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Working Paper No. 371

Credibility of Monetary Policy in Four Accession Countries: A Markov Regime-Switching Approach

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INTRODUCTION

The aim of this study is to estimate the credibility of monetary policy, with respect to a target level, in four accession countries based on the Markov regime-switching (MRS) framework. The four countries examined are the Czech Republic, Hungary, Poland and the Slovak Republic.¹ A number of studies have investigated the issue of credibility during the European Monetary System (EMS) period (Drazen and Masson, 1994; Dahlquist and Gray, 2000; Sarantis and Piard, 2000; and Arestis and Mouratidis, 2002). These studies, with the exception of Drazen and Masson (1994), utilize the Markov regime-switching model to capture the empirical and theoretical hypothesis that credibility is likely to be characterized by distinct regimes. Theoretical models on currency crises also show that credibility of monetary policy goes through different regimes. In particular, Jeane (1997) and Jeane and Masson (2000) show that strategic complementarities² between intended economic policies and policies actually pursued by the authorities, produce multiple equilibria, the dynamics of which can be studied utilizing regime-switching models (Durlauf, 1991). It is, thus, pertinent and appropriate to use the Markov regime-switching approach to study the credibility of monetary policy in the case of the four accession countries that are included in our sample.

We investigate in this paper the credibility of monetary policy of the four accession countries utilizing the theoretical proposition that in the conduct of monetary policy, there is uncertainty in terms of the type of central bank. We measure this uncertainty as a deviation of monetary policy from a target level. More concretely, we use a MRS with Autoregressive Conditional Heteroscedasticity (SWARCH) of the interest rate differential between the interest rates of the four individual accession countries and a "synthetic" interest rate of eleven EMU member countries.³ The advantage of this model is that it captures uncertainty regarding the behavior of agents (i.e. switches in the mean), and uncertainty regarding future random shocks (i.e. switches in the ARCH process). Moreover, switches in the variance capture the risk premium of the domestic monetary policy as it deviates from the monetary policy pursued by an anchor country.

This short introduction is followed by a section that is concerned with the theoretical underpinnings of the paper, especially with the issue of credibility in monetary policy. The MRS empirical methodology, adopted for our purposes, is explained in the section that follows. The penultimate section deals with the data employed and discusses the empirical findings of the paper. The final section summarizes and concludes.

THEORETICAL UNDERPINNINGS

The theoretical approach to credibility is based on the time inconsistency problem. A policy of no inflation is best in the long run but in the short-run monetary authorities have an incentive to inflate. In particular, if the public expect a zero inflation rate then the central bank finds it tempting to inflate. However, the public know about this incentive and adjust their inflation expectations at the higher level. The result will be a positive inflation rate without any output expansion since it is completely anticipated. This inflation bias is due to two reasons. First, a central bank has an incentive to inflate; and second, the central bank is unable to commit to zero inflation, since the marginal benefit of output gain is greater than the marginal cost of inflation.

A solution to this inflation bias can be achieved by increasing the marginal cost of inflation as perceived by the central bank to equal the marginal benefit. One way to increase the marginal cost of inflation takes the form of "reputation cost" in a repeated game version of the Barro-Gordon model (1983a and 1983b).⁴ In particular, if the central bank inflates today this will lead the public to expect higher inflation in the future. Therefore, the central bank suffers a reputation cost in view of its inability to deliver low inflation in the future. However, the public's expectations are based on the observed outcome of inflation and can be influenced by the actions of the central bank. Under such circumstances a central bank might find it optimal to build initially an anti-inflation reputation in order to achieve in the future output expansion at low inflation cost. This central bank behavior raises the issue of uncertainty regarding the type of central bank (Backus and Driffill, 1985; and Ball, 1995). More concretely, there is uncertainty as to whether the central bank prefers to follow a low inflation policy consistent with policy pursued by a credible central bank or to put more emphasis on issues such as employment and growth. Ball (1995) calls the credible central bank as a dry type and the central bank that mimics the behavior of the credible central bank, as a wet type (i.e. not-credible). It can, therefore, be hypothesized that a central bank behaves as a dry type in some circumstances, and in other instances reveals its true color and behaves as a wet type.

Moreover, Ball (1995) assumes that the type of central bank behavior just alluded to, follows a MRS process. That is if in the current period the central bank is a wet type, then there is a probability w to remain wet in the next period and a probability $1-w$ to switch to a dry type of central bank in the following period. This is also true if in the current period the central bank is a dry type. Ball (1995) shows that as long as supply shocks are absent, the wet type of central bank sets inflation equal to zero (i.e. it mimics the dry central bank). In the presence of supply shocks, the wet type of central bank inflates at the discretionary level (that is the optimum inflation rate given the public's inflation expectations). Since this action reveals its identity as a wet, not-credible, type of central bank, inflation will remain at the discretionary rate until such time as a credible central banker takes over.

In this study we measure the uncertainty of the type of central bank as the deviation of domestic interest rate policy from a target level where this target level is the interest rate policy of a credible central bank. We use the domestic interest rate of the four individual accession countries and the synthetic interest rate of the eleven existing EMU member countries as the target interest rate. Therefore, the four accession countries represent the wet type of central bank and the synthetic interest rate represents the dry type of central bank. We focus on the variability of the interest rate differential, that is on the risk premium for the wet type of central bank to deviate from the monetary policy pursued by the dry type of central bank.

ECONOMETRIC METHODOLOGY

In what follows we use an econometric method that takes into account empirical regularities and theoretical considerations that suggest that credibility goes through different regimes. This is undertaken in such a way that monetary policy can be considered credible in some circumstances and lacking credibility on other occasions. We use a two-state SWARCH model of interest rate differential between that of the four individual accession countries, and a weighted average of eleven EMU countries. The data generation process in the Markov regime-switching model consists of two parts: (i) the autoregressive dynamic generating process; and (ii) the regime generating process. The advantage of this statistical model is that it captures the uncertainty regarding the behavior of underlying macroeconomic relationships and the uncertainty regarding future shocks. Moreover, allowing the autoregressive coefficients of the conditional mean of interest rate differential to vary in different regimes, gives information regarding the convergence of the interest rate of the four accession countries with the rate of interest of the existing eleven EMU member countries. In particular, based on the definition of interest rate convergence given by Caporale et al. (1996), we assume that the interest rate differential converges to a long-run equilibrium (which must be close to zero in our case), if the sum of the autoregressive coefficients in one regime is close to unity and is less than unity in the other regime. This implies that as long as convergence prevails, the interest rate differential must follow a unit root process up to a point, and from thereon it must be stationary. Under such circumstances the interest rate differential for the whole period follows a stationary process. In fact, Ang and Bekaert (1998) show that if a series follows a two-state Markov process where one state has a unit root and the other does not, then the series is stationary.

A SWARCH model of the interest rate differential between that of the individual four accession countries and the synthetic

interest rate of eleven EMU countries, can be presented as follows:

$$[(i^D - i^S)]_{t-1} \sim \begin{cases} \mathbf{N} [b_0 + b_1(i^D - i^S)_{t-1}, h_{1t}] \\ \mathbf{N} [c_0 + c_1(i^D - i^S)_{t-1}, h_{2t}] \end{cases} \quad (1)$$

where i^D is the domestic interest rate of the four accession countries, i^S is the synthetic interest rate, and h_{st} (with $s = 1, 2$) is the variability of the error term u_t , defined as:

$$h_{1t} = a_0 + a_1 u_{t-1}^2 + a_2 u_{t-2}^2 \quad (2)$$

$$h_{2t} = d_0 + d_1 u_{t-1}^2 + d_2 u_{t-2}^2$$

The subscripts 1 and 2 in equations 1 and 2 denote regime 1 and regime 2 respectively. The transition between regimes is characterized by a (2x2) transition probability matrix p . This can be presented as follows:

$$p = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix} \quad (3)$$

which is the (2x2) transition probability matrix, where p_{12} and p_{21} stand for the transition probabilities from regime 1 to 2 and from 2 to 1 respectively. Moreover, every column of p sums to unity. This implies that $p'1 = 1$, where 1 is a (2x1) vector with unity elements. In this instance one of the eigenvalues of the transition probability matrix is unity and the rest less than unity, so that there is long-run convergence in the series.

Equations 1 and 2 are based on the theoretical framework that has been introduced by Froot and Rogoff (1991). In particular, the authors assume that the interest rate differential between two countries follows an ARMA(p,q) process of the form:

$$(i^D - i^F) = \alpha + A(L)(i^D - i^F) + \Delta S^E + B(L)e_t \quad (4)$$

where i^D is the domestic interest rate and i^F is the interest rate of a foreign country, α is a constant, $A(L)$ and $B(L)$ are the AR and MA lag polynomials of order p and q, ΔS^E is the expected exchange rate change and e_t is the foreign exchange risk premium. Froot and Rogoff (1991, p. 297) argue that credibility can be measured by the exchange rate risk premium and the expected exchange rate change. Under the assumption that the exchange rate follows a random walk, the error term (i.e. e_t) reflects the credibility of monetary policy regarding either an inflation target or an exchange rate target. Froot and Rogoff (1991) also suggest that the error term in (4) can be thought of as the credibility proxy of monetary policy. Faruqee (1992) and Fountas and Papagapitos (1997) adopt this framework and assume that variation in the error term due to variation in the credibility and reputation of monetary policy, will increase the variability of interest rate differential. However, since credibility and reputation in monetary policy is gained gradually over time, the conditional variance of the error term follows an ARCH process.

Equations 1 and 2 are an extension of the framework just described, where the interest rate differential follows different processes under different regimes. As mentioned in the introduction, this can be explained on the basis of the existence of strategic complementarities between market expectations of the adopted monetary policy, and the monetary policy that is actually pursued. Under such circumstances multiple equilibria arise and the switch between them might follow a Markov process. In particular, Howit and McAfee (1992) show that switches between equilibria are driven by waves of optimism and pessimism (i.e. self-fulfilling expectations) which follow a Markov process. The statistical properties of equilibria are characterized by a Markov regime-switching framework.

Equations 1 and 2 indicate that both the mean and variance of $(i^D - i^S)$ are subject to regime switching. Friedman and Laibson (1989) and Gray (1996) argue that the conditional variance in the high credible state is lower than the conditional variance in the low credible state. Friedman and Laibson (1989), also, show that small to moderate shocks are more persistent than large shocks. In particular, the authors argue that in a low credible regime where inflation expectations are high, the central bank will show its intention to reduce these expectations by exercising a strong pressure on short-term interest rates. This action will lead to a large, but with low persistence, change in the rate of interest, relieving the pressure arising from inflation expectations. This

implies that the sum of the autoregressive coefficients in the high credible regime must be higher than that in the low credible regime. Moreover, the transition probability from the low to the high credible regime must be higher than the transition probability from the high to the low credible regime. A switch in the variance of $(i^D - i^S)$ indicates an increase of the risk premium that forces the domestic central bank to deviate from the target level pursued by the weighted average of eleven EMU member countries.

DATA AND RESULTS

General Observations

We employ weekly data for the rate of interest for the four accession countries, i.e. the Czech Republic, the Slovak Republic, Poland and Hungary, and a synthetic interest rate of eleven EMU member countries. The country interest rate data, and the synthetic interest rate data, were collected from the *International Financial Statistics* data base (Datastream). They are weekly inter-bank rates for the individual accession countries, and cover the period 1992-2002. However, the data series for each of the four accession countries is not the same for all of them. The starting period is different. In the case of the Czech Republic data begin on the 12th of October, 1992; for the Slovak Republic on the 23rd of May, 1994; for Poland on the 23rd of April, 1993; and for Hungary on the 7th of August 1995. Nevertheless, the end-point is the same for all countries, i.e. 27th of May, 2002. The synthetic interest rate is a European average market interest rate. This is calculated as a weighted average of each individual country's short-term interest rate, using the weights of the EMS currencies in the ECU basket.

We specify a model where the autoregressive parameters are regime dependent. Under such specification we are able to test for different rates of convergence of accession country interest rates in relation to the synthetic interest rate in different regimes. As mentioned above, convergence takes place when in one of the two regimes the sum of the autoregressive coefficients implies a non-stationary process; and in the other regime the sum of the coefficients is less than one. We also allow the conditional variance to be regime dependent. This is so in view of the evidence in Lamoureux and Lastrapes (1990) that on the basis of Monte Carlo experiments, GARCH measures of persistence in variance can be affected by not taking into account structural shifts in the unconditional variance. More concretely, evidence of high persistence in the conditional variance might be due to regime switching and not to a high value of the autoregressive coefficients in the ARCH process. Moreover, allowing the conditional variance to be state dependent, one can distinguish between high (not-credible) and low (credible) volatility regimes.

Table 1 in the Appendix, reports the results of the SWARCH model for the four accession countries. The coefficients b_i and c_i ($i=1,2$) denote the autoregressive coefficients of the mean in the high and in the low credible regimes respectively.

However, this is not always the case since there are occasions (i.e. the Czech Republic and the Slovak Republic) where the coefficients c_i denote the autoregressive coefficients of the mean in the high credible regime and b_i denote the autoregressive coefficients of the mean in the low credible regime. We distinguish between a high credible regime, with low variance and high persistence, and a low credible regime, with high variance and low persistence. In view of the degree of persistence in the two regimes we expect the autoregressive coefficients on the mean in the high credible regime to be higher than that in the low credible regime. Moreover, the transition probability from the low credible regime to the high credible regime is expected to be higher than the transition probability from the high credible regime to the low credible regime. Finally, the conditional variance of the low credible regime is higher and less persistent than that of the high credible regime. The conditional variance in each regime is described by the coefficients α_i and d_i .

The results in Table 1 indicate that in the cases of the Czech Republic and the Slovak Republic, regime 2 is the high credible one, and regime 1 is the low credible one. In particular, the conditional variance of regime 2 is lower than that in regime 1 (i.e. $\alpha_1 < d_1$). Moreover, the persistence in regime 2 is higher than the persistence in regime 1 [i.e. $(1 - p_{21}) > (1 - p_{12})$].

Therefore, the coefficients of the c_i and d_i describe the conditional mean and conditional variance of the high credible regime (i.e. regime 2), and the coefficients b_i and α_i denote the conditional mean and variance of the low credible regime (i.e. regime 1). In the cases of Poland and Hungary regime 1 is the high credible regime and regime 2 is the low credible regime. These general observations indicate that the countries under consideration might be in different regimes. In particular, when the Czech Republic and the Slovak Republic are in the high/low credible regimes, Poland and Hungary are in the low/high credible regimes. With these general observations in mind, we turn our attention to the discussion of the country results.

Discussion of Country Results

The second column of Table 1 indicates that in the case of the Czech Republic the constant in the conditional mean is not significant in both regimes. This implies that there is convergence of the interest rate differential towards zero. The sum of the

autoregressive coefficients of the conditional mean in the high credible regime is equal to one (i.e. $\sum_{i=1}^2 c_i = 1$). This indicates that the process might be explosive or that another state should be included (i.e. three states instead of the two used). However, since the sum of the coefficients in the low credible state is less than one (i.e. $\sum_{i=1}^2 b_i = 0.93$), the process of interest rate differential may have two or three states, but it is not explosive. A formal test for the number of regimes is computationally demanding.⁵ As it is expected, the conditional variance in the low credible regime is higher than the conditional variance in the high credible regime (i.e. $\alpha_0 > d_0$), but less persistent (i.e. $\alpha_1 < d_1$). The sum of the autoregressive coefficients in the conditional variance is less than one in both regimes indicating a mean reversal of the variance in each regime. The transition probabilities indicate that both regimes are high persistent, especially in the high credible regime [$p_{22} = (1 - p_{21}) = 0.95$]. The high credible regime in the case of the Czech Republic shows the highest persistence along with the case of Hungary. This implies that in both the Czech Republic and Hungary the credibility of monetary policy in relation to the monetary policy pursued by eleven EMU member countries is high.

In the case of the Slovak Republic (i.e. third column of Table 1), as in the case of the Czech Republic, regime 2 is the high credible regime and regime 1 is the low credible regime. However, we use a different statistical specification in the case of the Slovak Republic, where an AR(1) state dependent process for the mean, and AR(2) for the conditional variance of each regime, are pertinent. In this specification, the constant coefficient of the conditional mean in the high credible regime is not significant, although the same coefficient is significant in the low credible regime. This implies an interest rate convergence towards long-run equilibrium. Moreover, the sum of the autoregressive coefficients of the mean in the high credible state is close to unity (i.e. $c_1 = 0.99$) and less than one in the low credible state (i.e. $b_1 = 0.94$). An interesting point is that in the case of the Slovak Republic, the sum of the autoregressive coefficients of the conditional variance in the high credible state is lower than that in the case of the Czech Republic. This indicates that the persistence of the high credible regime in the Czech Republic is higher than the persistence of the high credible regime in the Slovak Republic. This is consistent with the evidence that in the case of the Czech Republic the transition probability from the high credible state to low credible state (i.e. p_{21}) is lower than that in the case of the Slovak Republic. This result implies that monetary policy in the Czech Republic is more credible than that of the Slovak Republic in relation to the monetary policy pursued by eleven EMU member countries.

In the case of Poland (i.e. fourth column of Table 1) we use 2 lags to describe both the conditional mean and variance. The results indicate that, as mentioned above, regime 1 represents the high credible regime and regime 2 the low credible regime. Although the constant coefficient is not significant in both regimes, we cannot conclude that there is an interest rate convergence towards zero. This is due to the sum of the autoregressive coefficients of the conditional mean, both in the high and in the low credible regimes, being higher than one. This implies either that the conditional mean follows a non-stationary process or that a third state is required to model the conditional mean. We favor the second suggestion since the graph of interest rate differential (available from the authors upon request) implies that the series follows a stationary process. However, the implication of a high value of the sum of the autoregressive coefficients is that the process of interest rate convergence in Poland is slower than in the cases of the Czech Republic and of the Slovak Republic. Moreover, the degree of persistence in the low credible state is higher in Poland than the degree of persistence in the low credible state in the Czech Republic, the Slovak Republic and Hungary. This indicates that the credibility of monetary policy in Poland is the lowest in the sample of countries under consideration.

The fifth column of Table 1 indicates that in case of Hungary, regime 1 represents the high credible regime and regime 2 the low credible regime. Although this is the same as in the case of Poland, we cannot claim that the two countries are in the same regime in view of the possibility of a third regime. Especially so since in the case of Hungary the sum of the coefficients in the low credible regime is less than one, but close to one in the high credible regime. This indicates convergence of the interest rate differential towards a long-run equilibrium. A non-significant constant in the conditional mean in both regimes, implies a long-run value that is equal to zero. The transition probabilities show that the high credible regime is very persistent [i.e. $(1 - p_{12}) = 0.95$]. In fact, in Hungary the persistence in the high credible regime is higher than in any other country under consideration. Therefore, the credibility of monetary policy in relation to the monetary policy pursued by eleven EMU countries is high. However, the evidence that Hungary is in a different regime from that of the Czech Republic and the Slovak Republic, implies that either these countries have different monetary policy preferences or different economic structures. Therefore, the accession of these countries to EU has to be gradual and based not only on the degree of their convergence, but also on their credibility in relation to the monetary policy pursued by the European Central Bank (ECB).

Although the sample period for each country is not exactly the same, evidence that the four countries belong to different groups in terms of regimes, provides implications for asymmetry among them. In particular, evidence that monetary policies of the

countries under consideration might be in different regimes, indicates that the likelihood and timing of EU entry would depend on the degree and speed of convergence of these economies with the existing EU member countries. This can be explained by referring to two possible reasons. First, the four countries may have different economic structures. In particular, monetary authorities minimize a loss function where the constraints that represent the dynamics of the economy are different among countries. Second, even if these countries have the same economic structures, monetary authorities might have different preferences regarding the main components of their loss functions (i.e. output-gap variability and inflation variability). In general, under such circumstances there are implications for the countries under consideration in terms of whether they constitute an optimum currency area (OCA). However, in the case of the accession countries what matters is that the country that is to join the EU has to achieve sufficient convergence with respect to the existing EU countries. Therefore, different economic structures and monetary policy preferences among the accession countries have implications about the timing that each country should be joining the EU.

SUMMARY AND CONCLUSIONS

We have used a SWARCH model to estimate the credibility of monetary policy in four accession countries in relation to eleven EMU countries. More concretely, and based on theoretical considerations regarding currency crises models, we assume that the credibility of monetary policy in these countries goes through different regimes. Therefore, we use a Markov regime-switching framework to model both the mean and the variance of the interest rate differential between the interest rate of the individual accession countries and the synthetic interest rate of eleven EMU countries. Changes in the mean captures the behavior of economic agents under different regimes and changes in the variance reflects the risk premium when the monetary authorities of individual countries deviate from the target level (i.e. the interest rate prevailing in eleven EMU countries).

The results show that there are different groups of countries with different degrees of credibility. In particular, when the Czech Republic and the Slovak Republic are in the high credible regime, Poland and Hungary are in the low credible regime. Interest rate differentials converge to zero with the exception of Poland. In the case of Poland there is evidence that the conditional mean either follows a unit root process or that there are more than two states. Moreover, the high credible regime in the cases of the Czech Republic and Hungary, show very high persistence, and the highest in the sample of countries under scrutiny. This indicates that credibility of monetary policy in these countries is higher than that in the cases of the Slovak Republic and Poland. In the Slovak Republic monetary policy can be considered credible since the degree of persistence in the high credible regime is far higher than the degree of persistence in the low credible regime. Poland shows the least degree of credibility of monetary policy in our sample of countries. This is so, since the degree of persistence in the high credible regime is lower than that of the other three countries in our sample. Furthermore, in the case of Poland the degree of persistence in the high credible regime is slightly higher than the degree of persistence in the low credible regime.

The overall conclusion of this paper is that evidence that different blocks of accession countries have different degrees of credibility of monetary policy is evident. The clear implication of this evidence is that the accession procedures should do well to pay serious attention to the credibility of monetary policy of the countries involved in these procedures.

APPENDIX

Table 1: Parameter estimates and related statistics for regime-switching ARCH models.

	The Czech Republic	The Slovak Republic	Poland	Hungary
b_0	0.481 (0.385)	0.496 (0.000)	-0.075 (0.057)	-0.014 (0.765)
b_1	0.856 (0.010)	0.945 (0.000)	0.822 (0.000)	0.683 (0.000)
b_2	0.074 (0.827)	-	0.183 (0.000)	0.312 (0.000)
c_0	-0.007 (0.582)	0.020 (0.255)	-0.045 (0.838)	0.701 (0.316)
c_1	1.163 (0.000)	0.992 (0.000)	0.500 (0.000)	0.478 (0.072)
c_2	-0.163 (0.000)	-	0.495 (0.000)	0.435 (0.098)
α_0	1.425 (0.000)	2.159 (0.000)	0.138 (0.000)	0.309 (0.000)
α_1	-0.016 (0.803)	0.014 (0.181)	0.119 (0.044)	0.088 (0.039)
α_2	-	0.182 (0.000)	-0.088 (0.000)	-
d_0	0.131 (0.000)	0.121 (0.000)	0.796 (0.000)	1.492 (0.000)
d_1	0.953 (0.000)	0.646 (0.000)	-0.058 (0.075)	0.083 (0.358)
d_2	-	0.028 (0.036)	-0.008 (0.846)	-
p_{12}	0.286 (0.000)	0.269 (0.000)	0.207 (0.000)	0.046 (0.010)
p_{21}	0.051 (0.000)	0.149 (0.000)	0.231 (0.000)	0.473 (0.001)

Note: p-values are in brackets (i.e. the null hypothesis that the given coefficient is equal to zero).

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NOTES

1. The choice of these four countries is based on two reasons. The first is that they belong to the category of ten countries expected to join the EU by the end of 2002. This category includes, in addition to the four of this paper, Cyprus, Malta, Slovenia, Estonia, Latvia, and Lithuania. The second reason is that consistent data series are only available for the four accession countries referred to in the text.
2. Strategic complementarity refers to a situation where one's optimal strategy is affected by another's strategy.
3. The eleven countries mentioned in the text are all the current twelve countries that are members of the Economic and

Monetary Union (EMU) with the exception of Greece which joined the EMU only in January 2001.

4. Creating an independent central bank that puts a high weight on the stabilization of inflation (Rogoff, 1985), or appointing a central banker whose compensation is arranged so as to increase the marginal cost of inflation (Walsh, 1995), are further ways of increasing the marginal cost of inflation. Yet another way is to adopt targeting rules that limit the flexibility of the central bank to stabilize supply shocks.
5. Computational difficulties are evident because under the null hypothesis there are unidentified parameters and the scores are equal to zero. In particular, under the null hypothesis the transition probabilities are not identified since any value between 0 and 1 gives the same likelihood function. As for the problem of identically zero scores (i.e. the first derivatives of the log of the likelihood function), if the transition probability is either 1 or 0, then the scores with respect to the mean parameter of interest is identically zero and the asymptotic information matrix will be singular. Hansen (1992 and 1996) proposed a bound test that addresses these problems, and Garcia (1998) derives analytically the asymptotic null distribution of the likelihood ratio test for the two-state Markov switching model.