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Credibility of EMS Interest Rate Policies: A Markov Regime-Switching Approach

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INTRODUCTION

The primary objective of this paper is to use the Markov regime-switching modeling framework to study the credibility of monetary policy in five member countries of the European Monetary System (EMS) throughout its life, i.e. 1979 to 1998. The five countries examined for this purpose are: Austria, Belgium, France, Italy and the Netherlands, which are thought to have had different degrees of credibility over the period.

A number of other studies have investigated the issue of credibility during the EMS period (see Dahlquist and Gray, 2000, for a recent study). One of the main conclusions of this body of literature is that monetary policy may go through different stages of credibility, in a way that it is perceived to be credible in some circumstances and may lack credibility on other occasions. It is, thus, appropriate to use the Markov regime-switching modeling framework to study this phenomenon. Moreover, some of these studies allow the probability of switching between regimes to be a function of macroeconomic variables (see Engel and Hakkio, 1996; Gray, 1996; and Dahlquist and Gray, 2000). In particular most of these authors attempt to explain the currency crises in 1992 and 1993 by using as information variables in the transition probabilities, the position of the exchange rate within the band (i.e. target zone model framework), real exchange rates, budget deficits, interest rate differentials, and other variables. However, none of these studies include in the transition probability the two main variables that determine the loss function of monetary authorities, namely domestic output-gap variability and inflation variability. Introducing the latter two variables in this way, enables us to evaluate how credibility is affected by flexibility in terms of stabilization of aggregate supply and demand shocks.

Two questions, then, emerge: (a) whether output-gap variability and inflation variability affect the credibility of monetary policy of each EMS country during the convergence period towards the Economic and Monetary Union (EMU); and (b) whether the impact of these variables is the same across these countries. In this paper, based on a theoretical framework about the uncertainty of the type of central bank (see for example Ball, 1995), we evaluate the weights of inflation variability and output-gap variability in the loss function of central banks. Based on the weights of these variables, we examine the credibility of the interest rate policies pursued by the five EMS member countries referred to above, prior to their joining the Eurosystem in January 1999.

We begin with the theoretical and empirical underpinnings of credibility in general, and with that of EMS in particular, in the section that follows. The empirical methodology adopted is explored in the subsequent section, with the empirical results reported and discussed in the penultimate section. The final section summarizes and concludes.

THEORETICAL AND EMPIRICAL UNDERPINNINGS OF EMS CREDIBILITY

Theoretical Background

The theoretical approach to credibility adopted is based on the following loss function of a country's central bank:

$$L = 1/2\, \lambda\, (y - y^{n} - k)^{2} + 1/2(\pi - \pi^{*})^{2} \qquad (1)$$

where y = output, y^{n} = natural rate of output, π = inflation rate, π^{*} = inflation target which is assumed zero for simplicity, λ stands for the weight the central bank attaches to output, relative to inflation stabilization, and k is a parameter which may be justified on several grounds. For example, labour-market distortions, monopolistic competitive sectors, and other rigidities, all of which lead to an equilibrium rate of output that is inefficiently low. Still another justification of k is that it represents political pressures on the central bank to expand output, which enhances the chances of politicians to be re-elected. Equation (1) and the subsequent analysis are based on the assumption that the central bank has no independence, as the case was during the EMS era; it is simply a passive institution that carries out the government's instructions.

A Lucas-type aggregate-output relationship may be adopted (Barro and Gordon, 1983a, 1983b):

$$y = y^{n} + \phi(\pi - \pi^{e}) + s \qquad (2)$$

where π^{e} is expected inflation, and s stands for aggregate supply shocks that follow an independent and identical distribution; the rest of the symbols are as above. A further relationship is needed to link inflation and the central bank policy instrument, so that:

$$\pi = \Delta i + v \qquad (3)$$

where Δi is the change in the policy instrument, and v is a velocity disturbance with i.i.d. Furthermore, we assume that v and s are uncorrelated. With π^{e} taken as given (that is expectations are determined prior to the central bank's decision on Δi), and with the authority assumed to observe s, but not v, before setting Δi , a role for discretionary stabilization policy is firmly established.

We may substitute (2) and (3) into (1), and upon minimizing the expected value of the resulting loss function we arrive at (4):

$$\Delta i = [\phi^{2} \lambda \pi^{e} + \phi\lambda (k - s)]/(1 + \phi^{2} \lambda) \qquad (4)$$

Equation (4) contains three important elements: ϕ, the reaction of output to $(\pi - \pi^e)$, s, the aggregate supply shock, and λ, the central bank's weight on output stabilization relative to inflation. Given the objective of minimizing output and inflation variances, it is important for policy to be conditional on the realization of s. The clear implication is that not only is there an explicit role for stabilization policies established, but it also involves a trade-off between inflation variability and output-gap variability.[1]

Taking expected values in (4) and remembering that expectations are formed prior to observing s, implies:

$E[\Delta i] = \pi^e = [\phi^2 \lambda \pi^e + \phi\lambda k]/(1 + \phi^2 \lambda)$ (4a)

which can be solved for π^e to give:

$\pi^e \phi\lambda k > 0$ (4b)

This may be substituted into (4), alongside (3), to arrive at:

$\pi^d = \phi\lambda k - \phi\lambda s/(1 + \phi^2 \lambda)$ (5)

thus providing an expression for the equilibrium rate of inflation (discretionary). It implies a positive average rate of inflation $(\phi\lambda k)$, which has no effect on output since this element is completely anticipated (i.e. $\pi^e = \phi\lambda k$). This inflation bias may be due to two reasons. First, the central bank has an incentive to inflate; and second, the central bank is unable to commit to zero inflation (because the marginal benefit of inflation in terms of output gained is $\phi\lambda k$, greater than the marginal cost of inflation which is zero once $\pi = \pi^e = 0$). The central bank would wish an inflation rate that implies that the marginal benefit is equal to the marginal cost of inflation.

It follows that the solution to the inflation bias dictates that the basic model is modified so that the marginal cost of inflation is raised as perceived by the central bank. This cost takes the form of lost reputation in a repeated game version of the basic Barro-Gordon (1983a, 1983b) model. That is, giving in to the temptation to inflate in the current period affects negatively the central banks' reputation to achieve low inflation in the future. This leads the public to expect higher inflation in the future, which is the punishment of the central bank by the public. Higher future inflation lowers the central bank's reputation, and thereby raising the marginal cost of inflation. However, the evolution of the public's beliefs over time is based on observed outcomes of inflation; and the central bank can affect these beliefs by its actions. Consequently, a central bank that prefers to achieve some output expansion at the cost of inflation, may find it optimal initially to build an anti-inflation reputation. This behaviour of a central bank raises the issue of the public's uncertainty in relation to the 'type' of central bank (see, for example, Backus and Driffill 1985; Barro, 1986; Ball, 1995). More concretely, there is uncertainty as to whether the central bank prefers to stabilise inflation variability (i.e. the 'dry' type of central bank) or to stabilize output-gap variability (i.e. the 'wet' type of central bank).

We measure this uncertainty as a deviation of the interest rate policy from a target level, where this target is the interest rate of a country with low inflation reputation (Ball, 1995). Giavazzi and Pagano (1988) argue that during the 1980s, the EMS countries designated the Bundesbank as their 'dry central bank' by pegging their exchange rate to the German mark, themselves becoming the 'wet central banks'. In our case the domestic interest rate is the interest rate of each of the five individual countries and the target interest rate is the German interest rate. We, thus, use Germany to represent the dry type of central bank and the five countries to represent the wet type of central bank. We also follow Ball (1995) and adopt the assumption that the behaviour of the wet type of central bank follows a Markov process.

Empirical Background

Early empirical studies estimated the credibility of exchange rate and interest rate policy of ERM member countries (see, for example, Frankel and Phillips, 1992; Drazen and Masson, 1994). The dynamic impact of policy co-ordination on the credibility of the EMS has also been examined using an autoregressive conditional heteroskedasticity estimation (ARCH) of interest rate differentials between ERM countries and Germany. When the variance is explosive, then the ARCH/GARCH specification of the variance is subject to regime switches. Gray (1996) demonstrated that this strong persistence in variability might be due to changes in the mechanism generating the short-term rate of interest. Lamoureux and Lastrapes (1990) indicate that a structural shift in the unconditional variance is likely to lead to wrong estimation of the GARCH parameters such that they imply too much persistence in variability. Gomez-Puig and Montalvo (1997) propose credibility indicators based on realignment expectations, using a Markov Regime-Switching (MRS) model to estimate the inferred probabilities. In this they use a modification of the ARCH model that allows changes in regime, combining the idea of an Autoregressive Conditional Heteroscadasticity and of a Markov regime-switching (SWARCH) model.

We utilise a switching autoregressive conditional heteroskedasticity model (SWARCH) (Hamilton and Susmel, 1994). Switches between regimes have been driven by switches in the variance of interest rate differentials. We have experimented with ARCH models and with interest rate differentials for each individual country. They show explosive variance, which indicates that these models are subject to regime switching that can be modeled within a Markov framework. A switch in the variance captures the risk premium for the wet central bank to move from a low inflation regime to a high inflation regime.[2] Moreover, we introduce a time-varying transition probability, where the probability to switch between regimes is a function of macroeconomic variables. In our case we use the variables in the transition probability, first to test whether they are significant, and second to investigate the preferences of the central bank relating to the stabilization of the output-gap variability or of the inflation variability.

EMPIRICAL METHODOLOGY OF MODELING CREDIBILITY

We use a univariate Markov regime-switching (MRS) model of the SWARCH type, with time-varying transition probabilities (TVTP), in the case of five EMS countries. This allows us to deal with the question of whether macroeconomic variables affect the transition from high to low credible regimes and vice verca. Inflation, unemployment, fiscal deficit and the real exchange rate have all been used in previous studies (see, for example, De Grauwe, 1994; Svensson, 1993; Masson, 1995). We utilise the variables inflation variability and output-gap variability to test whether they have significant effects on the transition probabilities between low and high credible regimes. In this way we can estimate the preferences of the five individual countries concerning the output-gap variability and inflation variability, thereby enabling us to make inferences about credibility.

Hamilton (1989) developed a model that allows a given variable to follow a different time series process over different sub-samples, the path of which depends on unobserved stochastic state variables, thereby enabling the unobserved component to follow a Markov process. This can be extended to the case where the conditional variance in each regime follows an ARCH process (see, for example, Hamilton and Susmel, 1994). A spesific form of a SWARCH model of this type is:

$$i^D - i^G \; | I_{t-1} \sim \begin{cases} N[b_0 + b_1 (i^D - i^G)_{t-1}, h_{1t}] & \text{with Probability } \pi 1 \\ N[c_0 + c_1 (i^D - i^G)_{t-1}, h_{2t}] & \text{with Probability } \pi 2 \end{cases} \quad (6)$$

where i^D is the domestic EMS member country interest rate and i^G is the German interest rate, with

$$h_{1t} = a_0 + a_1 u^2_{t-1} + a_2 u^2_{t-2}$$
$$h_{2t} = d_0 + d_1 u^2_{t-1} + d_2 u^2_{t-2} \quad (7)$$

and $\pi 1$ $\pi 2$ denote the long-run probabilities of high and low credibility states respectively, and h_{st} (with s = 1, 2) denotes the variability of the error term u_t. Both the mean and variance of $(i^D - i^G)$ are subject to regime switching. A switch in the variance of $(i^D - i^G)$ indicates the risk premium of the individual central bank's monetary policy to deviate from that of Germany's. The conditional variance in the high credible regime is expected to be lower than the conditional variance in the low credible regime with a higher persistence (i.e. $a_0 < d_0$ and $a_i > d_i$, with i = 1, 2), and the opposite in the case of the low credible regime (see, for example, Gray, 1996 and Friedman and Laibson, 1989). Due to differences in variability across regimes we label them the low variability (i.e. high credible regime) and high variability regime (i.e. the low credible regime).

Furthermore, we define the two long-run probabilities as: $\pi_1 = 1 - p_{22} / 2 - p_{11} - p_{22}$ and $\pi_2 = 1 - p_{11} / 2 - p_{11} - p_{22}$ (see, for example, Hamilton, 1994), where p_{ij} are the transition probabilities from regime i to regime j (with i, j = 1,2). In view of the assumption that the probability of switching from one regime to another is a function of a (kx1) vector of macroeconomic variables $\mathbf{Z_t}$, the time-varying transition probabilities may have the following logistic form:

$$p_{ij} = exp(\beta_{ij.o} + Z'_{t-1} \beta_{ij.t}) / [1 + exp(\beta_{ij.0} + Z'_{t-1} \; \beta_{ij.t})] \quad (8)$$

with $i = 1, 2$; $j = 1, 2$. As argued by Filardo (1994), this formulation provides additional information to (6) and (7) as to whether a particular regime has occurred and whether a turning point is imminent. In what follows we include in vector $\boldsymbol{Z_t}$ the inflation variability and the output-gap variability variables. The aim of this excersise is to test whether these variables affect the transition probabilities of the SWARCH process that is followed by the interest rate differentials of the five EMS countries and that of Germany. Evidence of significant $\boldsymbol{Z_t}$ variables, reflects the preferences of the monetary authorities of each individual EMS member country, concerning the stabilization of the inflation variability and the output-gap variability. The credibiliy of the EMS member countries depends not only on the significance of these variables in the transition probabilities, but also on their signs.

The relationship between transition probababilities and inflation variability on the one hand, and transition probababilities and output-gap variability on the other, depends on the current regime. If the interest rate differential is in the high credible regime (i.e. state 1), then an increase of inflation variability that might be caused by a supply or a demand shock that is obsvervable to the central bank, but not to the public, reduces the credibility of monetary authorities and therefore increases the probability to switch to a low credible regime (state 2) (i.e. $\beta_{12.t} > 0$). Alternatively, if this coefficient is negative (i.e. $\beta_{12.t}$<0), it implies the strange result that as the variability of inflation increases the transition probability decreases. This, however, is plausible under the assumptions of Clarida et. al. (1999). They argue that if a central bank is able to convince the public that it will maintain a steady course in the face of a supply shock, this has the immediate effect of reducing current inflation. The monetary authority can, thus, maintain price stability with only a small contraction in output.

If the interest rate differential is in the low credible regime (i.e. that the central bank has already revealed its identity of a wet type), then there is a negative relationship between the transition probability and inflation variability (i.e. $\beta_{21.t}$<0). An increase in inflation variability leads to a decrease in the probability to switch from the low credible state to the high credible state. When the coefficient is positive (i.e. $\beta_{21.t}$>0), this might be due to the wet type of central bank setting inflation equal to that of the dry central bank, as long as aggregate supply and demand shocks are absent. In their presence, the wet type of central bank inflates at the discretionary rate[3] and since this reveals its identity, inflation remains at the discretionary level (i.e. the low credible state) until a dry bank emerges (see Ball, 1995). Therefore, if the public believes that a low credible regime is due to the accommodation of these shocks and that a dry bank will replace the wet type of central bank, then the coefficient $\beta_{21.t}$ can become positive. The same explanation can be given for the coefficient of the output-gap variability in the transition probabilities since the output-gap is subject to the same shocks as inflation.

Significant inflation variability and not output-gap variability implies a tough monetary policy against inflation (i.e. the case of extreme inflation targeting), and high credibility with respect to the objective of price stability. In the case where both variabilities were found significant and the coefficient of inflation variability is higher than that of output-gap variability, this would imply that the country under consideration puts more weight on the stabilization of inflation variability. The credibility of monetary policy in this case is also high. On the other hand, in the case where the coefficient of the output-gap variability is higher than that of inflation variability, or in the case where only the output-gap variability were found significant, then the credibility of monetary policy regarding price stability is low.

EMPIRICAL FINDINGS

Data and Empirical Estimates

We use monthly data (March 1979 to December 1998) for interest rates, inflation and industrial production for five EMU countries, i.e. Austria, Belgium, Fance, Italy and the Netherlands. The interest rate data were taken from line 60b of the *International Financial Statistics* data base (Datastream) and are monthly averages of day-to-day money rates. The Consumer Price Index (CPI) is taken from line 64 and industrial production from line 66.

The annualized inflation and output-gap are measured by $(CPI-CPI_{12})/CPI_{12}$ and $(IP-IP_{12})/IP_{12}$ respectively, where CPI denotes the consumer price index, IP stands for industrial production and the subscript denotes the lag order. We use the twelve order difference because of central bank concern with annual inflation rates. The output-gap series have been measured by assuming that the trend follows a random walk process. We have also experimented with the following additional assumptions relating to the trend: (i) a smooth stochastic process uncorrelated with the cyclical component (Hodrick-Prescott detrending method); (ii) a log-linear trend; and (iii) a linear deterministic trend uncorrelated with the cyclical part. We choose the random walk process on the basis of the results of this exercise which clearly indicate that it is a more precise measure of potential output. In fact, a random walk process is the only way to extract a sufficient degree of smoothing in the output-gap series.

In the estimation of the output-gap variability and of the inflation variability, we have employed a stochastic volatility model. This model is used for series that although are uncorrelated they might not be independent because of serial dependence in the second moment. In particular, if the squared of the logarithms of inflation and of output-gap are serially correlated, then there is evidence of nonlinearity. This can be modelled as follows:

$$log y^2_t = \kappa + h_t + \xi_\tau \qquad (9)$$

$$\xi_t = log\, \varepsilon^2_t - E(log\, \varepsilon^2_t) \qquad (10)$$

$$\kappa = log\, \sigma^2_t + E(log\, \varepsilon^2_t) \qquad (11)$$

where y_t is the log either of inflation or of output-gap, $E(\varepsilon_t)=0$, $var(\varepsilon_t)= 1$ and the conditional variance of y_t is equal to σ^2_t and $h_t = log(\sigma^2_t)$ Working with logarithms ensures that σ^2_t is always positive.[4] A practical problem arises when some of the observations are zero, in which case the following transformation based on Taylor series is undertaken (Breit and Carriquiry, 1996):

$$log y^2_t \cong log(y^2_t + cs^2_y) - cs^2_y/(x^2_t + cs^2_y) \qquad (12)$$

where ^2_y is the sample variance of y_t and c is a small number (a value of 0.02 is suggested by Koopmans et. al., 2000). Our estimates of the stochastic volatility model are based on (12). We, thus, avoid the problem of a two-step estimation that would arise if we based our estimate of h_t, i.e. the systematic part of $log y^2_t$, on (9). The computation of stochastic volatilities both for the inflation variability and for the output-gap variability, was undertaken on the STAMP 6.0 computer software (Koopmans et al., 2000).[5] The estimation of the MRS model has been done on a RATS 4.2 computer software. The estimates of SWARCH model with time varying transition probabilities are cited in Tables 1-5. We report estimates based both on individual variables and simultaneously introducing the inflation variability and the output-gap variability in the transition probability.

Tables 1-5 report the results of the SWARCH model for the five EMS countries. The coefficients b_i and c_i, denote the autoregressive coefficients of the mean in high and low credible regimes respectively. The conditional variance in each regime is described by the coefficients α_i (i.e. the coefficient in the high credible regime) and d_i (i.e. the coefficient in the low credible regime). The $\beta_{12.i}$ coefficients, where i = 0, 1, 2, denote the values of inflation variability (when i=1 in the first column of each Table) and output-gap variability (when i=2 in the second column of each Table) in the transition probability from the high credible state (i.e. state 1) to the low credible state (i.e. state 2). The $\beta_{21.i}$ coefficients, where i = 0, 1, 2, are the values of inflation variability (when i=1in the first column of each table) and output-gap variability (when i=2 in the second column of each Table) in the transition probability from the low credible state to the high credible state. In the case where the effects of inflation variability and of output-gap variability in the transition probabilities are estimated jointly (i.e. the third column in each Table), then the coefficient in the high credible state, $\beta_{12.1}$ and $\beta_{12.2}$, show the effects of inflation variability and output-gap variability respectively. In the same way $\beta_{21.1}$ and $\beta_{21.2}$ denote the impact of inflation variability and output-gap variability on the transition probability from the low credible state to the high credible state. Therefore, the subscripts 1 and 2 after the dot denote inflation variability and output-gap variability respectively. The significance and the sign of these coefficients indicate the preferences of the central bank concerning the stabilization of inflation or output-gap variability, and, therefore, its consistency with the objective of price stability. The specification test based on Box-Pierce Q statistics, see Tables 1-5, shows that there is no serial autocorrelation both on standardized and squared standardized residuals.[6]

In all cases the conditional variance in the low credible regime is higher than the conditional variance in the high credible regime (i.e. $d_0 > \alpha_0$), but less persistent (i.e. $d_i < \alpha_i$, when i = 1, 2, with the exception of Austria where $\alpha_2 < d_2$). Thus, the effects of individual shocks fade away quickly in the low credible regime and last longer in the high credible regime. The long-run mean in the high credible regime is equal to zero (i.e. $b_0/[1-\sum k]=0$), for k =1, 2) in all cases. In particular, when b_0 is included in the specification (i.e. in the cases of France, Italy and the Netherlands), it is insignificant. Zero long-run mean indicates a convergence of the individual EMS countries interest rate to the German interest rate. The constant, in absolute terms, in the high credible state is lower than the constant in the low credible state (i.e. $|b_0| < |c_0|$). This indicates that in the high variability regime, the deviation of monetary policy of each individual EMS member country from the German monetary policy is higher. Therefore, at least for some time periods, monetary authorities in each EMS member countries focused more on domestic issues (like unemployment, GDP growth etc.), rather than on credibility derived from shadowing the German monetary policy. In Belgium and Austria interest rate differentials follow an AR(1) process without a constant (i.e. b_0 and c_0 are not included). In this case the autoregressive coefficient in the mean of low credible state might reflect short-run changes of interest rate policy and it is expected to be lower than the autoregressive coefficient of the mean in the high credible state (with the exception of Belgium).

These results also show that credibility in the EMS went through different faces. In particular, Figures 1-5 show the filtered probabilities of a country being in the high credible state, derived from joint estimation. These figures demonstrate that the credibility of monetary policy of the EMS countries was low from 1979 to 1986, since the filtered probability of being in the high credible state was reduced on many occasions. This is consistent with the fact that during that period eleven exchange rate realignments took place. The probability of being in the high credible state increased in the period 1986 to 1991 when most of the interest rate convergence took place without any realignment. These figures also show that the probability of being in the high credible state declines exactly at the time of currency crises (1992, 1993 and 1995). Italy is the exception to these results; the probability of this country being in the high credible state decreases before the crisis of 1992. The probability of being in the high credible state increases for the Italian lira once it dropped out of the ERM after the September 1992 crisis. Since Italy was no longer subject to the EMS discipline, the probability of being in the high credible state remains high even during and after the 1993 crisis. In the case of Austria the filtered probability of being in the high credible state increased after 1995. This is consistent with the fact that Austria joined the EMS in January 1995.[7]

DISCUSSION

We commence the discussion of our results with France (Table 1). The first column of Table 1 indicates that inflation variability is positively significant only in the high credible state (i.e. $\beta_{12.1}$ = 0.434). The sign of the coefficient is consistent with the view that when inflation variability increases, the probability to switch from the high credible state to the low credible state increases. The positive and significant coefficient of inflation variability in the high credible state implies that shocks that have increased the inflation variability push the central bank to accommodate higher inflation at the discretionary level. The fact that inflation variability is not significant in the low credible is consistent with the evidence that only the autoregressive coefficient of the variance in the high credible state (i.e. α_1) is significant and positive. The presence of ARCH effects only in the high credible regime, indicates that shocks in this regime increase the cost to monetary authorities of high interest rates. Under such circumstances, monetary authorities inflate at the discretionary level to reduce the pressure arising from high inflation expectations. The second column of Table 1 indicates that output-gap variability has an insignificant impact on the transition probability in both states. Results from the simultaneous estimation of the effects of inflation variability and output-gap variability on the transition probability confirm the results from the individual estimations. In particular, only inflation variability in the high credible state found significant (see the third column of Table 1).[8] In other words, monetary policy in France has been more sensitive to inflation variability rather than to output-gap variability.

In Italy inflation variability is significant only in the high credible state at the 10 percent level (i.e.

$\beta_{12.1}$=0.678, with a p value of 0.093; see the first column of Table 2). The weak effects of inflation variability on the transition probability do not reflect the insignificance of inflation in the loss function of the Bank of Italy. It rather implies low credibility of the disinflation policy followed by the Italian authorities. The low weight on the inflation variability in the loss function did not lead to significant output-gap variability (see column two, Table 2). Although the coefficient of output-gap variability has the correct sign (i.e. positive in the high credible state and negative in the low credible state), it was not significant in any regime. Simultaneous estimation of the effects of inflation and output-gap variability on the transition probability shows that none of these variabilities are significant (see the third column of Table 2). The low credibility of Italy's policies might be due to the high debt/GDP ratio and to the overvaluation of the Italian lira against the DM prior to the September 1992 currency crisis (see De Grauwe, 1997). However, the success of the Italian authorities to reduce inflation at the level required by the Maastricht criteria and to stabilise the debt/GDP ratio at the beginning of the 1990s (still at a high level) might indicate how difficult it was for Italy to achieve credibility and to reduce inflation. This can be justified by the ARCH coefficients where the second lag in the low credible state (i.e. d_2) is significant and higher than that of the first lag in the high credible state (i.e. α_1). Once monetary policy switched from the high credible state into the low credible state it was no longer an easy task for the Italian monetary authorities to regain credibility and return back to the high credible state.

In the case of the Netherlands inflation variability is positive and significant only in the high credible regime ($\beta_{12.1}$ = 0.421). The insignificance of inflation variability in the low credible regime although with the correct sign (i.e. $\beta_{21.1}$ = -0.162) might be due to the high credibility of low inflationary policy, thereby helping to reduce inflationary expectations. This is consistent with the ARCH coefficients where the variance in the low credible state is higher and less persistence (i.e. $\alpha_0 < d_0$ and $\alpha_1 > d_1$). Both the constant and the autoregressive coefficients of the variance in the low credible regime are not significant. The second column of Table 3 shows that output-gap variability is positively significant in both regimes (i.e. $\beta_{12.2}$ = 0.507 and $\beta_{21.2}$ = 0.256). Although the positive coefficients in the low credible state is not consistent with the view that there is a negative relationship between output-gap variability and transition probability from the low credible state to the high credible state, it might be explained by a credible announcement and intention to achieve and maintain low rate of inflation in the future. Under these circumstances, the public has confidence that the central bank is of the low inflation type (i.e. dry type), and does not intend to deviate from the German interest rate policy. This is in line with the evidence that the autoregressive coefficient of the conditional variance in the low credible state (i.e. d_1) is negative. A negative autoregressive coefficient in the conditional variance has stabilizing effects on the unconditional variance. This implies that monetary policy pursued by the Dutch monetary authorities intended to reduce inflation expectations. This can also explain the higher coefficient of output-gap variability ($\beta_{12.2}$) than the coefficient of the inflation variability ($\beta_{12.1}$). Since monetary authorities enjoy high credibility, they can minimise the output-gap variability without undermining the objective of inflationary stability. In the third column of Table 3, simultaneous estimation of the effects of inflation variability and output-gap variability show that both of them are significant and positive only in the high credible regime. The autoregressive coefficients of the variance in both regimes are all significant. The first lag in the low credible regime (i.e. d_1) is negative, confirming the result that monetary policy in the Netherlands was directed towards stabilizing inflation expectations.

The first column of Table 4 shows that in Belgium inflation variability has significant and positive effects only in the high credible state (i.e. $\beta_{12.1}$ = 1.648). The significance of inflation variability and the insignificance of output-gap variability in the high credible state, indicate that the former was the primary objective in the loss function of the Belgian central Bank. The case of Belgium concerning inflation variability is similar to that of France. However, the third column of Table 4 shows that the variability of both the output-gap and inflation are not significant in any state. We rely, though, more on the results derived from the individual estimation (columns one and two of Table 4), since the number of coefficients estimated in these cases, is less than that of the simultaneous estimation (column three). With a smaller number of coefficients to be estimated, it is easier to achieve convergence of maximum likelihood estimation.[9]

The results for Austria (Table 5) clearly indicate that inflation variability is significant in both regimes with the correct sign (i.e. positive in the high credible regime, $\beta_{12.1}$ = 0.216, and negative in the low credible regime, $\beta_{21.1}$ = -0.352). Output-gap variability is also significant in both regimes but with a positive coefficient in the low credible state (i.e. $\beta_{12.2}$ = 11.4, $\beta_{21.2}$ = 4.5670). The positive coefficient in the low credible state might be due to high credible disinflationary policy so that output-gap variability is stabilized with a lower cost. This is consistent with the low value of the autoregressive coefficient of the conditional variance in the low credible state (i.e. d_1 = 0.053, d_2 = 0.057; note, however, that the first lag of the ARCH process in the low credible state is not significant). The coefficients of the output-gap variability in both states are higher than those of the inflation variability. This indicates that monetary authorities in Austria put more weight on the output-gap stabilization in their loss function.

SUMMARY AND CONCLUSIONS

We have used the Markov regime-switching framework, with a state-dependent transition probability, to analyse the credibility of monetary policies in a subset of EMS countries. Monetary policies over the entire EMS period have been assessed in relation to the German monetary policy over the period. The evidence produced in this study indicates the existence of asymmetric effects, with the information variables in the transition probabilities having different effects in each state. The impact of inflation variability and output-gap variability, for most countries, is significant in the high credible state and insignificant in the low credible state. This might be due to the high credibility of central bank monetary policy concerning future disinflationary policies. An important result is that inflation variability has higher effects than output-gap variability on the transition probabilities. In France and Belgium inflation variability is found significant only in the high credible state. In the Netherlands individual estimations show that output-gap variability had a higher impact on the transition probability than inflation variability. However, this result is contradicted by the results of the simultaneous estimation. The higher effects of output-gap variability in this country might be due to the high credibility of monetary policy there. Our results indicate that most of the countries under consideration enjoy high credibility concerning the disinflation policy required to join the EMU (with the exception of Italy).

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NOTES

1. The link between inflation and output-gap variabilities may be shown analytically. We follow Cecchetti (1998) and derive the trade-off between inflation and output-gap variability by assuming that the loss function (1) is additionally subject to the dynamics of output and prices; it can, thus, be made a function of the policy control variable (i.e. the interest rate) and the stochastic processes driving the economy. In particular, we may minimize (1) subject to:
   $y_t = \gamma(i_t - d_t) + s_t$
   $p_t = -(i_t + d_t) - \theta s_t$
   where γ is the inverse slope of the supply curve and θ is the slope of aggregate demand; d_t and s_t are the demand and the supply shocks respectively. In this linear model the optimal policy will be linear, i.e.
   $i_t = \alpha d_t + \beta s_t$
   Substituting this optimal policy into y_t and p_t we obtain their variances σ_y^2 and σ_π^2. Cecchetti (op. cit.) shows that the ratio σ_y^2/σ_π^2 is a function of policy preferences λ and of the inverse of the slope of the supply curve γ (i.e. $\sigma_y^2/\sigma_\pi^2 = [\lambda/\gamma(\lambda-1)]^2$).
2. Froot and Rogoff (1991) argue that interest rate differentials follow an ARMA (p, q) process. Under the assumption that the exchange rate is a random walk, the error term of the ARMA specification reflects the risk premium of the domestic interest rate to deviate from the foreign interest rate.
3. The discretionary rate is that rate set by the central bank as a result of the optimization of its loss function, given public's expectations.
4. One attractive feature of stochastic volatility models is that they can be extended to a multivariate framework (see Harvey et. al., 1994). Stochastic volatility models, based on the log of variabilities, can capture the presence of a variability trade-off between inflation and output-gap in a way that no other multivariate model of variabilities can capture (see Arestis et. al., 2002).
5. However, in the case of industrial production the series of stochastic volatility was so volatile that convergence did not take place in the estimation of the Markov regime-switching model with time varying transition probabilities. We were, thus, forced to smooth the series by using a twelve-order moving average.
6. There is just one exception to these results in the case of France. The squared standardized residuals are serially autocorrelated in regime 2. We tried to cure this in two ways: first, increasing the number of lags both of the conditional mean and of the conditional variance which, however, did not make any difference. Second, we experimented with a statistical model that includes three regimes. This proved impossible to complete because the maximum likelihood function did not converge.
7. Evidence of low filtered probability of being in the high credible state before 1995, indicates the high flexibility that monetary authorities in Austria experienced rather than their low credibility regarding the attempt to follow Germany's monetary policy. This is so, because the

interest rate differential between Germany and Austria was close to zero during the period under consideration.

8. Results of ARCH effects derived both from the estimation of output-gap variability and of simultaneous estimation are the same as in the case of inflation variability.
9. For the optimization of maximum likelihood function we employed the BFGS and BHHH algorithms.

APPENDIX

Table 1: France: Parameters Estimates and Related Statistics for Regime-Switching ARCH Models.

	Transition Probability in the case of inflation variability	Transition Probability in the case of output-gap variability	Transition probability in the case of joint estimation
b_0	0.0223(0.340)	0.0208 (0.413)	0.022 (0.352)
b_1	0.985 (0.000)	0.984 (0.000)	0.985 (0.000)
c_0	-0.955 (0.199)	-1.522 (0.017)	-1.035 (0.151)
c_1	0.637 (0.002)	0.469 (0.025)	0.620 (0.002)
α_0	0.201 (0.000)	0.206 (0.000)	0.202 (0.000)
α_1	0.508 (0.0002)	0.451 (0.003)	0.518 (0.0006)
d_0	2.099 (0.000)	2.066 (0.000)	2.104 (0.000)
d_1	0.0005 (0.983)	0.017 (0.590)	0.002 (0.929)
$\beta_{12.0}$	0.556 (0.643)	-4.488 (0.076)	0.008 (0.998)
$\beta_{12.1}$	0.434 (0.031)	-	0.413 (0.056)
$\beta_{12.2}$	-	-0.286 (0.356)	-0.050 (0.876)
$\beta_{21.0}$	14.451 (0.121)	-7.796 (0.351)	7.666 (0.510)
$\beta_{21.1}$	1.988 (0.104)	-	2.015 (0.168)
$\beta_{21.2}$	-	-1.062 (0.237)	-0.909 (0.255)

Box-Pierce Q-statistics on Residual Autocorrelation: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
0.07 (0.96)	0.26 (0.96)	0.51 (0.99)	3.95 (0.85)	6.17 (0.04)	9.94 (0.04)	10.79 (0.09)	12.48 (0.13)

Box-Pierce Q-statistics on Residual Heteroscadasticity: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
0.10 (0.94)	1.59 (0.80)	9.13 (0.16)	9.17 (0.32)	5.43 (0.06)	11.84 (0.01)	19.7 (0.008)	20.4 (0.004)

Notes: (1) p-values are in brackets (i.e. the null hypothesis that the given coefficient is equal to zero).
(2) Coefficients β12.1 and β21.1 in the second column denote the effects of inflation in the high and low credible state respectively.
(3) Coefficients β12.2 and β21.2 in the third column denote the effects of output-gap variability in the high and low credible state respectively.
(4) Coefficients β12.1 and β12.2 in the simultaneous estimation (in the third column) denote the effects of inflation variability and output-gap variability in the high credible state. Moreover, the coefficients β21.1 and β21.2 denote the effects of inflation variability and output-gap variability in the low-credible state.
(5) The Box-Pierce Q(m)-statistic follows a χ^2 (m) distribution, where m is the number of degrees of freedom.

Table 2: Italy: Parameters Estimates and Related Statistics for Regime-Switching ARCH Models.

	Transition Probability in the case of inflation variability	Transition Probability in the case of output-gap variability	Transition probability in the case of joint estimation
b_0	0.092 (0.122)	0.123 (0.030)	0.095 (0.119)
b_1	0.995 (0.000)	1.0007 (0.000)	0.992 (0.000)
c_0	-0.961 (0.0001)	-0.732 (0.003)	-0.921(0.0001)
c_1	0.931 (0.000)	0.956 (0.000)	0.932 (0.000)
α_0	0.288 (0.000)	0.284 (0.000)	0.283 (0.000)
α_1	0.243 (0.007)	0.234 (0.015)	0.242 (0.016)
α_2	0.004 (0.905)	0.001 (0.955)	0.0007 (0.979)
d_0	0.410 (0.00001)	0.478 (0.0008)	0.386 (0.000)
d_1	0.174 (0.122)	0.151 (0.147)	0.178 (0.117)
d_2	0.546 (0.006)	0.530 (0.028)	0.524 (0.002)
$\beta_{12.0}$	1.687 (0.470)	0.353 (0.918)	5.914 (0.297)
$\beta_{12.1}$	0.678 (0.093)	-	0.733 (0.108)
$\beta_{12.2}$	-	0.344 (0.466)	0.509 (0.388)
$\beta_{21.0}$	-3.437 (0.322)	-2.808 (0.617)	-13.195 (0.101)
$\beta_{21.1}$	-0.559 (0.367)	-	-0.864 (0202)
$\beta_{21.2}$	-	-0.283 (0.712)	-1.105 (0.145)

Box-Pierce Q-statistics on Residual Autocorrelation: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
3.72 (0.15)	7.40 (0.11)	10.13 (0.11)	11.28 (0.24)	4.21 (0.12)	7.49 (0.11)	10.35 (0.11)	10.41 (0.23)

Box-Pierce Q-statistics on Residual Heteroscadasticity: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
5.29 (0.07)	5.99 (0.19)	6.12 (0.40)	6.29 (0.61)	1.06 (0.58)	1.15 (0.88)	1.19 (0.99)	1.22 (0.99)

Notes: (1) p-values are in brackets (i.e. the null hypothesis that the given coefficient is equal to zero).
(2) Coefficients $\beta_{12.1}$ and $\beta_{21.1}$ in the second column denote the effects of inflation in the high and low credible state respectively.
(3) Coefficients $\beta_{12.2}$ and $\beta_{21.2}$ in the third column denote the effects of output-gap variability in the high and low credible state respectively.
(4) Coefficients $\beta_{12.1}$ and $\beta_{12.2}$ in the simultaneous estimation (in the third column) denote the effects of inflation variability and output-gap variability in the high credible state. Moreover, the coefficients $\beta_{21.1}$ and $\beta_{21.2}$ denote the effects of inflation variability and output-gap variability in the low-credible state.
(5) The Box-Pierce Q(m)-statistic follows a χ^2 (m) distribution, where m is the number of degrees of freedom.

Table 3: Netherlands: Parameters Estimates and Related Statistics for Regime-Switching ARCH Models.

	Transition Probability in the case of inflation variability	Transition Probability in the case of output-gap variability	Transition probability in the case of joint estimation
b_0	-0.004 (0.871)	-0.006 (0.689)	-0.002 (0.220)
b_1	0.934 (0.000)	0.932 (0.000)	0.936 (0.000)
c_0	-0.119 (0.664)	-0.109 (0.231)	-0.264 (0.000)
c_1	0.559 (0.000)	0.547 (0.000)	0.630 (0.000)
α_0	0.213 (0.000)	0.211 (0.000)	0.215 (0.000)
α_1	0.254 (0.078)	0.239 (0.076)	0.270 (0.002)
d_0	0.867 (0.177)	0.815 (0.000)	0.816 (0.000)
d_1	-0.216 (0.206)	-0.193 (0.000)	-0.204 (0.000)
$\beta_{12.0}$	-0.165 (0.749)	-0.136 (0.789)	-0.150 (0.734)
$\beta_{12.1}$	0.421 (0.00008)	-	0.230 (0.0008)
$\beta_{12.2}$	-	0.507 (0.000)	0.191 (0.001)
$\beta_{21.0}$	-2.335 (0.241)	-0.252 (0.628)	-1.235 (0.264)
$\beta_{21.1}$	-0.162 (0.776)	-	-0.192 (0.171)
$\beta_{21.2}$	-	0.256 (0.0002)	0.224 (0.210)

Box-Pierce Q-statistics on Residual Autocorrelation: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
4.21 (0.12)	6.33 (0.17)	6.52 (0.36)	10.89 (0.20)	4.20 (0.12)	12.57 (0.01)	14.53 (0.02)	15.11 (0.05)

Box-Pierce Q-statistics on Residual Heteroscadasticity: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
2.84 (0.24)	5.02 (0.28)	10.23 (0.15)	11.89 (0.15)	1.15 (0.56)	2.31 (0.67)	9.74 (0.13)	11.51 (0.17)

Notes: (1) p-values are in brackets (i.e. the null hypothesis that the given coefficient is equal to zero).
(2) Coefficients $\beta_{12.2}$ and $\beta_{21.2}$ in the second column denote the effects of inflation in the high and low credible state respectively.
(3) Coefficients $\beta_{12.2}$ and $\beta_{21.2}$ in the third column denote the effects of output-gap variability in the high and low credible state respectively.
(4) Coefficients $\beta_{12.2}$ and $\beta_{12.2}$ in the simultaneous estimation (in the third column) denote the effects of inflation variability and output-gap variability in the high credible state. Moreover, the coefficients $\beta_{21.2}$ and $\beta_{21.2}$ denote the effects of inflation variability and output-gap variability in the low-credible state.
(5) The Box-Pierce Q(m)-statistic follows a χ_2 (m) distribution, where m is the number of degrees of freedom.

Table 4: Belgium: Parameters Estimates and Related Statistics for Regime-Switching ARCH Models.

	Transition Probability in the case of inflation variability	Transition Probability in the case of output-gap variability	Transition Probability in the case of joint estimation
b_1	0.738 (0.000)	0.690 (0.000)	0.699 (0.000)
b_1	0.879 (0.000)	0.887 (0.000)	0.889 (0.000)
α_0	0.136 (0.000)	0.149 (0.000)	0.148 (0.000)
α_1	0.096 (0.330)	0.134 (0.544)	0.135 (0.018)
α_2	0.592 (0.004)	-0.010 (0.138)	-0.009 (0.133)
d_0	1.065 (0.000)	1.062 (0.000)	1.066 (0.000)
d_1	0.042 (0.151)	0.028 (0.145)	0.028 (0.205)
d_2	0.005 (0.752)	0.103 (0.013)	0.105 (0.017)
$\beta_{12.0}$	-5.144 (0.0006)	2.181 (0.734)	-0.480 (0.935)
$\beta_{12.1}$	1.648 (0.045)	-	0.729 (0.376)
$\beta_{12.2}$	-	0.770 (0.420)	1.786 (0.428)
$\beta_{21.0}$	-2.767 (0.000)	-0.123 (0.979)	0.278 (0.959)
$\beta_{21.1}$	-0.0007 (0.998)	-	0.488 (0.905)
$\beta_{21.2}$	-	0.454 (0.498)	0.067 (0.544)

Box-Pierce Q-statistics on Residual Autocorrelation: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
3.04 (0.21)	7.01 (0.13)	8.37 (0.21)	11.5 (0.17)	7.21 (0.04)	9.35 (0.052)	10.75 (0.06)	12.1 (0.11)

Box-Pierce Q-statistics on Residual Heteroscadasticity: Joint Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
1.67 (0.43)	1.99 (0.73)	2.25 (0.89)	2.57 (0.95)	9.52 (0.01)	9.53 (0.049)	11.3 (0.07)	11.8 (0.15)

Notes: (1) p-values are in brackets (i.e. the null hypothesis that the given coefficient is equal to zero).
(2) Coefficients $\beta_{12.1}$ and $\beta_{21.1}$ in the second column denote the effects of inflation in the high and low credible state respectively.
(3) Coefficients $\beta_{12.2}$ and $\beta_{21.2}$ in the third column denote the effects of output-gap variability in the high and low credible state respectively.
(4) Coefficients $\beta_{12.1}$ and $\beta_{12.2}$ in the simultaneous estimation (in the third column) denote the effects of inflation variability and output-gap variability in the high credible state. Moreover, the coefficients $\beta_{21.1}$ and $\beta_{21.2}$ denote the effects of inflation variability and output-gap variability in the low-credible state.
(5) The Box-Pierce Q(m)-statistic follows a χ^2 (m) distribution, where m is the number of degrees of freedom.

Table 5: Austria: Parameters Estimates and Related Statistics for Regime-Switching ARCH Models.

	Transition Probability in the case of inflation variability	Transition Probability in the case of output-gap variability	Transition Probability in the case of joint estimation
b_1	0.979 (0.000)	1.003 (0.000)	1.029 (0.000)
c_1	0.726 (0.000)	0.769 (0.000)	0.760 (0.000)
α_0	0.198 (0.000)	0.108 (0.000)	0.120 (0.000)
α_1	0.843 (0.0001)	0.849 (0.136)	0.715 (0.00001)
α_2	-0.027 (0.680)	0.047 (0.000)	0.066 (0.000)
δ_0	0.732 (0.000)	0.535 (0.000)	0.556 (0.000)
δ_1	-0.148 (0.000)	0.053 (0.664)	0.015 (0.857)
δ_2	-0.046 (0.379)	0.057 (0.000)	0.057 (0.000)
$\beta_{12.0}$	-0.632 (0.076)	46.112 (0.000)	2.850 (0.000)
$\beta_{12.1}$	0.216 (0.000)	-	0.169 (0.352)
$\beta_{12.2}$	-	11.450 (0.000)	0.714 (0.001)
$\beta_{21.0}$	0.216 (0.0002)	17.776 (0.027)	-1.197 (0.083)
$\beta_{21.1}$	-0.352 (0.044)	-	1.177 (0.33)
$\beta_{21.2}$	-	4.567 (0.011)	-0.470 (0.158)

Box-Pierce Q-statistics on Residual Autocorrelation: Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
1.17 (0.55)	5.70 (0.22)	10.67 (0.09)	13.77 (0.08)	0.90 (0.35)	2.05 (0.72)	6.40 (0.37)	9.09 (0.33)

Box-Pierce Q-statistics on Residual Heteroscadasticity: Estimation							
Regime 1				Regime 2			
Q(2)	Q(4)	Q(6)	Q(8)	Q(2)	Q(4)	Q(6)	Q(8)
1.98 (0.37)	2.97 (0.56)	5.60	7.11 (0.52)	2.05 (0.35)	2.39 (0.66)	4.12 (0.66)	4.20 (0.83)

Notes: (1) p-values are in brackets (i.e. the null hypothesis that the given coefficient is equal to zero).
(2) Coefficients $\beta_{12.1}$ and $\beta_{21.1}$ in the second column denote the effects of inflation in the high and low credible state respectively.
(3) Coefficients $\beta_{12.2}$ and $\beta_{21.2}$ in the third column denote the effects of output-gap variability in the high and low credible state respectively.
(4) Coefficients $\beta_{12.1}$ and $\beta_{12.2}$ in the simultaneous estimation (in the third column) denote the effects of inflation variability and output-gap variability in the high credible state. Moreover, the coefficients $\beta_{21.1}$ and $\beta_{21.2}$ denote the effects of inflation variability and output-gap variability in the low-credible state.
(5) The Box-Pierce Q(m)-statistic follows a χ^{0} (m) distribution, where m is the number of degrees of freedom.

FIGURE 1: The Filtered Probability of High Credible State of Joint Estimation: Francedible State of Joint Estimation: France

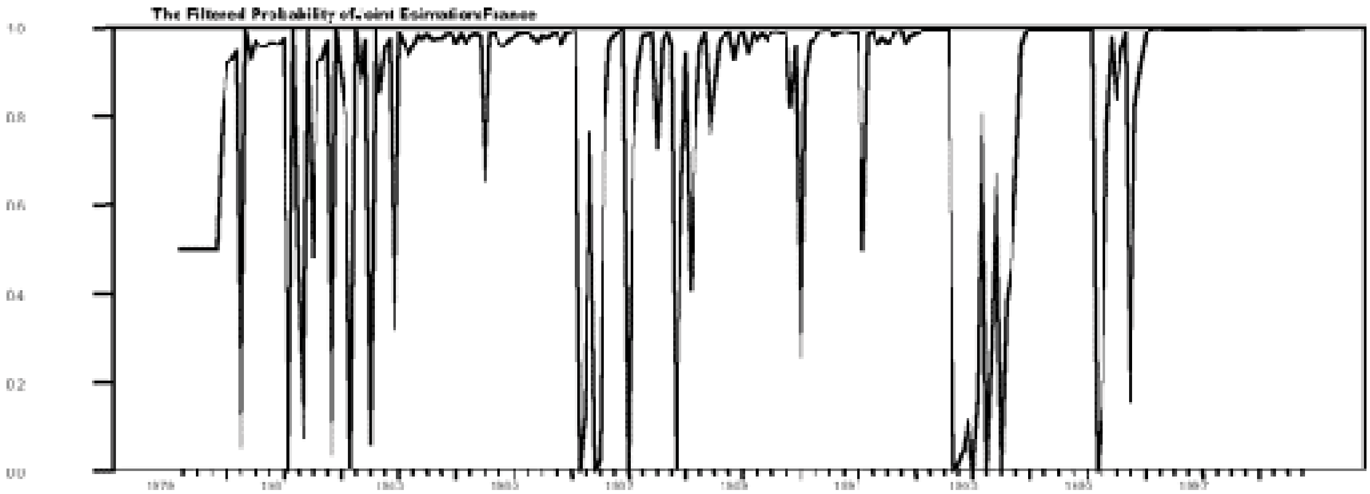


FIGURE 2: The Filtered Probability of High Credible State of Joint Estimation: Italy

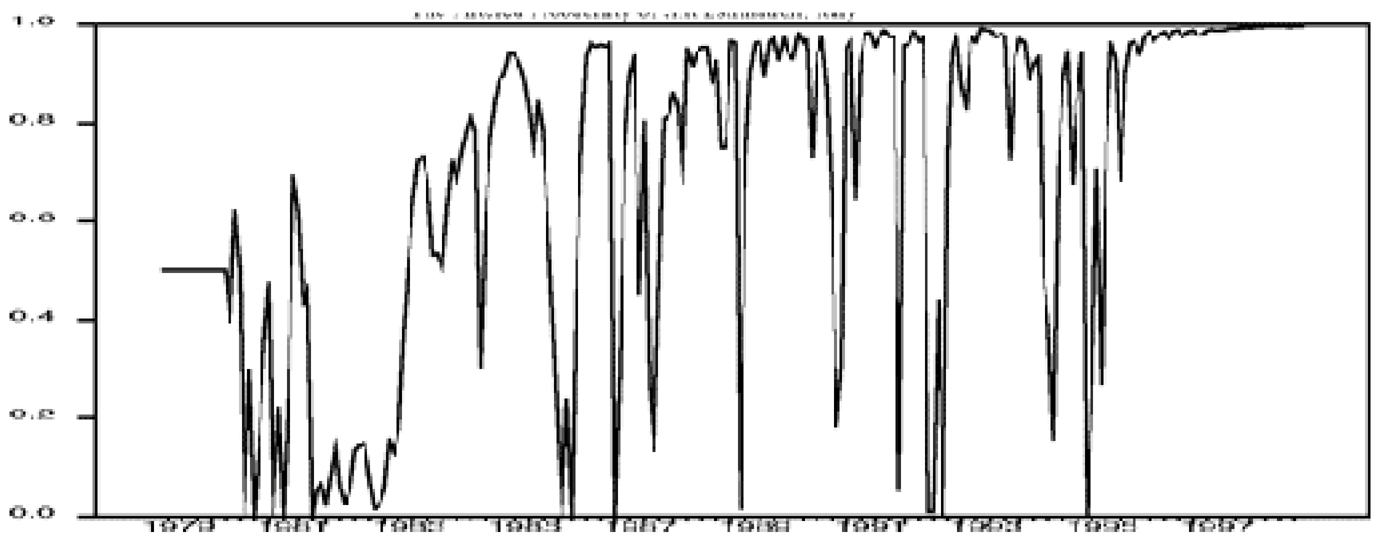


FIGURE 3: The Filtered Probability of High Credible State of Joint Estimation: The Netherlands

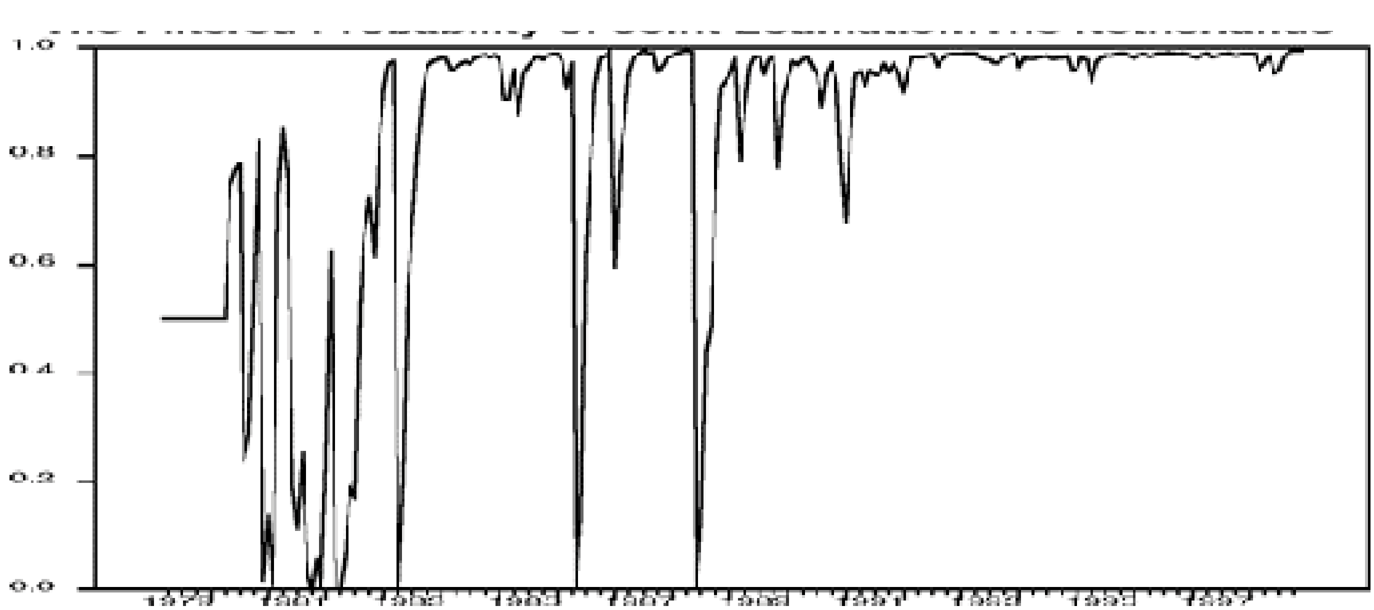


FIGURE 4: The Filtered Probability of the High Credible State of Joint Estimation: Belgium

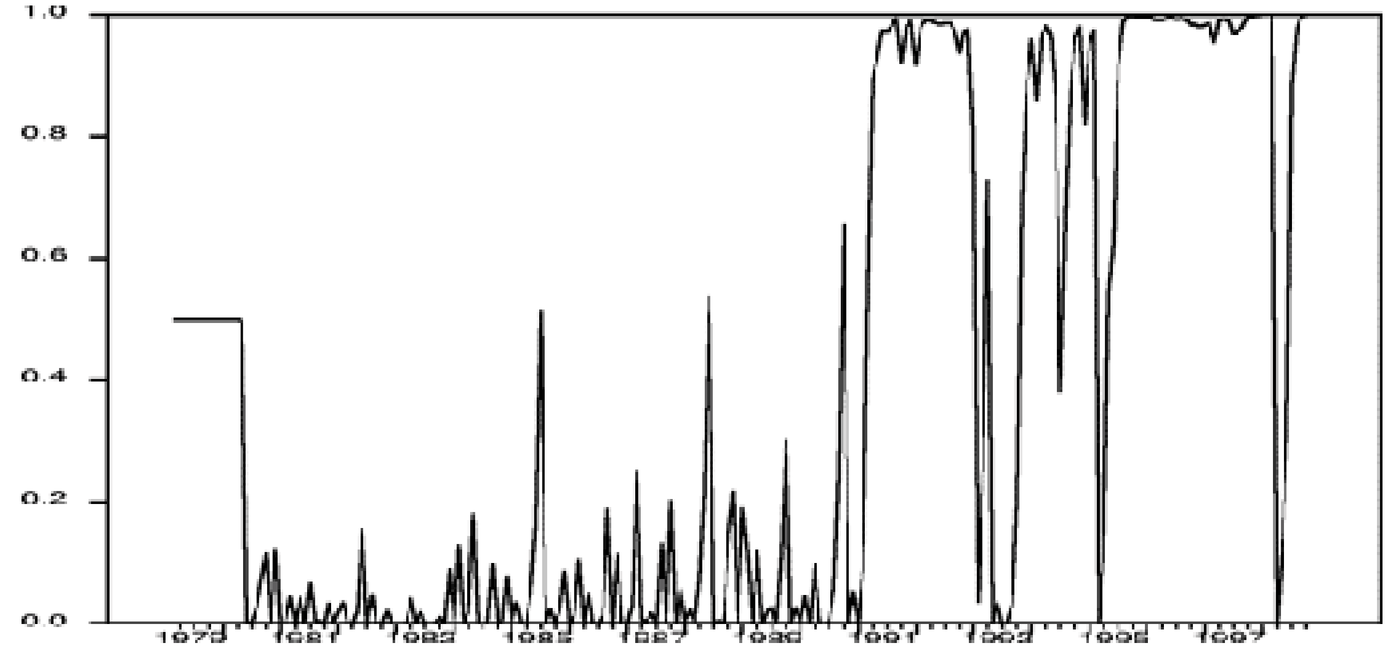
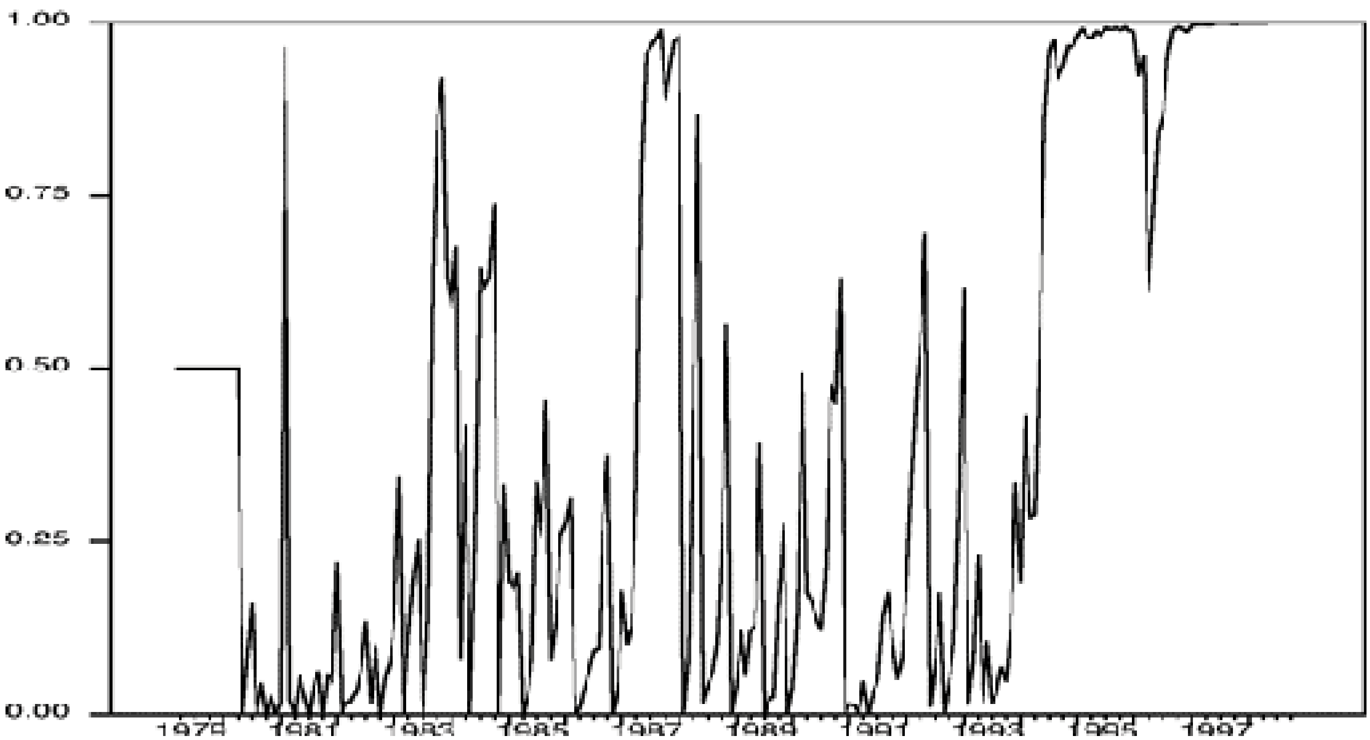
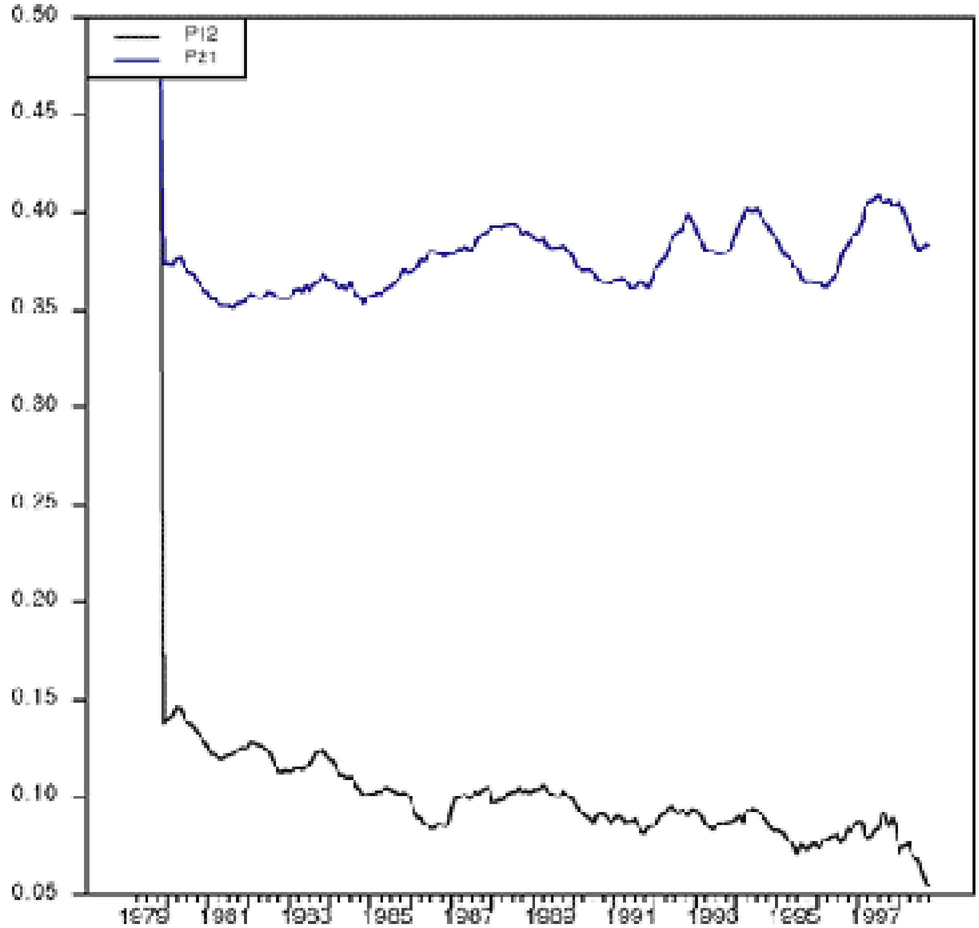


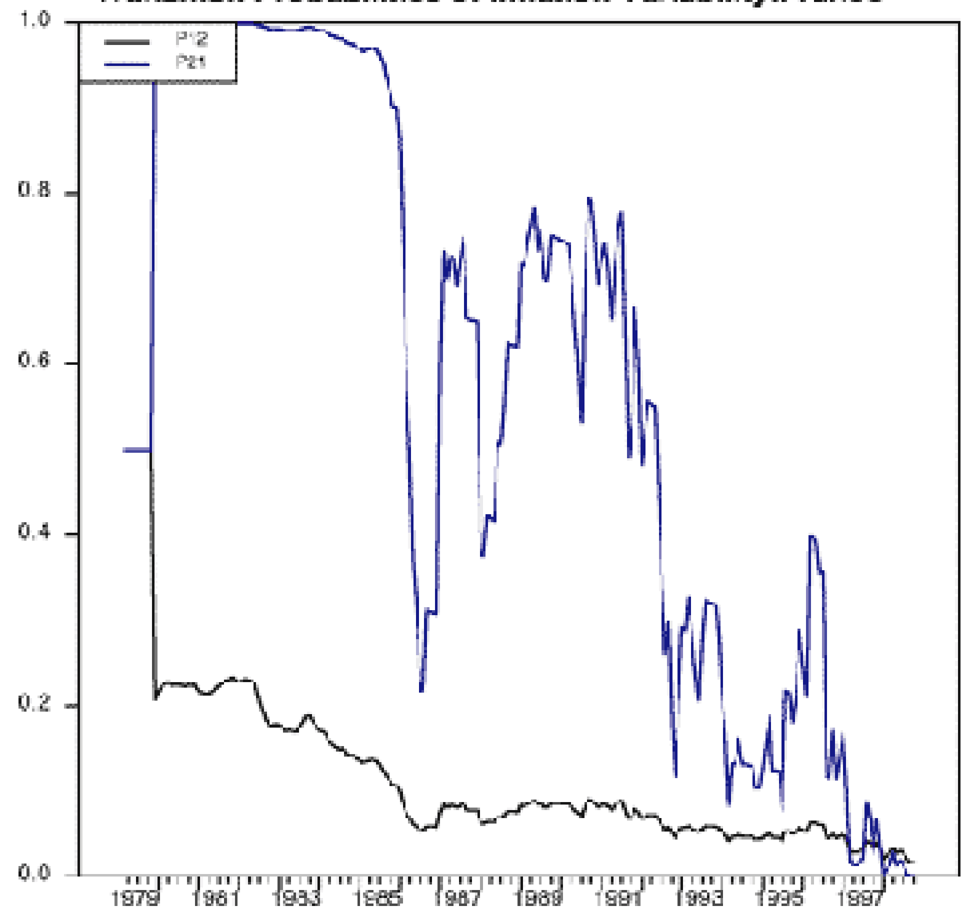
FIGURE 5: The Filtered Probability of the High Credible State of Joint Estimation: Austria



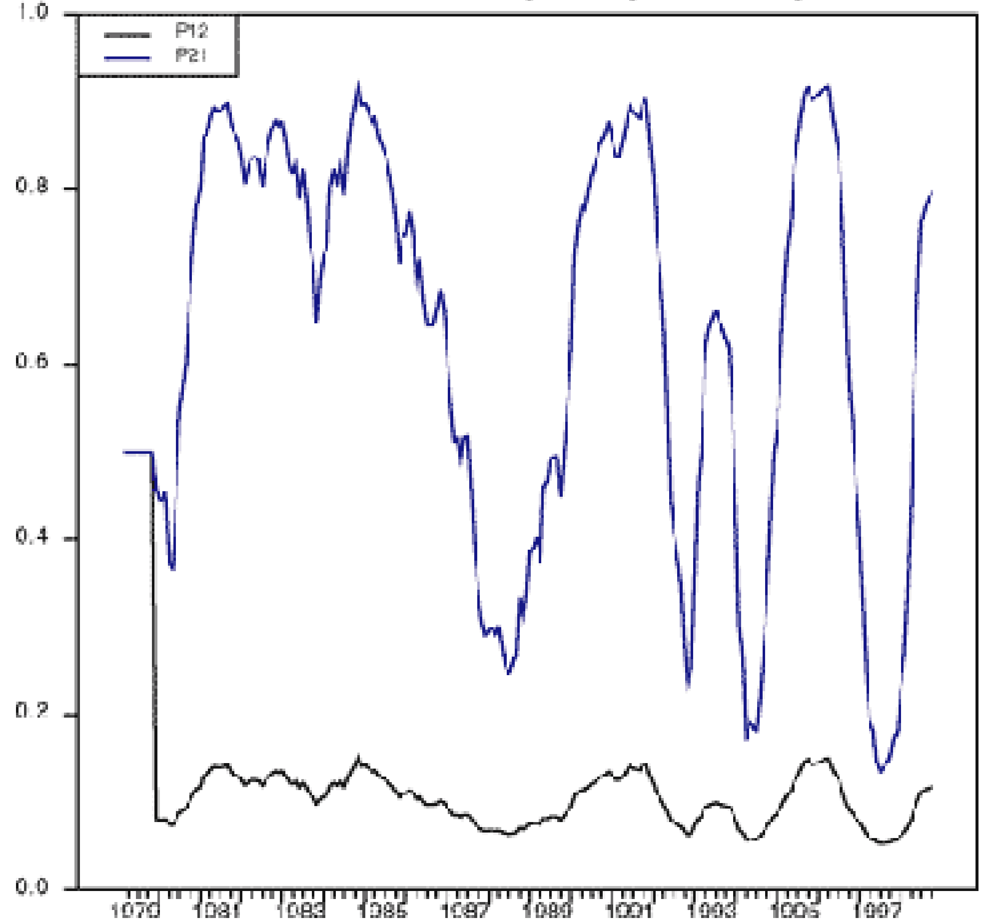
Transition Probabilities of Joint Estimation:France



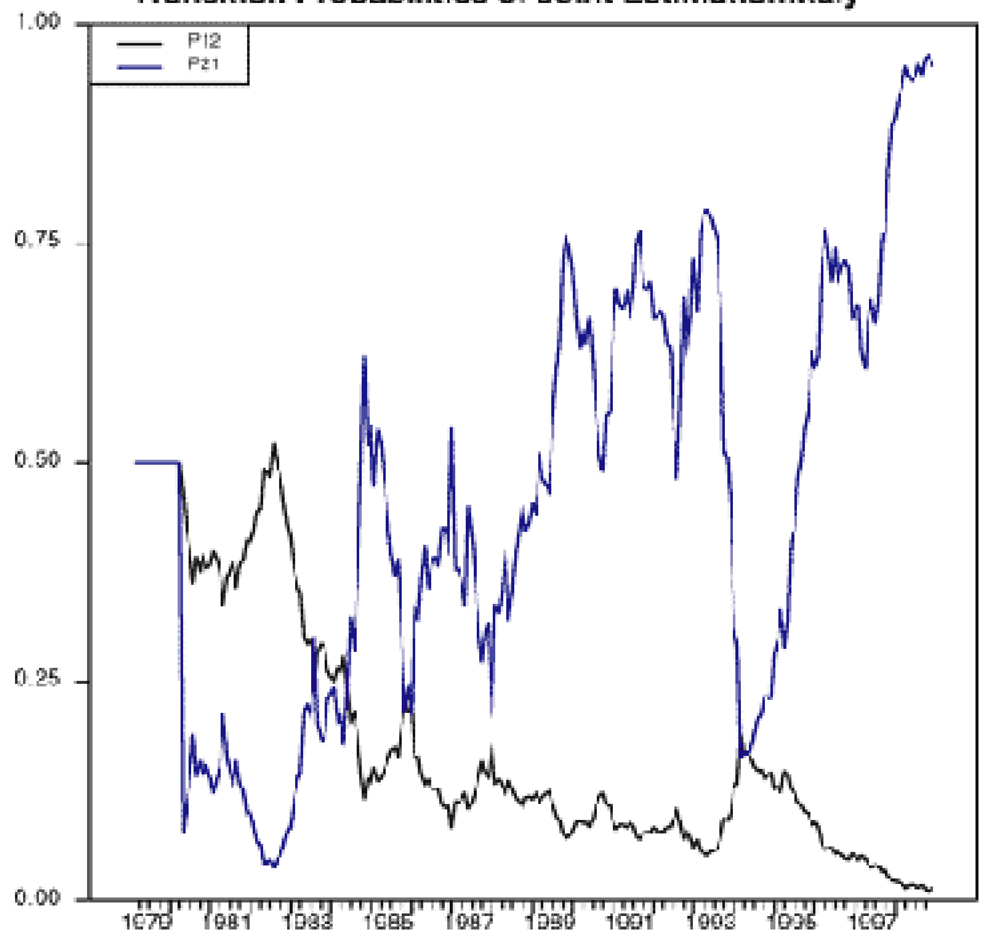
Transition Probabilities of Inflation Variability:France



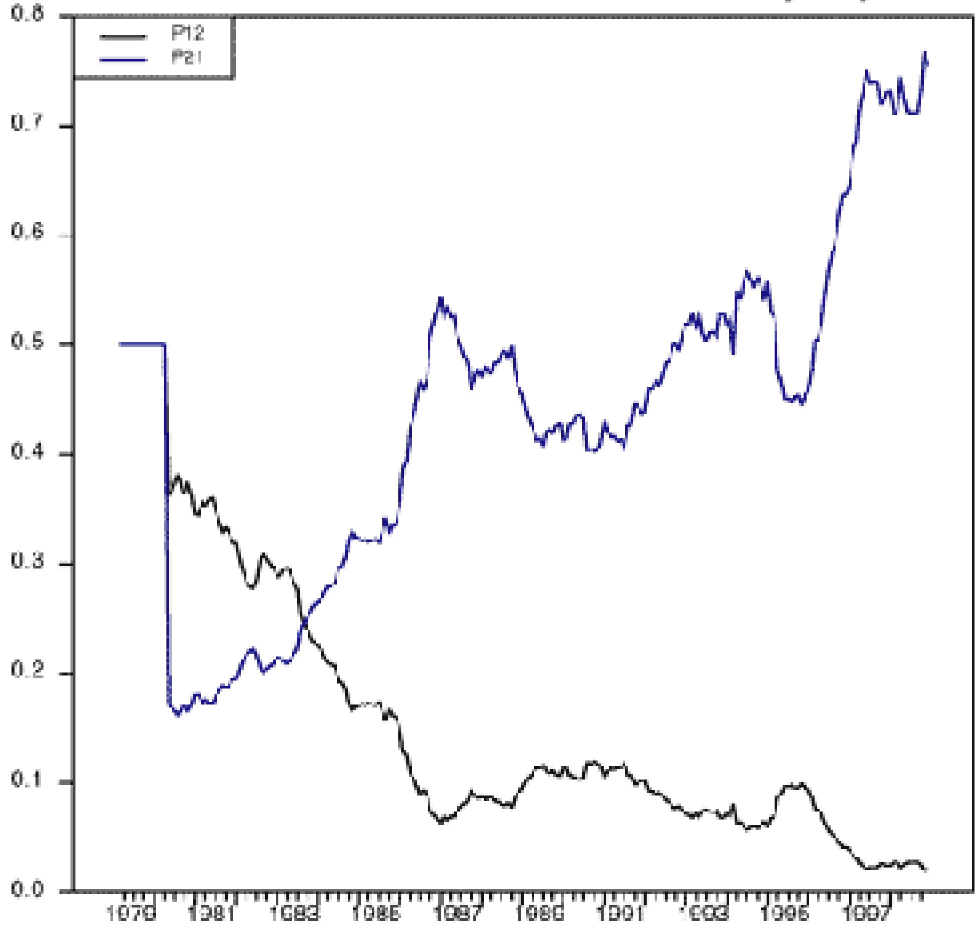
Transition Probabilities of Output-Gap Variability:France



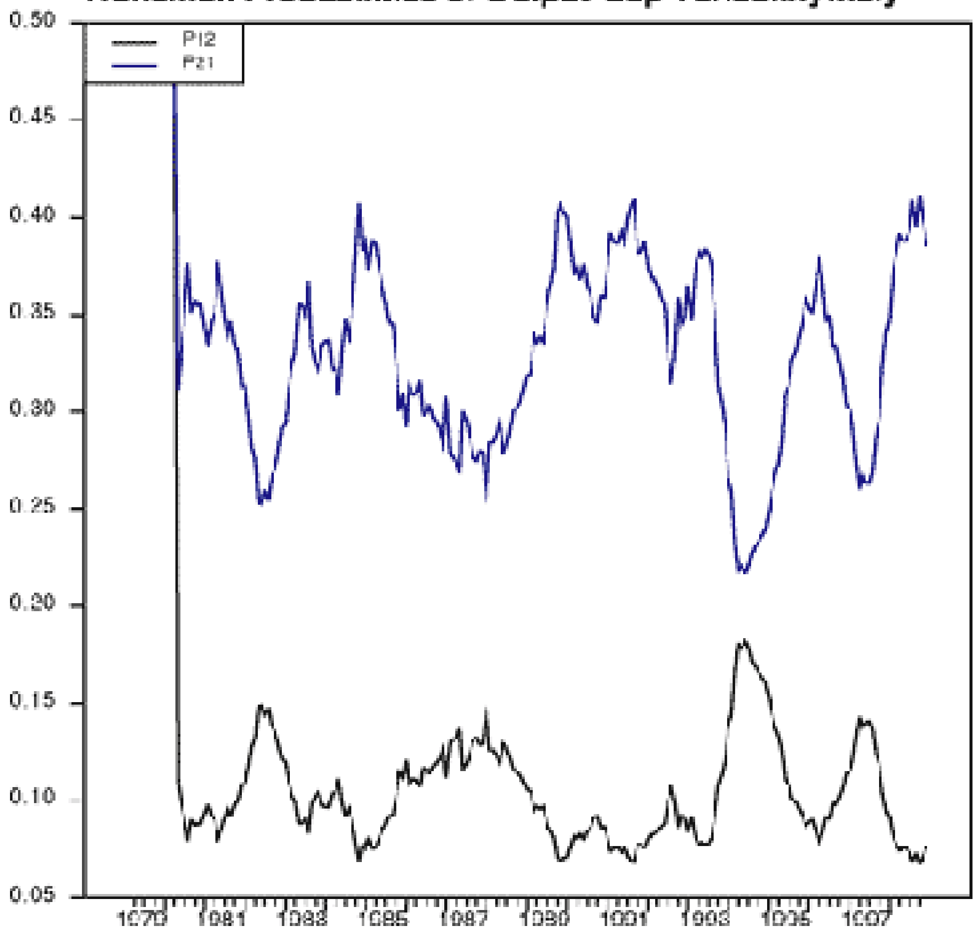
Transition Probabilities of Joint Estimation:Italy



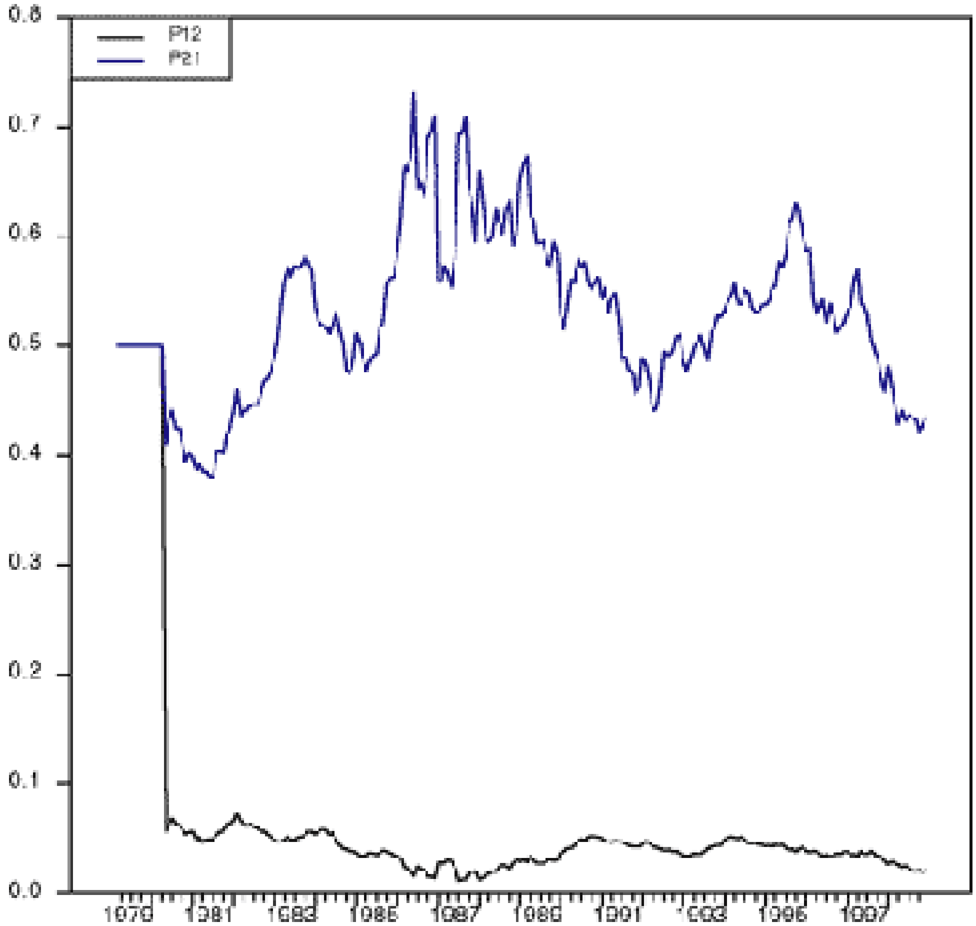
Transition Probabilities of Inflation Variability:Italy



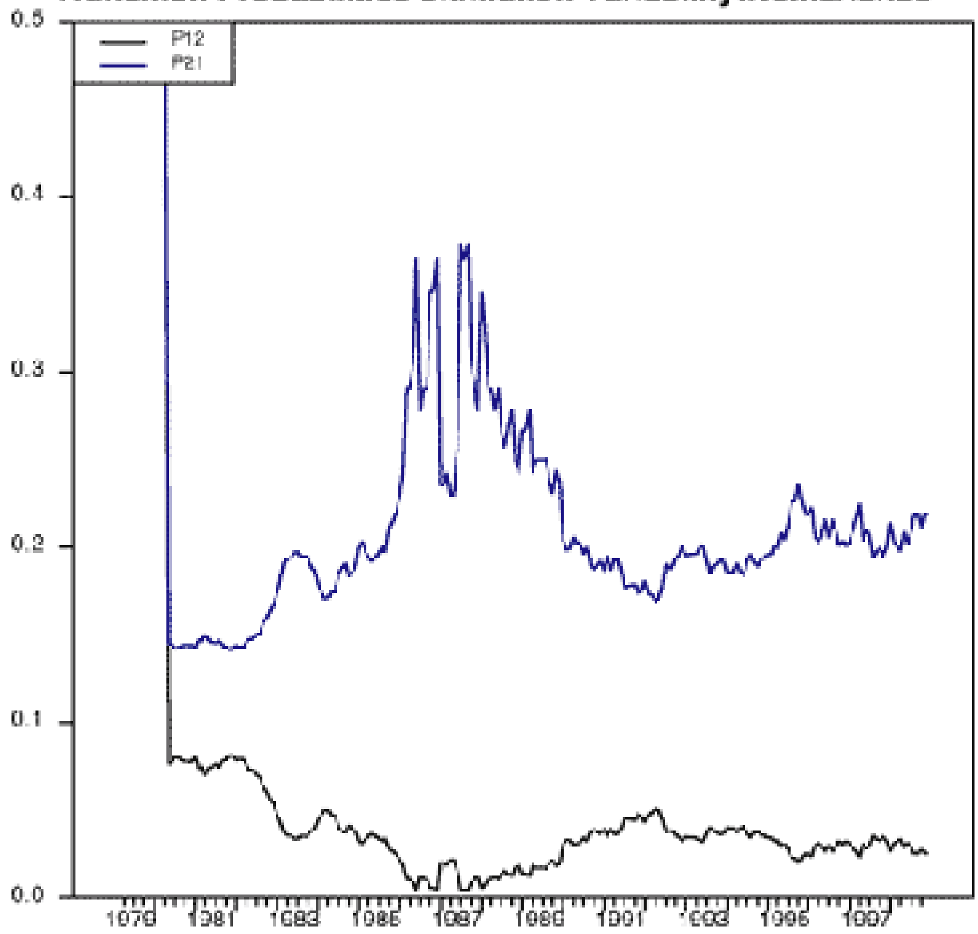
Transition Probabilities of Output-Gap Variability:Italy



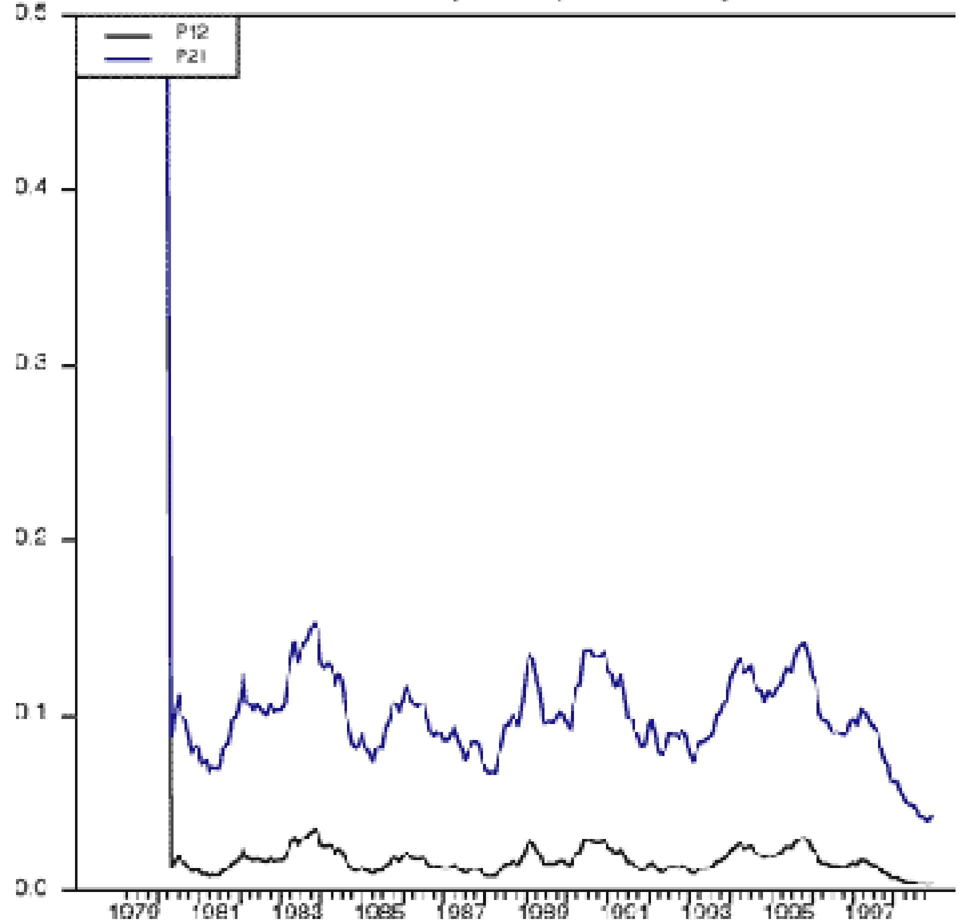
Transition Probabilities of Joint Estimation:Netherlands



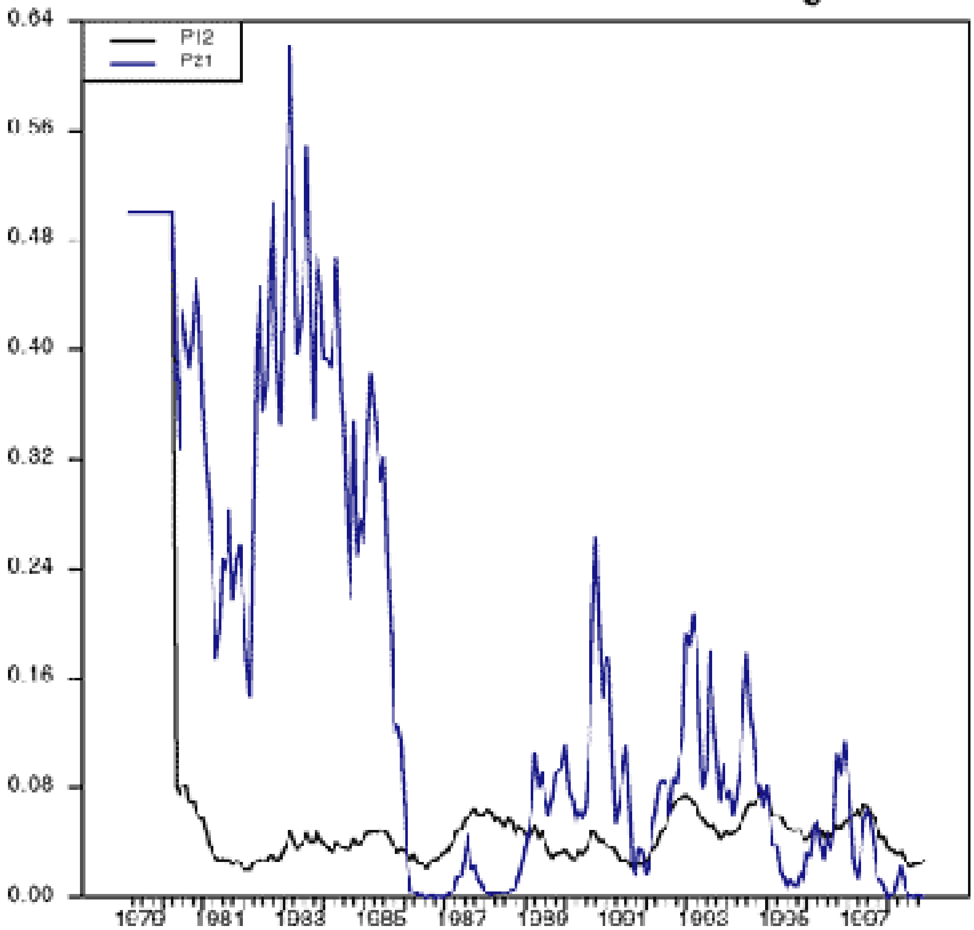
Transition Probabilities ofInflation Variability:Netherlands



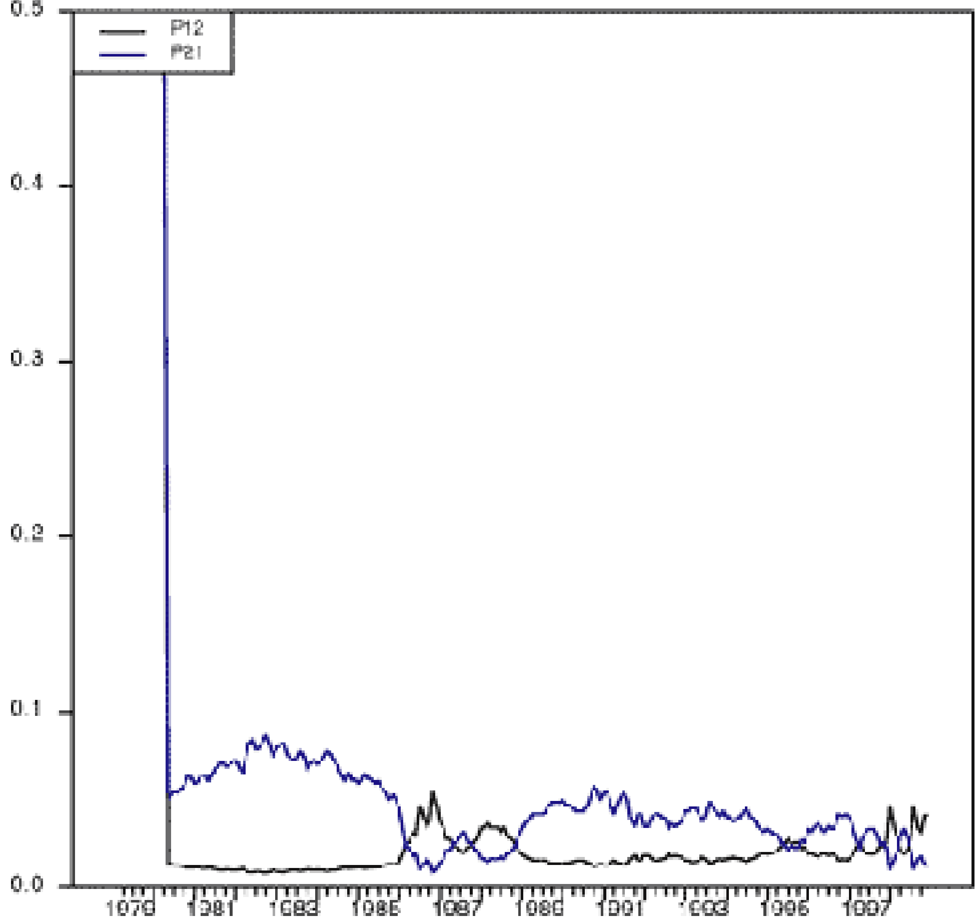
Transition Probabilities of Output-Gap Variability:The Netherlar



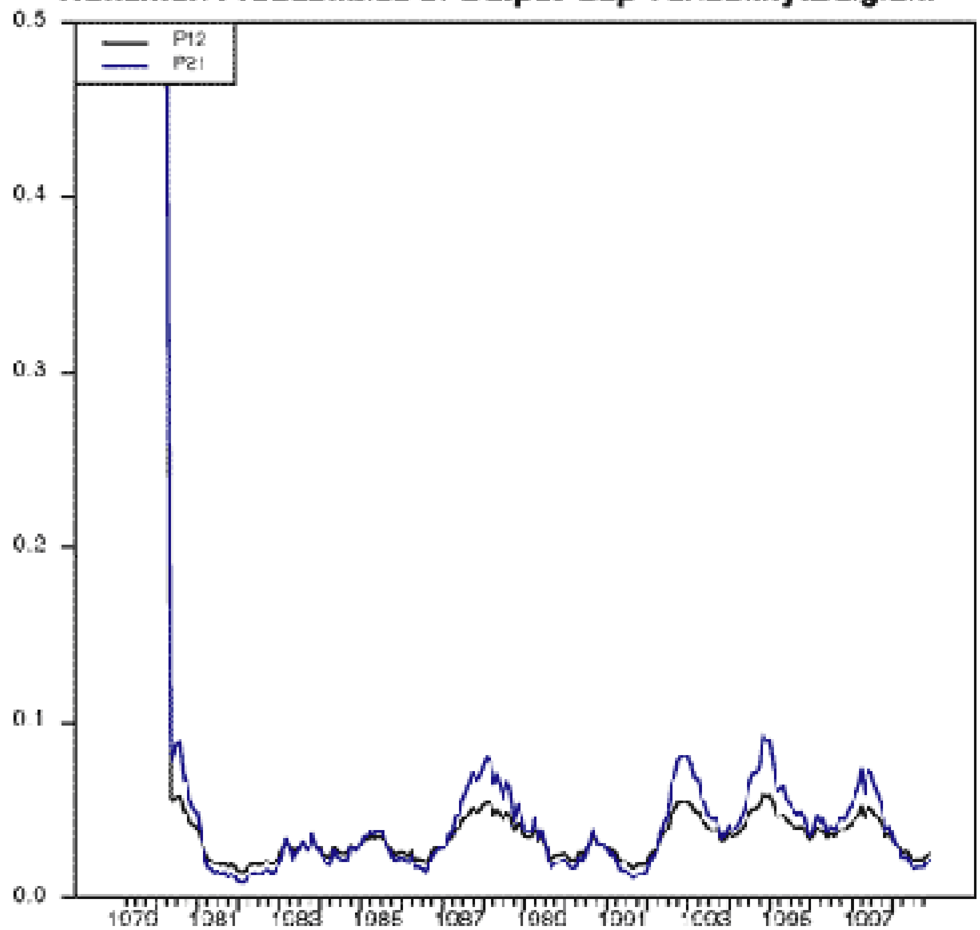
Transition Probabilities ofJoint Estimation:Belgium



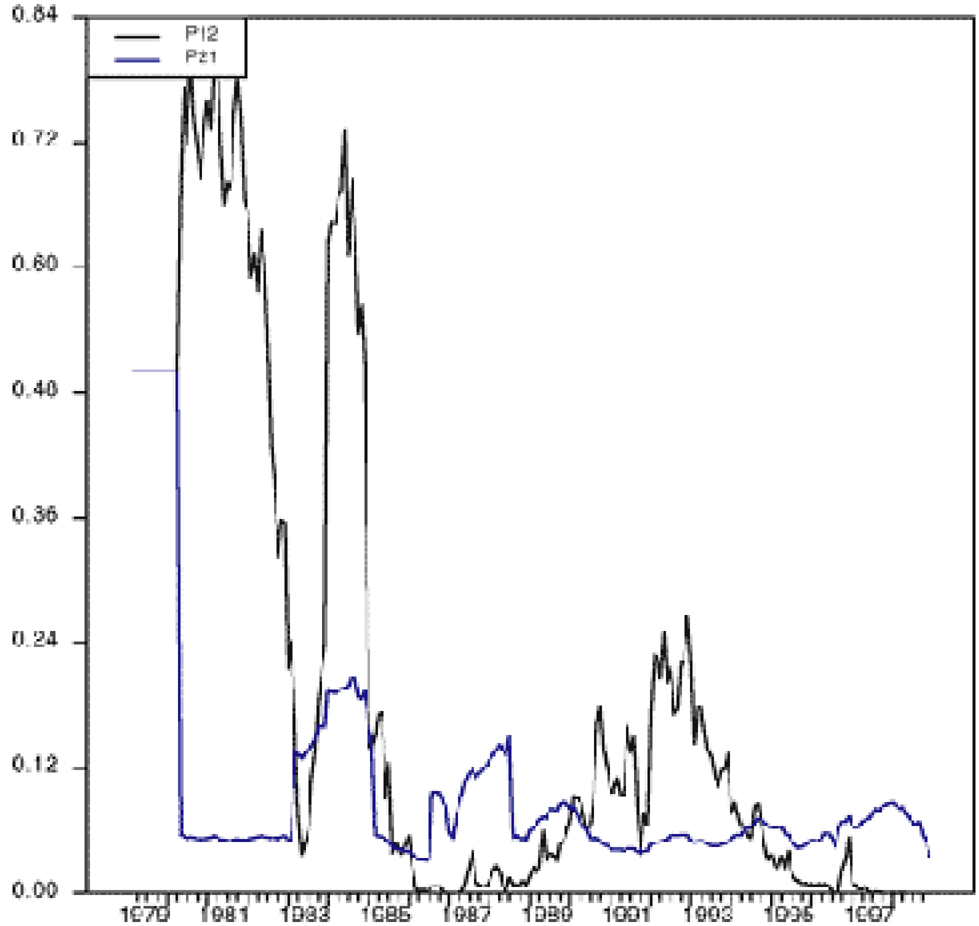
Transition Probabilities of Inflation Variability:Belgium



Transition Probabilities of Output-Gap Variability:Belgium



Transition Probabilities ofJoint Estimation:Austria



Transition Probabilities of Output-Gap Variability:Austria