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EXCHANGE RATE VARIABILITY AND MONETARY POLICY UNDER RATIONAL EXPECTATIONS

Some Euro–American Experience 1973–1979

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We analyze the sources of changes in nominal and real rates of exchange between six European currencies and the U.S. dollar. We conclude that over the period 1973–1979 unexpected changes in the price of oil, together with unanticipated monetary shocks at home or in the U.S. were the most important causes of changes in exchange rates. A multi-state Kalman filter technique is used to compute empirical proxies for unanticipated changes in the exogenous variables. Since both oil price shocks and changes in U.S. monetary trends effect the European currencies in different degrees, it follows that differential domestic rates of inflation are not the only reason why arrangements to restrict exchange rate fluctuations, such as the European Monetary System, may run into trouble.

1. Introduction

The recent record of nominal and real exchange rate movements of the main European currencies against the dollar raises a number of important questions. A *first* question is whether the large and often hectic fluctuations in nominal and real exchange rates during the floating rate period have identifiable economic causes. The answer to this question has obvious implications for the feasibility of a return to fixed parities in Europe. If it can be shown that exchange rates have moved a lot because large and variable shocks have hit the world economy in the 1970's, then the survival of the European Monetary System hinges not so much on the extent of political support for it, but on the non-occurrence of such shocks in the 1980's.[1]

A *second* question is why during the floating rate period some currencies, notably the Pound Sterling and the Italian Lira, have been depreciating against the dollar at a much slower rate than the excess of the British and Italian inflation rates over the U.S. rate of inflation would have led one to

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[1]See Korteweg (1979a).

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expect? Analogously, why have the D-Mark and the Swiss Franc appreciated at a much faster rate than the excess of the U.S. rate of inflation over the German rate of inflation would lead one to expect? Have there been shocks to these economies that affect exchange rates different from prices? If so, which shocks were these and what was the difference in their effects made up of: differences in speed or total size? A *third* and still more puzzling question is why currencies like the French Franc and the Dutch Guilder have appreciated, on average, against the dollar while at the same time experiencing inflation rates (sometimes well) in excess of the U.S. rate of inflation? In such cases, the traditional monetary approach to exchange rates, based on the postulate of purchasing power parity, would lead to expect these currencies to depreciate in nominal terms.[2]

It is this group of questions that this paper seeks to address: what factors have caused the size and variability of exchange rate movements to increase over the 1970's; and what are the determinants of real exchange rate movements? In trying to answer these questions we are especially interested in the consequences of differences in the speeds at which different countries produce money, and in the way in which markets react to news about monetary trends. Also, we shall try to incorporate the effects on nominal and real exchange rates of changes in the relative price of oil and the effects of changes in the degree of uncertainty that reigns with respect to future inflation rates in the different countries.

In the next section we present a model of these determinants and mechanisms supposedly governing fluctuations in real and nominal exchange rates. Following that we present and discuss the outcomes of some econometric tests of the model. In a final section, we discuss the policy implications of our findings.

2. The exchange rate model

2.1. Like much of the recent work on floating exchange rates our model takes an asset market approach to exchange rate determination.[3] Since the exchange rate is the relative price of two national monies, and since national monies are durable assets, we should observe that the relative price between any two monies today is closely linked to the relative price that the market expects to prevail over the future life of these assets.[4] The asset market approach to exchange rates implies that exchange rates, if free to move, mainly reflect expectations about future events whereas national price levels reflect more strongly present and past events that are embedded in existing

[2]See for example, Frenkel and Johnson (1978).

[3]See the most illuminating article by Mussa (1979, pp. 38–42).

[4]See the studies by Frenkel (1978a), Frenkel and Clements (1980), Levich (1978) and Mussa (1979).

contracts. These differences between asset prices and commodity prices imply that in periods dominated by 'news' departures from purchasing power parity — movements of the real rates of exchange — are likely to be the rule rather than the exception.

2.2. The following simple model of a two-country world embodies the asset approach to exchange rate determination.[5]

The model consists of the following 14 equations, where hats ($\hat{}$) indicate first differences of logarithms. Foreign variables are indicated by an asterisk. Superscript e denotes an expectation. For any variable x, $\hat{x}^e_{+1}$ is defined as $\ln x^e_{+1} - \ln x$, and $\hat{x}^e$ is defined analogously as $\hat{x}^e = \ln x^e - \ln x_{-1}$, where x^e_{+1} and x^e_{+1} are shorthand for Ex_{t+1} and Ex_t, respectively, with E denoting the expectation operator,

$$\hat{y} - \hat{y}^e = \alpha_1(\hat{p} - \hat{p}^e) - \alpha_2(\hat{p}^*_{oil} - \hat{p}^{*e}_{oil}) - \alpha_2(\hat{e} - \hat{e}^e) + u_1, \tag{1}$$

supply of domestic output.

$$\hat{y} - \hat{y}^e = -\beta_1\, \Delta r_L + \beta_2(\hat{Z} - \hat{Z}^e) + \beta_3(\hat{y}^* - \hat{y}^{*e}) + \beta_4(\hat{er} - \hat{er}^e) + u_2, \tag{2}$$

demand for domestic output.

$$\hat{M} = \eta\hat{y} + \hat{p} - \Theta\, \Delta \ln(f/e) - \varepsilon\, \Delta i_s + u_3, \tag{3}$$

supply equals demand for domestic money.

$$\hat{y}^* - \hat{y}^{*e} = \alpha^*_1(\hat{p}^* - \hat{p}^{*e}) - \alpha^*_2(\hat{p}^*_{oil} - \hat{p}^{*e}_{oil}) + u^*_1, \tag{4}$$

supply of foreign output.

$$\hat{y}^* - \hat{y}^{*e} = -\beta^*_1\, \Delta r^*_L + \beta^*_2(\hat{Z}^* - \hat{Z}^{*e}) + \beta^*_3(\hat{y} - \hat{y}^e) - \beta^*_4(\hat{er} - \hat{er}^e) + u^*_2, \tag{5}$$

demand for foreign output.

$$\hat{M}^* = \eta^*\hat{y}^* + \hat{p}^* + \Theta^*\, \Delta \ln(f/e) - \varepsilon^*\, \Delta i^*_s + u^*_3, \tag{6}$$

supply equals demand for foreign money.

$$\hat{er} = \hat{e} - (\hat{p} - \hat{p}^*), \qquad \text{the real exchange rate.} \tag{7}$$

$$\Delta i_s = \Delta i^*_s + \Delta \ln(f/e) + u_4, \qquad \text{interest rate parity.} \tag{8}$$

[5]For previous and further developments and applications of the approach, see Bilson (1978), Dornbusch (1976a, b), Frankel (1979a), Frenkel and Johnson (1978), Frenkel and Clements (1980), Hodrick (1978), Isard (1977) and Mussa (1976).

$$\Delta i_s = \Delta r_s + \Delta \hat{p}^e_{+1}, \quad \text{Fisher parity at home.} \tag{9}$$

$$\Delta i^*_s = \Delta r^*_s + \Delta \hat{p}^{*e}_{+1}, \quad \text{Fisher parity abroad.} \tag{10}$$

$$\Delta r_L = \Delta r_s + \gamma \Delta \sigma + u_5, \tag{11}$$

purchasing power risk differential between domestic long-term and short-term real interest rate.

$$\Delta r^*_L = \Delta r^*_s + \gamma^* \Delta \sigma^* + u^*_5, \tag{12}$$

purchasing power risk differential between foreign long-term and short-term real interest rate.

$$\Delta r_L - \delta \Delta \sigma = \Delta r^*_L - \delta^* \Delta \sigma^* + u_6, \tag{13}$$

purchasing power risk differential between domestic and foreign long-term real interest rate.

$$\Delta \ln (f/e) = \Delta \hat{e}^e_{+1}, \tag{14}$$

forward rate (f) an efficient forecast of the future spot rate (e^e_{+1}).

Variables endogenous to the model: p, p^*, y, y^*, e, f, e^e, er, i_s, i^*_s, r_s, r^*_s, r_L, r^*_L. Variables exogenous to the model: M, M^*, y^e, y^{*e}, Z, Z^*, σ, σ^*, P^*_{oil}, P^{*e}_{oil} and, *for the moment*, p^e and p^{*e}.

From eqs. (3) and (6) it follows that the supply of and the demand for domestic money (M) and foreign money (M^*) are assumed to be in equilibrium. Demand for domestic real money balances (M/p), for instance, is determined by domestic real income (y) and by opportunity costs. Opportunity costs of holding domestic money by domestic residents are measured by the rate of interest on short-term domestic non-monetary financial assets (i_s) and the rate at which domestic currency is expected to depreciate against foreign currency [$\ln (f/e)$]. For expositional simplicity it is assumed that short-term domestic non-monetary financial assets are a substitute for money balances held by domestic residents only, whereas short-term foreign non-monetary financial assets are assumed to be a substitute for money balances held by foreigners only.

Eq. (1) is a Lucas–Sargent type aggregate supply equation which states that domestic output (y) is supplied at its planned rate (y^e) if domestic product prices (p) and foreign factor prices in domestic currency units, as represented by the oil price (p^*_{oil}) multiplied by the exchange rate (e) are correctly foreseen (p^e; $e^e p^{*e}_{\text{oil}}$). Forecast errors with respect to these prices lead to deviations of actual output from its normal level. Analogously, aggregate supply of foreign output is described by eq. (4). No attempt is made here to uncover the factors that determine those levels of output (y^e, y^{*e}) that would occur if product and factor prices would be perfectly foreseen. Production theory suggests that an economy's normal level of output depends on human and non-human capital formation, population growth, technical progress in human and non-human capital via research and development, education and training, developments in the structure and institutions of product and factor markets, etc. Capital formation, research, training and schooling all are investment decisions that are dominantly determined by expectations about the future course of individual product and factor prices, and about the future developments of property rights, institutions, regulations and structures of the product and factor markets.[6] Since we cannot hope to obtain data on all these factors for the seven countries involved in this study, we proceed by treating y^e and y^{*e} as exogenous variables, changes in the growth rates of which are assumed to be unpredictable.

Eq. (2) is an aggregate demand equation for domestic output. Aggregate demand for output is assumed to depend, among other things, on expected real income (y^e) and on unanticipated changes in the long-term domestic real interest rate (r_L), the real exchange rate (er), foreign claims on domestic output based on foreign real income (y^*) and government claims on domestic output as determined by government consumption, investment and tax rates (all subsumed in Z). Analogously, aggregate demand for foreign output is described by eq. (5). Finally, the markets for foreign and domestic output are assumed to be in continuous equilibrium.

The efficient asset market characteristics of the model are embodied in eqs. (8)–(14). Eqs. (9) and (10) express the Fisher relationships between short-term nominal (i_s) and real (r_s) interest rates at home and abroad. Eqs. (11) and (12) take account of differences in purchasing power risks between short-term and long-term bonds that exist in a world of uncertainty. Specifically, risk averse investors must be compensated for the future purchasing power risks (σ, σ^*) they incur by holding long-term rather than short-term bonds, by a premium that depends on their risk-aversion (γ, γ^*). According to eq. (8), the activities of pure (covered) interest arbitragers with unlimited access to short-term investment funds eliminate any systematic profit opportunities from international asset arbitrage. According to eq. (13), real interest rate parity exists only on a risk-corrected basis. Risk-averse asset holders get compensated for the real exchange rate risk implied by international differences in purchasing power risks that exist between national monies, by a premium or discount on the long-term and short-term real interest rates:

$$r_L = r_L^* + \delta\sigma - \delta^*\sigma^* \quad \text{and} \quad r_s = r_s^* + (\delta - \gamma)\sigma - (\delta^* - \gamma^*)\sigma^*.$$

[6]See Korteweg (1979b) for an empirical application of this approach to the Dutch economy.

Finally, eq. (14) closes the model by assuming that the forward exchange rate (f) is a rational forecast of the future spot rate (e_{+1}), the assumption being that the forward exchange market is dominated by the profit-maximizing activities of pure speculators who are risk-neutral and have unlimited access to forward funds.

It follows from eqs. (8)–(13) that

$$\ln(f/e) = (\delta-\gamma)\sigma - (\delta^*-\gamma^*)\sigma + (\hat{p}^{e}_{+1} - \hat{p}^{*e}_{+1}) + \text{random errors.} \tag{15}$$

This, together with eq. (14) implies that

$$\hat{e}^{e}_{+1} = (\delta-\gamma)\sigma - (\delta^*-\gamma^*)\sigma^* + (\hat{p}^{e}_{+1} - \hat{p}^{*e}_{+1}) + \text{random errors.} \tag{16}$$

Eq. (16) states that the expected rate of depreciation or appreciation of one currency against the other is determined by those factors that determine expected inflation differentials and purchasing power risk differentials between countries. From eq. (16) it also follows that our model does not imply expected PPP. The rate at which the domestic currency is *expected* to depreciate against the foreign currency in *real* terms is

$$\widehat{er}^{e}_{+1} \equiv \hat{e}^{e}_{+1} - (\hat{p}^{e}_{+1} - \hat{p}^{*e}_{+1}) = (\delta-\gamma)\sigma - (\delta^*-\gamma^*)\sigma^* + \text{random errors.} \tag{17}$$

Alternatively, we could have closed the model by assuming expected PPP:

$$\hat{e}^{e}_{+1} = \hat{p}^{e}_{+1} - \hat{p}^{*e}_{+1}. \tag{18}$$

Together with eq. (15), eq. (18) would imply

$$\ln(f/e) = \hat{e}^{e}_{+1} + (\delta-\gamma)\sigma - (\delta^*-\gamma^*)\sigma^* + \text{random errors.} \tag{19}$$

In this alternative set-up, the forward rate (forward premium) is a biased predictor of the (rate of change of the) future spot rate, not because exchange markets are inefficient but because non-zero purchasing power risks and risk averting speculators are involved.[7] We have rejected this alternative assumption (18), because of the striking failure to date of empirical tests to reject the null-hypothesis that there is no risk premium in the forward exchange rate.[8]

2.3. We assume that expectations of both the endogenous and the exogenous variables are formed rationally. In the case of an exogenous

[7]Compare, for instance, Fama and Farber (1979).
[8]Such tests are reported by Frankel (1979b).

variable, we assume that the relevant information set on which the expectations are based consists of the variable's own past; expectations about the endogenous variables are based on the solution of the complete model.

Our model acknowledges the importance of expectations for economic behavior, but restricts attention to expectations about the next period, which are held to be representative for the whole future. The money demand functions underlying eqs. (3) and (6), for example, include only the *current* short-term nominal interest rate (i_s) as an explanatory variable. This short-term nominal interest rate consists of the rate of inflation currently expected to exist over the life of the short-term bond ($\hat{p}^e_{+1}$), plus the real interest rate currently expected over the life of the short-term bond (r_s): $r_s+\hat{p}^e_{+1}$.[9] Inclusion in the money demand function of only the *current* rate of interest is warranted only if it is assumed that future changes in the expected real interest rate and the expected rate of inflation *cannot* be predicted:

$$E(\Delta r_{+j})=E(\Delta \hat{p}_{+j+1})=0 \quad \text{for } j=1,2,\dots.$$

If one fails to make such simplifying assumptions, then expectations about the more distant future have to be included in the behavioral equations of the model: it may become necessary to incorporate a complete term structure of expectations about future real interest rates and future rates of inflation in the demand for money function, in order to avoid myopic and therefore irrational behavior.[10] We shall manage to avoid such term structures of expectations in our theoretical model by modelling the stochastics of the exogenous variables $\hat{M}$, $\hat{M}^*$, $\hat{y}^e$ and $\hat{y}^{*e}$ in an appropriately simple manner, and by assuming that the model has a solution for which it holds that no future changes in any of the four real rates of interest can be foreseen. Thus, we begin the solution procedure with the precise specification of the time series processes for money and expected output and subsequently derive reduced form expressions for a number of endogenous variables, including Δr_s. It will be seen then that Δr_s (and also Δr_s^*, Δr_L and Δr_L^*) is a function of current-period surprises only so that our assumption that future changes in the real rates of interest cannot be foreseen will be validated.

In view of the above, we assume that the following univariate models underly the development of the domestic and foreign stocks of money:

$$\Delta \hat{M}=(1-\psi B)(\hat{M}-\hat{M}^e), \tag{20}$$

$$\Delta \hat{M}^*=(1-\psi^* B)(\hat{M}^*-\hat{M}^{*e}), \tag{21}$$

[9]We assume the life of short-term bonds to be equal to our model's unit period of analysis.

[10]See Sargent and Wallace (1973) for a discussion of the stability problems that arise in that case. See Bomhoff (1980) for further discussion on the term structure of expectations.

where $(\hat{M}-\hat{M}^{e})$, $(\hat{M}^{*}-\hat{M}^{*e})$ are white noise series, B represents the lag operator $Bx_t \equiv x_{t-1}$, and ψ, ψ^{*} are time-dependent time-series parameters.

If expectations are formed rationally, it follows from eqs. (20) and (21) that

$$\Delta\hat{M}^{e}_{+1}=(1-\psi)(\hat{M}-\hat{M}^{e}), \quad \text{and} \tag{22}$$

$$\Delta\hat{M}^{*e}_{+1}=(1-\psi^{*})(\hat{M}^{*}-\hat{M}^{*e}). \tag{23}$$

It follows that $\Delta\hat{M}^{e}_{+1}$ can be computed after the current shock $(\hat{M}-\hat{M}^{e})$ has become known, but not before. Similarly, the computation of $\Delta\hat{M}^{e}_{+2}$ becomes feasible only after the shock $(\hat{M}_{+1}-\hat{M}^{e}_{+1})$ has occurred; until then the expectation $\hat{M}^{e}_{+1}$ has to serve as the best possible prediction for periods $t+2$ and beyond. In addition, we assume that the changes in the expected growth rate of domestic and foreign output $(\Delta\hat{y}^{e}_{+1}, \Delta\hat{y}^{*e}_{+1})$, and the changes in domestic and foreign purchasing power risks $(\Delta\sigma, \Delta\sigma^{*})$, are fully unpredictable.

When these results about the expectations of future growth in money and income are combined with the assumption that the model has a solution for which all future changes in real interest rates are unpredictable, then it follows from eqs. (8)–(10) and (14) that $E_{-1}(\hat{e}^{e}_{+1})=E_{-1}(\hat{e}^{e})$. Taking rational expectations of eqs. (3) and (6) then implies

$$\hat{p}^{e}=\hat{M}^{e}-\eta\hat{y}^{e}, \tag{24}$$

$$\hat{p}^{*e}=\hat{M}^{*e}-\eta^{*}\hat{y}^{*e}. \tag{25}$$

From substituting eqs. (24) and (25) into eq. (16) and shifting the result backward one period it follows that

$$\hat{e}^{e}=(\delta-\gamma)\sigma_{-1}(\delta^{*}-\gamma^{*})\sigma^{*}_{-1}+(\hat{M}^{e}-\hat{M}^{*e})$$
$$-\eta\hat{y}^{e}+\eta^{*}\hat{y}^{*e}+\text{lagged random errors.} \tag{26}$$

From eq. (17) it also follows that the determinants of the rate at which the domestic currency is expected to depreciate against the foreign currency in *real* terms $(\hat{er}^{e})$ is

$$\hat{er}^{e}\equiv\hat{e}^{e}-(\hat{p}^{e}-\hat{p}^{*e})$$
$$=(\delta-\gamma)\sigma_{-1}-(\delta^{*}-\gamma^{*})\sigma^{*}_{-1}+\text{lagged random errors.} \tag{27}$$

Next, we have to find out what causes the actual rates of change of the domestic price level, the foreign price level, the spot exchange rate and the real exchange rate to deviate from their expected rates of change. For that we derive four reduced-form equations for $\hat{p}-\hat{p}^e$, $\hat{p}^*-\hat{p}^{*e}$, $\hat{e}-\hat{e}^e$ and Δr_s, having reduced the model to four equations in these unknowns. The first of these equations is obtained by subtracting eq. (24) from eq. (3) and substituting for $(\hat{y}-\hat{y}^e)$, Δi_s and $\Delta\hat{e}^e_{+1}$ with the help of eqs. (1), (9), (20)–(23), and (24)–(26). The second equation is obtained similarly by subtracting eq. (25) from eq. (6). The remaining two equations are derived from eqs. (2) and (5) by substituting for $(\hat{y}-\hat{y}^e)$, $(\hat{y}^*-\hat{y}^{*e})$, Δr_L and Δr_L^* with the help of eqs. (1), (4) and (11)–(13). The complete system of four equations is presented and subsequently solved in a mathematical appendix to this paper which can be obtained on request from the authors. The corresponding reduced-form equations are

$$\hat{p}=\hat{p}^e+P_1(\hat{M}-\hat{M}^e)+P_2(\hat{M}^*-\hat{M}^{*e})+P_3(\hat{Z}-\hat{Z}^e)+P_4(\hat{Z}^*-\hat{Z}^{*e})$$
$$+P_5\Delta\hat{y}^e_{+1}+P_6\Delta\hat{y}^{*e}_{+1}+P_7\,\Delta\sigma+P_8\,\Delta\sigma^*+P_9(\hat{p}^*_{\text{oil}}-\hat{p}^{*e}_{\text{oil}})$$
$$+\text{random errors,} \tag{28}$$

$$\hat{p}^*=\hat{p}^{*e}+P_1^*(\hat{M}-\hat{M}^e)+P_2^*(\hat{M}^*-\hat{M}^{*e})+P_3^*(\hat{Z}-\hat{Z}^e)+P_4^*(\hat{Z}^*-\hat{Z}^{*e})$$
$$+P_5^*\,\Delta\hat{y}^e_{+1}+P_6^*\,\Delta\hat{y}^{*e}_{+1}+P_7^*\,\Delta\sigma+P_8^*\,\Delta\sigma^*+P_9^*(\hat{p}^*_{\text{oil}}-\hat{p}^{*e}_{\text{oil}})$$
$$+\text{random errors,} \tag{29}$$

$$\hat{e}=\hat{e}^e+E_1(\hat{M}-\hat{M}^e)+E_2(\hat{M}^*-\hat{M}^{*e})+E_3(\hat{Z}-\hat{Z}^e)+E_4(\hat{Z}^*-\hat{Z}^{*e})$$
$$+E_5\,\Delta\hat{y}^e_{+1}+E_6\,\Delta\hat{y}^{*e}_{+1}+E_7\,\Delta\sigma+E_8\,\Delta\sigma^*+E_9(\hat{p}^*_{\text{oil}}-\hat{p}^{*e}_{\text{oil}})$$
$$+\text{random errors,} \tag{30}$$

$$\Delta r_s=R_1(\hat{M}-\hat{M}^e)+R_2(\hat{M}^*-\hat{M}^{*e})+R_3(\hat{Z}-\hat{Z}^e)+R_4(\hat{Z}^*-\hat{Z}^{*e})$$
$$+R_5\,\Delta\hat{y}^e_{+1}+R_6\,\Delta\hat{y}^{*e}_{+1}+R_7\,\Delta\sigma+R_8\,\Delta\sigma^*+R_9(\hat{p}^*_{\text{oil}}-\hat{p}^{*e}_{\text{oil}})$$
$$+\text{random errors.} \tag{31}$$

The signs of the reduced-form coefficients are given in table 1. They are based on the obvious condition that $\delta \geqq \gamma > 0$ and $\delta^* \geqq \gamma^* > 0$, and on the simplifying assumptions that $\alpha_2 < \alpha_1$, $\alpha_2\eta < 1$, $\beta_3 < 1$, $\varepsilon=\varepsilon^*$, $\eta=\eta^*$, $\alpha_1=\alpha_1^*$, $\beta_1=\beta_1^*$, $\beta_3=\beta_3^*$, $\beta_4=\beta_4^*$, $\Theta=\Theta^*$.[11] In some cases these assumptions need to

[11]The condition that $\delta \geqq \gamma > 0 < \gamma^* \leqq \delta^*$ is obvious in that it is the only condition resulting in a domestic short-term real interest rate above (below) the foreign short-term real interest rate in case domestic purchasing power risk is larger (smaller) than foreign purchasing power risk.

be augmented by additional restrictions which are given in the notes to table 1. Basically, this set of assumptions reflects the case of an equal-country world. A different set of assumptions can serve to approximate the 'small-country' case, in which the home country is much smaller than the country represented by the starred (*) variables:

$$\alpha_2<\alpha_1,\quad \alpha_2\eta<1,\quad \beta_3<1,\quad \varepsilon=\varepsilon^*,\quad \eta=\eta^*,\quad \beta_3^*,\beta_4^*=0.$$

Those cases in which the reduced-form signs differ between the two sets of assumptions mentioned are indicated in the notes to table 1.

Table 1

Signs of coefficients of eqs. (28)–(31).

	Endogenous			
Exogenous	$\hat{p}-\hat{p}^e$	$\hat{p}^*-\hat{p}^{*e}$	$\hat{e}-\hat{e}^e$	Δr_s
$\hat{M}-\hat{M}^e$	$P_1>0$	$P_1^*<0$	$E_1>0$	$R_1\gtrless 0^k$
$\hat{M}^*-\hat{M}^{*e}$	$P_2<0$	$P_2^*>0$	$E_2<0$	$R_2\gtrless 0^l$
$\hat{Z}-\hat{Z}^e$	$P_3\gtrless 0^a$	$P_3^*>0^d$	$E_3<0$	$R_3\gtrless 0^m$
$\hat{Z}^*-\hat{Z}^{*e}$	$P_4>0$	$P_4^*>0$	$E_4>0^h$	$R_4>0$
$\Delta\hat{y}^e_{+1}$	$P_5<0$	$P_5^*>0$	$E_5<0$	$R_5\gtrless 0^n$
$\Delta\hat{y}^{*e}_{+1}$	$P_6>0$	$P_6^*<0$	$E_6>0$	$R_6>0$
$\Delta\sigma$	$P_7>0^b$	$P_7^*<0^e$	$E_7>0$	$R_7\gtrless 0^o$
$\Delta\sigma^*$	$P_8<0$	$P_8^*\gtrless 0^f$	$E_8<0^i$	$R_8<0$
$\hat{p}^*_{oil}-\hat{p}^{*e}_{oil}$	$P_9\gtrless 0^c$	$P_9^*\gtrless 0^g$	$E_9\gtrless 0^j$	$R_9\gtrless 0^p$

[a] $P_3>0$ if $\alpha_2=0$; $P_3<0$ if $\beta_3^*,\beta_4^*=0$ (small country case).
[b] $P_7>0$ if $\varepsilon=0$ or if $\gamma=0$.
[c] $P_9>0$ if $\alpha_2=\alpha_2^*$; $P_9\gtrless 0$ in small country case.
[d] $P_3^*=0$ in small country case.
[e] $P_7^*<0$ if $\delta>\gamma$ but zero if $\delta=\gamma$ in small country case.
[f] $P_8^*<0$ if $\delta=\gamma$; $P_8^*>0$ if $\gamma=0$; $P_8^*\gtrless 0$ in small country case.
[g] $P_9^*>0$ if $\alpha_2=\alpha_2^*$; $P_9^*>0$ in small country case.
[h] $E_4\gtrless 0$ in small country case.
[i] $E_8<0$ if $\gamma=0$, or if $\alpha_1=\alpha_1^*$ in small country case.
[j] $E_9=0$ if $\alpha_2=\alpha_2^*$; $E_9\gtrless 0$ in small country case.
[k] $R_1<0$ if $\Theta=0$, or if $\alpha_2=0$; $R_1>0$ in small country case.
[l] Sign of R_2 is opposite that of R_1.
[m] $R_3=0$ in small country case.
[n] $R_5<0$ if $\alpha_2=0$ or in small country case.
[o] $R_7>0$ if $\gamma=0$; $R_7<0$ if $\gamma=\delta$.
[p] $R_9>0$ in small country case.

Combination of eqs. (28)–(30) gives the expression for the determinants of the unexpected rate of change of the real exchange rate,

$$\hat{er} = \hat{er}^e + X_1(\hat{M} - \hat{M}^e) + X_2(\hat{M}^* - \hat{M}^{*e}) + X_3(\hat{Z} - \hat{Z}^e) + X_4(\hat{Z}^* - \hat{Z}^{*e})$$
$$+ X_5 \Delta \hat{y}^e_{+1} + X_6 \Delta \hat{y}^{*e}_{+1} + X_7 \Delta\sigma + X_8 \Delta\sigma^* - X_9(\hat{p}^*_{oil} - \hat{p}^{*e}_{oil})$$
$$+ \text{random errors.} \qquad (32)$$

The signs of the reduced-form coefficients in this equation are identical to those of eq. (30) for the unexpected rate of change of the nominal exchange rate, except in the small-country case where they become generally undetermined.

2.4. The above model differs from most existing asset approaches to the determination of exchange rates in one important respect: it does not assume purchasing power parity to exist at all times, neither in its absolute version ($e = p/p^*$) nor in its relative version ($\hat{e} = \hat{p} - \hat{p}^*$).[12] Replacement of eq. (7) by a purchasing power parity condition (PPP) would effectively preclude any explanation of real exchange rate movements as an increasingly important fact of life. Overall, the recent empirical literature points to a marked inferiority of the PPP relationship during the years of floating exchange rates.

Real exchange rate changes can only occur if PPP does not hold for all output or at all times. Those following Dornbusch (1976a, b) try to explain real exchange rate movements either by distinguishing tradables, for which PPP holds, and non-tradables for which it does not hold, or by introducing different time lags with which new information affects prices and exchange rates, with exchange rates affected faster than prices.[13] In our model real exchange rate changes can occur even in the absence of different lags in the adjustment of prices and output to new information, and even in case all goods are tradable. To see this, we derive two expressions for the short-run interest differential. Eqs. (9)–(13) imply that the difference between the domestic and foreign short-term nominal interest rate reflects a premium (discount) in compensation of expected inflation differentials and purchasing power risk differentials:

$$i_s - i_s^* = (\hat{p}^e_{+1} - \hat{p}^{*e}_{+1}) + (\delta - \gamma)\sigma - (\delta^* - \gamma^*)\sigma^* \qquad (33)$$

At the same time, eqs. (8) and (15) imply

$$i_s - i_s^* = \hat{e}^e_{+1}.$$

[12] For comprehensive surveys of the theoretical and empirical literature and the interpretations surrounding PPP, see Officer (1976) and Katseli-Papaefstratiou (1979). Recent empirical work can be found in Kravis and Lipsey (1971), Kravis et al. (1978), Isard (1977), Richardson (1978), Genberg (1978), Vaubel (1976), and Frenkel (1978b).

[13] Frankel (1979 a, b) and Dornbusch (1979, part II).

It follows that only if $\delta=\gamma$ and $\delta^*=\gamma^*$ will (relative) purchasing power parity be expected to prevail. As long as $\delta\neq\gamma$ and $\delta^*\neq\gamma^*$ and purchasing power risk differentials are present, however, will the rate of change of the spot exchange rate deviate from relative PPP. This means that agents foresee ever-increasing divergences of the spot exchange rate from its absolute PPP-value, or — to put it more realistically — that they are unable to predict the timing and magnitude of future reversals from any current tendencies away from PPP.

Moreover, as follows from eq. (32), in addition to deviations from PPP owing to expected purchasing power risk differentials, our model is capable of generating deviations from PPP that are due to randomly arriving new information about the exogenous variables driving the system, and which affect the price level ratio between countries differently from the spot exchange rate between currencies even in the case of perfectly flexible prices and exchange rates. In particular, our model makes room for real exchange rate effects of unanticipated changes in (the growth rates) of domestic and foreign money, output, government expenditure and/or taxes, oil prices and purchasing power risks. At the same time, after full adjustment to such shocks has taken place, and in the absence of further news, our model is compatible with relative PPP. Deviations of absolute PPP will persist, however, as long as the initial shock is not completely reversed.[14]

To illustrate the real exchange rate effects of unanticipated shocks we turn off anticipated real exchange rate movements by assuming purchasing power risks and risk aversion to be the same at home and abroad ($\sigma=\sigma^*$, $\delta=\delta^*$, $\gamma=\gamma^*$). In addition, we assume that up to time t domestic and foreign price levels were stable. Now let at time t new information arrive that causes agents to expect the rate of growth of the domestic money stock to increase from zero to some positive value, while the foreign money stock is expected to remain constant. Let at time $t+j$ further news lead agents to foresee the growth rate of the domestic money stock to return to zero again. The new information that induces agents to change their expectations of the future monetary growth rate will also bring a proportional change in their expectations of the future rate of domestic inflation. Given interest parity and the Fisher conditions, this will immediately cause them to change their expectations about the rate at which the value of the domestic currency will depreciate against the foreign currency. As a result, *eventually* the relative price (p/p^*) and the exchange rate (e) will rise first in proportion to the speed at which the ratio of the domestic to the foreign money stock (M/M^*) is expected to rise, and stabilize later when the proportion M/M^* is expected to

[14]Inspection of the model solution shows that all shocks (with a possible exception for the oil price only) have well-determined once-and-for-all effects on the real exchange rate. Whether the shocks lead to ever-increasing deviations from PPP depends on whether they affect Δr_s and Δr_s^* differently. Eq. (33) indicates that this will be the case only for unexpected changes in purchasing power risk.

stabilize. But this is not all. Owing to the unanticipated domestic monetary expansion, the expected rate of domestic inflation increases whereas the expected rate of foreign inflation remains unaffected. Consequently, the domestic short-term nominal interest rate rises relative to the foreign short-term nominal interest rate. By implication, the forward premium $(\hat{e}^e_{+1})$ goes up. The rise in the domestic short-term interest rate and the forward premium decreases the demand for domestic money, whereas the rise of the forward premium increases the demand for foreign money. Since only the supply of domestic money has risen whereas the supply of foreign money has remained unchanged, domestic prices and output must increase, and foreign prices and output must fall, in order to restore money market equilibrium at home and abroad. As a result, output market equilibrium is disturbed, with domestic output in excess supply and foreign output in excess demand. In the 'equal-country world' whatever happens to long-term real interest rates affects both domestic and foreign output in the same direction so that only an unanticipated rise in the real exchange rate can restore output market equilibrium. In the 'small-country case', where $\beta_3^*, \beta_4^* = 0$, the unanticipated domestic monetary impulse leads to an increase in the foreign long-term real interest rate which, together with the fall in foreign output supply causes a rise in the real exchange rate in order to restore equilibrium in the domestic and foreign output markets.

Output market equilibrium is thus maintained in that the unexpected domestic monetary expansion leads to an initial rise of the spot exchange rate that exceeds the initial rise in the ratio between the domestic and the foreign price level, thereby causing the spot exchange rate to persistently deviate from its PPP-value. Reversal of the monetary shock, whereby from $t+j$ onwards the growth rate of the domestic money returns to zero again, reverses the previous outcomes and restores the spot exchange rate to its PPP value. Graphically, this sequence of affairs is illustrated in fig. 1.

The picture shows that, in the absence of further news and on the assumption of a zero purchasing power risk differential, unexpected domestic monetary expansion may create a persistent deviation of the spot exchange rate from PPP. Only reversal of the anticipated rate of domestic money growth to its original level can put an end to this persistent deviation from PPP. Between times t and $t+j$, absolute PPP is absent all of the time, whereas relative PPP is absent only some of the time.[15] Beyond time $t+j$ absolute and relative PPP is restored. Real depreciation of the currency is seen to coincide with rising anticipations of the determinants of domestic relative to foreign inflation, whereas real appreciation of the currency is seen

[15]If our theory of why absolute PPP is absent most of the time is correct, this might well explain the positive autocorrelations typically encountered by regression equations that are specified in the (logs of the) levels of the exchange rates and its determinants, rather than in their growth rates.

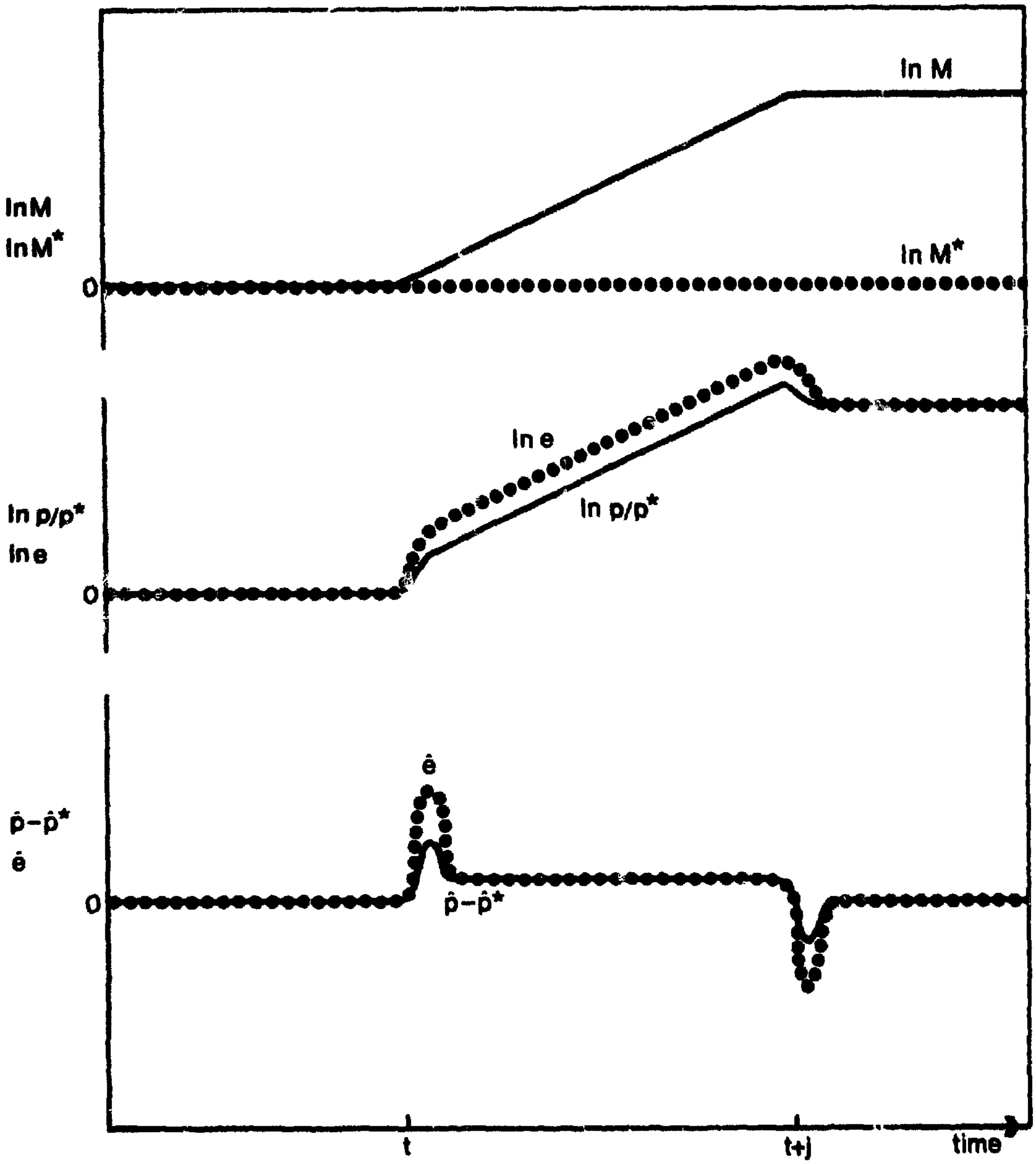

Fig. 1. Dynamics of money, prices and the exchange rate.

to coincide with falling expectations of (the determinants of) domestic relative to foreign inflation.

3. Empirical tests of the model

3.1. In this section our model of exchange rate determination is subjected to regression analysis over the period 1973IV through 1979II. We shall proceed as follows:

One, we estimate eq. (30) for the spot exchange rates of the Dutch Guilder, the D-Mark, the Swiss Franc, the French Franc, the Italian Lira and the Pound Sterling against the dollar. We measure the expected rate of change of a currency's spot rate ($\hat{e}^e$) by $\ln(1+fp_{-1})$, where fp is readily observable and represents the three-month forward premium,[16] and constrain the coefficient of $\hat{e}^e$ to unity.

Two, we substitute eq. (27) into eq. (32) and estimate the result for the six real exchange rates. Since the expected rate of change of the real exchange rate of a currency is not directly observable, we estimate jointly the effects of its determinants and the effects of unanticipated real and monetary shocks and try to explain the actual rates of change of these real exchange rates.

Three, we substitute eqs. (24) and (25) into eqs. (28) and (29) and estimate the result for the rate of inflation in the Netherlands, Germany, Switzerland, France, Italy, the U.K. and the U.S.A. Since the expected rate of inflation is not directly observable, we estimate jointly the effects of its determinants and the effects of unexpected real and monetary shocks in regressions for the actual rates of inflation.

Because of the many countries involved, space limitations make it imperative that for each of the above steps only the 'best' regression equations be reported. In selecting these, we have tried to maximize $\bar{R}^2$ under a number of self-imposed constraints: generally only those coefficients will be reported that have a t-value greater than 1.3. This corresponds roughly to the 0.20 level of significance on a two-tailed test. However, if by so doing variables that come in with lags would become disconnected in time, their whole time-connected string of lags will be reported even if some lagged terms fail to pass acceptable levels of significance. The coefficients are ordinary least estimates.

Our regression analysis involves reduced-form estimation that has the draw-back of being unsuitable for discriminating between alternative theoretical models. But, our prime interest in this paper lies in measuring the influence of (exogenous) shocks and changes in risk on nominal and real exchange rates, so that reduced-form estimation is the obvious route to take.

The data employed and variables constructed are described in the data and statistical appendices. At this point we note that the money supply series used are both *M1* and *M2*; data on foreign holdings of domestic currency are not readily available. The output series used normally concern real gross domestic product. For real government expenditure we use series of real government consumption, except for Italy and Switzerland for which such quarterly series are not available. Quarterly series for real government investment are unavailable for most countries involved. The same is true for

[16]Since $fp=(f-e)/e$, where f is the forward rate and e the spot rate, and $f=\dot{e}^e_{+1}$ it follows that $\ln(1+fp_{-1})=\ln(f/e)_{-1}=\hat{e}^e$.

quarterly series on tax revenue changes because of changes in tax rates. In explaining each currency's exchange rate against the dollar, the foreign country is always represented by the U.S., and foreign variables in our exchange rate and inflation equations are always U.S. variables.

The expected and unexpected variables figuring in eqs. (24), (25), (28)–(32) are not directly observable, except for the anticipated rate of change of the spot exchange rate.[17] Series for the expected and unexpected rates of growth of money, output, government consumption and oil prices are obtained by applying Multi-State Kalman filtering formulas to the logarithmic growth rates of these variables in order to derive efficient linear prediction rules with time dependent coefficients. The Kalman filtering formulas employed allow agents to learn to update their optimal forecasting rules from period to period as new information becomes available, and to distinguish between temporary and permanent shocks. Other than univariate Box–Jenkins models, Kalman filters do not imply the presumption that agents have already learned the probability distributions they face. A valuable by-product of Kalman filter algorithms is that they provide the estimated variance of the one-step-ahead predictions of the series involved. Such time-dependent measures of uncertainty about the predicted rates of growth of domestic, foreign and oil price levels are used in our regression analysis as indices of foreign and domestic purchasing power risk ($\operatorname{var}\hat{p}$, $\operatorname{var}\hat{p}^*$, $\operatorname{var}\hat{p}^*_{\text{oil}}$). A fuller description of the Kalman filter algorithm used can be found in the statistical appendix.

In judging the success of our model from the results of the regression analysis one needs a standard of what constitutes success. We have no problems in accepting the standard set by Mussa (1979), according to whom '...a model that was consistently able to explain 10 percent of the actual quarter-to-quarter changes in exchange rates...would be a successful model. A model that was able to explain 25 percent of quarter-to-quarter changes in exchange rates would be an extraordinary successful model. A model that was able to explain more than 50 percent of quarter-to-quarter changes in exchange rates should either be rejected on the grounds that it is too good to be true or should be reported to the Vatican as a miracle...'.

3.2. Our first step aims at apportioning the errors in predicting the rate of change of the spot rate of exchange ($\hat{e}-\hat{e}^e$) to their sources by estimating eq. (30). The results are reported in table 2.

In all regressions of table 2 last period's anticipated rate of change of the current spot rate ($\hat{e}^e$) is measured by $\ln(1+fp_{-1})$, where fp is the three-month

[17] The rates of change of all variables used are calculated by taking first differences of their natural logarithms and multiplying these by 100%. The resulting logarithmic growth rates are indicated by a hat ($\hat{}$). Unanticipated rates of change of some variable $\hat{x}$ are indicated as $\hat{x}^{ue}=\hat{x}-\hat{x}^e$.

Table 2

Spot exchange rate regressions.[a]

Eq: $\hat{e} = \hat{e}^e + a_0 \hat{M}^{ue} - a_1 \hat{M}^{*ue} - a_2 \hat{g}^{ue} + a_3 \hat{g}^{*ue} - a_4 \Delta \hat{y}^e_{+1} + a_5 \Delta \hat{y}^{*e}_{+1} + a_6 \hat{p}^{*ue}_{oil} + a_7 \Delta \operatorname{var} \hat{p} + a_8 \Delta \operatorname{var} \hat{p}^*_{oil} - a_9 \Delta \operatorname{var} \hat{p}^* + c$

Exchange rate	No.	1973IV–1979II	*VARU*	$\bar{R}^2$	*DW*
DF/$	(1)	$\hat{e} = \hat{e}^e + 0.348 \hat{M}2^{ue}_{-5} - 3.588 \hat{M}1^{*ue}_{-2} - 2.630 \hat{M}1^{*ue}_{-3}$	5.95	0.67 ++	2.12
	(*t*-stat.)	(–) (1.64) (3.66) (2.42)			
		$-4.037 \hat{g}^{ue}_{-1} + 2.781 \Delta \hat{y}^{*e} + 0.038 \hat{p}^{*ue}_{oil} + 0.681 \Delta \operatorname{var} \hat{p}_{-1}$			
		(2.47) (4.11) (1.66) (3.05)			
		$+0.152 \Delta \operatorname{var} \hat{p}^*_{oil-1} - 0.921$			
		(3.13) (1.73)			
DM/$	(2)	$\hat{e} = \hat{e}^e + 1.324 \hat{M}1^{ue}_{-6} - 1.832 \hat{M}2^{*ue}_{-2} + 0.331 \hat{M}2^{*ue}_{-3}$	5.99	0.72 ++	1.64
		(–) (2.77) (1.95) (0.33)			
		$-2.283 \hat{M}2^{*ue}_{-4} - 2.293 \hat{M}2^{*ue}_{-5} + 1.097 \Delta \hat{y}^{*e}$			
		(2.40) (3.54) (1.68)			
		$+0.063 \hat{p}^{*ue}_{oil-2} + 0.062 \hat{p}^{*ue}_{oil-3} + 0.048 \hat{p}^{*ue}_{oil-4}$			
		(1.69) (2.59) (1.48)			
		$+0.365 \Delta \operatorname{var} \hat{p}^*_{oil-1} - 1.025$			
		(4.64) (1.83)			
SF/$	(3)	$\hat{e} = \hat{e}^e + 1.179 \hat{M}1^{ue}_{-4} + 1.263 \hat{M}1^{ue}_{-5} - 3.312 \hat{M}1^{*ue}_{-2}$	14.24	0.56 +	1.79
		(–) (1.92) (1.92) (2.10)			
		$-4.088 \hat{M}1^{*ue}_{-3} - 1.936 \hat{M}1^{*ue}_{-4} - 2.519 \hat{M}1^{*ue}_{-5}$			
		(2.55) (1.14) (1.59)			
		$+2.352 \Delta \hat{y}^{*e}_{+1} + 0.122 \hat{p}^{*ue}_{oil} + 2.164 \Delta \operatorname{var} \hat{p}_{-1} - 2.890$			
		(2.34) (3.62) (2.35) (3.41)			
FF/$	(4)	$\hat{e} = \hat{e}^e + 0.908 \hat{M}2^{ue}_{-2} + 2.059 \Delta \hat{y}^{*e} + 0.062 \hat{p}^{*ue}_{oil}$	10.15	0.47 ++	0.95
		(–) (1.71) (2.44) (2.09)			
		$+0.229 \Delta \operatorname{var} \hat{p}^*_{oil-1} + 0.214 \Delta \operatorname{var} \hat{p}^*_{oil-2} - 0.276$			
		(3.29) (3.08) (0.40)			
IL/$	(5)	$\hat{e} = \hat{e}^e + 1.501 \hat{M}2^{ue}_{-1} + 1.353 \hat{M}2^{ue}_{-2} + 2.083 \hat{M}2^{ue}_{-3}$	6.73	0.70 ++	2.20
		(–) (2.60) (2.16) (3.01)			
		$-1.821 \hat{M}1^{*ue}_{-4} - 2.403 \hat{M}1^{*ue}_{-5} - 1.659 \Delta \hat{y}^e_{-2}$			
		(1.77) (2.33) (2.13)			
		$+1.636 \Delta \hat{y}^{*e}_{-2} + 0.064 \hat{p}^{*ue}_{oil-1} - 0.741$			
		(2.25) (2.98) (1.34)			
£/$	(6)	$\hat{e} = \hat{e}^e - 2.242 \hat{M}2^{*ue}_{-4} - 2.226 \hat{M}2^{*ue}_{-5} - 1.976 \hat{M}2^{*ue}_{-6}$	17.02	0.16	1.92
		(–) (1.78) (1.70) (2.16)			
		$-1.911 \Delta \hat{y}^e_{-2} + 0.079 \hat{p}^{*ue}_{oil} - 0.709$			
		(1.37) (1.90) (0.81)			

[a] DF = Dutch Guilder, FF = French Franc, £ = Pound Sterling, $ = U.S. Dollar, DM = D-Mark, IL = Italian Lira, SF = Swiss Franc, $\hat{e}$ = rate of change of spot rate of exchange against the dollar. $\hat{e}^e = \ln(f/e)_{-1}$, with f the 3-month forward exchange rate and e the spot exchange rate. $\hat{M}1^{ue}$ = unanticipated rate of growth of narrow money stock $M1$ ($\hat{M}1^{ue} = \hat{M}1 - \hat{M}1^e$), $\hat{M}2^{ue}$ = unanticipated rate of growth of broad money stock $M2$ ($\hat{M}2^{ue} = \hat{M}2 - \hat{M}2^e$), $\hat{y}^{ue}$ = unanticipated rate of output growth ($\hat{y}^{ue} = \hat{y} - \hat{y}^e$), $\hat{g}^{ue}$ = unanticipated rate of growth of real government consumption ($\hat{g}^{ue} = \hat{g} - \hat{g}^e$), $\hat{p}^{*ue}_{oil}$ = unexpected change in the dollar price of oil, var p, var p^*, var p^*_{oil} measures of uncertainty in the one-period ahead forecasting errors as estimated by the MSKF-method, * indicates U.S. variables, *VARU* = error sum of squares, corrected for degrees of freedom, $\bar{R}^2$ = coefficient of determination, adjusted for degrees of freedom, + = *F*-test indicates significance at 0.05 level, ++ = *F*-test indicates significance at 0.01 level. *D.W.* = Durbin–Watson coefficient.

forward premium. If the foreign exchange markets are efficient and if exchange rates are perfectly free to fluctuate, unhampered by official intervention, we should expect that current exchange rates reflect all available information: the residuals from the estimated regressions should be serially uncorrelated[18] and the constant terms in our regressions should not differ significantly from zero.

A number of observations stand out from table 2.

One, between 16 and 60 percent of the variation of the unexpected rate of change of the various spot exchange rates can be explained by the current and lagged effects of randomly arriving new information with respect to monetary growth, output growth, government expenditure growth and purchasing power and relative price risks at home and abroad.

Two, those unforeseen domestic and foreign impulses that are found to affect the rates of change of the spot rates virtually all have the right signs at a confidence level of 80 percent and above. The Durbin–Watson statistic points to positive autocorrelation of the residuals only in the case of the French Franc. This would seem to indicate that in the case of the French Franc the forward rate is a biased predictor of the future spot rate, a possibility to which we return below. By implication, the coefficient estimates of eq. (4) of table 2, although unbiased, do not have minimum variance and their statistical significance may be overestimated.

Three, most equations contain both domestic and U.S. monetary impulses. The unforeseen domestic monetary impulse is absent only from the equation for the Pound and the U.S. monetary shocks are included everywhere except the equation for the French Franc. Note that we have used either a narrow (*M1*) or a broader monetary aggregate (*M2*) in the regressions. In some instances there are lags of over one year before the domestic or foreign monetary impulses have their effects on the spot rates. That seems quite a long interval between cause and effect, even when it is recognized that some countries publish their monetary statistics with substantial delay and that in all countries preliminary data on monetary growth are liable to substantial revision later on. A possible explanation for the duration of the lags could be that official intervention succeeded occasionally in postponing a change in the spot rate for a number of quarters. This seems to have been the case in 1977 and 1978 when the central banks of the major industrialized countries changed their attitudes towards a policy of massive resistance to exchange market forces. This change was triggered by the sharp acceleration of U.S. monetary expansion late in 1976 and during 1977 that brought the dollar under heavy pressure. Central banks in Europe and elsewhere, especially

[18]Since we measure all our variables as quarterly averages, first-order serial correlation will be present if unanticipated shocks do not only take place at the beginning of each period but also in the course of each quarter. In our theoretical model we implicitly assume that all shocks take place at the start of each quarter.

those of strong-currency and surplus countries, apparently decided not to let their currencies appreciate sharply against the dollar but to respond with massive dollar purchases, which resulted in official reserve increases of more than $30 billion during the second half of 1977 and the first quarter of 1978.[19] This willingness of foreign countries to accumulate claims on the U.S. government reached its limits by the second quarter of 1978, when they changed away from massive dollar interventions to a policy of virtually no interventions. As a result of this temporary bout of massive intervention most European central banks managed to postpone the full adjustment of their currencies to the massive acceleration of U.S. monetary expansion in 1967–1977 by 3 to 4 quarters. The unanticipated increases in U.S. money growth that set off this episode stand out clearly in our estimated series for $(\hat{M}^* - \hat{M}^{*e})$, so that the estimated lags in table 2 must have been significantly affected.

Four, according to our estimates, an unanticipated unit increase in the growth rate of the U.S. money stock would change the structure of the European exchange rates, leading eventually to a depreciation of the French Franc and an appreciation of the Swiss Franc against all other European currencies under review, and causing an appreciation of the Guilder, the D-Mark and the Pound Sterling against the Lira.

Five, changing expectations about the normal rate of U.S. production $(\Delta\hat{y}^{*e})$ result in expectational errors with regard to the rate of change of all European spot rates reviewed except the Pound, with leads and lags between plus one and minus two quarters. Changing expectations about domestic output growth are found to affect only the Italian Lira and the Pound Sterling, both with a two-quarter lag.

Six, of all spot exchange rates against the dollar, only that of the Dutch Guilder is affected by unanticipated growth of domestic real government expenditure, with a one-quarter lag.[20] Unanticipated growth of U.S. real government expenditure is not found to affect any of the spot exchange rates.

Seven, unexpected increases in the rate of change of the dollar price of oil lead to unexpected depreciations of all European currencies investigated against the dollar, indicating that the European economies are more vulnerable to oil price changes than the U.S.[21] The depreciating effects on European currencies of unanticipated oil price rises come without delay, except for the Lira and the D-Mark where they have a short lag. The effects of unanticipated oil price rises are the weakest and least significant for the currency of Holland which can be characterized as a semi-OPEC country during the complete sample period. Their effects are strongest and most significant for the currencies of Germany and Switzerland. By implication, an

[19]See Morgan Guaranty Trust's issue of *World Financial Markets* of September 1978, p. 2.
[20]Recall that data on real government expenditure are not available for Italy and Switzerland.
[21]See the data appendix for the definition and source of our oil price data.

unanticipated unit increase of the oil price would, ceteris paribus, eventually not only depreciate all European currencies investigated against the dollar; eventually it would also depreciate the D-Mark and the Swiss Franc against all other European currencies.

Eight, unanticipated increases in purchasing power risk because of uncertainty about inflation at home, as measured by changes in the estimated variance of the one-step-ahead forecast errors of the rates of change of the domestic price level and the oil price level, are found to cause unanticipated depreciations of all European currencies against the dollar, except the Lira and Pound Sterling, with a one-to-two quarter lag. Unexpected changes in purchasing power risk abroad, as measured by changes in the variance of the U.S. inflation rate from its predicted course are found, quite surprisingly, to leave the rates of change of the European spot rates unaffected.

Finally, with regard to the constant terms we find that the hypothesis of a zero constant term is rejected at the 5 percent level for the unexpected rates of change of the spot rates of the Swiss Franc against the dollar and at about the 10 percent level for the Guilder and the D-Mark. We find negative constant terms, indicating quarterly trend rates of appreciation against the dollar of almost 3 percent for the Swiss Franc and 1 percent for the Guilder and the D-Mark. On one interpretation, the presence of significant constant terms in equations such as those in table 2 suggests that forward exchange rates (forward premiums) are biased predictors (of the growth rate) of the future spot exchange rates not because markets are inefficient but because there are non-zero risk premiums involved. According to this argument the negative constants in the spot exchange rate regressions for the Guilder, the D-Mark and the Swiss Franc would mean that assets denominated in these currencies are considered riskier than dollar assets, an implication that would seem at odds with intuition.

We reject this view, but acknowledge that the alternative hypothesis of market inefficiency is unattractive also.

3.3. Our second step aims at isolating the expected and unexpected impulse variables that determine the rate of change of a currency's real exchange rate against the dollar ($\hat{e}-\hat{p}+\hat{p}^*$). For that purpose we substitute eq. (27) into eq. (32) of section 2 above and estimate the resulting equation. The regression equations are summarised in table 3.

A number of interesting observations can be made from the real exchange rate regression equations of table 3.

One, on comparing tables 2 and 3 it is clear that for all currencies most of the impulse variables that were found to affect the unexpected rate of change of the spot rates are also found to affect the unanticipated rate of change of the corresponding real exchange rates. Often, these unexpected impulse variables appear to affect the unexpected rates of change of the

Table 3

Real exchange rate regression.[a]

Eq: $\hat{er} = c \pm a_0 \operatorname{var} \hat{p}_{-1} \pm a_1 \operatorname{var} \hat{p}^*_{-1} \pm a_2 \operatorname{var} \hat{p}_{oil\,-1} + a_3 \hat{M}^{uc} - a_4 \hat{M}^{*uc} - a_5 \hat{g}^{uc} + a_6 \hat{g}^{*uc} - a_7 \Delta \hat{y}^{c}_{+1} + a_8 \Delta \hat{y}^{*c}_{+1} + a_9 \hat{p}^{*uc}_{oil} + a_{10} \Delta \operatorname{var} \hat{p} + a_{11} \Delta \operatorname{var} \hat{p}^*_{oil} - a_{12} \Delta \operatorname{var} \hat{p}^*$

Exchange rate	No.	1973IV 1979II	VARU	$\bar{R}^2$	DW
DF/$	(7)	$\hat{er} = -1.964 + 0.168 \operatorname{var} \hat{p}_{oil\,-1} + 0.340 \hat{M}2^{uc}_{-5}$	5.73	++ 0.67	1.61
	(t-stat.)	(3.29) (2.67) (1.64)			
		$-3.123 \hat{M}1^{*uc}_{-2} - 2.592 \hat{M}1^{*uc}_{-3} - 4.422 \hat{g}^{uc}_{-1}$			
		(3.30) (2.35) (2.71)			
		$+3.231 \Delta \hat{y}^{*c} + 0.065 \hat{p}^{*uc}_{oil} + 0.581 \Delta \operatorname{var} \hat{p}_{-1}$			
		(5.03) (3.08) (2.63)			
DM/$	(8)	$\hat{er} = -0.978 + .167 \hat{M}1^{uc}_{-6} - 2.013 \hat{M}2^{*uc}_{-2} + 0.025 \hat{M}2^{*uc}_{-3}$	6.44	++ 0.70	1.69
		(1.69) (2.36) (2.07) (0.02)			
		$-2.571 \hat{M}2^{*uc}_{-4} - 2.362 \hat{M}2^{*uc}_{-5} + 1.211 \Delta \hat{y}^{*c}$			
		(2.61) (3.52) (1.79)			
		$+0.078 \hat{p}^{*uc}_{oil\,-2} + 0.059 \hat{p}^{*uc}_{oil\,-3} + 0.046 \hat{p}^{*uc}_{oil\,-4}$			
		(2.01) (2.39) (1.38)			
		$+0.387 \Delta \operatorname{var} \hat{p}^*_{oil\,-1}$			
		(4.74)			
SF/$	(9)	$\hat{er} = -2.813 + 0.937 \hat{M}1^{uc}_{-4} + 1.196 \hat{M}1^{uc}_{-5} - 2.941 \hat{M}1^{*uc}_{-2}$	15.02	+ 0.44	1.77
		(3.24) (1.48) (1.77) (1.82)			
		$-3.978 \hat{M}1^{*uc}_{-3} - 1.793 \hat{M}1^{*uc}_{-4} - 2.603 \hat{M}1^{*uc}_{-5}$			
		(2.41) (1.02) (1.60)			
		$+2.175 \Delta \hat{y}^{*c}_{+1} + 0.078 \hat{p}^{*uc}_{oil} + 2.052 \Delta \operatorname{var} \hat{p}_{-1}$			
		(2.11) (2.25) (2.17)			
FF/$	(10)	$\hat{er} = -1.368 + 2.285 \Delta \hat{y}^{*c} + 0.089 \hat{p}^{*uc}_{oil} + 0.035 \hat{p}^{*uc}_{oil\,-1}$	6.32	++ 0.67	0.71
		(2.13) (2.94) (2.88) (0.59)			
		$+0.069 \hat{p}^{*uc}_{oil\,-2} + 0.079 \hat{p}^{*uc}_{oil\,-3} + 0.280 \Delta \operatorname{var} \hat{p}^*_{oil\,-1}$			
		(1.97) (2.38) (1.79)			
		$+0.272 \Delta \operatorname{var} \hat{p}^*_{oil\,-2}$			
		(2.33)			
IL/$	(11)	$\hat{er} = 0.371 - 4.601 \operatorname{var} \hat{p}^*_{-2} + 1.626 \hat{M}2^{uc}_{-1} + 1.450 \hat{M}2^{uc}_{-2}$	4.57	++ 0.68	2.56
		(0.46) (1.80) (3.20) (3.06)			
		$+2.029 \hat{M}2^{uc}_{-3} - 1.542 \hat{M}1^{*uc}_{-4} - 1.806 \hat{M}1^{*uc}_{-5}$			
		(3.55) (1.88) (2.17)			
		$-1.874 \Delta \hat{y}^{c}_{-2} + 0.045 \hat{p}^{*uc}_{oil\,-1}$			
		(3.01) (2.44)			
£/$	(12)	$\hat{er} = -1.620 - 2.029 \hat{M}2^{*uc}_{-4} - 1.563 \hat{M}2^{*uc}_{-5} - 2.031 \hat{M}2^{*uc}_{-6}$	11.91	++ 0.47	2.38
		(2.19) (1.92) (1.48) (2.66)			
		$-1.712 \hat{g}^{uc} + 2.967 \Delta \hat{y}^{*c} + 0.110 \hat{p}^{*uc}_{oil}$			
		(2.17) (3.23) (3.13)			

[a] $\hat{er} = \hat{e} - \hat{p} + \hat{p}^*$, $\hat{p}$ = rate of change of gross domestic product implicit price deflator (consumer price index for Switzerland). For explanation of other symbols, see footnote a to table 2.

corresponding spot rates and real exchange rates in the same direction and with much the same coefficients.

Two, for all currencies except the Swiss Franc and the D-Mark the set of unanticipated impulse variables that was found to produce the best fit in explaining the unexpected rate of change of the spot rates differs somewhat from the set of unexpected impulse variables that is found to produce the best fit in explaining the unanticipated rate of change of the corresponding real exchange rates against the dollar. Unexpected impulses that affect the spot exchange rate without affecting the real exchange rate must affect the unexpected inflation differential in the same direction and with the same coefficients as they affect the unanticipated rate of change of the spot rate.[22] We return to these implications in paragraph 5 below.

Three, for all currencies except the Lira the expected rate of change of their real exchange rate against the dollar is found to be characterized by a negative constant term, indicating a trend rate of real appreciation against the dollar. In addition, the real exchange rates of the Guilder and the Lira are expected to change as a result of the effects of purchasing power uncertainty at home and/or abroad, with such purchasing power uncertainty measured by the level of the estimated variance of the one-step-ahead prediction errors in either the domestic or foreign rate of inflation, or in the rate of change of the dollar price of oil. When the equations for the Guilder and the Lira are re-estimated without the level-of-uncertainty terms, the constant terms become -1.194 (t-value 1.93) for the Guilder and -0.826 (t-value 1.70) for the Lira.

Four, most of what was said in the first three comments about our findings for the spot rates in table 2 applies with equal force to what we found for the real exchange rates in table 3. In particular, between 44 and 70 percent of the variation of the rate of change of the real exchange rates of the various European currencies against the dollar can be explained. Virtually all of the explanatory variables that are found to more or less significantly affect the rate of change of the real exchange rates involved have theoretically correct signs. The Durbin–Watson coefficients point to positively autocorrelated residuals in the case of the French Franc only

Finally, from both table 2 and table 3 it follows that a unit increase in the expected output growth capacity of the U.S. economy ($\Delta\hat{y}^{*e}$) eventually *weakens* all European currencies against the dollar, both in nominal terms (except the Pound) and in real terms (except the Lira). This finding seems to go against the view that relatively fast-growing countries are characterized by weak currencies (and current account deficits), and vice versa.

3.4. Our third step aims at determining the determinants of the expected and unexpected rates of domestic and foreign inflation. For that purpose we

[22]Recall that $\hat{er} = \hat{e} - (\hat{p} - \hat{p}^*)$ and $\hat{er}^{ue} = \hat{e}^{ue} - (\hat{p}^{ue} - \hat{p}^{*ue})$.

substitute eqs. (24) and (25) into eqs. (28) and (29) of section 2 above and estimate the resulting equations for all countries involved. The regression results are summarized in table 4.

A number of observations can be made from table 4.

One, apart from the constant term, inflationary expectations ($\hat{p}^e, \hat{p}^{*e}$) are determined mainly by the anticipated rate of domestic monetary expansion. The expected growth rates of broad money (*M2*) provide a somewhat better fit in explaining inflation in all countries investigated except the U.S., where expected growth in narrow money (*M1*) is found to provide the best fit. Anticipated growth of real output is never found to be a significant determinant of expected inflation. Most probably, the reason is that the series used to measure expectations of output growth exhibit very little variation. As a result, the effects of expected output growth on inflationary expectations have been subsumed in the constant terms of the regressions.

Two, for high-inflation countries such as Italy and the United Kingdom, and for the United States the coefficient estimates of the effects of expected monetary growth on (expected) inflation are not significantly different from unity at either the 5 percent or 1 percent level of significance. For low-inflation countries such as the Netherlands, Germany and Switzerland, this coefficient is significantly smaller than unity. In the case of France the coefficient is determined very poorly. The optimal lag was selected in this case by investigating the inflation equation over a longer period of estimation. For the period 1970I–1979II, for example, the coefficient of $\hat{M2}^e_{-9}$ becomes 0.379 with a t-value of 4.25.

A unit coefficient is expected in the case of perfectly flexible exchange rates. Dirty floating and capital controls with respect to the dollar tend to keep the elasticity of anticipated inflation with respect to foreseen monetary expansion below unity.

Three, expected monetary expansion appears to affect (expected) inflation with a 4–6 quarter lag in the Netherlands, Germany and the United States, with a lag as long as 8–9 quarters in France, the United Kingdom and Switzerland, and with a lag as short as 1–2 quarters in Italy. By implication, even if a unit-elasticity between anticipated monetary growth and inflation would hold for all countries investigated, a pre-announced policy of reducing monetary growth in all these countries to the same extent would give rise to temporary international inflationary divergencies.

Four, the rate of change of the price level is found to be determined not only by the determinants of expected inflation but also by those factors determining unexpected inflation. All unexpected impulse variables appear to affect unanticipated inflation with the proper signs. Together with the determinants of expected inflation, they explain 67–77 percent of the variation of inflation in the Netherlands, Germany, Switzerland, Italy, the U.K. and the U.S., and 42 percent of the variation of inflation in France.

Table 4
Inflation regression.[a]

Eq: $\hat{p}=c+a_0\hat{M}^{e}-a_1\hat{y}^{e}+a_2\hat{M}^{ue}-a_3\hat{M}^{*ue}+a_4\hat{g}^{ue}+a_5\hat{g}^{*ue}-a_6\,\Delta\hat{y}^{e}_{+1}+a_7\,\Delta\hat{y}^{*e}_{+1}+a_8\hat{p}^{*ue}_{oil}-a_9\,\Delta\operatorname{var}\hat{p}-a_{10}\,\Delta\operatorname{var}\hat{p}^{*}_{oil}-a_{11}\,\Delta\operatorname{var}\hat{p}^{*}$

Country	No.	1973IV–1979II	VARU	$\bar{R}^2$	DW
NL	(13) (t-stat.)	$\hat{p}=0.687+0.316\hat{M}2^{e}_{-4\frac{1}{2}}+0.150\hat{M}2^{ue}_{-4}+1.156\hat{g}^{ue}$ (1.92) (3.38) (2.03) (2.31) $-0.018\,\Delta\operatorname{var}\hat{p}^{*}_{oil-2}-3.948\,\Delta\operatorname{var}\hat{p}^{*}_{-2}$ (1.35) (6.45)	0.55	++ 0.72	1.92
G	(14)	$\hat{p}=0.704+0.162\hat{M}2^{e}_{-4\frac{1}{2}}-0.235\hat{M}2^{*ue}_{-5}-0.171\hat{M}2^{*ue}_{-6}$ (5.10) (2.73) (2.19) (2.30) $-0.461\,\Delta\hat{y}^{e}_{+1}+0.010\hat{p}^{*ue}_{oil-2}+0.008\hat{p}^{*ue}_{oil-3}$ (1.79) (2.36) (2.51) $+0.015\hat{p}^{*ue}_{oil-4}-0.385\,\Delta\operatorname{var}\hat{p}^{*}_{-2}$ (3.34) (1.35)	0.12	++ 0.67	2.72
SW	(15)	$\hat{p}=-0.158+0.379\hat{M}2^{e}_{-8}-0.403\hat{M}1^{*ue}_{-2}-0.597\hat{M}1^{*ue}_{-3}$ (0.63) (4.17) (1.82) (2.50) $-0.712\hat{M}1^{*ue}_{-4}-0.578\hat{M}1^{*ue}_{-5}-0.644\hat{M}1^{*ue}_{-6}$ (2.89) (2.49) (2.89) $+0.030\hat{p}^{*ue}_{oil}$ (6.28)	0.30	++ 0.77	1.61
F	(16)	$\hat{p}=1.730+0.176\hat{M}2^{e}_{-9}-0.256\hat{M}2^{*ue}_{-5}+0.396\hat{g}^{ue}_{-1}$ (2.76) (1.13) (2.24) (1.75) $+0.017\hat{p}^{*ue}_{oil-2}+0.007\hat{p}^{*ue}_{oil-3}+0.013\hat{p}^{*ue}_{oil-4}$ (3.20) (1.72) (2.62) $-0.546\,\Delta\operatorname{var}\hat{p}^{*}_{-2}$ (1.42)	0.22	+ 0.42	1.30
I	(17)	$\hat{p}=-2.142+1.307\hat{M}2^{e}_{-1\frac{1}{2}}+0.201\hat{M}2^{ue}_{-5}-0.927\hat{M}2^{*ue}_{-4}$ (1.76) (5.09) (1.43) (4.62) $+0.016\hat{p}^{*ue}_{oil-3}-0.106\,\Delta\operatorname{var}\hat{p}_{-2}-1.270\,\Delta\operatorname{var}\hat{p}^{*}_{-2}$ (2.73) (2.91) (2.51)	0.40	++ 0.73	1.95
UK	(18)	$\hat{p}=1.720+0.550\hat{M}2^{e}_{-8\frac{1}{2}}+0.135\hat{M}2^{ue}_{-4}+0.337\hat{M}2^{ue}_{-5}$ (2.61) (2.62) (1.60) (3.85) $-0.910\hat{M}2^{*ue}_{-4}+0.395\hat{g}^{*ue}+0.884\,\Delta\hat{y}^{*e}_{+1}$ (2.66) (1.43) (3.43) $+0.019\hat{p}^{*ue}_{oil-2}+0.031\hat{p}^{*ue}_{oil-3}$ (2.55) (3.45)	0.76	++ 0.76	2.17
US	(19)	$\hat{p}^{*}=0.213+1.043\hat{M}1^{*e}_{-5\frac{1}{2}}+0.479\hat{M}1^{*ue}_{-4}+0.252\hat{M}1^{*ue}_{-5}$ (0.68) (5.04) (3.55) (1.86) $+0.200\hat{M}1^{*ue}_{-6}+0.009\hat{p}^{*ue}_{oil-2}+0.005\hat{p}^{*ue}_{oil-3}$ (1.70) (2.59) (2.01) $+0.014\hat{p}^{*ue}_{oil-4}$ (3.96)	0.10	++ 0.72	1.90

[a]See table 2 footnote a, continued. G = Germany, NL = Netherlands, F = France, I = Italy, UK = United Kingdom, US = United States, SW = Switzerland. $\hat{p}$ = rate of growth of gross domestic product implicit price deflator (consumer price index for Switzerland). $\hat{M}^{e}$ = anticipated rate of growth of narrow ($M1$) or broad ($M2$) money stock.

Finally, and notably, unexpected monetary acceleration in the U.S. is found to lead to unforeseen *reductions* in all European inflation rates. According to our model unforeseen declines in inflation translate themselves into unexpected reductions in output growth. This finding thus implies that an unanticipated expansionary monetary policy in the U.S. lowers output growth in Europe, an implication which is at odds with the occasionally popular so-called Locomotive Approach.[23]

3.5. It is possible in principle to check the internal consistency of the results reported in tables 2–4. From the definition of the rate of change of the real exchange rate of a currency with respect to the dollar, viz. $\hat{er} \equiv \hat{e} - (\hat{p} - \hat{p}^*)$, it follows that $\hat{er}^{ue} \equiv \hat{e}^{ue} - (\hat{p}^{ue} - \hat{p}^{*ue})$. From this it follows in turn that $\hat{e}^{ue} - \hat{er}^{ue} \equiv \hat{p}^{ue} - \hat{p}^{*ue}$: combining the results in tables 2 and 3 provides us with one set of estimates of the determinants of the unanticipated inflation differential and the inflation regressions in table 4 provide us with a second estimate for the unexpected difference in inflation between each European country and the U.S.

Our limited sample size precludes a formal statistical test of the consistency between these two different estimates. An informal comparison shows that the agreement is far from perfect. Unanticipated monetary growth in the U.S., for example, has a negative effect on inflation in the European countries; a finding that is inconsistent with the result that unanticipated U.S. money growth has similar effects on nominal and real exchange rates of the European currencies. It should be noted also, however, that there is good agreement about the effects on the inflation differentials of unanticipated oil price shocks. This finding collaborates the contention that unexpected changes in the price of oil have been a prime mover of exchange rates and inflation rates in the 1970's.

The lack of consistency between the empirical results in tables 2 and 3 on the one hand and table 4 on the other hand points to weaknesses in our empirical work. The reasons for these deficiencies may be many, both economical and technical. We return to them in the concluding section that follows.

4. Summary and policy conclusions

4.1. In this paper we have formulated and tested a model of exchange rate behavior that is based on market efficiency and expectational rationality. The model incorporates the main elements of the asset approach except one: the usual purchasing power parity condition is absent from the model, and consequently real exchange rate movements are explicitly allowed for. The

[23]See McCracken et al. (1977) for the Locomotive Approach and Korteweg (1979c) for a comment.

reduced-form implications of the model have been tested against the null-hypothesis, using the exchange rate experiences of six European currencies during the period 1973IV–1979II.

Our main findings may be summarized as follows.

One, much of the variation in the unanticipated rate of change of the spot exchange rates of the major European currencies is due to 'news'. Indeed, in five out of the six countries investigated something like 50 percent and more of the variation in the unanticipated changes of the spot rates can be explained this way.

Two, expected and unexpected changes in money, as well as unexpected changes in oil prices and real government absorption play a considerable part in explaining the variation in inflation rates. In six out of seven countries the regressions explain two thirds of the variation in the GDP deflator over the period of estimation. A noteworthy aspect of the inflation regressions is that they show significant negative effects of unexpected U.S. monetary growth on European inflation. The fact that a positive impulse in the U.S. has negative effects on the rate of price change in Europe and consequently depressing short-run effects on the growth rate of output in Europe, agrees with our theoretical model, but runs counter to a strand of opinion which holds that a positive monetary impulse in one (large) country should have short-run positive effects on the output of its trading partners (the locomotive approach).

Three, movements in the rate of change of the real exchange rates of the major European currencies against the dollar can in large part be attributed to our unexpected impulses and to changes in price uncertainty at home and in the U.S.

4.2. On the standard set by Mussa (1979) and quoted in section 3.1 above, the empirical success of our model would be rated good to excellent. This does not mean, however, that we find our augmented monetary approach to the exchange rate squarely supported by the facts. Rather, the support is mixed.

First, although our results indeed indicate that expected domestic monetary growth affects (expected) inflation with a coefficient not significantly different from unity in the U.S., Italy and the U.K., the coefficient estimate is considerably below unity for Holland, Germany, Switzerland and France.

Second, whereas for six out of seven countries the expected and unexpected growth rates of *M2* seem to be superior to the growth rates of *M1* in explaining inflation, for a number of countries the unexpected growth rate of *M1* is required in the equations for the spot and real exchange rates.

Third, there are quite long lags, not only in the inflation regressions, where this can be rationalized by the existence of contractual arrangements but also in the equations for the spot and real exchange rates. These findings could cast doubt on our assumptions of expectational rationality and exchange market efficiency, unless we can accept the explanation given in section 3.2 above, that the Seventies were a period of managed rather than free floating, characterized by temporary bouts of massive exchange market interventions.

Fourth, an informal test of the consistency between the three sets of regressions produces evidence of serious shortcomings in our empirical work. The inconsistencies are minor with respect to the oil price shocks, but they appear to be substantial in the case of the variables that measure monetary shocks and price level uncertainty at home and in the U.S.

There may be many reasons why our regression results offer only mixed support for the model used. One reason might be, of course, that the model just does not offer a valid description of the process of exchange rate determination, for which reason it would need to be extended or reformulated.[24] Another reason might be that the way we have distinguished between the expected and unexpected parts of the exogenous impulse variables needs to be improved. A further reason could be that in our paper 'new information' (unexpected impulses) that causes expectations and, consequently, exchange rates to change relates to economic variables only, although political 'news' may well be as important as economic 'news' in shaping expectations and affecting exchange rates. A final reason for the mixed support our model gets from the facts has been mentioned before: our model holds for a world of freely floating exchange rates, whereas in fact there has been a significant degree of exchange market intervention since the inception of floating in 1973.[25] Rather than being free, the float has been firmly managed. Clearly, this issue is related to the assumed exogeneity of our monetary impulses and ties in with what has been said about the relative importance of economic shocks and political news.

4.3. What remains to be done is to bring our findings to bear on the questions raised in section 2.2 above. First, to which economic causes can we attribute the volatility of the real and spot exchange rates of the European currencies during the floating rate period. Second, why have there been changes in real exchange rates that persisted beyond the short run?

As regards the first question, the answer suggested by our results is that this volatility reflects predominantly unexpected changes in spot exchange

[24]For instance, the current account has not yet made it back in our model explicitly. Recently, a link between the asset market approach to exchange rate determination and the current account has been established by virtue of the fact that current account imbalances lead to accumulation or decumulation over time of net foreign assets. Accordingly, as stressed by Kouri (1976), Kouri and Braga de Macedo (1978), Dornbusch (1976b), and Artus and Young (1979), the evolution of the current account influences the evolution of exchange rate expectations over time.

[25]For figures on official intervention see Lamfalussy (1979) and Swoboda (1979).

rates. These unexpected changes can be largely attributed to monetary and oil price impulses, emitted on the European economies both from within and from outside.

As regards the second question, our theoretical model indicates two reasons for persisting changes in real exchange rates.

First, because of differences in real rates of interest between countries. These differences are represented by the constant terms in our real exchange rate regressions and by the expressions that stand for the levels of purchasing power uncertainty. The second reason for sizeable changes in real exchange rates is that there can be significant shocks, notably monetary and oil shocks, that are not washed out immediately by similar shocks in the opposite direction. The results in table 3 show that both causes have been operative during the seventies.

4.4. Finally, as an illustration of our findings we show what happens to the nominal and/or real exchange rates of the six European currencies against the dollar as the result of two different kinds of shocks which are truly exogenous to Europe and beyond its control. The first shock to be considered is a U.S. monetary policy shock, the second an oil price shock.

Let us start with the exchange rate effects of an unexpected one-percent contraction of the U.S. stock of both *M1* and *M2*. Since we do not know the effects of changes in anticipated monetary growth on the expected rate of change of the spot rates of exchange, we are unable to calculate from our regression equations the effects on European spot exchange rates of the one-percent unexpected contraction in U.S. money, but the eventual effects of such a shock on the real exchange rates can be computed. According to the regressions of table 3 they are as follows:

Guilder/dollar	+ 5.7%
D-Mark/dollar	+ 6.9%
Swiss Franc/dollar	+11.3%
French Franc/dollar	+ 0%
Lira/dollar	+ 3.3%
Pound Sterling/dollar	+ 5.6%

These changes in the real exchange rates will persist until they are nullified by other impulses in the opposite direction. Since the effects on the six currencies differ in size, the U.S. monetary impulse will cause a substantial change in the structure of exchange rates between the European currencies. The 1 percent decrease in the U.S. money stock corresponds to a decrease of about 0.6 percentage points in the *expected* quarterly growth rate of the U.S. money supply (this can be derived from the Kalman filter results). It follows that we can also interpret the numbers in a slightly different way: assume that the rates of inflation in all six European countries are the same as in the

U.S. Now let the U.S. money supply decelerate unexpectedly at a rate that brings the expected annual rate of monetary expansion and inflation in the U.S. at $4 \times 0.6 = 2.4$ percentage points below the expected rates of inflation in Europe. The numbers then show the permanent effects, ceteris paribus, on the real exchange rates between the European currencies and the U.S. dollar. We note that a deceleration in the U.S. money supply will lead, ceteris paribus, to a significant real depreciation of all European currencies except the French Franc, irrespective of whether the rate of inflation in these European countries happens to be above or below the rate of inflation in the U.S. Consequently, these countries could at times experience real depreciations of their currencies against the U.S. dollar, while at the same time having lower rates of inflation than the U.S.

Let us next consider the effects on the nominal and real exchange rates of the European currencies against the dollar of an unexpected ten-percent increase in the dollar price of oil. The eventual effects of this type of shock can be calculated from tables 2 and 3. They are as follows:

	Nominal	Real
Guilder/dollar	+0.4%	+0.7%
D-Mark/dollar	+1.7%	+1.8%
Swiss Franc/dollar	+1.2%	+0.8%
French Franc/dollar	+0.6%	+2.7%
Lira/dollar	+0.6%	+0.4%
Pound Sterling/dollar	+0.8%	+1.1%

Again, we note that this shock leads to nominal and real depreciations with respect to the dollar and at the same time changes the structure of exchange rates between European currencies.

The Kalman filter indicates that an unanticipated 10 percent increase in the oil price has little effect, on average, on the expected growth rate of the oil price, so that the figures above have to be interpreted as the *permanent* effects on the nominal and real exchange rates of a permanent increase in the *level* of the oil price.

The regressions in tables 2, 3 and 4 show that monetary impulses and increases in the oil price have been the major events that shocked the nominal and real exchange rates in our sample during the seventies. Other impulses, such as unexpected changes in the growth rates of output and government expenditure, had smaller effects on the exchange rates. Finally, changes in the amount of price level uncertainty, both with respect to national price levels, and with respect to the price of oil, were seen to be of some relevance for the determination of exchange rates. Since the effects of all these impulses were different in each country, every shock did not only change the nominal and real exchange rate with respect to the dollar, but also caused changes in the structure of the European currencies.

4.5. What are the policy implications of these findings?

They are neither novel nor particularly surprising. They are that consistency, stability, and predictability in the behavior of the monetary authorities of the European countries, but especially those of the U.S., are prerequisites to achieving more exchange rate stability and exchange rate predictability. In particular, the spot exchange rates of the major European currencies against the dollar would have behaved in a much more stable manner and much more in accordance with PPP if the monetary authorities of the U.S. and Europe would have followed more disciplined, more predictable, and more consistent paths of monetary policy. The European Monetary System currently in operation can only survive and will only bring exchange rate stability if the fixing of parities is accompanied by greater, and more consistent, monetary policy discipline of the countries involved.

Data appendix

M1 and M2 money supply series

Germany: Statistische Beihefte zu den Monatsberichte der Deutsche Bundesbank.
France: OECD Main Economic Indicators.
Italy: OECD Main Economic Indicators.
Netherlands: De Nederlandsche Bank, internal data series.
U.K.: Bank of England Quarterly Bulletin, and OECD Main Economic Indicators.
U.S.A.: Federal Reserve Bulletin (*M1*), IFS (*M2*).
Switzerland: Soziales Jahrbuch der Schweiz.

Quarterly averages of *M1* and *M2* are calculated from monthly data (end-of-month or monthly averages).

M1 is defined as currency and demand deposits held by residents. *M2* is *M1* plus time deposits. For Switzerland, *M2* is *M1* plus Spareinlagen. For the U.S.A., *M2* is *M1* plus Quasi Money as defined in the IMF International Financial Statistics. The Quasi Money Series as reported in IFS changes drastically in 1979. Therefore we have taken the monthly data for *QM* from the Federal Reserve Bulletin for 1979 (March through July) and used these to calculate *QM* for 1979II. For the U.K., our *M2* equals *M3* minus residents' deposits in other currencies, where *M3* is defined as *M1* plus U.K.

private sector sterling time deposits plus U.K. public sector sterling deposits plus U.K. residents' deposits in other currencies

Exchange rates (number of domestic currency units per dollar)

Spot exchange rates (e) for all countries were taken from the IMF International Financial Statistics (the inverse of line ah for the U.K., and lines af for all other countries). Data used are period averages.

Three-month forward exchange rates (f) are taken from the IMF International Financial Statistics also, except for Italy, in which case they were calculated from forward premiums, taken from the Banca d'Italia Annual Reports. Three-month forward premiums (fp) are calculated from spot and forward rates in case they were not supplied directly by the IFS. The forward premium on the Pound Sterling for 1975/3 through 1978/11 was taken directly from the Bank of England Quarterly Bulletin. For Italy, the forward premium was taken directly from the Banca d'Italia Annual Reports. Data used are period averages.

Real gross domestic product (y) and real government expenditure (g)

Real gross domestic products for all countries except Germany, Switzerland and the Netherlands were taken from the OECD Quarterly National Accounts Bulletin. For Germany, they were taken from the Statistische Beihefte zu den Monatsberichte der Deutsche Bundesbank, January 1980. For Switzerland, real industrial production data were used as supplied in Soziales Jahrbuch der Schweiz. For the Netherlands, real gross national product was taken from the Dutch Central Planning Bureau up to 1978IV, and data for 1979 were estimated by us from the Quarterly Reports of de Nederlandsche Bank.

Real government expenditure is proxied by real government consumption of final output. Quarterly series of this variable are available only for the U.S., the U.K., France, Germany and the Netherlands. For Germany, nominal government consumption expenditure was taken from the IMF International Financial Statistics and deflated by the consumer price level. For the U.S.A., the U.K., and France, real government consumption was taken from the OECD Quarterly National Accounts Bulletin. For the Netherlands, real government consumption was supplied by the Dutch Central Planning Bureau up to 1978IV and data for 1979 were estimated by us.

Price index (p) and oil price (p_{oil})

For all countries except Switzerland, the price level used is the GDP deflator These series are calculated from real and nominal GDP series taken from the sources described in the real GDP section above. For Switzerland no real or nominal GDP series were available; here we used the consumer price index from the IMF International Financial Statistics.

Our series for the oil price has been generously provided by the Nederlandse Organisatie van Olie- en Kolenhandelaren, 'NOVOK'. p_{oil} represents the mean monthly price in U.S. dollars of light fuel oil (1% sulfur), barges f.o.b. Rotterdam, according to Platt's Oilgram Price Service.

All series mentioned above have been seasonally adjusted if necessary. This proved to be the case for our *M1*- and *M2*-series, our *y*-series, and our *g*-series.

Statistical appendix

Expectations of the growth rates of our exogenous variables have been computed using Kalman filters. The main attraction of these filters is that they can compute a forecast of a time series for period t without any knowledge about the realisations of the series for periods $t+1$ and beyond. By contrast, Box–Jenkins models provide forecasts for each period t that are based on a model which is estimated over the complete length of the time series, including periods $t+1$ etc. In this respect, therefore, the Kalman filter method resembles more the actual formation of forecasts by economic agents who, too, have to base their predictions on the past and cannot make use of future observations.

On the other hand, the simple Kalman filter would hardly be suitable for economic forecasting, since it is a method only for producing forecasts, not for finding the forecast formula that best fits the data. With a simple Kalman filter, one starts the computations with certain assumptions about the series to be forecast and the filter algorithm then produces a forecast for each period on the basis of these assumptions together with the actual data as they come in. There is no feedback from the data to the algorithm. If, for example, a Kalman filter is used to estimate the velocity of some flying object, then each new observation about the position of that object helps to improve the estimate of its velocity, but all the computations are made on the assumption that we possess perfect knowledge about the physical laws that describe motion in space. For this reason, Kalman filters have been used extensively in the physical sciences, where the laws regarding motion in space etc. are known, whereas there are few applications in economics, where we are far from sure about the (stochastic) laws that govern our variables.

This drawback of the Kalman filter approach can be overcome by applying not just one but a number of separate filters to the data, and computing the forecasts as a weighted average of the forecasts from the individual filters. With the passing of time the weights of the separate forecasts are adjusted according to the success of each separate filter over the (recent) past. In this way, there is a feedback from the data to the algorithm with which the forecasts are computed.

The empirical proxies for the expected and unexpected growth rates of the money stock, gross domestic product, real government expenditure and the oil price have been calculated with such a so-called multistate Kalman filter. The method is best explained by way of an example, for which we use part of an artificial series depicted in fig. A.1 by a solid line. The series could represent the growth rate of some economic variable. Usually, the series is well-behaved, but has occasional outliers. In the data segment shown, two types of outliers appear: at A and B we notice a single exceptional value, whereas at C, D and E level of the series is shifted permanently (ex-post we observe that the shifts at C and D lasted for four periods, and the shift at E for five periods).

The dotted line in fig. A.1 shows the predictions of the Kalman filter for this part of the series. These predictions are weighted averages of four distinct forecasting models, numbered 1–4. Models 1 and 2 are appropriate for those periods in which no outliers occur. Models 3 and 4 are relevant in the case of outliers. We can write the following system of equations to describe the background of each of the forecasting models:

$$y_t = \bar{y}_t + \varepsilon_{j,t}, \qquad (A.1)$$

$$j = 1, 2, 3, 4,$$

$$\bar{y}_t = \bar{y}_{t-1} + \gamma_{j,t}. \qquad (A.2)$$

Here, y_t is the observed value of a time series y; $\bar{y}_t$ represents the 'true' underlying value of y at time t and ε, γ are serially uncorrelated white noise series. ε is an observation noise which contaminates the series, and γ shifts the true level of y from period to period. Since all shifts in the level of y are unpredictable (γ is white noise), an estimate of the true level $\bar{y}_t$, made after observation y_t has been processed, is equivalent to a prediction of the level y_{t+1} for the next period (equal to the optimal prediction for all subsequent periods as well).

Each of the four separate forecasting models is designed to produce optimal forecasts for the series y_t. The models differ in the values that have been assumed for var ε and var γ. These values have been set as follows:

$$\operatorname{var}\varepsilon_{1,t} = 1.1V_0, \qquad \operatorname{var}\gamma_{1,t} = 0.003V_0,$$

$$\operatorname{var}\varepsilon_{2,t} = 0.06V_0, \qquad \operatorname{var}\gamma_{2,t} = 1V_0,$$

$$\operatorname{var}\varepsilon_{3,t} = 16V_0, \qquad \operatorname{var}\gamma_{3,t} = 0.2V_0,$$

$$\operatorname{var}\varepsilon_{4,t} = 1V_0, \qquad \operatorname{var}\gamma_{4,t} = 16V_0.$$

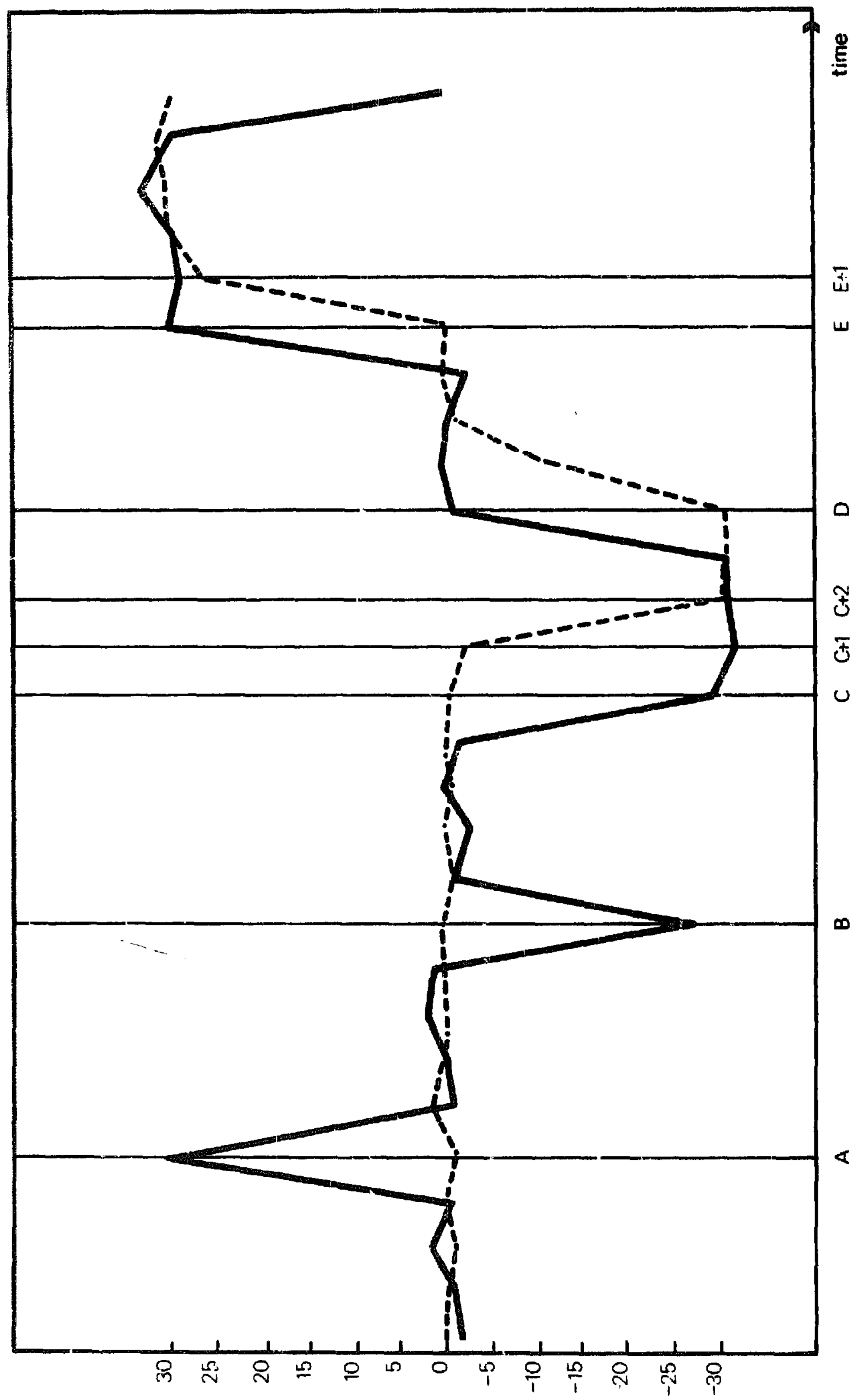

Fig. A.1. Kalman filtering for an artificial series.

The values for $\text{var}\,\varepsilon_t$ and $\text{var}\,\gamma_t$ have been chosen after a number of experiments with artificial data; they are used for all the calculations in the paper.

V_0 is a common factor in all these expressions. The initial value of V_0 is estimated from the first 10 observations in the series. This value is then used by the filter algorithm during these 10 periods, which introduces a certain ex-post element in the forecasts for the first 10 periods. (In the paper, this applies to the forecasts for 1968, 1969 and 1970, none of which are included in the regression equations of tables 2–4.) Beginning with the 11th period, the estimate of V_0 is updated adaptively on the basis of the recent history of the time series, so that all expectations are purely ex ante from that point onwards.

Forecasting model 1 would produce optimal forecasts if series y behaved as in eqs. (1) and (2) with $\text{var}\,\varepsilon_t = 1.1V_0$, $\text{var}\,\gamma_t = 0.003V_0$. With this specification of the average size of the two noises, the series y behaves almost like a stationary series; the permanent shocks are much less important than the temporary disturbances. The opposite is the case with forecasting model 2. This model fits to a series which is virtually a pure random walk: the γ's are much larger on average than the ε's, so that each observed shift in y_t must be assumed to be almost 100 percent permanent.

Forecasting models 3 and 4 are devised to deal with outlier situations. Model 3 is appropriate if the series y is influenced by 'normal' shocks γ_t and extremely large disturbances ε_t: $\text{var}\,\varepsilon_t = 16V_0$, $\text{var}\,\gamma_t = 0.2V_0$.

This model is suitable for any single outliers that may occur. The outlier is assumed to be of a temporary nature, so that the expected level of the series is hardly affected. Finally, forecasting model 4 can deal with large permanent shifts in the level of the series. It is designed for the case in which the variances of ε_t and γ_t are as follows:

$$\text{var}\,\varepsilon_t = 1V_0, \qquad \text{var}\,\gamma_t = 16V_0.$$

Now the change in y is due to the shock γ_t, so that the expected level of the series changes equiproportionally.

The four separate models 1–4 are used in each period to generate four different forecasts for the next period, and the final forecasts are linear composites of these individual forecasts. The weights of four separate forecasts in the composite depends in a Bayesian manner both on prior probabilities and on the likelihood of the most recent observations. The priors are set as follows at the beginning of the algorithm:

Model 1: 0.475, Model 2: 0.475,

Model 3: 0.045, Model 4: 0.005.

These prior probabilities are updated in the course of time, in view of the evolution of the posterior probabilities. The following constraints on the priors have been imposed after some experiments with artificial series:

(1) prior of model 1 + prior of model 2 = 0.95,
(2) prior of model 3 + prior of model 4 = 0.05,
(3) each prior not less than 0.001.

Posterior probabilities are calculated on the basis of current priors and the last two observations.

Take, for example, the forecast that has to be formed at point A. It is clear from the last two observations of the series that an outlier occurred at A, but it is still impossible to determine which type of outlier. Accordingly, the next forecast gives a weight of almost one hundred percent (0.98) to the outlier model with the greatest prior probability at that moment in time (model 3). It gives a small weight (0.02) to the outlier model 4 which is based on the assumption that the outlier that occurred at A indicates a permanent shift in the level of the series, since this alternative outlier model has a much smaller prior weight. Models 1 and 2 get posterior weights of 0. The composite forecast therefore is a weighted average of the forecasts of models 3 and 4, with a very large weight for model 3 and a small weight for model 4. We find therefore that the level of the series is expected to go up by only a small fraction of the outlier in the previous period.

Consider next the situation when we are at C and the forecast for period C+1 has to be formed. At point C the same situation applies as at points A and B: there has been an outlier, but it is too early to tell which type of outlier, so that the contemporary values of the prior probabilities of models 3 and 4 determine the position of the composite forecast. Consider now the forecast that has to be formed at point C+1 for period C+2. Looking back at the last two observations, the explanation that fits these two values is: a permanent outlier in period C and no outlier at C+1. Consequently, the importance of model 4 is increased and its prior probability goes up whereas the prior of model 3 decreases. We notice the difference at point D, when a fresh outlier has just been observed and we forecast for period D+1: instead of assuming again that the outlier is temporary, the algorithm now attaches substantial probability to the possibility that the outlier was permanent. When it has become clear that the outlier at D was indeed permanent, the prior of model 4 dominates that of model 3 almost completely. We see the effects by looking at the forecast for period E+1. Of course, the occurrence of a number of temporary outliers after E would cause the algorithm to 'unlearn' its recent insights in the permanent nature of the outliers.

The updating of the priors for each of the four models, together with the adapative calculation of the basic variance factor makes the multistate

Kalman filter into a flexible forecasting tool, which combines the advantage of 100 percent ex ante forecasts with a feedback mechanism from the data to the way in which the forecasts are formed. [See Harrison and Stevens (1971, 1976), Lawson (1980) and Bomhoff (1982) for examples of similar work.]

References

Artus, J.R. and J.H. Young, 1979, Fixed and flexible rates: A renewal of the debate, IMF Staff Papers 26, Dec., 654–698.

Bilson, J.F.O., 1978, Rational expectations and the exchange rate, in: J.A. Frenkel and H.G. Johnson, eds., The economics of exchange rates (Addison-Wesley, Reading, M.A.).

Black, S.W., 1977, Floating exchange rates and national economic policy (Yale University Press, New Haven, CT).

Bomhoff, E.J., 1980, Inflation, the quantity theory, and rational expectations; Studies in Monetary Economics, Vol. 5 (North-Holland, Amsterdam).

Bomhoff, E.J., 1982, Predicting the price level in a world that changes all the time, in: K. Brunner and A.H. Meltzer, eds., Economic policy in a world of change (North-Holland, Amsterdam).

Dornbusch, R., 1976a, Capital mobility, flexible exchange rates and macroeconomic equilibrium, in: E.M. Claassen and P. Salin, eds., Recent issues in international monetary economics (North-Holland, Amsterdam).

Dornbusch, R., 1976b, The theory of flexible exchange rate regimes and macroeconomic policy, Scandinavian Journal of Economics 78, May, 255–279, repr. in Frenkel and Johnson 1978.

Dornbusch, R., 1979, Monetary policy under exchange rate flexibility, in: Managed exchange rate flexibility: The recent experience, Conference Series no. 20 (Federal Reserve Bank of Boston, Boston, MA).

Fama, E.F. and A. Farber, 1979, Money, bonds, and foreign exchange, American Economic Review 69, Sept., 639–649.

Frankel, J.A., 1979a, On the mark: A theory of floating exchange rates based on real interest differentials, American Economic Review, Sept., 610–622.

Frankel, J.A., 1979b, A test of the existence of the risk premium in the foreign exchange market vs. the hypothesis of perfect substitutability, International Finance discussion papers, no. 149, Aug. (Board of Governors of the Federal Reserve, Washington, DC).

Frenkel, J.A., 1978a, A monetary approach to the exchange rate: Doctrinal aspects and empirical evidence, in: J.A. Frenkel and H.G. Johnson, eds., The economics of exchange rates (Addison-Wesley, Reading, MA).

Frenkel, J.A., 1978b, Purchasing power parity: Doctrinal perspective and evidence from the 1920's, Journal of International Economics 8, May, 169–191.

Frenkel, J.A. and K. Clements, 1980, Exchange rates in the 1920's: A monetary approach, in: M.J. Flanders and A. Razin, eds., Development in an inflationary world (Academic Press, New York).

Frenkel, J.A. and H.G. Johnson, 1978, The economics of exchange rates (Addison-Wesley, Reading, MA).

Genberg, H., 1978, Purchasing power parity under fixed and flexible exchange rates, Journal of International Economics 8, May, 247–276.

Harrison, P.J. and C.F. Stevens, 1971, A Bayesian approach to short-term forecasting, Operational Research Quarterly 22, no. 4, 341–362.

Harrison, P.J. and C.F. Stevens, 1976, Bayesian forecasting, Journal of the Royal Statistical Society B, 38 no. 3, 205–247, with Discussion.

Hodrick, R.J., 1978, An empirical analysis of the monetary approach to the determination of the exchange rate, in: J.A. Frenkel and H.G. Johnson, eds., The economics of exchange rates (Addison-Wesley, Reading, MA).

Isard, P., 1977, How far can we push the 'law of one price'?, American Economic Review 67, Dec., 942–948.

Isard, P., 1978, The process of exchange rate determination: A survey of popular views, Princeton Studies in International Finance, no. 42, May.

Katseli-Papaefstratiou, L.T., 1979, The reemergence of the purchasing power parity doctrine in the 1970's, Special Papers in International Economics 13, International Finance Section, Princeton University.
Korteweg, P., 1978, The economics of inflation and output fluctuations in the Netherlands, 1954–1975 — A test of the dominant impulse-cum-rational expectations hypothesis, in: K. Brunner and A.H. Meltzer, eds., The problem of inflation (North-Holland, Amsterdam).
Korteweg, P., 1979a, The European Monetary System — Will it really bring more monetary stability for Europe, De Economist 128, no. 1, March 1980, 15–49.
Korteweg, P., 1979b, The economics of stagflation: Theory and Dutch evidence, Zeitschrift für die gesamte Staatswissenschaft 135, no. 4, Dec., 553–583.
Korteweg, P., 1979c, Towards full employment and price stability: An assessment and appraisal of the OECD's McCracken report, in: K. Brunner and A.H. Meltzer, eds., Policies for employment, prices, and exchange rates (North-Holland, Amsterdam).
Kouri, P.J.K., 1976, The exchange rate and the balance of payments in the short run and in the long run: A monetary approach, Scandinavian Journal of Economics 78, June, 280–304.
Kouri, P.J.K., 1977, International investment and interest rate linkages under flexible exchange rates, in: R.Z. Aliber, ed., The political economy of monetary reform (Macmillan, London).
Kouri, P.J.K. and J. Braga de Macedo, 1978, Exchange rates and the international adjustment process, Brookings Papers on Economic Activity 1, 111–150.
Kravis, I.B. and R.E. Lipsey, 1971, Price competitiveness in world trade (NBER, New York).
Kravis, I.B., et al., 1978, International comparisons of real product and purchasing power (Johns Hopkins University Press, Baltimore, MD).
Lamfalussy, A., 1979, The failure of global flexibility?, in: R. Triffin, ed., EMS: The emerging European Monetary System, Bulletin de la Banque Nationale de Belgique, April.
Lawson, T., 1980, Adaptive expectations and uncertainty, Review of Economic Studies 47, 305–320.
Levich, R.M., 1978, Tests of forecasting models and market efficiency in the international money market, in: J.A. Frenkel and H.G. Johnson, eds., The economics of exchange rates (Addison-Wesley, Reading, MA).
McCracken, P., et al., 1977, Towards full employment and price stability: A Report to the OECD by a group of Independent Experts (OECD, Paris).
Mussa, M., 1976, The exchange rate, the balance of payments and monetary and fiscal policy under a regime of controlled floating, Scandinavian Journal of Economics 78, June, 229–248.
Mussa, M., 1979, Empirical regularities in the behavior of exchange rates and theories of the foreign exchange market, in: K. Brunner and A.H. Meltzer, eds., Policies for employment, prices, and exchange rates (North-Holland, Amsterdam).
Officer, L.J., 1976, The purchasing-power-parity theory of exchange rates: A review article, IMF Staff Papers 13, March, 1–61.
Richardson, J.D., 1978, Some empirical evidence on commodity arbitrage and the law of one price, Journal of International Economics 8, May, 341–351.
Sargent, T.J. and N. Wallace, 1973, The stability of money and growth with perfect foresight, Econometrica 6, Nov., 1043–1048.
Solnik, B., 1978, International parity conditions and exchange risk: A review, Journal of Banking and Finance 2, Oct., 281–293.
Stockman, A.C., 1978, Risk, information, and forward exchange rates, in: J.A. Frenkel and H.G. Johnson, eds., The economics of exchange rates (Addison-Wesley, Reading, MA).
Swoboda, A.K., 1979, Exchange-rate flexibility in practice: A selective survey of experience since 1973, Paper presented at the Conference on 'Macroeconomic Policies for Growth and Stability — The European Perspective', June (Kiel).
Vaubel, R., 1976, Real exchange-rate changes in the European Community: The empirical evidence and its implications for European currency unification, Weltwirtschaftliches Archiv 112, Heft 3, 429–470.
Vaubel, R., 1980, International shifts in the demand for money, their effects on exchange rates and price levels, and their implications for the preannouncement of monetary expansion, Weltwirtschaftliches Archiv 116, Heft 1, 1–40.
Wihlborg, C., 1978, Currency risk in international financial markets, Princeton Studies in International Finance no. 44, Dec. (Princeton, NJ).