entER
for
nomic Research

Discussion paper

[redacted]

TILBURG UNIVERSITY

No. 8803

THE CREDIBILITY OF MONETARY POLICIES, POLICYMAKERS' REPUTATION AND THE EMS-HYPOTHESIS: Empirical Evidence from 13 Countries

by

Axel A. Weber

September 1988

The Credibility of Monetary Policies, Policymakers' Reputation and the EMS-Hypothesis: Empirical Evidence from 13 Countries

by Axel A. Weber[1)]

University of Siegen, West Germany

This paper is an attempt to estimate empirically the credibility of monetary policies and the reputation of central banks participating in the EMS. The main focus of interest is on the 'EMS-credibility hypothesis' - that is, that the EMS itself in connection with the high anti-inflation reputation of the German Bundesbank is responsible for the inflation reduction and convergence which member countries have experienced. The empirical approach taken in this paper is based on the theoretical models of Backus & Driffill [(1985a), (1985b)] and Barro (1986b), in which rational expectations of economic agents with respect to future monetary policy are used to derive measures of governments' reputation for being 'hard-nosed' or 'wet' in his commitment to fight inflation from the public's rational expectations about future monetary policy. In forming inflation expectations, rational agents pursue a Bayesian learning strategy whereby the probability that the central bank sets the monetary growth rate such that the domestic inflation rate follows a stationary stochastic process with both constant mean and finite variance is continuously updated. For truly 'hard-nosed' monetary authorities this probability should be close to one and the expected rate of money growth should be close to zero. However, reputation is affected by the actual course of policy and a rise in inflation rates leads to higher expected future inflation, which lowers the reputation of the central bank for being hard-nosed. The paper derives and compares time-varying estimates of reputation for all 8 EMS participants and some major non-member countries and finds some empirical support for the 'EMS-credibility hypothesis'.

1. Introduction.

Since the early 1980's there has been a vast increase in literature on the EMS. A number of recent contributions focus on the so-called 'EMS-inflation hypothesis', according to which the EMS itself is responsible for the inflation reduction and convergence experienced in all member countries. No consensus has yet been reached on this issue. In evaluating the empirical evidence on the EMS-inflation hypothesis Rogoff (1985) concludes:

....

1) Paper completed during my visit to the Center for Economic Research (CentER) at Tilburg University in September 1988. I should like to thank Torben Andersen, John Driffill, Patrick Minford, Theodoor Nijman and the participants of the CentER's economic and econometric seminar for helpfull comments and discussions.

> "...there is no evidence whatsoever of any convergence between France's, Germany's and Italy's inflation rates. ... Even if French, German and Italian inflation rates do ultimately converge at a low level, one should be cautious in attributing this success to the existence of the EMS."[Rogoff (1985), p.96.]

The same conclusion is derived by Collins (1987), who states:

> "...all countries tended to have lower inflation rates after 1979, but there was little difference between the EMS and nonEMS countries after 1979. ... Between 1979 and 1986 there was an impressive reduction and convergence of inflation rates among EMS members. However coincidence alone is not enough to determine causality. The fact that little convergence occurred during the first half of the system makes claims especially suspect." [Collins (1987), p. 27, 28.]

This pessimism about the achievements of the EMS in its early stage from 1979-1982 is shared by Ungerer, Evans & Nyberg, OECD (1983):

> "...The lack of coordination of policies has been reflected in a lack of convergence of economic performances and, in particular, of costs and prices. An opinion held by many, however, is that the existence of the constraints imposed by the EMS have helped to prevent a greater divergence..." [OECD (1983), p. 10.]

Schioppa (1985), in considering the period 1979-1984, is slightly more optimistic about the successes of the EMS, especially in its later phase:

> "...in terms of price stability the EMS can only claim some modest results. ... Consumer price inflation during the five EMS years did not come down in some EMS member countries compared with the pre EMS period, although the average inflation rate of the member countries was reduced. ... Starting in 1980 the disciplinary effects began to exert pressure, the average inflation rate fell..." [Schioppa (1985), p. 346-349.]

In contrast to much of the evidence referred to above, De Grauwe (1985) suggests that compared with other OECD countries the EMS countries have been able to lengthen and soften the adjustment process towards lower inflation rates when compared with other OECD countries. Artis (1987), however, finds that based on data up to 1987 the reduction in both the level of and the dispersion in inflation rates is somewhat larger for non-EMS countries than for EMS countries. Adding further observations may yet again alter this result in favour of the EMS. This clearly shows the weakness of such policy evaluations, based on comparisons of the period-averages or time-paths of pre and post EMS inflation rates (and other key economic variables) for EMS member and non-member countries.

The present study takes a different approach and focuses exclusively on the credibility and reputation effects resulting from membership in the EMS. The analysis below concentrates on what I shall call the 'EMS-credibility hypothesis', that the high anti-inflation reputation of the German Bundesbank in connection with a binding commitment to EMS-membership has provided the exchange rate pegging policies of high inflation member countries with counterinflation credibility, and hence enabled these economies to move to a low-inflation reputational equilibrium, which without EMS-membership would not have been credible. Some references to this EMS-credibility hypothesis will be given below.

As Artis (1987) and Artis & Miller (1987) stress, the EMS has been consciously used as part of a counterinflationary framework and this was intended from the start. While there is no formal leader within the EMS, it is commonly agreed that on the inflation front Germany is the de-facto or acknowledged leader:

> "...Since Germany had the best reputation for price stability, there was a commonalty to converge to the German inflation rate." [Frenkel & Goldstein (1988), p.15.]

With Germany as the low inflation centre or anchor of the EMS, the Exchange Rate Mechanism (ERM) of the EMS, which aims at keeping the bilateral exchange rates of the EMS-member countries within their agreed bands, thus provides the official EMS exchange rate targets with their counterinflation credibility. As Fischer (1987a) emphasizes, the main motivation for high inflation countries to peg their bilateral exchange rates with the mark is therefore the move towards a reputational low-inflation equilibrium within the EMS, an equilibrium which would not be credible without the binding commitment of EMS-membership:

> "...The EMS is currently an arrangement for France and Italy to purchase a commitment to low inflation by accepting German monetary policy." [Fischer (1987a).]

Even for potential future participants in the ERM of the EMS these reputational aspects have been put forward as a major argument in favour of the EMS:

> "...For a country contemplating the relative merits of independent exchange rate targeting and adherence to the EMS, the credibility factor may weigh decisively in favour of the latter option." [Artis (1987), p. 195.]

This argument is, however, only valid if the country in question - in this case Great Britain - has a reputation for pursuing anti-inflation policies which is currently lower than that of Germany. As Sachs and Wyplosz (1987) argue, it is obvious that Britains current economic policy after almost a decade of Thatcherism is sufficiently austere by itself, but EMS membership could be viewed as one avenue to bind the actions of a successor government.[2)] However, entering the EMS with a high reputation for anti-inflation policies might be undesirable since the loss in autonomy over monetary policy can result in a depletion of the stock of credibility which has accumulated over recent years. Such concerns are expressed in Vaubel (1985) and in Vaubel's discussion of a paper by Hellwig & Neumann (1987). Vaubel states that the EMS has hung like a millstone around the mark's neck [3)] and adds that within the German institutional framework membership in the EMS provided the Federal Government of Chancellor Schmidt and his conservative successor Kohl de facto with control over monetary policy of the de jure autonomous central bank, and may after all have been the most important motive for Germany to join the EMS.

Further doubts about the German Bundesbank's gains from the current EMS arrangement are expressed in Giavazzi & Giovannini (1987). They describe the EMS as a system of managed exchange rates where the mark effectively plays the role of the nth currency and the other EMS members are free, at least in part, to influence their own bilateral exchange rates with the mark. When faced with a common price shock from outside, such as a dollar appreciation, the non-German EMS countries have an incentive to appreciate their currencies against the mark, thus exporting some of their inflation to Germany and hence undermining the Bundesbank's anti-inflation reputation.[4)] In addition, Henderson & Canzoneri (1988) provide further theoretical arguments indicating that it might not be in the German interest to have foreign countries pegging their exchange rates to the mark.

Arguments in favour of joining the EMS as a low inflation country with high anti-inflation reputation are provided by Frenkel & Goldstein (1988). They describe the EMS as a system of informal hegemony where Germany exports price-stability as well as anti-inflation credibility. Since the other members are "tying their hands" on domestic

....

2) On this point see Sachs & Wyplosz (1987), p. 295.
3) See Vaubel in the discussion of Hellwig & Neumann (1987), p. 141.
4) See Giavazzi & Giovannini (1987), p. 476.

monetary policy and since realignments do not always provide full compensation for past inflation differentials, the resulting real appreciation for the high inflation countries acts as a disincentive to inflation, while low inflation countries benefit from improved competitiveness, which provides some compensation for their export of anti-inflation credibility.[5)]

To summarize the above arguments, the EMS can be viewed as an institutional framework within which high inflation countries with low anti-inflation credibility can increase their reputation and pursue credible anti-inflationary policies. With respect to the low inflation countries with high counterinflation reputations two outcomes of the EMS are possible: under fully cooperative realignments, low inflation as well as high counterinflation reputation will persist; under non-cooperative, 'beggar-thy-neighbour' realignments, however, an increase in inflation rates and a loss in anti-inflation reputation are likely. Which outcome actually results from the EMS is therefore an empirical question and will be dealt with below.

The remainder of the paper is organized as follows: In section 2 a rudimentary model of the price level effects of monetary policy, both in and outside of the institutional framework of the EMS, is developed. Since this paper is the first empirical attempt to quantify empirically some measure of credibility or reputation in the context of the EMS, a simple time-series model is used to extract signals about the tightness of monetary policy and policymakers' counterinflation reputations from observable consumer price data. The signal-extraction algorithm employed is the multi-process Kalman filter (MPKF), which is taken from Weber (1988b) and briefly reviewed in appendix A. The most relevant part of the MPKF in the context of the present paper is its Bayesian probability learning, which can be viewed as the empirical counterpart of the Bayesian learning strategies used in Backus & Driffill [(1985a), (1985b)] and Barro (1986b) and is described in section 3. Section 3 also defines our measures for policymakers' anti-inflation reputation and section 4 presents the empirical estimates for all 8 EMS member countries and 5 selected non-member countries. Finally, some conclusions and suggestions for further research are presented in section 5.

....

5) See Frenkel & Goldstein (1988), p. 15.

2. The Model.

In their attempt to explain the apparent inflationary bias of market economies in a natural rate model, Barro & Gordon [(1983a), (1983b)] put forward a macromodel in which low inflation is dynamically inconsistent in the sense of Kydland & Prescott (1977) and represents a non-credible policy if the government is known to care about output. This inferiority of the time-inconsistent Nash solution relative to the time-consistent solution with binding policy commitments reflects the more general fact that in game theoretical models the non-cooperative equilibrium need not be Pareto optimal.

Backus & Driffill [(1985a), (1985b)] and Barro (1986b) extend the work of Barro & Gordon to situations where the public is uncertain about the preferences of the government, in particular, whether or not it cares about output (and unemployment). Thus, when the government announces its intention to fight inflation regardless of the output costs, the public is uncertain whether this is in fact the case or whether it is simply an attempt to manipulate their expectations. In the following section such a model of monetary policy in the presence of a sceptical public is developed.

2.1. Public and Policymaker's Preferences

As in Barro & Gordon (1983b), aggregate output (y_t) is determined by a Phillips curve with natural rate properties:

$$(1) \qquad y_t = y^n + (x_t - x_t^e) \ ,$$

where y^n is the natural rate, and x_t and x_t^e are actual and expected changes in the price level.

Expectations are assumed to be formed rationally in the sense of Muth (1961) and defined to be of the least-squares error type. In Barro & Gordon [(1983a), (1983b)] this implies that the public resists being fooled, as can be formalized by the objective (payoff) function:

$$(2) \qquad U_p(x_t, x_t^e) = (x_t - x_t^e)^2 \ ,$$

which the public attempts to minimize.

Following Barro & Gordon [(1983a), (1983b)], the government is assumed to maximize a policy preference function $U_g(x_t, x_t^e)$ each period. With respect to $U_g(x_t, x_t^e)$, it is postulated that the government cares about both output and inflation, which implies the general objective function:

(3a) $$U_g(x_t, x_t^e) = \frac{1}{2} x_t^2 + b_t (y_t - y^n)^2 ,$$

(3d) $$b_t = \bar{b}_t + z_t , \; E(z_t)=0, E(z_t)^2=\sigma^2_z ,$$

with b_t as a time-varying preference parameter, postulated to be the sum of a systematic component ($\bar{b}_t$) and a random component z_t. The error-term z_t is defined as an independently normally distributed random variable with zero mean and constant finite variance (σ^2_z). The random component thus reflects the fact that the public can only observe a noisy signal about the government's true preferences.[6] At the present, no further assumptions about the systematic component $\bar{b}_t$, which could be constant ($\bar{b}_t = \bar{b}_{t-1} = \bar{b}$) as in Barro & Gordon [(1983a), (1983b)] or follow a non-stationary time-path ($b_t = b_{t-1} + z_t'$) as in Cukierman & Meltzer [(1983), (1986a), (1986b)], are made. However, following Backus & Driffill [(1985a), (1985b)], Barro (1986b) and Weber (1988c) two different types of governments are introduced into the analysis:

A 'wet government' is defined as one which cares about both inflation and output, but places a stronger emphasis on its output target. In terms of the objective function (2) above, this corresponds to a large value of $\bar{b}_t$ and hence b_t (b_t^w), which can be formalized as:

(4) $$U_g^w(x_t, x_t^e) = \frac{1}{2} x_{t-1} + b_t^w (x_t - x_t^e)^2 .$$

In the context of the Barro (1986b) model such a wet government is unable to make a binding commitment to low inflation policies.

A 'hard-nosed government' on the other hand is assumed to care mainly about inflation, which in terms of the objective function (3a,b) implies a low value of $\bar{b}_t$ and hence b_t (b_t^h):

....

6) I assume that the government knows the current value of this disturbance, but the public only knows the stochastic laws driving this process. For a similar concept of disguising one's true preferences by adding a noisy signal see Cukierman & Meltzer [(1983), (1986b)] in their analysis of strategically biased money supply announcements.

(5) $$U_g^h(x_t,x_t^e) = \frac{1}{2} x_{t-1} + b_t^h (x_t-x_t^e)^2 .$$

The wet [hard-nosed] government aims at maximizing objective function (4) [(5)]. General equilibrium is then characterized by:

(6) $$x_t = b_t^h , \quad x_t^e = E_{t-1}x_t = \bar{b}_t^h ,$$

if the public faces a hard-nosed government, and by:

(7) $$x_t = b_t^w , \quad x_t^e = E_{t-1}x_t = \bar{b}_t^w ,$$

if the government is known to be wet. Note that here a hard-nosed government has less incentive to inflate, regardless of the public's expectations. In the context of the Barro (1986b) model, such a hard-nosed government is one which can make a binding commitment to a low-inflation policy in each period.

Now it is assumed that the public does not know exactly at each point in time what type of government is in office. However, an objective probability distribution exists, whereby the objective probability for a hard-nosed policymaker is given by $(1-q_t)$ and the corresponding probability for a wet policymaker is q_t. Due to the stochastic nature of policymaker's preferences and given that inflation is a non-dichotomous variable, the public can infer the true type of government only slowly by observing actual prices and revising its subjective estimate $E_{t-1}q_t$ of the above probability in each period. Hence, faced with the uncertainty about the type of policymaker in office, the public's expectations are required to fulfill the equilibrium condition:

(8) $$x_t^e = E_{t-1}x_t = E_{t-1}(1-q_t) E_{t-1}b_t^h + E_{t-1}q_t E_{t-1}b_t^w ,$$

and are a probability weighted average of the expectations of the low-inflation equilibrium $(x_t=b_t^h)$ and the high-inflation equilibrium $(x_t=b_t^w)$.

In order to quantify these expectations empirically, a measure for the subjective probability $E_{t-1}q_t$, which may be interpreted as the reputation of a government for being hard-nosed, is required. Since actual inflation x_t in this model always reveals a noisy signal about the hard-nosed (wet) government's true preferences $\bar{b}_t^h$ ($\bar{b}_t^w$) and since $\bar{b}_t^w > \bar{b}_t^h$ holds, the application of a suitable signal-extraction procedure to observable price data can yield such a measure for the government's reputation once a model is specified for the time-paths for the true preferences of a hard-nosed ($\bar{b}_t^h$) or wet ($\bar{b}_t^w$) government. Given the results from above, the specification of the time-paths of $\bar{b}_t^h$ and $\bar{b}_t^w$ corresponds to specifying time-paths for the target inflation rate under both types of government, to which I shall now turn.

2.2. National Monetary Policies, Prices and the EMS.

In order to characterize the inflation process under a low-inflation government in an economy with flexible exchange rates, a low-order 'dynamic linear model' for observable domestic prices p_t is considered:

(9a) $$p_t = m_t + v_t \quad , \quad E(v_t)=0, E(v_t)^2=\sigma_v^2,$$

(9b) $$m_t = m_{t-1} + g_t + n_t \quad , \quad E(n_t)=0, E(n_t)^2=\sigma_n^2,$$

(9c) $$g_t = g_{t-1} = g \quad ,$$

which relates the observable domestic price level (p_t) to the domestic money stock (m_t) via a stochastic quantity equation, with v_t as an independently normally distributed error-term with mean zero and constant finite variance σ_v^2. Inflation or changes in the price level ($x_t=p_t-p_{t-1}$) are stochastically related to changes in the nominal money stock ($g_t=m_t-m_{t-1}$). For the 'hard-nosed' government money growth is assumed to be the sum of a controllable component g_t^h, regarded for simplicity as a constant, and an uncontrollable component n_t, defined to be independently normally distributed with zero mean and constant finite variance σ_n^2.

On the other hand, the 'dynamic linear model', which characterizes the observable domestic prices p_t of a 'wet' or strongly inflationary government is represented by assuming higher-order processes, such as:

(10a) $$p_t = m_t + v_t \quad , \quad E(v_t)=0, E(v_t)^2=\sigma_v^2,$$

(10b) $$m_t = m_{t-1} + g_t + n_t \quad , \quad E(n_t)=0, E(n_t)^2=\sigma_n^2,$$

(10c) $$g_t = g_{t-1} + d_t + r_t \quad , \quad E(r_t)=0, E(r_t)^2=\sigma_r^2,$$

(10d) $$d_t = d_{t-1} + s_t \quad , \quad E(s_t)=0, E(s_t)^2=\sigma_s^2,$$

where the change in the controllable rate of money growth g_t is now allowed to follow a random walk with a stochastic drift term d_t, which itself follows a random walk. The two error-terms r_t and s_t are also defined to be independently normally distributed with zero mean and constant finite variances σ_r^2 and σ_s^2 respectively. Note that for $d_t=d_{t-1}=0$ and $\sigma_r^2=\sigma_s^2=0$, however, the controllable money growth is constant $[g_t^w=g_{t-1}^w=g^w\ (>g^h)]$ and the observable price level series p_t is determined by a difference stationary stochastic process.

Under flexible exchange rates the foreign country is assumed to have a similar price determination equation, which for the more general case of a strongly inflationary foreign government is given by:

$$\text{(11a)}\qquad p_t^* = m_t^* + v_t^* \quad , \quad E(v_t^*)=0, E(v_t^*)^2=\sigma_{v*}^2 \; ,$$
$$\text{(11b)}\qquad m_t^* = m_{t-1}^* + g_t^* + n_t^* \; , \quad E(n_t^*)=0, E(n_t^*)^2=\sigma_{n*}^2 \; ,$$
$$\text{(11c)}\qquad g_t^* = g_{t-1}^* + d_t^* + r_t^* \; , \quad E(r_t^*)=0, E(r_t^*)^2=\sigma_{r*}^2 \; ,$$
$$\text{(11d)}\qquad d_t^* = d_{t-1}^* + s_t^* \quad , \quad E(r_t^*)=0, E(r_t^*)^2=\sigma_{s*}^2 \; ,$$

where the superscript "*" characterizes the foreign country's variables.

Under a fixed exchange rate (or adjustable peg) arrangement like the EMS with an explicitly low-inflation centre country (Germany), the n-1 non-German EMS member countries (with higher inflation) are assumed to peg their exchange rates to the low-inflation centre country on the basis of a purchasing-power-parity (PPP) condition:

$$\text{(12)}\qquad p_t = p_t^* \bar{e}_t \; ,$$

where $\bar{e}_t$ is the official bilateral nominal exchange rate in terms of the foreign country's currency (Hfl) per units of the domestic country's currency (DM). For simplicity it is assumed that $\bar{e}_t=\bar{e}_{t-1}=\bar{e}$ holds for all t except the realignment dates, where $\bar{e}_t=\bar{e}_{t-1}+k_t$ holds. Hence, each realignment (k_t) can be interpreted as a permanent price level shock in the non-centre EMS countries. Under such an exchange rate arrangement the foreign price determination process results as:

(13a) $p_t^* = m_t \bar{e}_t + v_t^*$, $E(v_t^*)=0, E(v_t^*)^2=\sigma_{v*}^2$,

(13b) $m_t = m_{t-1} + g_t + n_t$, $E(n_t)=0, E(n_t)^2=\sigma_n^2$,

(13c) $g_t = g_{t-1} + d_t + r_t$, $E(r_t)=0, E(r_t)^2=\sigma_r^2$,

(13d) $d_t = d_{t-1} + s_t$, $E(s_t)=0, E(s_t)^2=\sigma_s^2$.

Under this exchange rate arrangement the high-inflation countries can therefore reduce their inflation rates (for $g_t^h < g_t^*$) by fixing their n-1 exchange rates with the low-inflation centre country, which continues to pursue an independent monetary policy.

3. Expectations, Learning and Policymakers' Reputation.

3.1. The Public's Expectations.

In the derivation of an empirical measure of the policymaker's reputation for being 'wet' or 'hard-nosed', a model of the public's price level expectation formation process is essential. In order to clarify the approach taken here, it is assumed for the moment that the dynamic linear model (9a) to (9c) describes the observable domestic price level series, and that $g_t^h=0$ holds for all t. In this case, the dynamic linear model (9a) to (9c) is equivalent to the difference stationary time series model $p_t=n_t+v_t-v_{t-1}$. This in turn corresponds to an ARIMA (0,1,1) time series model $p_t=(1-d_1\mathbf{B})u_t$, with $\mathbf{B}$ as the back-shift operator, d_1 as a moving-average parameter and u_t as an independently normally distributed error-term with mean zero and constant finite variance x_t. As outlined in Weber (1988a), the rational expectation of p_t given $\sigma_v^2>0$ and $\sigma_n^2>0$ then follows as:

(14) $p_t^e = p_{t-1}^e + d_1 (p_{t-1} - p_{t-1}^e)$,

where d_1 is a non-linear function of the two variances σ_v^2 and σ_n^2. For the sake of simplicity, let us now assume that a 'hard-nosed' government is characterized by $\sigma_v^2=0$ and $\sigma_n^2>0$, while a 'wet' government is characterized by $\sigma_v^2>0$ and $\sigma_n^2=0$. The rational expectations of the price level p_t under a hard-nosed government is then given by:

(15) $p_t^e = p_{t-1}^e$,

which implies $d_1=0$ in equation (14) above. The corresponding rational expectations of p_t under a wet government result as:

(16) $$p_t^* = p_{t-1} ,$$

which implies $d_1=1$ in equation (14). Given the public's subjective probability q_t for the occurrence of a 'wet' government, the probability weighted average of the two expectations (15) and (16) follows as: and can be interpreted as a time-varying rather than fixed error-learning process. The optimality of fixed error-learning processes ($q_t=d_1$) is derived in Muth (1960) and used in Cukierman & Meltzer [(1983), (1986a), (1986b)] in the context of deriving a measure for the credibility of monetary policy announcements. The time-varying version ($q_t=d_{1t}$) of the error-correction model is derived by Turnovsky (1969) in a Bayesian learning context and by Friedman (1979) in the context of optimal-least squares learning and Kalman filtering. The Bayesian MSKF used here combines both forms of learning and estimates the probability q_t $(1-q_t)$ which is used in Backus & Driffill [(1985a), (1985b)] and Barro (1986b) as a measure of the government's reputation for being wet (hard-nosed).

For the analysis of real world price data and policy credibility, however, the dynamic linear model (9a) to (9c) is too restrictive, because it requires the expected inflation rate to be constant and defines a hard-nosed policymaker as one who forces prices to follow a stationary stochastic time-path. Thus, in order to study the deflation process during the EMS period, the more general dynamic linear model (11a) to (11d) is used and the more realistic definitions of 'hard-nosed' or 'wet' governments from section 2 are adopted.

In the general case with independently normally distributed random variables v_t, n_t, r_t and s_t in the dynamic linear model (11a) to (11d) the third difference of the price level series p_t follows a stationary stochastic process:

(17) $$\Delta^3 p_t = s_t + r_t - r_{t-1} + n_t - 2n_{t-1} + n_{t-2} + v_t - 3v_{t-1} + 3v_{t-2} - v_{t-3} ,$$

and is equivalent to an ARIMA (0,3,3) time series model:

(18) $$\Delta^3 p_t = (1 - d_1 \mathbf{B} - d_2 \mathbf{B}^2 - d_3 \mathbf{B}^3) x_t ,$$

with d_1, d_2 and d_3 as three moving-average parameters. Deriving the autocovariance functions of the dynamic linear model and the time series model and equating terms yields:

$$(19a) \qquad \sigma_v^2 = d_3 \sigma_x^2 ,$$
$$(19b) \qquad \sigma_n^2 = -(d_2 - d_1 d_3 + 6d_3) \sigma_x^2 ,$$
$$(19c) \qquad \sigma_r^2 = (d_1 - d_2[d_1+d_2] - 4[d_2-d_1 d_3] + 9d_3) \sigma_x^2 ,$$
$$(19d) \qquad \sigma_s^2 = (1 - d_3 - d_2 - d_1)^2 \sigma_x^2 ,$$

which can be used to find the moving-average parameters d_1, d_2 and d_3 as functions of the error-variances σ_v^2, σ_n^2, σ_r^2 and σ_s^2. Furthermore, by taking $\Delta^3 p_t = (1-\mathbf{B})^3 p_t = p_t - 3p_{t-1} + 3p_{t-2} - p_{t-3}$ into consideration, equation (19) can be modified to:

$$(20) \qquad p_t^e = p_{t-1}^e + (p_{t-1}^e - p_{t-2}^e) + (\Delta p_{t-1}^e - \Delta p_{t-2}^e) + (3-d_1)(p_{t-1} - p_{t-1}^e) - (3+d_2)(p_{t-2} - p_{t-2}^e) + (1-d_1)(\Delta p_{t-2}^e - \Delta p_{t-3}^e) ,$$

which for given values of the moving-average parameters d_1, d_2 and d_3 in the intervals $0<d_1<3$ and $-3<d_2<0$ and $0<d_3<1$ and for a normalized variance of the prediction errors ($E[p_t-p_t^e]^2=x_t=1$) implies the following four pure process specifications:

(a) **purely transitory level shocks** with $\sigma_v^2=1$ and $\sigma_n^2=\sigma_r^2=\sigma_s^2=0$ and hence $d_1=3$, $d_2=-3$, $d_3=1$ and $\sigma_x^2=1$.
(b) **purely permanent level shocks** with $\sigma_n^2=1$ and $\sigma_v^2=\sigma_r^2=\sigma_s^2=0$ and hence $d_1=2$, $d_2=-1$, $d_3=0$ and $\sigma_x^2=1$;
(c) **purely permanent first difference shocks** with $\sigma_r^2=1$ and $\sigma_v^2=\sigma_n^2=\sigma_s^2=0$ or $d_1=1$, $d_2=d_3=0$ and $\sigma_x^2=1$;
(d) **purely permanent second difference shocks** with $\sigma_s^2=1$ and $\sigma_v^2=\sigma_n^2=\sigma_r^2=0$ or $d_1=d_2=d_3=0$ and $\sigma_x^2=1$;

In the specification of the multi-process filter (outlined in the appendix) it is assumed that these four alternative process models are sufficient to cover the range of possible stochastic patterns of the price level series. Specifically, it is postulated that the four alternative models, characterized by a superscript j (for all j=1,2,3,4), differ only in the specification of the variances $\sigma_v^{2(j)}$, $\sigma_n^{2(j)}$, $\sigma_r^{2(j)}$ and $\sigma_s^{2(j)}$ of the dynamic linear model [or the moving-average terms d_1, d_2 and d_3 of the corresponding time series model], and that at each point in time t [with t=(1,2,...,N)] each model has a certain probability $\pi_t^{(j)}$.

In order to capture the possibility of process-switching, such as adopting counterinflation policies by entering the EMS, the observable process p_{t-1} in period t-1 may be described by model i [denoted by $M_{t-1}^{(i)}$ for all i(=1,2,3,4)], and the process p_t in period t is represented by model j [denoted by $M_t^{(j)}$ for all j(=1,2,3,4)]. Thus, for a possible process-switch a prediction on the basis of all models i in period t-1 with the different specification of all models j [denoted by $M_t^{(i,j)}$ for all i,j(=1,2,3,4)] is required. The probability of such process-switching or state-transition is defined as $\pi_t^{(i,j)}$.

3.2. The Concept of Bayesian Probability Learning.

In order to infer process-switching, economic agents use Bayesian techniques. In the Bayesian multi-process Kalman filter a combination of prior information and sample information is used to calculate and update the probability distribution of the alternative process models via Bayes' law. This updating process is referred to as 'Bayesian learning' and closely resembles the Bayesian probability learning with regard to the reputation of policymakers in the models of Backus & Driffill [(1985a), (1985b)] and Barro (1986b).[7)]

According to Bayes' theorem the conditional posterior probability $\pi_t^{(i,j)}$ can be separated into prior information and sample information by employing the Markov properties of the observable process. Thus, the probability $\pi_t^{(i,j)}$ can be calculated as:

$$
\begin{aligned}
(21) \qquad \pi_t^{(i,j)} &= \textbf{\textit{PROB.}} \, [\, M_t^{(j)} , M_{t-1}^{(i)} \mid (p_t, p_{t-1}, p_{t-2}, \ldots) \,] \\
&= \textbf{\textit{PROB.}} \, [\, p_t \mid M_t^{(j)} , M_{t-1}^{(i)} , (p_{t-1}, p_{t-2}, p_{t-3}, \ldots) \,] \\
&\quad * \textbf{\textit{PROB.}} \, [\, M_t^{(j)} \mid M_{t-1}^{(i)} , (p_{t-1}, p_{t-2}, p_{t-3}, \ldots) \,] \\
&\quad * \textbf{\textit{PROB.}} \, [\, M_{t-1}^{(i)} \mid (p_{t-1}, p_{t-2}, p_{t-3}, \ldots) \,] \\
&\quad / \textbf{\textit{PROB.}} \, [\, p_t \mid (p_{t-1}, p_{t-2}, p_{t-3}, \ldots) \,] .
\end{aligned}
$$

The first term in equation (22) represents the value of the likelihood function $L_t^{(i,j)}$ for observation p_t conditional on the specification of

....

7) See also Driffill (1988b) for this interpretation of my approach to modelling reputation and credibility in Weber (1988d).

model $M_t^{(i,j)}$. It is determined by the recursive residuals of the Kalman filter iteration of model $M_t^{(i,j)}$ - that is, by the one-period prediction errors $e_t^{(i,j)}$ and their variance $F_t^{(i,j)}$ according to:

$$(22) \quad L_t^{(i,j)} = [2\pi\ \sigma^2\ F_t^{(i,j)}]^{-(1/2)}\ \mathbf{exp}\ [\ -\{(e_t^{(i,j)})^2/2\sigma^2 F_t^{(i,j)}\}\ ]\ ,$$

where 'exp' characterizes the exponential function. The second term in equation (22) describes the prior probability attached to model j [$M_t^{(j)}$] before the observation of p_t in period t. This prior probability is denoted by $E_{t-1}\Pi_t^{(j)}$. The third term in equation (22) is the posterior probability attached to model i [$M_t^{(i,j)}$] in period t-1 conditional on the observation of p_{t-1} and is denoted by $\Pi_{t-1}^{(i)}$. The last term in equation (22) is the common denominator of all probabilities $\Pi_t^{(i,j)}$ and represents a normalizing constant:

$$(23) \qquad \sum_i \sum_j \Pi_t^{(i,j)} = 1\ .$$

The normalized posterior probabilities $\Pi_t^{(i,j)}$ can thus be written as:

$$(24) \qquad \Pi_t^{(i,j)} = k_t\ L_t^{(i,j)}\ E_{t-1}\Pi_t^{(j)}\ \Pi_{t-1}^{(i)}\ ,$$

and represent the relative probability (weight) of the individual process model $M_t^{(i,j)}$ within the overall model M_t. These relative weights depend in Bayesian tradition on both sample information, as captured by the performance indicator of the likelihood function $L_t^{(i,j)}$ of model $\Pi_t^{(i)}$ and the posterior probability [$\Pi_{t-1}^{(i)}$] of the process models $M_{t-1}^{(i)}$, and on prior information as reflected by the prior probability [$E_{t-1}\Pi_t$] of model $M_t^{(j)}$.

The prior information conveyed by the probabilities $\Pi_t^{(i,j)}$ in equation (25) is determined subject to the numerical values of the prior and posterior probabilities $E_{t-1}\Pi_t^{(j)}$ and $\Pi_{t-1}^{(i)}$.

The posterior probability $\Pi_{t-1}^{(i)}$ of a process i in period t-1 is defined as:

$$(25) \qquad \Pi_{t-1}^{(i)} = \sum_j \Pi_{t-1}^{(i,j)}\ ,$$

and represents the probability - conditional on the realization p_{t-1} - that model i describes the observable process in period t-1.

A second posterior probability, which can be calculated from last period's process probabilities $\pi_{t-1}^{(i,j)}$, is the posterior probability $\pi_{t-1}^{(j)}$, and represents the probability - conditional on the realization p_{t-1} - that model j describes the observable process in period t-2:

$$\psi_{t-1}^{(j)} = \sum_i \pi_{t-1}^{(j,i)} . \tag{26}$$

This second posterior probability is used to calculate the new prior probability $E_{t-1}\pi_t^{(j)}$ of the process model j for period t given all information up to but not including period t. Applying Bayes' law, the prior probability $E_{t-1}\pi_t^{(j)}$ can be derived as the normalized sum of both last period's prior probability $[E_{t-2}\pi_{t-1}^{(j)}]$ and the posterior probability $\pi_{t-1}^{(j)}$ $[=\sum_i \pi_{t-1}^{(j,i)}]$ of process model j according to:

$$E_{t-1}\pi_t^{(j)} = \frac{E_{t-2}\pi_{t-1}^{(j)} + \sum_i \pi_{t-1}^{(j,i)}}{\sum_j \left(E_{t-1}\pi_{t-1}^{(j)} + \sum_i \pi_{t-1}^{(j,i)} \right)} . \tag{27}$$

This transformation of old prior and posterior probabilities into a new posterior probability for the subsequent period represents the Bayesian learning mechanism, and is determined by the relative performance of the individual models over the most recent periods.

3.3. The Reputation of Policymakers

It is now possible to define the policymaker's reputation for being 'hard-nosed' (h) or 'wet' (w) as a modified version of the measures put forward in Backus & Driffill [(1983a), (1983b)], Barro (1985).

The reputation of a policymaker for being hard-nosed is taken to be the probability that the observable price level series p_t exhibits only transitory or permanent level shocks over time, and is given by:

$$R_t^h = E_{t-1}(1-q_t) = \frac{\sum_{j=1}^{2} \left(E_{t-2}\pi_{t-1}^{(j)} + \sum_i \pi_{t-1}^{(j,i)} \right)}{\sum_j \left(E_{t-1}\pi_{t-1}^{(j)} + \sum_i \pi_{t-1}^{(j,i)} \right)}. \tag{28}$$

Thus, the reputation of a policymaker is related to the Bayesian learning mechanism of the public as modelled by the multi-process Kalman filter and depends on the relative forecasting performance of both the level and first difference stationary price determination models.

Similarly, the policymaker's reputation for being wet and allowing non-stationary inflation rate behaviour is defined as:

$$(29) \qquad R_t^W = E_{t-1}q_t = \frac{\sum_{j=3}^{4} (E_{t-2}\Pi_{t-1}^{(j)} + \sum_i \Pi_{t-1}^{(j,i)})}{\sum_j (E_{t-1}\Pi_{t-1}^{(j)} + \sum_i \Pi_{t-1}^{(j,i)})}.$$

The time-varying estimates for these measures of a government's reputation for being 'hard-nosed' and fighting inflation, or for being 'wet' and allowing for inflation, are presented below for all 8 EMS member countries and for some major non-member countries such as the United States, Canada, Japan, the United Kingdom and Switzerland.

4. The Empirical Evidence on the EMS-Credibility Hypothesis.

4.1. Reputation and EMS Membership.

As stated in the introduction, the German Bundesbank is usually assigned a high reputation for anti-inflation policies at the onset of the EMS, while the central banks of high-inflation countries such as France and Italy on the other hand are viewed to have had a low reputation for strict adherence to anti-inflation policies. If the EMS-reputation hypothesis were true, the counterinflation reputation of the non-German EMS countries, such as France and Italy, should have increased during the EMS period. Table 1 presents the empirical evidence on this hypothesis:

Tab. 1.: Estimated reputation for being 'hard-nosed' and adopting an 'inflation first strategy'.8)

	65.I-87.IV	65.I-71.I	71.II-79.I	79.II-87.IV
Germany	0.88 (0.13)	0.72 (0.13)	0.96 (0.02)	0.91 (0.08)
France	0.61 (0.16)	0.69 (0.12)	0.54 (0.20)	0.61 (0.13)
Italy	0.64 (0.13)	0.58 (0.07)	0.60 (0.12)	0.71 (0.13)
Netherlands	0.85 (0.14)	0.67 (0.10)	0.90 (0.11)	0.93 (0.07)
Belgium	0.69 (0.18)	0.66 (0.11)	0.56 (0.16)	0.83 (0.14)
Luxembourg	0.67 (0.15)	0.59 (0.08)	0.78 (0.12)	0.62 (0.14)
Denmark	0.78 (0.11)	0.70 (0.12)	0.76 (0.09)	0.85 (0.07)
Ireland	0.75 (0.11)	0.69 (0.11)	0.80 (0.08)	0.75 (0.11)

....

8) The numbers in parenthesis are standard-deviations of the estimates.

Among the EMS member countries the reputation measures for the overall period (1965.I-1987.IV) are highest for Germany (0.88) and the Netherlands (0.85) and lowest for France (0.61) and Italy (0.64). In the three sub-periods of the Bretton-Woods era (1965.I-1971.I)[9], the more freely floating pre-EMS period (1971.II-1979.I) and the recent EMS period (1979.II-1987.IV), Germany's reputation is highest in the second sub-period and falls significantly during the EMS period. On the other hand, the reputation measures for the two large high-inflation countries, France and Italy, and the two small high-inflation countries, Denmark and Belgium, increase considerably during the EMS period, while the reputation measure for the 'hard-currency' country Holland increases only slightly. Thus, with the exception of Luxembourg[10] and Ireland[11], the reputation of most non-German EMS countries has increased, while Germany's reputation for strict anti-inflation policies has declined slightly in the EMS period. The former result is in line with most of the literature on the EMS-credibility hypothesis and suggests that the EMS has in fact provided an easy way for the (pre-EMS) high-inflation and low-reputation countries France, Italy, Belgium and Denmark to establish some reputation for an anti-inflation stance and to gain counterinflationary credibility by locking into the German anti-inflation policies. The second result, which suggests that the (pre-EMS) low-inflation and high-reputation country Germany has lost some of its initial reputation, supports the concern of Gleske (1987), who fears that at present in Germany exchange rate considerations are given too much weight in the formulation and implementation of monetary policy.[12] Both matters are dealt with below in some more detail.

Germany's Reputation.

To explain the decline in the reputation measure for Germany, some comments are in order about the way in which the Bayesian multi-process Kalman-Filter algorithm works. For this purpose, the time-paths of the probabilities of the four alternative process models for the German consumer price level are displayed in Fig. 1a and Fig. 1b.

....

9) This ranking is not affected when the pre-EMS period is chosen to be 1973.II-1979.II.
10) The existence of a currency union with fixed parity between Luxembourg and Belgium does not prevent national differences in price level movements and hence in the reputation measures derived here.
11) The traditional 1:1 link of the Irish and the British Pound was suspended when Ireland entered the EMS and Britain chose to not participate in the ERM of the EMS.
12) See Gleske (1987), pp. 21,22 for this interpretation.

As outlined in the appendix, all four process models are initialized for each country in 1965.II with identical probabilities of $\Pi_t^{(j)}=0.25$ (j=1,2,3,4). Since the sum of the probabilities of the two process models with either purely temporary or purely permanent level shocks (Fig. 1a) represents the reputation measure, an initial reputation of $R_t^h=0.5$ is implied for each country.

As can be seen from Fig. 1a and Fig. 1b, the probability of the model with purely permanent level shocks (model B) increases more or less continuously throughout the sample, while the probability of the model with transitory level shocks (model A) fluctuates around its initial value until early 1983 and falls rapidly thereafter. In addition, there is an apparent inverse symmetry between the probabilities of the transitory and permanent level shock models up to early 1983, especially in the floating exchange rate period from 1973.II-1979.II. This symmetry breaks down in 1983. Furthermore, the probabilities of the permanent second and third difference shock models in Fig. 1b decrease continuously until 1979.II. Coinciding with the onset of the EMS, the probability of the permanent inflation shock model increases slightly in the 1979.II to 1983.I period and greatly thereafter. Finally, German consumer price data clearly indicates that a model with third difference shocks has little empirical relevance.[13] However, Fig. 1b shows that the onset of the EMS caused a major structural change in the degree of difference-stationarity of consumer prices as reflected by the probabilities of the alternative models.

Increases in the probability $\Pi_t^{(c)}$ of the model with permanent first difference shocks (model C), which captures permanent changes in the inflation rate, negatively affect the reputation [$R_t^h=1-\Pi_t^{(c)}-\Pi_t^{(d)}$] of each country. For Germany, the probability $\Pi_t^{(c)}$ (reputation R_t^h) in Fig. 1 exhibits four major permanent increases (decreases) towards the sample end. The first small permanent increase in $\Pi_t^{(c)}$ occurs after[14] the onset of the EMS in 1979.I[15] and the second rise is observed just

....

13) This is not true for the price data of high inflation countries.
14) Due to the adaptive nature of the multi-process Kalman filter, a change in the structure of the underlying time series is reflected in a change of the models' probabilities with a one-period lag.
15) Hellwig & Neumann (1987) argue that the Bundesbank's deliberate overshooting of monetary targets in 1978 had contributed to a rekindling inflation and to lessening its credibility. Given the time-lags in the transmission of monetary policy on prices this view is compatible with the results presented here.

after the federal elections in March 1983, which were followed by a revaluation (+5.5%) of the mark within the EMS.[16] There is a more There is a more transitory increase in $\Pi_t^{(c)}$ after 1984.III[17], and was followed by a large permanent increase in $\Pi_t^{(c)}$ after the revaluation (+2%) of the mark in the April 1986 EMS realignment. While the 1983 and 1986 increases of the probability are due to high deflationary outliers, the late 1984 increase in the probability $\Pi_t^{(c)}$ is caused by a large inflationary outlier in the German consumer price series. Owing to the mean-squares properties of the Bayesian multi-process Kalman filter, these two types of outliers are treated symmetrically and an increase in the mean-squares prediction-errors of the transitory and permanent prediction-errors of the transitory and permanent price level shock models result in a decline in anti-inflation reputation. This is in line with the approach taken by Meltzer [(1984), (1985), (1986a), (1986b), (1986c), (1987a), (1987b)], who implicitly relates credibility to a decline in the variance of the prediction-errors. In Perry (1983), Blanchard (1984) and Christensen [(1987a), (1987b), (1988)], however, positive and negative price level prediction-errors are treated asymmetrically and increases in anti-inflation credibility are explicitly related to lower than expected prices and hence negative errors. In this concept, a drastic and unexpected sharp disinflation establishes credibility, whereas in the present context only gradual disinflation policies enhance reputation. Given the limitation that expectations are backward-looking within the context of an expectations augmented Phillips curve, the choice made in the present study is consistent with the views of Collins (1987), who notes: "More disinflation is not necessarily a good thing. In fact, welfare is higher under less deflationary EMS regimes than under the most deflationary non-cooperative regime" [Collins (1987), p. 29]. This need not necessarily be the case if price expectations are formed in a rational, forward-looking manner by using relevant economic information contained in long-run interest rates, forward exchange rates or interest rate differentials between countries. Thus some doubts about the decline in the German reputation measure at the sample end are justified.

....

16) In Dudler (1984) and Eggerstedt & Sinn (1987) it is argued that the large-scale official intervention before the realignment caused a massive increase in bank liquidity in the Federal Republic and the Bundesbank feared losing its control over the money supply.

17) This can be attributed to the tax reform related increase in value-added tax as well as the inflationary effects of higher disposable incomes.

However, it cannot be overlooked that all major changes in reputation occurred in politically sensitive time-periods and were largely caused by external events (dollar appreciation 1981.II-1985.I and depreciation 1985.II-1986.IV, oil price fall), political events (strikes, elections) and the federal government's policies (revaluations, consolidation of the budget) and to a much lesser extent by the monetary policy actions of the German Bundesbank, despite the fact that transfers to the government of Bundesbank profits, accumulated during the dollar appreciation, might have partially undermined the Bundesbank's anti-inflation stance.[18] In Hellwig & Neumann (1987) German economic policy is interpreted as a game between three independent players - the federal government, the Bundesbank and the public. Assuming that two of these players - the Bundesbank and the public - did not fundamentally change their position after 1982,[19] this leaves the federal government as the player, whose policy actions have caused the decline in anti-inflation reputation.

France's Reputation.

In Fig. 2 the reputation measure for France is plotted together with the corresponding measure for Germany. During the 1970s and 1980s France's reputation for anti-inflation policies is consistently higher than Germany's and the recent decrease in Germany's reputation is relatively modest in size compared to the substantial fluctuations in France's reputation throughout the period. With respect to the EMS-credibility hypothesis, the time-path of the French reputation measure suggests the following:

Given the initial value of R_t^h=0.5, France's reputation increases initially, but falls short of the increase in Germany's reputation after the devaluation of the French franc in November 1969. The French reputation measure rises slightly with the move to free floating in March 1973, and then falls drastically after the occurrence of the first oil price shock in June 1973 and France's withdrawal from the

....

18) Walter (1982), p. 46, argues rightly that measured prices are influenced by monetary policy, but also distorted by tax measures (VAT increases), passing through characteristics of the price system (wage increase impacts) and the degree of openess, i.e. both the import and oil price dependency of the economy (revaluation and foreign inflation impacts). In the absense of major changes in monetary policy, changes reputation therefore have to be attributed to these factors above.

19) See Hellwig & Neumann (1987), p. 476 for this interpretation.

'snake' in January 1974. It reaches its minimum in mid 1976. France's reputation for anti-inflation policies exhibits an upward jump after the policy switch from the expansionary (reflationary) policies of prime minister Jacques Chirac to the (deflationary) stabilization policies of the Barre Plan under prime minister Raymond Barre in late 1976. Under the Barre plan the French central bank adopted a more stringent monetary policy than previously, aiming at a control of monetary expansion and adopting official monetary (M2) targets. Even though money growth was stabilized at an average of 12.5 percent, growth objectives were exceeded in every year except in 1980, the year which shows the highest measure of reputation in the entire Barre period.[20] Furthermore, in contrast to the evidence for Germany, the onset of the EMS in March 1979 has little initial effect on the French reputation measure.[21]

After the socialist Mitterand's election as President of the Republic in May 1981, there is an initial sharp temporary decline in France's reputation for tight monetary policy. However, the socialist government continued to control monetary growth by using the same techniques as its predecessor and in 1982 stressed the reduction of inflation as the main policy aim, with targets for M2 growth of 10 percent in 1982 and 8 percent in 1983. In addition, prices and wages were frozen from June until the end of October 1982 and the freeze was gradually phased out over 1983. These policy measures explain the strong increase in reputation during 1982 and early 1983 following the initial decline in 1981. It should, however, be noted that this reputation gain reflects the existence of strict short-term inflation control rather than a reduction in the underlying inflation trend. This is seen in the drastic decline in the reputation measure as the price freeze was gradually phased out at the end of 1982 and in early 1983.

The devaluation (-2.5%) of the French franc in the March 1983 realignment and the austerity programme introduced under prime minister Pierre Mouroy shortly afterwards indicate a new policy regime in France

....

20) It should be noted that the present application does not use monetary the reputation measures. Such information will, however, be included in a subsequent paper, which aims at the empirical quantification of the theoretical credibility measures derived in Cukierman & Meltzer [(1983) (1986a), (1986b), (1986c)]. See also Hardouvelis & Barnhard for a similar, less formal concept of the credibility of monetary announcements.

21) This is consistent with the evidence reported in Collins (1987), who states for France: "While joining the EMS may have altered the rules of the game, it had little initial impact...on the credibility of the high inflation goverment. Changes in credibility...came a few years later"

involving strict foreign exchange controls and a tightening of fiscal and monetary policy. These restrictive policies have, however, not resulted in a permanent increase in France's reputation measure, which after mid 1983 is seen to fluctuate around a slightly negative trend and exhibits large temporary changes after the two realignments in June 1985 (+2%) and April 1986 (-3%).

Summarizing, it can be stated that the temporal development of France's reputation for counterinflation policies is influenced by two main factors: firstly, reputation depends largely on domestic economic policies, such as the Barre plan and the price freeze under President Mitterand. This result is not surprising, since France - as one of the larger EMS member countries - after 1979.II continued to pursue independent domestic policy targets, such as M2-growth, in addition to the official EMS exchange rate targets. Secondly, reputation is affected by the EMS-realignments, which corresponded to permanent shocks in the level of the prices of imported goods in units of domestic currency ($\bar{e}_t P_t^*$), and resulted in a temporary increase in the probability of the permanent price level shock model (model B) and hence in reputation.[22)]

Italy's Reputation.

The time-path for the reputation measure of Italy, which after France and Germany is the third largest EMS country, is depicted in Fig. 3. It is interesting to note that the three periods of monetary restriction of 1974, 1976-1977, and the last one starting in 1980, which are analysed in Caranza and Fazio (1983), can be clearly identified in Fig. 3 by an increase in anti-inflation reputation. During the late 1960's and early 1970's Italy's reputation measure fluctuates slightly above its initial value until late 1973 and is little affected by the first oil price shock in June 1973. Under the restrictive policies of 1974, which included the adoption of total domestic credit (TDC) as the intermediate target for monetary control, reputation reaches its highest pre-EMS value. The (expansionary) lifting of bank

....

22) Since realignments represent some adjustment for cumulated past inflation differentials between EMS countries, this increase in reputation can be justified on the grounds that realignments provide high-inflation EMS countries with the chance for a politically feasable turnaround to anti-inflation policies. Such 'scapegoat' arguments are put foreward in Eggerstedt & Sinn (1987), p. 17.

credit ceilings March 1975 and their (contractionary) reintroduction in late 1976 show up as drastic declines and increases in the reputation measure. Thereafter, reputation declines until late 1979. In response to the second oil price shock in mid 1979 monetary policy became restrictive again towards the end of 1979 and remained restrictive throughout 1980.[23] As a result, reputation is observed to increase sharply and temporarily in early 1980, and fluctuate strongly thereafter. This result is consistent with the findings of Caranza & Fazio (1983) that the restrictive monetary policies in 1980 were "less effective, or less rapid...in slowing down domestic demand and inflation. The reasons for this slower and weaker effect are...the extent and persistence of inflationary expectations." [Caranza & Fasio (1983), p. 80]. A more permanent increase in reputation is, however, achieved after the devaluations (-6%) of the Italian lira in the March 1981 realignment and the so-called 'divorce' between the Bank of Italy and the Treasury in July 1981, which established a new technique for financing the treasury.[24] After mid 1981, all three devaluations of the Italian lira in the October 1981 (-3%), June 1982 (-2.75%) and March 1983 (-2.5%) realignments can be identified as temporary increases in reputation for reasons explained above. Reputation then falls temporarily with the move to more market-orientated instruments of monetary control, such as the lifting of ceilings on bank loans in June 1983, and fluctuates thereafter. Finally, after the latest lira devaluation (-6%) in the June 1985 realignment Italy's reputation measure reaches its highest ever value and subsequently shows a remarkable synchronization in both level and time-development with the German reputation measure.

Summarizing this evidence, it can be stated that Italy's reputation measure was lower than France's during the late 1960's and early 1970's, but was less affected by the first oil price shock in June 1973. In addition, Italy entered the EMS with a lower reputation than France in March 1979. During the EMS period Italy's reputation has exhibited a clear upward trend and convergence to the German reputation measure, especially with the move to restrictive monetary policies in 1980 and after the March 1981 realignment, while France's reputation has

....

23) See Caranza and Fazio (1983) for a more detailed analysis of Italian monetary policy.

24) In Juli 1981 the practice whereby the Bank of Italy took up the government securities not placed with the public or banks was terminated. See Caranza and Fazio (1983) and Tabelllini (1987) on this point.

fluctuated stationarily around its pre-EMS value. Finally, France's reputation for anti-inflation policies at the end of 1987 was still considerably lower than that of Italy or Germany. Thus, although there is some evidence on a convergence between the estimates of Germany's and Italy's reputation in their commitment to fight inflation, the evidence for France denies the existence of such a convergence. Further evidence from the smaller EMS countries is therefore required to evaluate the EMS-credibility hypothesis.

The smaller EMS countries such as the Netherlands, Belgium and Denmark, traditionally place a higher weight on external stability and can therefore be expected to have gained more than the larger countries France and Italy from the provision of a 'hard currency' option within the EMS. These gains in reputation can be expected to be higher for Belgium and Denmark, which prior to the EMS were typically referred to as high-inflation countries with low anti-inflation reputation, than for the Netherlands, where reputation for tight monetary policies is generally agreed to have been already high prior to the EMS.

Holland's and Belgium's Reputation.

It is instructive to discuss the two Benelux countries first. The time-paths of the reputation measure are displayed in Fig. 4 for Belgium and in Fig. 5 for Holland, both in comparison with Germany. During the Bretton Woods system and the early 1970's the reputation measures for both countries show a striking similarity. After an initial increase in 1966 both measures decline until late 1969. In October 1969 the German mark was revalued. Since a revaluation of the currency of both countries' main trading partner is equivalent to a permanent price level shock - via the price increase of imported goods - both reputation measures increase sharply for reasons explained above and decline again thereafter. After the institution of the 'snake', the joint exchange rate agreement between Germany, France, the Benelux countries and Denmark in April 1972, and the move to joint floating in February 1973, the two reputation measures for Belgium and Holland lose their initial similarity.

The Dutch reputation measure increases drastically after 1973.I and is almost identical with the reputation measure for Germany from 1975.I to 1979.I. Furthermore, the onset of the EMS in March 1979 has little initial effect on the apparent symmetry between Germany's and Holland's reputation measures. After the revaluation (+2%) of the German mark in the first EMS-realignment of September 1979, the Dutch reputation measure falls below that of Germany. This relative position is not affected by the two realignments of October 1981 and June 1982, which left the bilateral exchange rate of both currencies unaltered. However, the revaluations of the Dutch guilder (+3.5%) and the German mark (+5.5%) in the March 1983 realignment, which implied a devaluation of the guilder relative to the mark, contributes to a sharper decline in Dutch relative to German reputation after March 1983. Finally, after late 1984 the Dutch and the German reputation measures follow different time-paths. This is due to the marked decline in the probabilities $\Pi_t^{(c)}$ and $\Pi_t^{(d)}$ of the models with permanent first and second difference shocks (model C and D) for Holland, which are depicted in Fig. 6a and Fig. 6b, as compared with the increase of the probability $\Pi_t^{(c)}$ for Germany.

There are several factors involved here. Firstly, the sharp rise of the dollar in late 1984 and especially in early 1985, which affected the mark more than any other EMS currency, resulted in a sharp rise in the prices of imports and energy and led to the strong increase in German consumer prices in early 1985. Given the smaller dependency of Holland on energy imports due to its North Sea gas industry, which in 1983 accounted for 7.3 per cent of Dutch GNP, Dutch consumer prices increases were much smaller in late 1984 and early 1985. Secondly, after the interventions of other EMS members in support of the mark, the Dutch guilder weakened somewhat relative to the mark. In February 1985 the interest rate differential between Holland and Germany jumped from virtually zero to 1.5% in February 1985, reflecting expectations of a devaluation of the guilder relative to the mark. However, the EMS realignment in June 1985 left the exchange rate between the guilder and the mark unaffected as the mark strengthened relative to the dollar. As a result of all these factors, Holland's transition to low - and in 1986 slightly negative -inflation rates was much smoother than the German deflation.[25)]

....

25) In Germany there was a sharp price increase in 1985.I, very low inflation over the rest of 1985, deflation in 1986 and a reflation again in late 1986 and early 1987. In Holland, inflation was low and almost constant after late 1984 and slightly only negative in 1986.

In summary it can be said that the reputation gains from a 'hard-currency' option for Holland were clearly obtained by committing monetary policy to a level pegging of the Dutch guilder with the German mark at the onset of the European 'snake' in 1973 and the continuing of this commitment with the setting up of the EMS in 1979.

The Belgian reputation measure does not rise with the onset of the European 'snake' in 1973. On the contrary, the Belgian reputation measure declines sharply during 1974, when the Belgium experienced massive wage increases[26] and high inflation, partly caused and aggravated by the Belgian system of wage-indexation. The attempt of the Belgian government in 1976 to bring wages and inflation under control shows up as a temporary increase in the reputation measure, which declines again after the government was obliged to resign in 1977. The picture then changes considerably with the onset of the EMS in March 1979. Between March 1979 and the end of 1981, the German 'period of grace' for the EMS according to Dudler (1984), the Belgian reputation measure increases sharply and converges to the German reputation measure. This rise in reputation is brought to a halt by the first devaluation (-8.5%) of the Belgian franc in the February 1982 realignment, which was followed by temporary wage and price freezes. Finally, since 1982 there has been an apparent and striking similarity in the time-development of the Belgian and German 1982 and the clear commitment to a level pegging policy for the Belgian franc vis-a-vis the German mark.

Denmark's Reputation.

Finally, Fig. 10 displays Denmark's reputation for pursuing 'anti-inflation' policies. In the late Bretton Woods system this reputation measure follows a similar time path to those of Holland and Belgium. Like the Belgian reputation, Danish reputation declines sharply after the move to generalized floating in February 1973 and the first oil price shock in June 1973. Reputation fluctuates strongly during 1975 and 1976 but rises again in 1977 and 1978.

At the onset of the EMS, the Danish reputation measure is relatively high, but clearly still much lower than that of Germany or

....

26) During 1974-1977 Belgian wages rose by 73.5% compared with the EEC average of 68.5% and Germany (39%) and Holland (57%), the two main trading partners of Belgium (40% of total exports and imports). See Stokx (1982), p. 52.

Holland, and it declines slightly in mid 1979. Despite the two transitory increases in reputation, firstly after the election of the new Social-Democratic Government in October 1979, which was followed by a short-term price freeze and a second devaluation in November 1979, and then again after the Government's re-election in December 1981, the reputation measure shows no upward trend in the initial EMS period. This is consistent with the view put forward by Christensen (1987a), that the disinflation policies of the first government, which did not interfere in the two-year wage negotiations, were unsuccessful and did not result in a gain in reputation.

The second EMS phase can be characterized by the election of the Liberal-Conservative government in October 1982, which resulted in an apparent policy switch. Reputation rises slightly after April 1982, when the government limited the maximum annual wage increase to 4%, and then rapidly, exhibiting a clear upward trend after April 1985, when the government enforced a legal upper-limit for wage increases of 2%. This result is again consistent with the findings of Christensen (1987a), who derives that the disinflation policies of the second government were much more effective than the disinflation policies under the former government. Furthermore, the above findings support the views of Artis (1987) and Artis & Miller (1987), who suggest that Denmark appears to have used the EMS initially more as a crawling peg[27)] and only later moved to a more strongly counterinflationary stance by pursuing level pegging policies. Finally, it is worth noting the similarity between the time-paths of the Danish and Dutch reputation measures after early 1985.

4.2. Reputation and Monetary Independence.

Before presenting any conclusions on the validity of the EMS-credibility hypothesis, a comparison of the above time-paths of the EMS members' reputation with the corresponding measures for some major non-EMS countries will be carried out. The estimates of reputation for the United States, Canada, Japan, the United Kingdom and Switzerland together with the German reputation measure are presented in Table 2.

....

27) Artis (1987) defines a crawling peg as an exchange rate arrangement where inflation is not fully accomodated and realignments are under-indexed adjustments, that is a x% crawling peg with $x<100$.

Tab. 2.: Estimated reputation for being 'hard-nosed' and adopting an 'inflation first strategy.

	65.I-87.IV	65.I-71.I	71.II-79.I	79.II-87.IV
Germany	0.88 (0.13)	0.72 (0.13)	0.96 (0.02)	0.91 (0.08)
United States	0.40 (0.21)	0.61 (0.09)	0.29 (0.22)	0.35 (0.17)
Canada	0.53 (0.10)	0.54 (0.07)	0.55 (0.11)	0.52 (0.11)
Japan	0.78 (0.13)	0.66 (0.13)	0.77 (0.08)	0.87 (0.07)
United Kingdom	0.72 (0.17)	0.76 (0.14)	0.63 (0.18)	0.77 (0.14)
Switzerland	0.72 (0.12)	0.72 (0.15)	0.76 (0.10)	0.70 (0.10)

As among the EMS countries, Germany's reputation for being 'hard-nosed' and pursuing 'tight' monetary policies is here again the highest for the overall period and for the pre-EMS and EMS sub-periods. During the flexible exchange rates period prior to the EMS the reputation of Germany (0.96), Japan (0.77) and Switzerland (0.76) are high, whereas the reputation of the United States policymakers' is extremely low (0.29). In addition, while Germany's reputation decreases significantly during the EMS period (0.91), Japan's reputation increases significantly (0.87), but is on average still lower than Germany's reputation. Table 2 also shows that the United States' reputation declines significantly with the move to flexible exchange rates and that Switzerland's and Canada's reputation have fluctuate around mean values of 0.72 and 0.53 respectively. Finally, the United Kingdom's reputation is relatively high throughout the sample and close to that of Switzerland.

United States' Reputation.

Looking at the temporal development of the United States' reputation measures displayed in Fig. 8, the effects of the collapse of the Bretton Woods system in 1971.III and the 1973.II oil-induced inflationary shock, when reputation falls to almost zero, are apparent. After the adoption of a policy of monetary target announcements in mid 1975 and the election of President Carter in late 1976, reputation rises slightly, but declines again with the acceleration of inflation in early 1978 and the second oil price shock in 1979. Reputation is not affected by the changes in Federal Reserve policy in October 1979. However, the change in the Federal Reserve's operating procedures in July 1982 and the sharp decline in M1 velocity in late 1982 lead to a major permanent increase in reputation. A similar result is derived in Blanchard (1984).

who finds no direct credibility effects of the Volcker deflation until 1982 and some evidence of an increase in credibility after 1982.[28] Furthermore, the estimates presented strongly support the views of Meltzer (1986b), who states that "the credibility of monetary policy in the United States, while perhaps higher now than in the late 1970's is probably lower than it was during the period of low inflation in the 1960s" [Meltzer (1986b), p. 680].

Japan's Reputation.

The time-path of Japan's reputation measure in Fig. 9 closely follows that of Germany up to 1971.III and remains almost constant between the end of the Bretton Woods era in 1971.III and Japan's move to free floating in 1973.I. Japan's reputation declines considerably after the oil price shock in June 1973 and fluctuates strongly in response to the activist, discretionary policies adopted during the rest of 1973 and 1974, when inflation rates in Japan reached their peak. After the major change in monetary policy in early 1975, when Japan abandoned most of the activist policies and moved to a new policy regime with non-managed exchange rates and pre-announced monetary targets, the reputation measure shows a clear upward trend. This upward trend is only once slightly interrupted, when Japan, like the United States, experienced a large demand shock following President Carter's use of credit controls in 1980. Finally, after 1980 reputation increases further and less erratically than before. Thus, the time-path of the reputation measure for Japan after 1975 is also consistent with the views of Meltzer (1987a), that "for Japan, the change in policy arrangements provided an opportunity to reduce inflation and increase the credibility of economic policy" [Meltzer (1987a), p. 10].

Britain's Reputation.

The time-path of the United Kingdom's reputation measure is displayed in Fig. 10. Reputation increases sharply at the start of the sample and fluctuates around a value of 0.8 until late 1971. With the collapse of the Bretton Woods system and the reform of the system of

....

28) See Blanchard (1984), p. 213 on this point.
29) On this point see also Meltzer (1987a), p. 11.

monetary and credit control in 1973.III the reputation measure declines slightly, but rises again after the move to managed floating in June 1972. Reputation then falls drastically at the end of the Heath period with the election of the Labour government in February 1974, and continues to decline until mid 1978. After the election of the Conservative government under Thatcher in May 1979 the reputation measure rises again sharply, fluctuates strongly until mid 1981, but becomes less erratic and remains high after the reform of monetary control techniques in August 1981. Thus, the estimate of reputation here supports the views of Minford, who states that "Mrs. Thatcher's government has sunk a good deal of political capital into the creation of counter-inflation credibility without resort to foreign entanglements" [Minford (1988), p. 37]. Furthermore, given the fact that Britain's reputation lately is as high as Germany's, the present results are also in line with the views of Currie (1988), who states that "the British government has independently and painfully established a sound reputation for resisting inflation, and it is not clear that EMS membership will enhance that reputation, especially since realignments mean that the EMS permits inflation differentials to persist, even if it acts to narrow them" [Currie (1988), p. 3].

5. Summary and Conclusions.

The empirical evidence on the EMS hypothesis discussed in this paper allows a number of important conclusions.

Firstly, the EMS has provided smaller EMS participants, for example Belgium or Denmark, with an institutional framework to move from high to low inflation rates, initially by using the system as an underindexed crawling peg and later by adopting more counterinflationary level pegging policies. These countries have gained considerable counterinflation credibility during the EMS period, although for Belgium the transition period to higher reputation appears to have been shorter than for Denmark. Furthermore, in both countries the increase in reputation is far from being the result of some intrinsic dynamics of the EMS; the timing of the gains in reputation clearly shows that the gains in reputation have been the outcome of deliberate domestic policy reforms and a stronger commitment to lower inflation rates within the rules of the EMS. This view is supported by the fact that Holland, which at the onset of the EMS had the same counterinflation reputation as Germany, has gained most of its reputation at the start of the European 'snake' arrangement. Thus Holland committed its monetary policy to the 'hard-currency' option provided by the German mark in the 'snake', while Belgium used the early and Denmark the late EMS arrangement to bring domestic inflation under control. Hence, if exchange rate pegging policies are given absolute priority over domestic policy considerations, the results presented here suggest the validity of the EMS-credibility hypothesis.

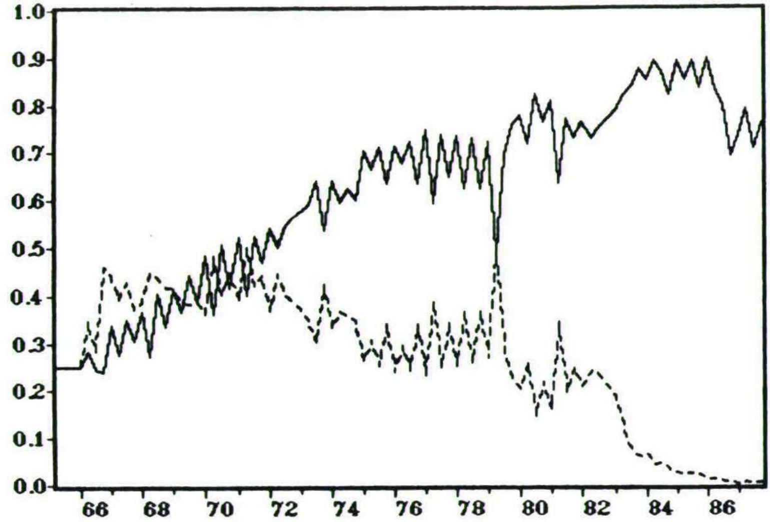
Secondly, with respect to the larger non-German EMS participants, the evidence from above suggests some gains in counterinflation reputation for Italy, while the EMS has had no apparent influence on French reputation. Thus, it is only with respect to Italy the underindexed EMS realignments seem to have exerted some disciplinary effects on domestic monetary policy, while for France this would not appear to be the case. However, this result is not too surprising, given the considerable degree of foreign exchange controls in both countries, which have tended to undermine and prevent such disciplinary effects. Thus, for both France and Italy, some further research, taking the effects of exchange controls on reputation into account, is required. The paper of Giavazzi & Pagona (1985), which relates the existence of capital controls to on-shore and off-shore interest rate differentials, provides a useful starting point for such an analysis.

Thirdly, Germany's reputation for counterinflation policies appears to have been slightly undermined during the EMS period, and theoretical arguments exist that can explain such a loss in reputation. However, the special least-squares error type of the signal extraction algorithm together with the backward-looking expectations formation process used here may also partly be responsible for this result, especially after the sharp deflation in 1986. The robustness of this result needs to be checked by applying other forms of expectation formation processes, such as forward-looking expectations in connection with an application of the structural MPKF described in Weber [(1988b), (1988d)]. Moreover, a comparison of different concepts of reputation and credibility, such as the credibility measures put forward in Cukierman & Meltzer (1986b) or the prediction error approach taken in Perry (1983), Blanchard (1984) and Christensen [(1987a), (1987b), (1988)], may also be used to evaluate the robustness of the above result.

Finally, the results for the United Kingdom and Japan show that countries outside the EMS have also been successful in establishing counterinflation reputation. As within the EMS, the timing of these gains in reputation is related to major political events, such as elections, and reforms in economic policies, which have marked the adoption of a more counterinflationary policy stance. While Japan and the United Kingdom have been able to pursue such u-turns of policies, the results above suggest that the United States have been much less successful in doing so.

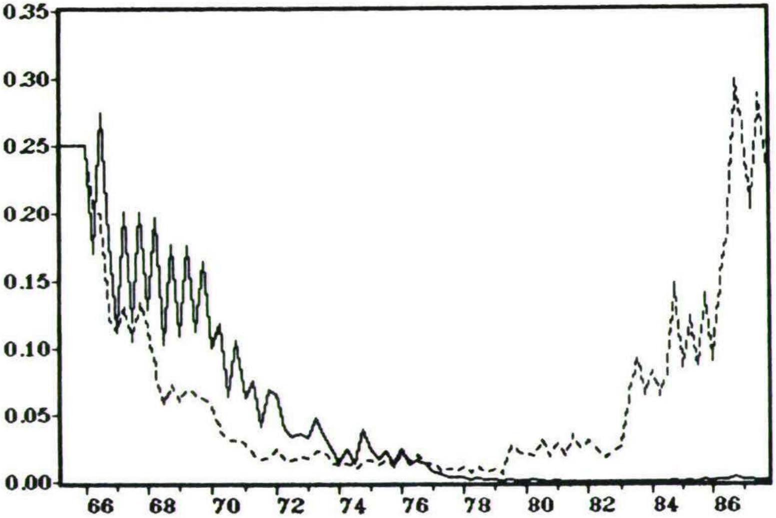
In evaluating the overall evidence provided in this paper, it is worth noting that the reputation measures presented here are fairly consistent with the majority of views expressed on these issues in the literature on credibility and reputation. Thus, the measures of reputation developed in the game-theoretical models of Backus & Driffill [(1985a), (1985b)] and Barro (1986) can be viewed as valuable concepts for empirically evaluating the importance of credibility and reputation in real world policy making. The present paper showes that reputation effects have been important in the conduct of the counterinflation policies, especially for the smaller EMS countries. However, since this paper takes a new approach to estimating credibility, the robustness of the results need to be checked and the demand for further research along the lines indicated above is pressing.

Fig. 1a: Probabilities of the Bayesian multi-process Kalman filter



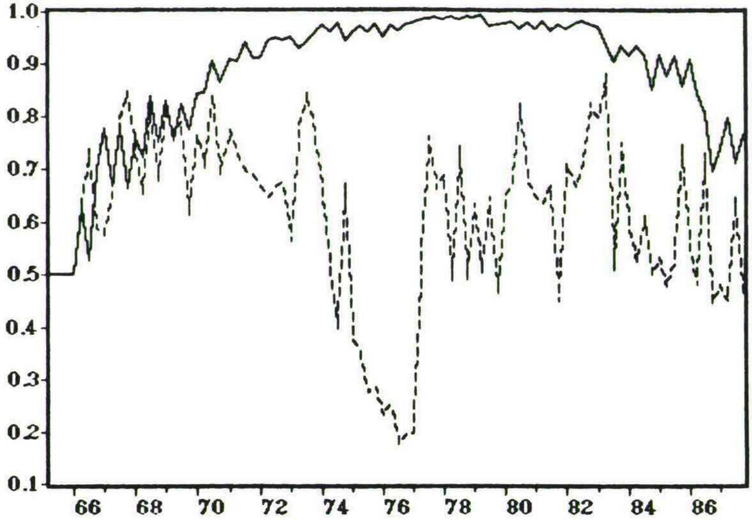
------- probability of model A ——— probability of model B

Fig. 1b: Probabilities of the Bayesian multi-process Kalman filter



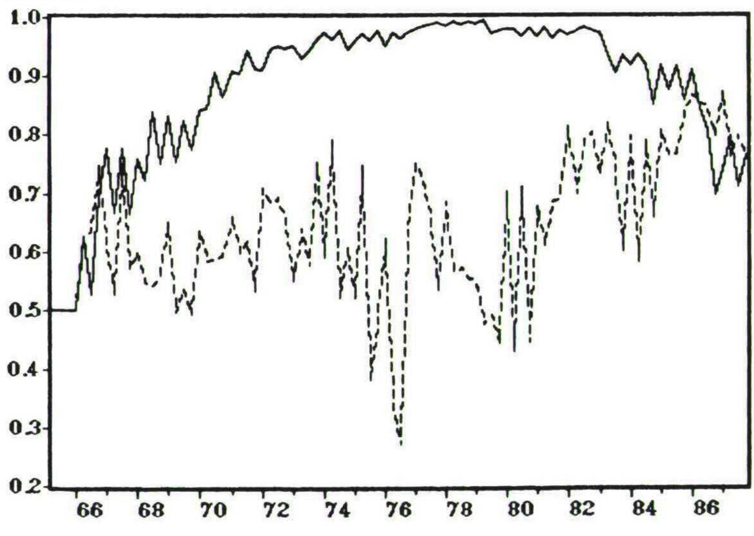
------- probability of model C ——— probability of model D

Fig. 2: **Reputation Measures for 'counterinflation' policies**



German reputation - - - - French reputation

Fig. 3: **Reputation measures for 'counterinflation' policies**



German reputation - - - - Italian reputation

Fig. 4: Reputation measures for 'counterinflation' policies

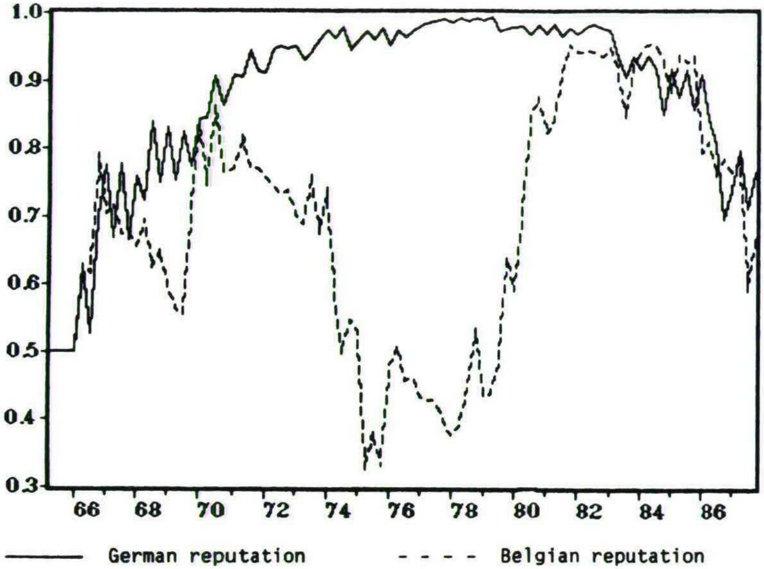


Fig. 5: Reputation measures for 'counterinflation' policies

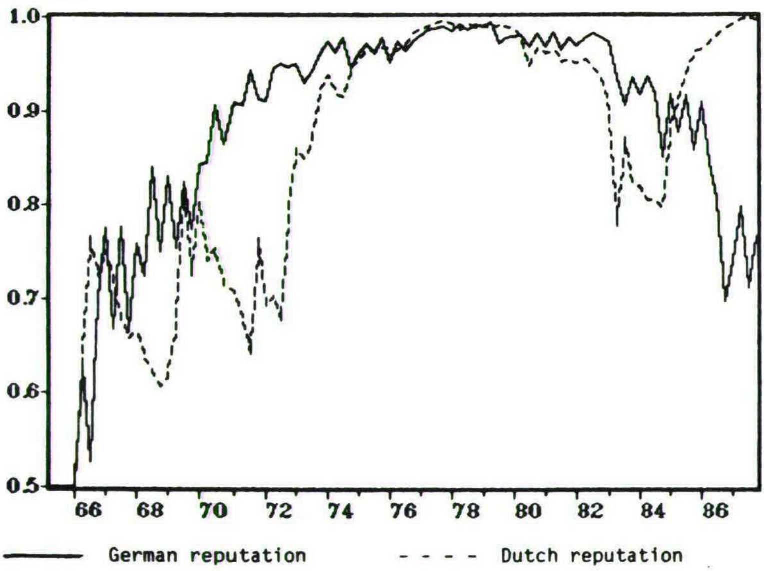


Fig. 6a: Probabilities of the Bayesian multi-process Kalman filter

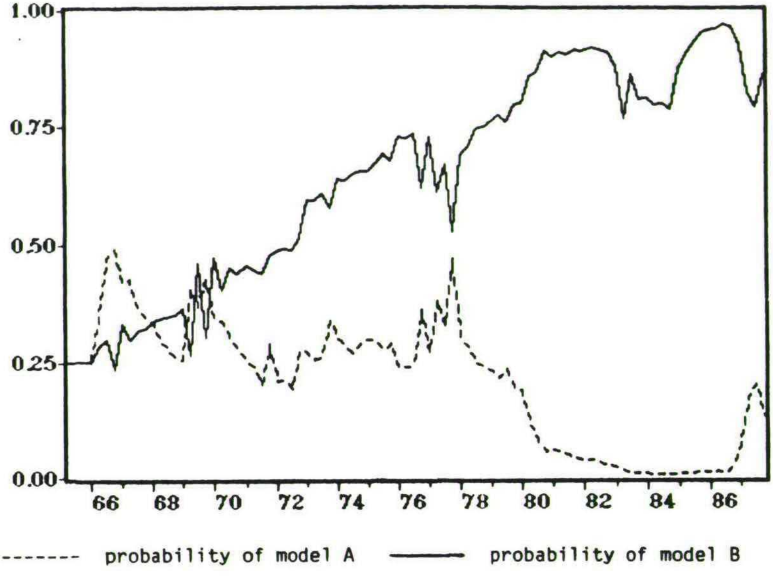


Fig. 6b: Probabilities of the Bayesian multi-process Kalman filter

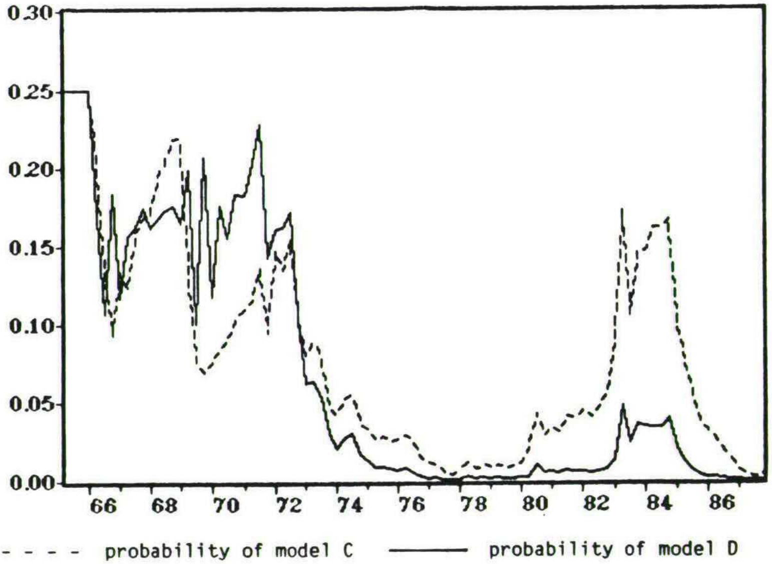


Fig. 7: Reputation measures for 'counterinflation' policies

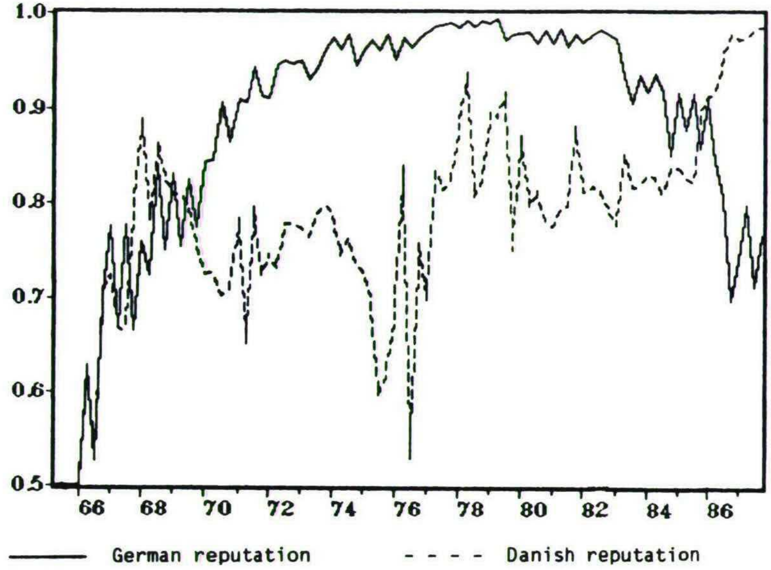


Fig. 8: Reputation measures for 'counterinflation' policies

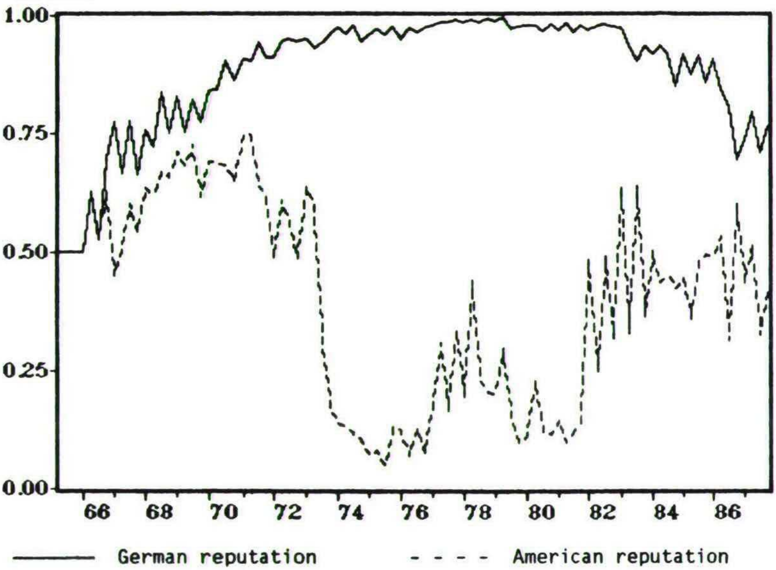


Fig. 9: Reputation measures for 'counterinflation' policies

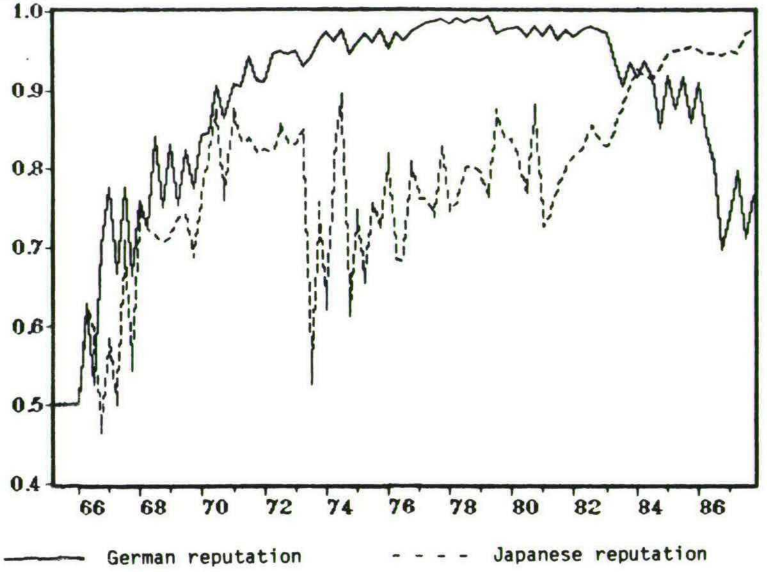
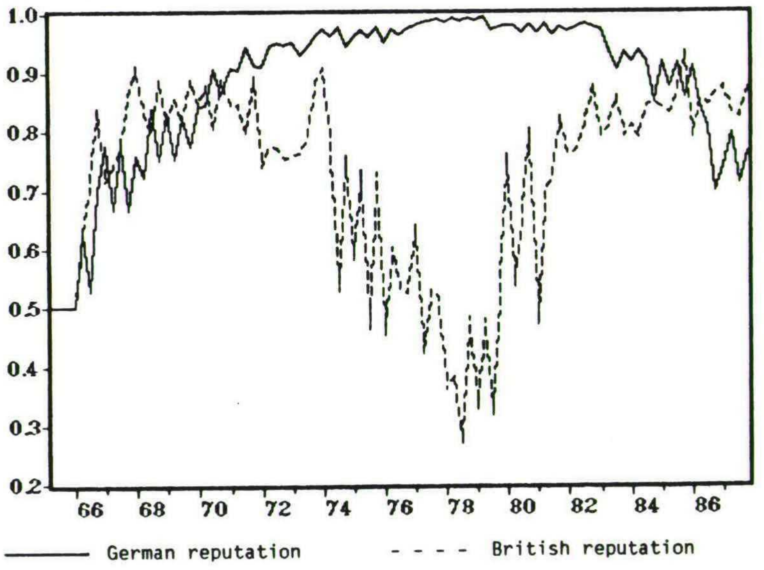


Fig. 10: Reputation Measures for 'counterinflation' policies



6. Appendix: Description of the Bayesian Multi-Process Kalman Filter

The time series version of the state-space model which correspond to the ARIMA (0,3,3) time series model is given by:

(1a) $$y_t = z^T a_t + S v_t \quad , \quad E(v_t)=0, E(v_t v_t^T)=\sigma^2 H \ ,$$

(1b) $$a_t = T a_{t-1} + R w_t \quad , \quad E(w_t)=0, E(w_t w_t^T)=\sigma^2 Q \ ,$$

with fixed system vectors z^T, S and matrices T, R, H and Q. The vectors of error-terms v_t and w_t are independently normally distributed with mean-vector zero and constant finite variance-covariance matrices $\sigma^2 H$ and $\sigma^2 Q$ respectively. In addition, the unobservable state vector a_t of the state-space model is assumed to be normally distributed:

(2) $$a_t - \alpha_t \equiv \Theta_t \sim N(0, \sigma^2 P_t) .$$

The scaling term σ^2 from the measurement equation is introduced into the definition of the estimator of the state vector's variance-covariance matrix $\sigma^2 P_t$ in order to ensure the independence of the Kalman filter algorithm from the process variance σ^2.[30)]

Given a suitable initalization of the Kalman filter, the projection of the unknown state vector a_t and its variance-covariance matrix P_t can be determined recursively by applying the Kalman filter algorithm under the following specification of the system vectors and matrices:

$$a_t = \begin{bmatrix} b_t \\ g_t \\ d_t \end{bmatrix}, \quad P_t = \frac{1}{\sigma^2} E \begin{bmatrix} \Theta_{1t}\Theta_{1t} & \Theta_{1t}\Theta_{2t} & \Theta_{1t}\Theta_{3t} \\ \Theta_{2t}\Theta_{1t} & \Theta_{2t}\Theta_{2t} & \Theta_{2t}\Theta_{3t} \\ \Theta_{3t}\Theta_{1t} & \Theta_{3t}\Theta_{2t} & \Theta_{3t}\Theta_{3t} \end{bmatrix},$$

$$z_t = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}, \quad T_t = T = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}, \quad R_t = R = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}.$$

....

30) See Harvey (1981b), p. 107 for this argument in the context of Kalman filter estimation of standard regression models.

$$S_t=S=\begin{bmatrix}1\end{bmatrix}, \quad H_t=H=\begin{bmatrix}h_v\end{bmatrix}, \quad Q_t=Q=\begin{bmatrix}q_n & 0 & 0\\ 0 & q_r & 0\\ 0 & 0 & q_s\end{bmatrix}, \quad w_t=\begin{bmatrix}n_t\\ r_t\\ s_t\end{bmatrix}.$$

This specification of the Kalman filter follows Harrison & Stevens (1971), Bomhoff & Korteweg (1980), Bomhoff [(1982), (1983)], Kool (1982) and Bomhoff & Kool (1983) in introducing a common factor in all variance terms of the stochastic processes according to $\sigma_v^2=\sigma^2 h_v$, $\sigma_n^2=\sigma^2 q_n$, $\sigma_r^2=\sigma^2 q_r$ and $\sigma_s^2=\sigma^2 q_s$.

The specification of the multi-process filter assumes that four alternative process models are sufficient to cover the range of possible stochastic patterns of the time series to be predicted. Specifically, it is postulated that the four alternative models differ only in the specification of the variances σ_v^2, σ_n^2, σ_r^2 and σ_s^2 of the dynamic linear model (30a) to (30d), or in the specification of the moving-average parameters d_1, d_2 and d_3 and the process variance σ_x^2 of the corresponding time series model. In the formal presentation of the model each alternative model will be characterized by a superscript j (with j=1,2,3,4), and differs only in the error term variances [$\sigma_v^{2(j)}$, $\sigma_n^{2(j)}$, $\sigma_r^{2(j)}$, $\sigma_s^{2(j)}$]. Furthermore, for each point in time t [with t=(1,2,...,N)] each model has a certain probability $\Pi_t^{(j)}$ and can be completely described by the estimates of the state vector $\alpha_t^{(j)}$ and its variance-covariance matrix $P_t^{(j)}$.

The overall estimate of the state vector a_t and its variance-covariance matrix P_t in the multi-process Kalman filter is then given by a probability-weighted normal distribution according to:

$$(3) \qquad \alpha_t \sim \sum_j \Pi_t^{(j)} N\left(\alpha_t^{(j)}, \sigma^2 P_t^{(j)}\right).$$

where $\Pi_t^{(j)}$ is the posterior probability that model j describes the observable process y_t in period t.

It is assumed that the observable process y_{t-1} in period t-1 is described by model i [denoted by $M_{t-1}^{(i)}$ for all i(=1,2,3,4)] and the process y in period t is represented by model j [denoted by $M_t^{(j)}$ for all j(=1,2,3,4)]. In order to capture the possibility of such process-switching a prediction on the basis of all models i in period t-1 with the different specification of all models j [denoted by $M_{t,t-1}^{(i,j)}$ for all i,j(=1,2,3,4)] is required. The probability of such process-switching or state-transition is defined as $\Pi_t^{(i,j)}$. The relevant Kalman filter prediction and update equations of the multi-process Kalman filter algorithm can then be written as:

prediction equations:

(4a) $$\alpha_{t,t-1}^{(i,j)} = T\, \alpha_{t,t-1}^{(i)} ,$$

(4b) $$P_{t,t-1}^{(i,j)} = T\, P_{t,t-1}^{(i)}\, T^T + R\, Q^{(j)}\, R^T ,$$

update equations:

(4c) $$\alpha_{t,t}^{(i,j)} = \alpha_{t,t-1}^{(i,j)} + K_t^{(i,j)} \{ e_t^{(i,j)} \} ,$$

(4d) $$P_{t,t}^{(i,j)} = [I - K_t^{(i,j)} z^T]\, P_{t,t-1}^{(i,j)}\, [I - K_t^{(i,j)} z^T]^T + K_t^{(i,j)}\, H^{(j)}\, K_t^{(i,j)T} ,$$

(4e) $$e_t^{(i,j)} = y_t - z^T \alpha_{t,t-1}^{(i,j)} ,$$

(4f) $$F_t^{(i,j)} = z^T P_{t,t-1}^{(i,j)}\, z + S^T H^{(j)} S ,$$

(4g) $$K_t^{(i,j)} = P_{t,t-1}^{(i,j)}\, z\, (F_t^{(i,j)})^{-1} .$$

As the result of one Kalman filter iteration in period t sixteen estimates of the state vector $\alpha_{t,t}^{(i,j)}$ and its variance-covariance matrix $P_{t,t}^{(i,j)}$ conditional on the realization of the observable process y_t and the specification of model i in period t-1 $[M_{t-1}^{(i)}]$ and model j in period t $[M_t^{(j)}]$ are calculated and can be characterized by the conditional density distribution:

(5) $$\alpha_t \,|y_t, M_t^{(j)}, M_{t-1}^{(i)} \sim N\,(\, \alpha_{t,t}^{(i,j)} \, , P_{t,t}^{(i,j)} \,) .$$

The posterior estimate of the state vector α_t conditional only on the realization of the observable process y_t can then be derived as a probability-weighted average of these conditional density distributions according to:

(6) $$\alpha_t \,|y_t \sim \sum_i \sum_j \Pi_t^{(i,j)}\, N\,(\, \alpha_{t,t}^{(i,j)} \, , P_{t,t}^{(i,j)} \,) ,$$

where the posterior transition probabilities $\Pi_t^{(i,j)}$ are used as a weighting factor for the posterior estimates $\alpha_{t,t}^{(i,j)}$ of the different process models.

The Bayesian part of the Multi-process Kalman Filter then uses a combination of prior information and sample information to calculate and update the probability distribution of the alternative process models via Bayes' law. This updating process is referred to as a 'Bayesian learning' process and closely resembles the Bayesian probability learning used in Backus & Driffill [(1985a), (1985b)] and Barro (1986b).

According to Bayes' theorem the conditional posterior probability $\pi_t^{(i,j)}$ can be calculated as:[31)]

$$(7)\quad \pi_t^{(i,j)} = \textbf{PROB.}\ [\ M_t^{(j)}\ ,\ M_{t-1}^{(i)}\ |\ (y_t, y_{t-1}, y_{t-2}, \ldots)\ ]$$

$$= \textbf{PROB.}\ [\ y_t\ |\ M_t^{(j)}\ ,\ M_{t-1}^{(i)}\ ,\ (y_{t-1}, y_{t-2}, y_{t-3}, \ldots)\ ]$$

$$*\ \textbf{PROB.}\ [\ M_t^{(j)}\ |\ M_{t-1}^{(i)}\ ,\ (y_{t-1}, y_{t-2}, y_{t-3}, \ldots)\ ]$$

$$*\ \textbf{PROB.}\ [\ M_{t-1}^{(i)}\ |\ (y_{t-1}, y_{t-2}, y_{t-3}, \ldots)\ ]$$

$$/\ \textbf{PROB.}\ [\ y_t\ |\ (y_{t-1}, y_{t-2}, y_{t-3}, \ldots)\ ]\ ,$$

and can be formalized in terms of the Kalman filter from above as:

$$(8)\quad \pi_t^{(i,j)} = k_t\, L_t^{(i,j)}\, E_{t-1}\pi_t^{(j)}\, \pi_{t-1}^{(i)}\ ,$$

$$(9)\quad L_t^{(i,j)} = [2\pi\, \sigma^2\, F_t^{(i,j)}]^{-(1/2)}\ \textbf{exp}\ [\ -\{(e_t^{(i,j)})^2 / 2\sigma^2 F_t^{(i,j)}\}\ ]\ ,$$

$$(10)\quad \sum_i \sum_j \pi_t^{(i,j)} = 1\ ,$$

$$(11)\quad \pi_{t-1}^{(i)} = \sum_j \pi_{t-1}^{(i,j)}\ ,$$

$$(12)\quad \psi_{t-1}^{(j)} = \sum_i \pi_{t-1}^{(j,i)}\ ,$$

$$(13)\quad E_{t-1}\pi_t^{(j)} = \frac{E_{t-2}\pi_{t-1}^{(j)} + \sum_i \pi_{t-1}^{(j,i)}}{\sum_j\ (\ E_{t-1}\pi_{t-1}^{(j)} + \sum_i \pi_{t-1}^{(j,i)}\ )}\ .$$

The transformation of old prior and posterior probabilities into a new prior probability for the subsequent period in equation (A13)

....

31) See also Harrison & Stevens [(1971), (1976)] and Bomhoff & Kool (1983).

represents the Bayesian learning mechanism, and is determined by the relative performance of the individual models over the most recent periods.

In order to make the forecasting model described above operational, some sort of condensation procedure is required. To summarize the state estimates of the models $M_t^{(i,j)}$ in one process model $M_t^{(j)}$, the individual posterior process probabilities $\Pi_t^{(i,j)}$ and the condensed posterior probabilities $\Pi_t^{(j)}$ are used as a time-variable weighting scheme for the updated estimates of the state vectors:

$$(14)\quad \alpha_t^{(j)} = \sum_i \Pi_t^{(i,j)}\ \alpha_t^{(i,j)} \ /\ \Pi_t^{(j)}\ ,$$

and their variance-covariance matrices:

$$(15)\quad P_t^{(j)} = \sum_i \Pi_t^{(i,j)}\ \{P_t^{(i,j)} + [(\alpha_t^{(i,j)}-\alpha_t^{(j)})\ (\alpha_t^{(i,j)}-\alpha_t^{(j)})^T]\}\ /\ \Pi_t^{(j)},$$

where $\Pi_t^{(j)}=\sum_i \Pi_t^{(i,j)}$ holds. Note that the condensed estimator for the variance-covariance matrix $P_t^{(j)}$ of the state vector $\alpha_t^{(j)}$ in equation (A15) includes a term $[(\alpha_t^{(i,j)}-\alpha_t^{(j)})(\alpha_t^{(i,j)}-\alpha_t^{(j)})^T]$ in addition to the individual estimates $P_t^{(i,j)}$. The reasoning behind this is that the estimates of the individual variance-covariance matrices $P_t^{(i,j)}$ define a confidence measure or measure of uncertainty attached to the point estimates of the state vector $\alpha_t^{(i,j)}$ of the process model $M_t^{(i,j)}$. The probability weighted sum of these individual estimates of the variance-covariance matrices thus represents a confidence measure for the point estimate $\alpha_t^{(j)}$ of the aggregate model. If, however, the individual point estimates $\alpha_t^{(i,j)}$ differ substantially, then this dispersion of the point estimates represents an additional element of uncertainty, which would be disregarded using $P_t^{(i,j)}$ alone in equation (A15). Thus, this uncertainty is accounted for by the inclusion of the dispersion term $[(\alpha_t^{(i,j)}-\alpha_t^{(j)})(\alpha_t^{(i,j)}-\alpha_t^{(j)})^T]$, which can be neglected for small differences between the individual and the average point estimates.

Finally, in our application of the algorithm, the initialization of the state vector $\alpha_t^{(j)}$ and its variance-covariance matrix $P_t^{(j)}$ is, for convenience, taken to be identical for all models and given by:

$$(16) \qquad a_{t_0}^{(j)} = (1 \quad 0 \quad 0)^T \; y_{t_0-1} ,$$

$$(17) \qquad P_{t_0}^{(j)} = \kappa \mathbf{I} ,$$

where t_o is the initalization period, κ represents a very large number and $\mathbf{I}$ a [3*3] identity matrix. The initalization of the level component in the state vector using the past actual value of the observable process together with a very low confidence measure for this initialization ensures that - due to the special form of the Ricatti equation (A4d) - a fast convergence of the initial state estimate to the true sample estimate is guaranteed and simultaneously the initial prediction errors are small. In practical data applications κ=100000 was chosen, which resulted in a reduction of the variance of the state estimate to approximately 0,002 percentage points after processing only four observations.

In the initialization of the probabilities of the four different models the Laplace principle was employed and identical posterior $[\Pi_{t_0-1}^{(i)}]$ and a-priori probabilities $[E_{t_0-1}\Pi_{t_0}^{(j)}]$ were assigned:

$$(18a) \qquad E_{t_0-1}\Pi_{t_0}^{(j)} = E_{t_0-1}\Pi_{t_0}^{(i)} = 0.25 \quad \text{for all } i,j(=1,2,3,4),$$

$$(18b) \qquad \Pi_{t_0-1}^{(j)} = \Pi_{t_0-1}^{(i)} = 0.25 \quad \text{for all } i,j(=1,2,3,4).$$

Hence it is equally likely in the initial period that the government is 'hard-nosed' or a 'wet'.

7. References

Aftalion,F., 1983, The Political Economy of French Monetary Policy, in: Hodgman,D.R., edit., The Political Economy of Monetary Policy: National and International Aspects, Proceedings of a Conference Held at Perugia, Italy, July, 1983.

Anderson,T.M. & Risager,O., 1983, Stabilization Policies, Credibility and Interest Rate Determination in a Small Open Economy, European Economic Review 32 (1988), pp. 669-679.

Artis,J.M., 1987, The European Monetary System: An Evaluation, Journal of Policy Modelling 9 (1987), pp. 175-198.

Artis,M.J. & Miller,M.H., 1987, On Joining the EMS, Midland Bank Review 1987.

Backus,D. & Driffill,J., 1985a, Inflation and Reputation, American Economic Review 75 (1985), pp. 530-538.

Backus,D. & Driffill,J., 1985b, Rational Expectations and Policy Credibility Following a Change in Regime, Review of Economic Studies 52 (1985), pp. 211-221.

Barro,R.J., 1986a, Recent Developments in the Theory of Rules versus Discretion, The Economic Journal ,Supplement, 96 (1986), p. 23-37.

Barro,R.J., 1986b, Reputation in a Model of Monetary Policy with Incomplete Information, Journal of Monetary Economics 17 (1986), pp. 3-20.

Barro,R.J. & Gordon,D.B., 1983a, A Positive Theory of Monetary Policy in a Natural Rate Model, Journal of Political Economy 91 (1983), pp. 589-610.

Barro,R.J. & Gordon,D.B., 1983b, Rules, Discretion and Reputation in a Model of Monetary Policy, Journal of Monetary Economics 12 (1983), pp. 101-121.

Baxter,M., 1985, The Role of Expectations in Stabilization Policy, Journal of Monetary Economics 15 (1985), pp.343-362,

Baxter,M., 1988, Towards an Empirical Assessment of Game-Theoretic Models of Policymaking, in: Brunner,K. & Meltzer,A.H., edit., Carnegie Rochester Conference Series on Public Policy 28, North Holland Publishers, Amsterdam, 1988, pp. 141-152.

Blanchard,O.J., 1984, The Lucas Critique and the Volcker Deflation, American Economic Review 74 (1984), Papers and Proceedings, pp. 211-215.

Blanchard,O.J., 1987, Reagonomics, Economic Policy, Oct. 1987.

Blinder,A.S., 1987, The Rules-versus-Discretion Debate in the Light of Recent Experience, Weltwirtschaftliches Archiv 123, No. 3, 1987, pp. 399-414.

Bomhoff,E.J., 1982, Predicting the Price Level in a World that changes all the time, in: Brunner,K. & Meltzer,A.H., edit., Carnegie Rochester Conference Series on Public Policy 17, North Holland Publishers, Amsterdam, 1982, pp. 7-56.

Bomhoff,E.J., 1983, Monetary uncertainty, Elseries Science Publishers B.V., Amsterdam, New York, Oxford, 1983.

Bomhoff,E.J. & Kool,C.J.M., 1983, Forecasts with Multi-State Kalman Filters, Appendix 1, in: Bomhoff,E.J., Monetary uncertainty, Elseries Science Publishers B.V., Amsterdam, New York, Oxford, 1983, pp. 229-246.

Bomhoff,E.J. & Korteweg P., 1980, Exchange Rate Variability and Monetary Policy under Rational Expectations: Some Euro-American Experience 1973 - 1979, Paper prepared for the Konstanzer Seminar on Monetary Policy (1980), pp. 1-48.

Canzoneri,M.B. & Henderson,D.W., 1988, Is Sovereign Policymaking Bad?, in: Brunner,K. & Meltzer,A.H., edit., Carnegie Rochester Conference Series on Public Policy 28, North Holland Publishers, Amsterdam, 1988.

Caranza,C. & Fazio,A., 1983, Methods of Monetary Control in Italy: 1974-1983, in: Hodgman,D.R., edit., The Political Economy of Monetary Policy: Natinal and International Aspects, Proceedings of a Conference Held at Perugia, Italy, July, 1987.

Christensen,M., 1987a, Disinflation, Credibility and Price Inertia - A Danish Exposition, University of Aarhus Discussion Paper 1987-5, Mimeo.

Christensen,M., 1987b, Policy Credibility and the Lucas Critique - Some New Tests with an Application to Denmark, University of Aarhus Discussion Paper 1987-8, Mimeo.

Christensen,M., 1988, On Interest Rate Determination, Testing for Policy Credibility, and the Relevance of the Lucas Critique. Some Danish Experience, University of Aarhus Discussion Paper 1988, Mimeo.

Cobham,D., 1984, French Macro-economic Policy under President Mitterand: An Assesment, National Westminster Bank Quarterly Review, Feb. 1984, pp. 41-51.

Collins,S.M., 1987, Infation and the EMS, Paper presented at the Conference on the EMS, Perugia, Oct. 1987, Mimeo.

Currie,D., 1988, Options for UK Macroeconomic Policy, Oxford Review of Economic Policy 3 (1988), pp. 1-8.

Cukierman,A. & Meltzer,A.H., 1982, A Positive Theory of Credibility and Monetary Inflation, Mimeo, Paper presented at the Konstanz Seminar of Monetary Theory and Monetary Policy 1983.

Cukierman,A. & Meltzer,A.H., 1986a, The Credibility of Monetary Announcements, in: Neumann, M.J.M., edit., Monetary Policy and Uncertainty, Baden-Baden, pp. 39-67.

Cukierman,A. & Meltzer,A.H., 1986b, A Positive Theory of Discretionary Policy, the Cost of Democratic Government and the Benefits of a Constitution, Economic Inquiry 24 (1986), pp. 367-388.

Cukierman,A. & Meltzer,A.H., 1986c, A Theory of Ambiguity, Credibility, and Inflation under Discretion and Asymmetric Information, Econometrica 54 (1986), pp. 1099-1128.

Danthine,J.-P. & Lambelet,J.-C., 1987, The Swiss Recipe: Conservative Polices ain't Enough!, Economic Policy, Oct. 1987

De Grauwe,P., 1985, European Monetary Cooperation and Financial Stability, in: Van Ewijk,C.C. & Klant,J.J., edit., Monetary Conditions for Economic Recovery, Finanial and Monetary Policy Studies, Vol. 11, Dordrecht, Boston, Lancaster, 1985, pp. 161-186.

De Grauwe,P., Fratianni,M. & Nabli,M.K., 1985, Exchange Rates, Money and Output, Macmillan Press, Hong Kong, 1985.

Dennis,G. & Nellis,J., 1984, The EMS and UK Membership: Five Years On, Lloyds Bank Review, Oct. 1984.

Driffill,J., 1985, Macroeconomic Stabilization Policy and Trade Union Behaviour as a Repeated Game, Scandinavian Journal of Economics 87 (1985), pp. 300-326.

Driffill,J., 1988a, Macroeconomic Policy Games with Incomplete Information: A Survey, European Economic Review 32 (1988), pp. 533-541.

Driffill,J., 1988b, Empirical Analysis of Models of Credibility and Reputation in Macroeconomic Policy, Paper Presented at the CEPR Conference on "International Regimes and Macroeconomic Policy", London, 8/9 September 1988, Mimeo.

Dudler,H.-J., 1984, Domestic Monetary Policy in EC Countries under Different Exchange Rate Regimes: National Concerns and Community Options, in: Masera,R.S. & Triffin,R., edit., Europe's Money, Problems of European Monetary Co-ordination and Integration, Oxford, 1984, pp. 227-261.

Eggerstedt,H. & Sinn,S., 1987, The European Monetary System 1979-1986:

The Economics of Muddling Through, Geld und Waehrung/ Monetary Affairs, 1987, 1/2.

Fels,G. & Froehlich,H.-P., 1987, Germany and the World Economy: A German View, Economic Policy, Oct. 1987.

Fischer,S., 1987a, British Monetary Policy, in: Dornbusch,R. & Layard, R., edit., The Performance of the British Economy, Oxford University Press, Oxford, 1987.

Fischer,S., 1987b, International Macroeconomic Policy Coordination, NBER Working Paper No. 2244.

Fratianni,M., 1980, The European Monetary System: A Return to an Adjustable-Peg Arrangement, in: Brunner,K. & Meltzer,A.H., eds., Carnegie-Rochester Conference Series on Public Policy, North Holland Publishers, Amsterdam, 1980, pp. 139-172.

Frenkel,J.A. & Goldstein,M., 1988, The International Monetary System: Developments and Prospects, IMF Working Paper 88/45, Mimeo.

Friedman,B.M., 1979, Optimal Expectations and the Extreme Information Assumption of 'Rational Expectations' Macromodels, Journal of Monetary Economics 5 (1979), pp. 12-41.

Giavazzi,F., 1988, Incentives to Fix the Exchange Rate, European Economic Review 32 (1988), pp. 382-387.

Giavazzi,F. & Giovannini,A., 1987, The EMS and the Dollar, Economic Policy, Oct. 1987.

Giavazzi,F. & Pagona,M., 1985, Capital Controls and the European Monetary System, in: Capital Control and Foreign Exchange Legislation, Occasional Paper, Euromobiliare, Milano, 1985.

Giavazzi,F. & Pagano,M., 1988, The Advantage of Tying one's Hands, EMS Disipline and Central Bank Credibility, European Economic Review 32 (1988), pp. 1055-1082.

Gleske,L., 1987, Monetary Policy: Priorities and Limitations, in: Volcker,P.A. et al, edit., International Monetary Cooperation, Essays in Honor of Henry C. Wallich, Princeton University, Essays in International Finance, No. 169, Dec. 1987.

Harrison,P.J., 1965, Short-Term Sales Forecasting, Applied Statistics 14 (1965), pp. 102-139.

Harrison,P.J. & Stevens,C.F., 1971, A Bayesian Approach to Short-term Forecasting, Operational Research Quarterly 22 (1971), pp. 341-362.

Harrison,P.J. & Stevens,C.F., 1976, Bayesian Forecasting (with discussions), Journal of the Royal Statistical Society Ser. B 38 (1976), pp. 205-247.

Hodgman,D.R. & Resek,R.W., 1983, Determinants of Monetary Policy in France, The Federal Republic of Germany, Italy and the United Kingdom: A Comparative Analysis, in: Hodgman,D.R., edit., The Political Economy of Monetary Policy: Natinal and International Aspects, Proceedings of a Conference Held at Perugia, Italy, 1987.

Hellwig,M. & Neumann,M.J.M., 1987, Economic Policy in Germany: was there a Turnaround?, Economic Policy, Oct. 1987.

Howitt,P., 1987, Disinflation and Exchange Rate Stabilization: Canada, 1980-1985, Journal of Policy Modelling 9 (1987), pp. 637-660.

Kool,C.J.M., 1982, The Multi-State-Kalman Filter Method, in: Brunner,K. & Meltzer,A.H., edit., Carnegie-Rochester Conference Series on Public Policy 17, North Holland Publishers, Amsterdam, 1982, pp. 39-46.

Kreps,D.M. & Wilson,R., 1982, Reputation and Imperfect Information, Journal of Economic Theory 27 (1982), pp. 253-279.

Kydland,F.E. & Prescott,E.C., 1977, Rules Rather than Discretion: The Inconsistency of Optimal Plans, Journal of Political Economy 85 (1977), pp. 473-491.

Laidler,D., 1984, Monetary Policy in Britain: Successes and Short-

commings, Oxford Review of Economic Policy 1 (198), pp. 35-43.
Matthews,K. & Minford,P., 1987, Mrs Thatchers Economic Policies 1979-1987, Economic Policy, Oct. 1987.
Meltzer,A.H., 1984, Overview, in Price Stability and Public Policy: A Symposium Sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming, Aug. 1-3, 1984, pp. 209-222.
Meltzer,A.H., 1985, Variability of Prices, Output and Money under Fixed and Fluctuating Exchange Rates: An Empirical Study of Monetary Regimes in Japan and the United States, in: Bank of Japan, edit. Monetary and Economic Studies, Dec. 1986, pp. 1-46.
Meltzer,A.H., 1986a, Some Evidence on the Comparative Uncertainty Experienced Under Different Monetary Regimes, in: Campbell, D.D. & Dougan,R.W, edit., Alternative Monetary Regimes, Baltimore and London, 1986, pp. 122-167.
Meltzer,A.H., 1986b, Monetary and Exchange Rate Regimes: A Comparison of Japan and the United States, Cato Journal 6 (1988), pp. 667-683.
Meltzer,A.H., 1986c, Size, Persistence and Interrelation of Nominal and Real Shocks, Some Evidence from Four Countries, Journal of Monetary Economics 17 (1986), pp. 161-194.
Meltzer,A.H., 1987a, Limits to Short-run Stabilization Policy, Presidential Address to the Western Economic Association, July 3, 1986, Economic Inquiry 25 (1987), pp. 1-14.
Meltzer,A.H., 1987b, On Monetary Stability and Monetary Reform, Cato Journal 10 (1987), pp. 13-34.
Minford,P., 1988, Exchange Rate Regimes and Policy Coordination, Paper Presented at the CEPR Conference on "International Regimes and Macroeconomic Policy", London, 8/9 September 1988, Mimeo.
Muth,J.F., 1960, Optimal Properties of Exponentially Weighted Forecasts, Journal of the American Statistical Association 55 (1960), pp. 299-306.
Muth,J.F., 1961, Rational Expectations and the Theory of Price Movements, Econometrica 29, (1961), pp. 315-335.
OECD, 1979, Monetary Targets and Inflation Control, OECD Monetary Studies Series, 1979.
Perry,G.L., 1983, What Have We Learned About Disinflation?, Brookings Papers on Economic Activity, Vol. 2, pp. 484-490.
Rich,G., 1987, Swiss and United States Monetary Policy: Has Monetarism Failed?, Federal Reserve Bank of Richmond Economic Review 73/3 (1987), pp. 3-16.
Rogoff,K., 1985, Can Exchange Rate Predictability be Achieved without Monetary Convergence: Evidence from the EMS, European Economic Review 28 (1985), pp. 93-115.
Sachs,J. & Wyplosz,C., 1987, The Economic Consequences of President Mitterand, Economic Policy, Oct. 1987.
Schioppa,T.P., 1985, Policy Cooperation and the EMS Experience, in: Buiter,W.H. & Martson,R.C., eds., International Economic Policy Coordination, pp. 331-365, Cambridge, 1985.
Solow,R., Budd,A. & Von Weizsacker,C., 1987, The Conservative Revolution: A Roundtable Discussion, Economic Policy, Oct. 1987.
Stokx,J., 1982, Belgian Economic Reforms 1982, The Irish Banking Review, Dec. 1982.
Tabellini,G., 1986, Central Bank Reputation and the Monetization of Deficits: The 1981 Italian Monetary Reform, Economic Inquiry (1986), pp. 185-200.
Turnovsky,S.J., 1969, A Bayesian Approach to the Theory of Expectations, Journal of Economic Theory 1 (1969), pp.220-227.
Ungerer,H. Evans,O. & Nyberg,P., 1983, The European Monetary System: The Experience, 1979-1982, IMF Occasional Paper No. 19.
Vaubel,R., 1985, Evidence to the House of Commons Select Commitee, in:

House of Commons Select Commitee, edit., The European Monetary System, 13th Report from the Treasury and Civil Service Commitee, and Evidence, 1985.

van Ypersele,J. & Koeune,J.C., 1984, The European Monetary System: Origins, Operation and Outlook, The European Perspectives Series, Commission of the European Communities, Brussels, 1984.

Vickers,J., 1986, Signalling in a Model of Monetary Policy with Incomplete Information, Oxford Economic Papers 38 (1986), pp. 443-455.

Walter,N., 1982, The EMS: Performance and Prospects, in: Summers,M.T. & Zis,G., edit. European Monetary Union: Progress and Prospects, pp. 33-70.

Weber,A.A., 1988a, Rational Expectations, Optimal Expectations and Learning under Certainty Equivalence, Risk and Uncertainty: An Information and Decision Theoretical Approach, Mimeo.

Weber,A.A., 1988b, Uncertainty, Adaptive Expectations and Error Learning: An Application of the Time Series Analytical Bayesian Multi-Process Kalman-Filter to Inflation Expectations, Mimeo.

Weber,A.A., 1988c, Uncertainty, Rational Expectations and Optimal Learning: An Application of the Regression Analytical Bayesian Multi-Process Kalman-Filter to Inflation Expectations, Mimeo.

Weber,A.A., 1988d, The Role of Expectations in Stabilization Policy: An Evaluation of the Credibility of Monetary and Fiscal Reforms by Bayesian Multi-Process Kalman-Filtering, Mimeo.

Willms,M., 1983, The Monetary Policy Decision Process in the Federal Republic of Germany, in: Hodgman,D.R., edit., The Political Economy of Monetary Policy: Natinal and International Aspects, Proceedings of a Conference Held at Perugia, Italy, 1983.

Wood,G.E., 1983, The Monetary Policy Decision Process in the United Kingdom, in: Hodgman,D.R., edit., The Political Economy of Monetary Policy: Natinal and International Aspects, Proceedings of a Conference Held at Perugia, Italy, 1983.

Already published in this series:

No.	Author(s)	Title
8801	Th. van de Klundert and F. van der Ploeg	Fiscal Policy and Finite Lives in Interdependent Economies with Real and Nominal Wage Rigidity.
8802	J.R. Magnus and B. Pesaran	The Bias of Forecasts from a First-order Autoregression.

In publication:

8804	F. van der Ploeg and A.J. de Zeeuw	Perfect Equilibrium in a Model of Competitive Arms Accumulation.
8805	M.F.J. Steel	Seemingly Unrelated Regression Equation Systems under Diffuse Stochastic Prior Information: A Recursive Analytical Approach.
8806	Th. Ten Raa and E.N. Wolff	Secondary Products and the Measurement of Productivity Growth.

P.O. BOX 90153. 5000 LE TILBURG. THE NETHERLANDS