term U.S. interest rates leads to a sharp depreciation of the DM-$ exchange rate during the first two quarters. Second, this initial depreciation gives rise to a J-curve effect and a worsening German current balance

CHART 4

EFFECTS OF U.S. MONETARY RESTRAINT WITHOUT A CHANGE IN MONETARY POLICY IN GERMANY



during the next few quarters. Third, the decline in economic activity in the United States gradually leads to an improvement in the U.S. current balance and a further worsening of the German current balance. After three years, the DM-$ exchange rate has declined by 27 per cent in nominal terms and 20 per cent in real terms. The depreciation of the DM-$ exchange rate, in turn, causes a rise in the German inflation rate, as measured both by the GDP deflator and the domestic demand deflator. After three years, the GDP deflator has increased by 1.2 per cent and the domestic demand deflator by 2.9 per cent. With an unchanged rate of money growth, real interest rates increase in Germany, bringing about a small increase in the GDP gap. All these effects become unwound in the long run, but it takes a large number of years at some cost in terms of cumulated lost output in Germany. The cumulated lost output in Germany accounts for 0.5 per cent of a year's GDP already after three years and 1.5 per cent after five years.

Not surprisingly, the effects under assumption B are similar as to their direction, but their magnitude is larger. For example, the rise in the German inflation rate is much larger as a result of a larger rise in import prices. After three years, the GDP deflator has risen by nearly 4.0 per cent and the domestic demand deflator by nearly 9.9 per cent. This leads to a larger cumulated lost output in Germany; the lost output amounts to 2.2 per cent of a year's GDP after three years and 5.4 per cent after five years. These results illustrate how much Germany benefits if other industrial countries keep their real exchange rates vis-à-vis the deutsche mark constant.

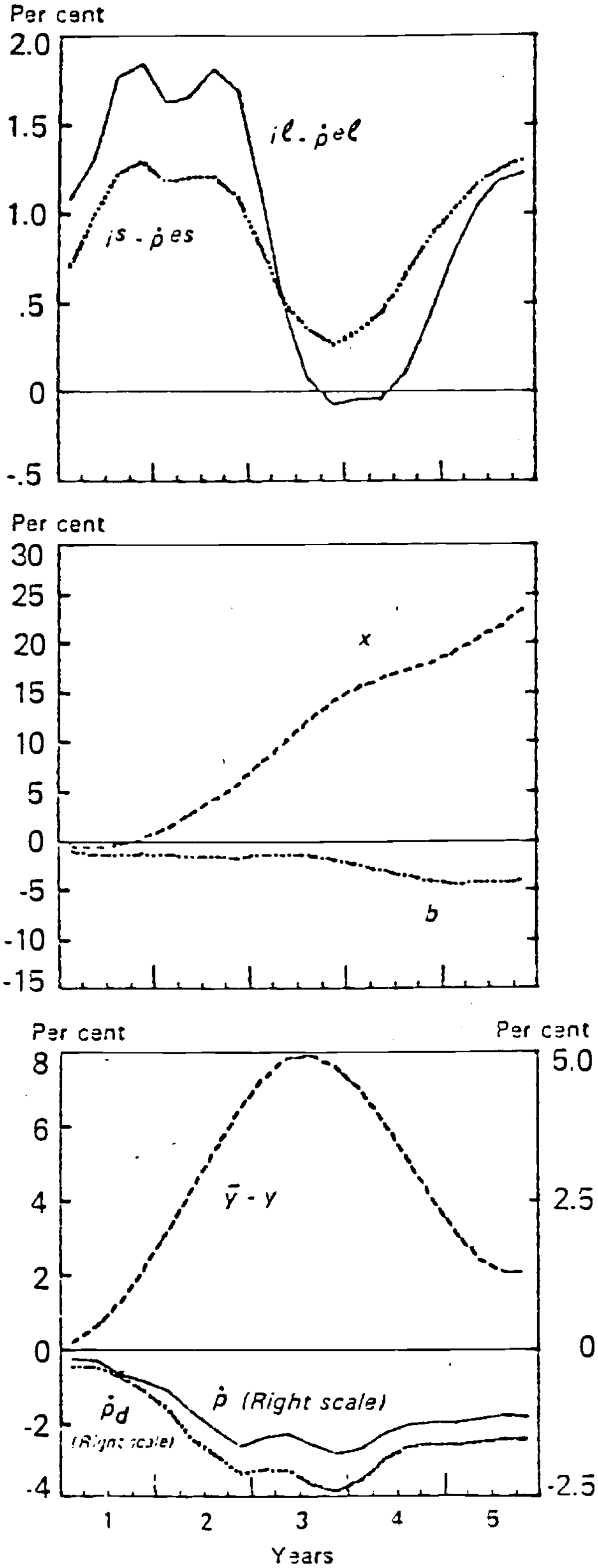
A possible policy response of the German monetary authorities is to reduce their rate of money growth in order to offset the effect of U.S. monetary restraint on the DM-$ exchange rate.[17] The implications of this policy response are depicted in Chart 5 for the case where other industrial countries adopt the same response.[18] The favorable effect of such a response is that the rate of inflation declines sharply in Germany. After a year, the rate of inflation has declined by about one percentage point (at a quarterly rate), whether the rate of inflation is measured by the GDP deflator or the domestic demand deflator. Furthermore, this decline in the rate of inflation persists in subsequent years as a result of a permanent decline in the rate of money growth in Germany. However, the cost of such a policy is extremely large in terms of lost output in Germany. The output gap increases gradually to reach about eight percentage points after two years, before declining slowly. By the end of the fifth year, the cumulated lost output accounts for 21.5 per cent of a year's GDP. This can be compared to the cumulated loss of 1.5 per cent in the case where neither Germany nor the other industrial countries respond to the shift in U.S. monetary policy by an equivalent shift in their own monetary policies.

2. <u>Changes generated by the Reagan effect</u>

To estimate the changes in the German economy generated by a development such as the Reagan effect, I have simulated the model after introduction of an exogenous shift in the value of the deutsche mark against the U.S. dollar of -6.5 per cent per quarter from the fifth to the sixth quarter of the simulation period. For simplification purposes,

CHART 5

EFFECTS OF U.S. MONETARY RESTRAINT WITH A CHANGE IN MONETARY POLICY IN GERMANY AND OTHER INDUSTRIAL COUNTRIES[1]



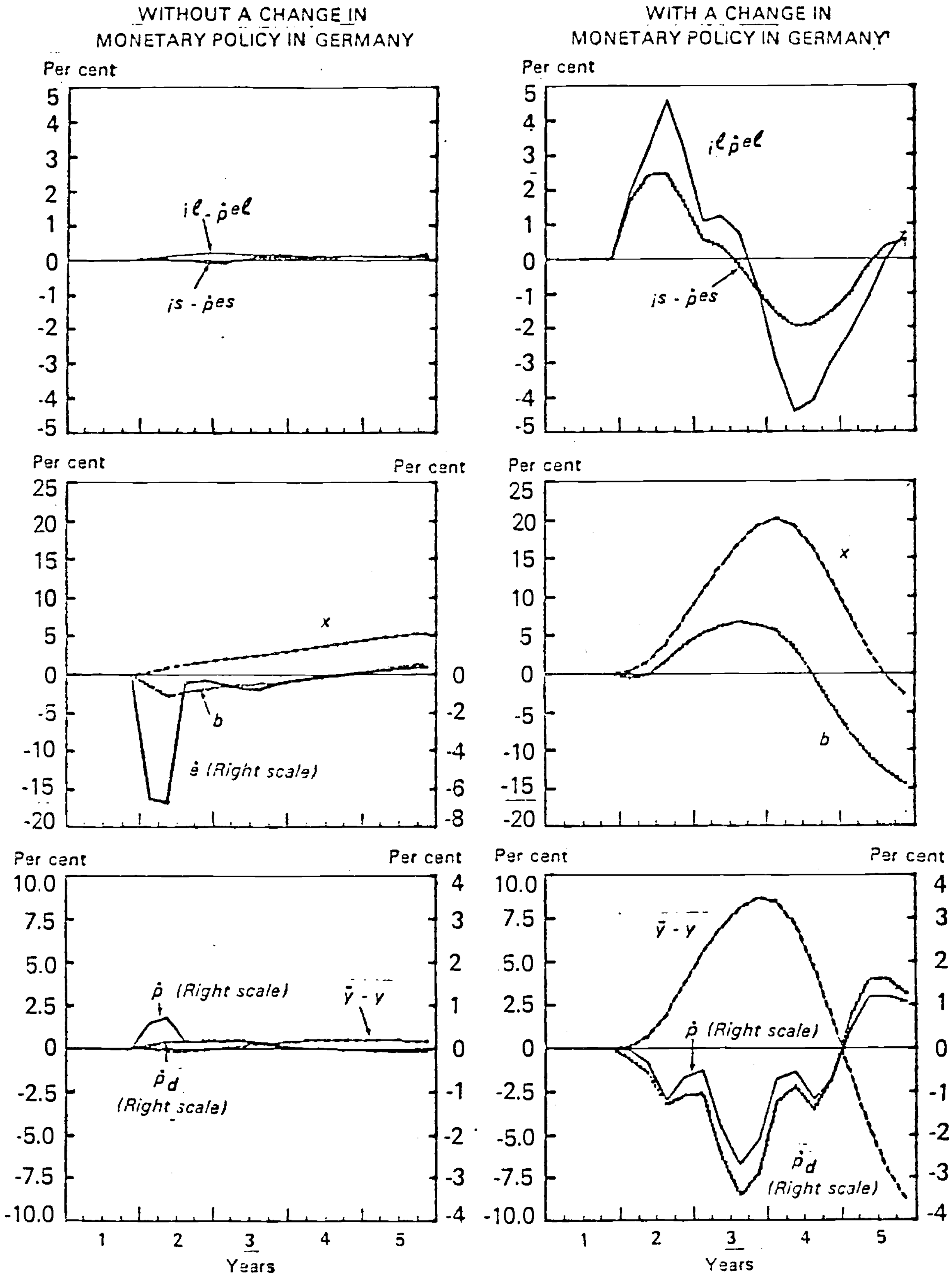
[1] Germany and the other industrial countries are assumed to reduce their money growth rates to offset the effect of U.S. monetary restraint on their exchange rates vis à vis the $.

it has been assumed that economic activity, inflation and the current balance in the United States remain as in the control solution. Differences between the new simulation results and those obtained in the control solution are presented in Chart 6. The results on the left-hand side of the chart assume that the German monetary authorities do not change the rate of money growth, while the results on the right-hand side assume that the authorities reduce the rate of money growth in order to offset the Reagan effect on the DM-$ exchange rate. In both cases, the other industrial countries are assumed to follow monetary policies that keep their exchange rates vis-à-vis the deutsche mark constant in real terms.[19]

The left-hand side results clearly indicate the inflationary impact of a depreciation of the DM-$ exchange rate on the German economy. The rate of inflation measured by the domestic demand deflator increases by more than half a percentage point at a quarterly rate during the first two quarters. After about two and a half years, the cumulated effect on the domestic demand deflator reaches 2 1/2 per cent. The rate of inflation measured by the GDP deflator is less affected; the cumulated effect on the GDP after two years and a half is about 1 1/2 per cent. In part, the inflationary consequences of the Reagan effect are enhanced because the depreciation of the deutsche mark initially leads to a worsening of the German current balance, which results in a further depreciation. This mechanism maintains the downward pressure on the deutsche mark even after the two quarters of the Reagan effect. With an unchanged rate of

CHART 6

CHANGES GENERATED BY THE REAGAN EFFECT



[1] The German monetary authorities are assumed to change the rate of growth of money in order to keep the exchange rate constant.

money growth, the increase in the domestic demand deflator gradually brings about a liquidity squeeze and a rise in both short-term and long-term real interest rates. The recessionary effect on output of the rise in long-term interest rates is at first offset by the expansionary effect coming from the increase in the ratio of exports over imports in volume terms, but, after one year, the recessionary effect starts to dominate.

These effects become unwound in the long run, but at a cost. Because of the increase in the output gap, the rate of inflation, measured either by the GDP deflator or the domestic demand deflator, starts falling in comparison with the control solution. A gradual improvement in the current account, resulting from the lagged relative price effects and the increase in the GDP gap, stops the depreciation of the deutsche mark in time, and then leads to a gradual appreciation. However, it takes a long period of economic slack before the price increases of the first two and a half years are fully offset by subsequent price declines. Five years after the initial shock, the cumulated effect on the domestic demand deflator still amounts to an increase of 2 per cent, which is only 1/2 per cent less than after two and a half years, despite an additional output gap of about half a percentage point maintained continuously from the third year onward.

The alternative strategy for the German monetary authorities and the monetary authorities of other industrial countries is to shift to a policy of monetary restraint in order to offset the effect of the exogenous development that puts downward pressure on their exchange rates. However, the results presented on the right-hand side of Chart 6 indicate that, at times, the cost in terms of economic slack may be so large that this will not be a realistic alternative. In the case of the Reagan effect, the model indicates that the German monetary authorities would have had to reduce the rate of monetary growth by about seven percentage points in each of the two quarters directly affected to offset the Reagan effect on the DM-$ exchange rate. Not surprisingly, the model indicates that this would have led not only to a reduction in inflation in Germany, as measured by both the domestic demand deflator and the GDP deflator, but also to a major recession. After two years, the output gap would have been increased by about 8 1/2 percentage points. Then, the German monetary authorities would have had to carry out a major monetary expansion to offset the upward pressures on the DM-$ exchange rate that would have resulted from a sharp increase in the German current balance. This would, in turn, have lead to a sharp economic recovery.

IV. Conclusions

This paper indicates that a shift to a policy of monetary restraint in the United States has major effects on Germany. If the German monetary authorities keep their rate of money growth unchanged, they will experience a sharp and sustained depreciation of the deutsche mark against the U.S. dollar in real terms. This will lead to a significant increase in the inflation rate in Germany for a large number of years. The GDP gap will also increase gradually. The magnitude of these effects is greatly increased when other industrial countries choose to respond to the U.S. policy by adopting equivalent policies of monetary restraint.

In this latter case, a simulation based on a schematic description of the effects of the 1979 shift to monetary restraint in the United States on U.S. interest rates, prices, output, and current balances, indicates the following effects on the German economy. Prices increase substantially in Germany; after three years, the GDP deflator is nearly 4 per cent higher than in the control solution corresponding to no shift to monetary restraint in the United States, and the domestic demand deflator nearly 10 per cent higher. Furthermore, output decreases substantially in Germany by comparison with the control solution. The cumulated lost output amounts to 2.2 per cent of a year's GDP after three years and 5.4 per cent after five years. It is true that all these effects become unwound in the long run, but the long run seems so far away in this case as to be irrelevant.

If the German monetary authorities respond to the change in U.S. policy by adopting an equivalent policy of monetary restraint and other industrial countries follow suit, Germany benefits from a marked decline in its inflation rate, but the cost in terms of lost output is extremely large. After a year, the rate of inflation, in terms of the GDP deflator or domestic demand deflator has declined by about one percentage point (at a quarterly rate), and the lower level persists in subsequent years. The output gap increases gradually to reach about eight percentage points after two years, before declining slowly. By the end of the fifth year, the cumulated lost output accounts for 21.5 per cent of a year's GDP.

An appreciation of the U.S. dollar due to an exogenous development gives rise to a similar dilemma for the German monetary authorities.

Here again, the dilemma is increased when other industrial countries choose to change their monetary policies in order to stabilize their exchange rates vis-à-vis the U.S. dollar. If the exogenous development is as large as what is called in the present paper the Reagan effect, that is, a depreciation of about 13 per cent within two quarters, the analysis indicates that it would be very costly for the German monetary authorities to try to offset the impact of this development on their exchange rate through a policy of monetary restraint. The necessary reduction in money growth would push the German economy into a major recession.

This paper also indicates that the large effects on the German economy of a U.S. policy of monetary restraint or of an exogenous development affecting the DM-$ exchange rate are mainly due to the following factors: (1) the inflation rate in Germany responds slowly to a change in the money growth rate or the emergence of a GDP gap, (2) there is a direct link in Germany between import prices and domestic factor prices, (3) the DM-$ exchange rate is highly sensitive to variations in uncovered short-term interest rate differentials and to the level of the relative current balance position of the two countries, and (4) the volumes of German foreign trade flows respond slowly to relative price changes.

Dummy Variables z_1 and z_2

The dummy variables z_1 and z_2 represent the discretionary component of the monetary policy stance. Consider first the policy reaction function (1')

$$(1') \quad \sum_{k=1}^{k=6} \dot{m}_k/6 = \sum_{j=1}^{j=n} \alpha_{1,j}\, \dot{m}_{-j} - \alpha_2(y-\bar{y})_{-1} - \alpha_3\, z_1 - \alpha_4 \sum_{k=1}^{k=6} \dot{r}_k$$

If the rate of growth of money on the left-hand side of the equation covers a period that includes the beginning of the implementation of a major stabilization program, then its value may deviate substantially from the value that the first two explanatory variables would normally imply. To take this into account, the dummy variable z_1 is given a value that increases from zero to one in proportion to the number of quarters covered by the left-hand side variable that are affected by the policy shift. If the left-hand side variable covers a period that immediately follows a policy change, only one or two of the lagged money growth rates included as explanatory variables will be affected by the policy change, so that the historical series cannot be considered to reflect adequately the information available to private market participants. To offset this fact, the value of z_1 is allowed to decay gradually from one to zero in eight quarters. In the empirical study, the rate of decay was chosen to be consistent with the estimates of the values of the lag coefficients of the variables $\dot{m}_{-j}$ in equation (1').

At any point in time, private market participants can look back and estimate the coefficients of the policy reaction function (1') from past data. To predict money growth, they must then forecast the discretionary component of the policy stance. In the present model, it is assumed that private market participants do not anticipate discretionary policy changes but that their long-run expectations are revised once a policy change is announced. The change in their expectations depends on the coefficient of the variable z_1, the magnitude of which depends on the effectiveness of past policy changes.

Thus, in equation (1)

$$(1) \qquad \dot{m}^{e\ell} = \sum_j \alpha_{1j} \dot{m}_{-j} - \alpha_2 (y-\bar{y})_{-1} - \alpha_3 z_2$$

which is used to predict money growth, the variable z_1 enters, but in a modified form denoted by z_2. The variable z_2 takes the value of zero up to the period when the policy change is announced; then, like z_1, it takes a value of one when the policy change is announced, after which z_2 decays gradually.

Eight monetary stabilization programs were identified during the period 1955-81 (second quarter) with the following initial impact periods: the second quarter of 1956, the first quarter of 1962, the fourth quarter of 1965, the second quarter of 1972, the fourth quarter of 1972, the second quarter of 1973, the third quarter of 1979, and the first quarter of 1981. The two programs with initial impact in the second quarter of 1972 and the fourth quarter of 1972 were given an intensity that was one half that of the other programs. Following the rules explained above, z_1 and z_2 were given the values presented in Table 3.

Table 3. Dummy Variables z_1 and z_2

Year	z_1 Quarter 1	z_1 Quarter 2	z_1 Quarter 3	z_1 Quarter 4	z_2 Quarter 1	z_2 Quarter 2	z_2 Quarter 3	z_2 Quarter 4
1955	0.2	0.3	0.5	0.7	0.0	0.0	0.0	0.0
1956	0.8	1.0	0.9	0.8	0.0	1.0	0.9	0.8
1957	0.7	0.6	0.5	0.4	0.7	0.6	0.5	0.4
1958	0.3	0.1	0.0	0.0	0.3	0.1	0.0	0.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
1961	0.3	0.5	0.7	0.8	0.0	0.0	0.0	0.0
1962	1.0	0.9	0.8	0.7	1.0	0.9	0.8	0.7
1963	0.6	0.5	0.4	0.3	0.6	0.5	0.4	0.3
1964	0.1	0.0	0.2	0.3	0.1	0.0	0.0	0.0
1965	0.5	0.7	0.8	1.0	0.0	0.0	0.0	1.0
1966	0.9	0.8	0.7	0.6	0.9	0.8	0.7	0.6
1967	0.5	0.4	0.3	0.1	0.5	0.4	0.3	0.1
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.1	0.1	0.3	0.4	0.0	0.0	0.0	0.0
1972	0.8	1.1	1.3	1.6	0.0	0.5	0.4	0.9
1973	1.6	1.5	1.4	1.1	0.7	1.7	1.4	1.3
1974	0.9	0.7	0.5	0.4	1.0	0.9	0.6	0.5
1975	0.3	0.1	0.0	0.0	0.3	0.1	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.2	0.3	0.5	0.0	0.0	0.0	0.0
1979	0.7	0.8	1.0	0.9	0.0	0.0	1.0	0.9
1980	1.1	1.2	1.3	1.3	0.8	0.7	0.6	0.5
1981	1.4	1.2			1.4	1.2		

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FOOTNOTES

[1] This view was developed, in particular, by Lucas ((1972), (1975)), Sargent and Wallace (1975), and Barro (1978).

[2] Most of the labor contracts in Germany are for a period of a year and require a few months of negotiations so that the six-quarter period chosen to evaluate the expected long-run rate of inflation seems adequate.

[3] Lagged money growth rates are usually included in the policy reaction function because they may contain information on the normal behavior of the authorities that cannot be readily derived from the way they react to values assumed by specific target variables.

[4] See the Appendix for a detailed explanation concerning the use of the z_1 variable in equation (1') and the corresponding z_2 variable in equation (1).

[5] For a discussion of these identification problems, see Germany and Srivastava (1979) and Buiter (1980).

[6] See Artus (1981, footnote 12, p. 508), for a discussion of the sign of the coefficient of the expected long-run inflation term.

[7] For the sake of convenience, the current balance variables are expressed as ratios of exports of goods and services over imports of goods and services in logarithmic form.

[8] An attempt was made in Artus (1981) to differentiate between these two effects of the current balance by introducing the change in the current balance in the exchange rate equation. This change was viewed as a proxy for unanticipated current balance develoments on the grounds that

FOOTNOTES (Continued)

quarterly changes in the current balance are difficult to forecast. The level of the current balance was then assumed to identify the effect of the limited asset substitutability. However, in the empirical analysis, the coefficient of the change in the current balance was found to be small and not significantly different from zero at the 5 per cent significance level, while the coefficient of the level of the current balance was found to be large and significant. This result could be interpreted as suggesting that either the limited-substitutability effect was the important one, or that even the level of the current balance was difficult to anticipate and came often as a "surprise." In the present study, the effect of the change in the current balance was again found to be not significant, and this variable was dropped from the exchange rate equation.

[9] The sources of the data are described in Artus (1981, Appendix II).

[10] The regression results indicated in Table 2 for equations (1'), (3'), and (4') are those based on the full sample period extending to the second quarter of 1981.

[11] The standard error of the estimate is indicated in parentheses.

[12] The expression statistically significant is used in this paper as an abbreviation for "significantly different from zero at the 5 per cent significance level."

[13] A similar conclusion is reached in Branson (1980).

[14] The implied elasticity of money with respect to the long-term interest rate is 0.4.

FOOTNOTES (Continued)

[15] The first half of 1981 was certainly influenced by many factors other than the election of Ronald Reagan, including political problems in Germany and the crisis in Poland.

[16] The dummy variable for the oil embargo takes the value 0.5 in the fourth quarter of 1973, 1.5 in the first quarter of 1974, -2 in the second quarter of 1974, and zero otherwise. The dummy variable for the collapse of the Herstaff bank takes the value 1 in the third quarter of 1974, -0.5 in the fourth quarter of 1974, -0.5 in the first quarter of 1975, and zero otherwise. Finally, the dummy variable for the election of Ronald Reagan takes the value 1 in the first two quarters of 1981 and zero otherwise.

[17] In the simulation, the reduction in money growth in Germany is accompanied by a change in money growth anticipation in the first quarter due to the effect of the dummy variable z_2 (See Appendix for a description of this variable.) That is the reduction in money growth is defined as a major policy shift that is viewed as such by private market participants.

[18] In the model, it is not possible to simulate the case where the German monetary authorities stabilize the DM/$ exchange rate while other industrial countries do not adopt any monetary response. In particular, there is no equation in the model that would determine what would happen to the exchange rates of other industrial countries in this case.

FOOTNOTES (Concluded)

[19] In the simulation where the German monetary authorities and the monetary authorities of other industrial countries reduce the rate of money growth, the level of economic activity in other industrial countries is assumed to be reduced in proportion to the reduction in the German level of economic activity.