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ABSTRACT

Moving the Escudo into the Euro*

When the 1987 general elections brought a durable government to Portugal, the national environment was still inflationary. Nevertheless, thanks to the efforts of successive minister of finance/central bank governor pairs, the criteria for Economic and Monetary Union (EMU) were met and the seventh pair saw the euro conversion rate set at 200 escudos. The agreed rate represents a depreciation of some 16% over the one at which the escudo entered the ECU basket in 1989. As the change in regime towards stability-oriented macroeconomic policies was completed when the parity grid of the Exchange Rate Mechanism of the European Monetary System (ERM) was under severe stress, escudo depreciations were agreed upon at realignments initiated by the peseta (PTA).

The Portuguese authorities' understanding of the ERM code of conduct as they prepared to join after the 1991 general elections made it possible to acquire a financial reputation very quickly. But the enhanced national credibility abroad caused tension within several minister/governor pairs, especially with respect to the timing of ERM entry, the speed at which to move to full currency convertibility and whether the escudo should respond to PTA realignments. Moreover, both the opposition and the governing party initially resisted the stability-oriented policy, stalling structural reforms and allowing the opposition to win the 1995 general elections on a reformist platform. As a consequence, the stability-oriented policy was maintained until EMU qualification but there were no other major reforms, raising the threat of a 'euro hold-up'.

The weekly escudo-Deutsche mark (escudo-DM) rate reveals widely different volatility states that were accompanied by six successive exchange rate regimes. Before entering the ERM, a crawling peg was discreetly replaced by DM-shadowing with reinforced controls on capital inflows at the beginning of the first stage of EMU. Yet, the escudo-DM rate, even allowing for the last realignment, was more stable in the ERM than when it was inconvertible and the central bank controlled the currency. The comparison excludes the subperiod of crises before widening the bands and the one after volatility in prospective EMU qualifying currencies subsided. Markov switching autoregressive conditional heteroskedasticity (SWARCH) models with more

than three states capture all regimes. The specification with five states is favoured because it suggests the nature of the response of the central bank to speculative attacks during the crisis regime.

JEL Classification: C22, F31, F33
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NON-TECHNICAL SUMMARY

When the 1987 general elections brought a durable government to Portugal, the national environment was still inflationary. Nevertheless, thanks to the efforts of successive minister of finance/central bank governor pairs, the criteria for Economic and Monetary Union (EMU) were met and the seventh pair saw the euro conversion rate set at 200 escudos. The agreed rate represents a depreciation of some 16% over the one at which the escudo entered the ECU basket in 1989. As the change in regime towards stability-oriented macroeconomic policies was completed when the parity grid of the Exchange Rate Mechanism of the European Monetary System (ERM) was under severe stress, escudo depreciations were agreed upon at realignments initiated by the peseta (PTA).

The understanding by the Portuguese authorities of the ERM code of conduct as they prepared to join after the 1991 general elections made it possible to acquire a financial reputation very quickly. But the enhanced national credibility abroad caused tension within several minister/governor pairs, especially with respect to the timing of ERM entry, the speed at which to move to full currency convertibility and whether the escudo should respond to PTA realignments. Moreover, both the opposition and the governing party initially resisted the stability-oriented policy, stalling structural reforms and allowing the opposition to win the 1995 general elections on a reformist platform. As a consequence, the stability-oriented policy was maintained until EMU qualification but there were no other major reforms, raising the threat of a ‘euro hold-up’.

The weekly escudo-Deutsche mark (escudo-DM) rate from early 1987 to late 1998 reveals widely different volatility states that were accompanied by six successive exchange rate regimes. Before entering the ERM, a crawling peg was discreetly replaced by DM-shadowing with reinforced controls on capital inflows at the beginning of first stage of EMU. Yet, the escudo-DM rate, even allowing for the last realignment, was more stable in the ERM than when it was inconvertible and the central bank controlled the currency. The comparison excludes the subperiod of crises before widening the bands and the one after volatility in prospective EMU qualifying currencies subsided.

Even though an inconvertible currency, not being market determined, would tend to reveal a lower volatility than a convertible one, the results show the opposite. The conditional volatility is 0.3% and 0.43% per week in the first and second sub-periods respectively, whereas during two sub-periods after the widening of the ERM bands, separated by the last realignment, it is 0.28% and 0.4% per week respectively. During the ERM crises the volatility reaches 0.47% whereas it falls to 0.08% per week after October 1997. A fully credible

EMU came about by steadily declining smoothed probabilities of the medium and then the low volatility states as the probability of the very low volatility state rises to 100% in March 1998. From September 1996 until June 1997 the medium volatility state drops monotonically, and then it drops from 87% to 70%. The probability of the low volatility state begins then to rise until it reaches 100% in November 1997, only to fall abruptly from 97% to 16% in late December.

Markov switching autoregressive conditional heteroskedasticity (SWARCH) models with more than three states capture all regimes. The specification with five states is favoured because it suggests the nature of the response of the central bank to speculative attacks during the crisis regime. The very low volatility state which otherwise only occurred near the end of the full sample, is also identified just ahead of the first realignment of the escudo, from 7 October to 4 November 1992, switching to high volatility in the week of 11 November, while the conditional standard deviation drops from 0.65% to 0.06% per week. This is an episode of what might be called ‘false stability’, where a strong market intervention by the central bank was able to maintain the rate glued to the top of the band before adjusting the central rate. While this interpretation of response of the central bank to speculative attacks should be further tested using appropriate intervention data, it is consistent with the presumption that the decision to enter the ERM was correctly timed. Had entry been delayed beyond April 1992, it probably could not have been agreed upon by the member states until after the last PTA realignment three years later. By then, however, the general election was too close to allow such a decisive step to be taken.

The change towards stability and convertibility, which only became possible in 1989, began gradually and was nearly reversed in 1990 and 1991. During stages one and two of EMU, gradualism reflected the balancing by the Prime Minister of two conflicting objectives: earning credibility abroad and selling stability at home. EMU is now in stage three but the pattern may re-emerge and bring about the ‘euro hold-up’.

The research agenda on the stochastic properties of the escudo-DM rate includes robustness tests, returning to daily data, to the effect of the dollar-DM rate, of central bank intervention and of ‘news’ (such as those of financial panics outside the euro area).

1. INTRODUCTION

This paper documents how the code of conduct implied by membership of the *escudo* in the Exchange Rate Mechanism of the European Monetary System (ERM) allowed Portugal to qualify for Economic and Monetary Union (EMU), ultimately moving the currency into the euro. This unwritten code of conduct reflects the conditions under which the ERM can be seen as a convergence instrument. Following the ERM multilateral surveillance procedures through successive convergence programs enhanced national credibility abroad in 1992-93. The "stability culture" was then unknown in the two major political parties, and therefore likely to be questioned by whoever would be in opposition. As the preference for stability was revealed at home and abroad, the benefits of policy credibility became more apparent in economic activity and employment. This has certainly been the case with the current government, who has claimed moving the *escudo* into the euro as one of its achievements since taking office in October 1995. Yet, until a broad EMU became fully credible, there were fears that the *escudo* would suffer by contagion with the *peseta* and would therefore not qualify. Contagion reflects imperfect market information about peripheral economies devoid of financial reputation and is especially grave in turbulent or crisis periods. Yet a rule-based regime like the ERM proved stronger than these so-called "geographic fundamentals".

The paper is organized into three sections, a conclusion, an appendix and a set of Appendix Tables and Figures. Following Braga de Macedo (1997), Section 2 explains how the change towards stability and convertibility, which only became possible in 1989, began gradually and was nearly reversed in 1990 and 1991. During stages one and two of EMU, gradualism reflected the balancing by the prime minister of two conflicting objectives: earning credibility abroad and selling stability at home. EMU is now in stage three but the pattern may re-emerge and bring about the "euro hold-up". The stochastic properties of the weekly *escudo*-DMark rate since the last realignment of the French and Belgian francs in January 1987 are consistent with five subperiods before the dying out of volatility in late 1997. The turning points are the beginning of stage one of EMU in July 1990, ERM entry in April 1992, the widening of the ERM bands in August 1993, and the last realignment involving the *peseta* and the *escudo* in March 1995. Even though an inconvertible currency, not being market determined, would tend to reveal a lower volatility than a convertible one, Section 3 shows that conditional volatility under the crawling peg (abbreviated as *crawl*) and DMark shadowing (abbreviated as *DM*) is larger than after the widening of the bands (abbreviated as *wide*) and the last realignment (abbreviated as *peseta*). The comparison excludes both the regime between *DM* and *wide* (abbreviated as *crises*) and the last subperiod (abbreviated as *EMU*).

Section 4 takes a closer look at the first year of ERM membership for the *escudo*, which coincides with the attacks on the parity grid ultimately leading to the widening of the fluctuation bands to 15%. An attempt is made at sorting out domestic disturbances from the consequences of system instability in the behaviour of the weekly *escudo*-DMark rate. The result suggests that, had entry been delayed beyond April 1992, it probably could not have been agreed upon by the member states until after the last *peseta* realignment three years later. By then, however, the general election was too close to allow such decisive step to be taken. Section 5 concludes, stressing the unfinished research agenda on the stochastic properties of the *escudo*-DMark rate, to include the effect of the dollar-DMark rate, of central bank intervention and of "news". The absence of structural reforms to lock in the benefits of EMU is seen as an instance of "euro hold up". It could ultimately bring back the conflict between earning credibility abroad and selling stability at home which was characteristic of the 1987-95 era.

2 FROM GRADUAL REGIME CHANGE TO "EURO HOLD-UP"

The gradual change in economic regime towards price stability and currency convertibility featured several exchange rate regimes before ERM membership. Not all helped the regime change, and one almost reversed it. After membership, though, the system became unstable and the last realignment took place in 1995. We now describe the exchange regimes for the escudo prevailing until EMU became fully credible, except for the crisis regime which is analysed separately in Section 4 below.

In September 1989, the *escudo* entered the ECU basket at a rate of 172[1]. With hindsight, this marks the beginning of the change in the economic regime which eventually would move the *escudo* into the euro. Two kinds of measures define the change. Some, like a constitutional amendment reversing the 1976 freeze on privatization, were public but their relation to financial liberalisation was not immediate. Others, like the multi-annual fiscal adjustment strategy (MAFAS) presented to the Commission services were relevant but not public[2]. In spite of these reforms, neither the government nor social partners saw ERM membership as iminent. The cabinet was reshuffled shortly after the 1989 local elections, further delaying public awareness of the ongoing regime change. A *Foreign Exchange Law* where criminal charges were replaced by fines had been approved in the Fall of 1989 and was heralded by Miguel Cadilhe, then finance minister, as a major reform. When it was published in early 1990, however, it allowed Miguel Beleza, Cadilhe's successor, to keep the administration of exchange controls with the central bank, from whose board he came to the ministry. In fact, until after the 1991 general elections, the central bank, led since 1986 by Tavares Moreira, determined macroeconomic policy almost completely.

The crawling peg policy, introduced in 1977 upon advise from the International Monetary Fund (IMF) was replaced sometime in the Spring of 1990 by a shadowing of the DM, known - but not officially acknowledged - as "hard *escudo*" policy. Since the change was not announced publicly, it cannot be interpreted as a pre-pegging exchange rate regime (PPERR) which would complement the MAFAS. But a very low level of unemployment coupled with a strong upward pressure on public sector wages led to to strong inflationary pressures and to the appreciation of the real exchange rate. Moreover, the fear that financial freedom would threaten monetary control and the soundness of the banking system was ingrained at the central bank who administered the exchange controls. Decree law 13/90 of January 8 allowed the central bank to reinstate several controls which remained under Decree law 176/91 of 14 May, in spite of the principle of freedom stated in article 3. The *Foreign Exchange Law* gave the central bank competence to issues *avisos* (signed by the minister of finance) where capital controls could be introduced or relaxed. On 21 May, the first *aviso* was used to introduce an interest free deposit of 40% of loans contracted abroad (except when the operation related to financing of current transactions) and a prohibition of forward purchases of escudos between resident and non resident banks (forward sales were still not allowed). The controls were reinforced before the general election (*aviso* 7 of 5 July, 1991) with explicit refernce to the threat to monetary and exchange rate policy that was posed by excessive capital inflows. The tightening of controls was supposed to help prevent inflation from accelerating and to increase the cost of servicing the public debt. Central bank's foreign reserves more than doubled from 1989 to 1991, with disastrous

[1] Like the *real* it replaced at par (1 to 1000) after the 1910 revolution, the *escudo* remained inconvertible; but it stabilised after the 1926 revolution, at a rate around 25 to the dollar. From the 1974 revolution until accession to the European Community in 1985, the parity (measured against the ECU) rose from 30 to 130.

[2] The call for a MAFAS, made in Bliss and Braga de Macedo (1990), reflects the latter author's experience with the multilateral supervision procedures at the European Commission in Brussels together with a criticism of the ambiguous response to the challenge of European integration prevailing in the late 1980s.

consequences for the bank's operating results. This opaque arrangement managed by the central bank also allowed banks to delay adjusting to a single market in financial services. In short, the bank was accumulating huge dollar deposits earning 5 %, while paying 20 % on the *escudo* debt being issued to mop up the resultant "excess" liquidity and shadowing the DMark, so as to fight inflation[3].

In July 1990, Beleza had proposed a *National Adjustment Framework for the Transition to Economic and Monetary Union*, known as QUANTUM, but it was not until after the 1991 elections that Braga de Macedo, his successor, presented a convergence program combining MAFAS and PPERR with capital account liberalisation, which he discussed in parliament, calling it Q2 to stress the continuity of the gradual regime change. In spite of Q2, the decision to request entry of the *escudo* in the ERM was a genuine surprise. On 4 April, 1992 - the weekend following the approval in parliament of the 1992 budget - the monetary committee (whose members were acting as personal representatives of the then twelve minister/governor pairs who meet with the Commission in the so-called informal ECOFIN)[4] responded to the government's application to join the ERM at a rate of 180 *escudos* agreed upon at a special cabinet meeting on Friday afternoon. Even though there was a precedent with sterling, the prior declaration of a parity generated great resistance among some members of the monetary committee. Fearing that, on the eve of the British general election, a weaker *escudo* might be contagious to sterling, the consensus was on the notional central rate of 178,735 - that is the one prevailing since the entry of sterling in October 1990. After the cabinet meeting Macedo briefed the social partners and the following week ERM entry was debated in parliament[5]. Nevertheless the rule-based exchange rate regime which culminated the gradual change in economic regime was neglected at home. This remained true when the outcome of the Danish referendum and the severe recession made it clear that the *escudo* would have been unable to join the ERM in time to meet the EMU criterion of two years' membership. It would have trailed with the Greek drachma outside the parity grid, rather than following the *peseta* inside.

Domestic neglect of ERM membership may be due to the fear of "geographic fundamentals" involving Spain. One of the major consequences of this fear is the prevailing expectation of an unfavourable future performance with unemployment, against the evidence of the last ten years. As a consequence of the severe structural adjustment agreed in 1983-85 with the IMF, Portugal has recorded a rate of unemployment about one third that of the rate in neighbouring Spain. Even the perceived link of the *escudo* with the *peseta* does not fully explain why international financial markets believed in the regime change almost five years before trade unions, employers associations and citizens. Alternatively, the fact that the domestic stability culture was paradoxically recovered at a time of system instability may be what explains domestic neglect. The experience before the 1974 revolution, when the central bank had private shareholders and the currency was stable, if not fully convertible, had been either forgotten or associated with the absence of political freedom (or both). Available indicators still show much greater current account than capital account openness and the consequences for firms, regions and cities of moving the *escudo*

[3] In a financial system highly protected from competition and facing weak supervision, central bank policy increasingly depended on issuing short-term domestic debt to mop up the growing capital inflows attracted by the highly remunerative real interest rates to be earned on pure arbitrage operations.

[4] To stress the departure from DM shadowing, the parity was declared in terms of ECU. While welcome by the Commission, the innovation was frowned upon by the Bundesbank representative.

[5] There the oppposition criticized the move and one socialist MP even claimed that Britain had presented an "ultimatum", like the one in 1890 which, whilst unrelated, preceded the exit from the gold standard. Actually, as hinted at in note 1 above, the combination of financial discipline and political stability in a multi-party democracy had not been seen since those days.

into the euro have only begun to be appreciated. In any event, the central rate the *escudo* kept after the realignment of the *peseta* in March 1995, around 196, would have been difficult to reach without the benefit of the ERM code of conduct as suggested in section 4 below.

The MAFAS retained in the *Revised Convergence Program* (PCR) approved with the 1994 budget kept the nominal ceiling on non-interest expenditures from Q2 but adjusted the deficit for the revenue shortfall. This was well accepted by international investors who heavily oversubscribed a global bond issue of one billion dollars in September and by the monetary committee who approved the PCR in November. A cabinet reshuffle was announced shortly before the December local elections, involving finance and three spending ministries. Eduardo Catroga, Macedo's successor, kept economic policy consistent with the PCR. In early 1994, a global bond issue in ECU was received with the same success as the previous one. Yet Catroga's call for lower interest rates, while directed at a domestic business audience, had foreign repercussions, especially when they were thought to have the approval of the prime minister. In this context, an Austrian news agency reported rumours of a military coup in Portugal. While entirely groundless, the story was picked up by *Bloomberg* and led to a renewed attack on the *escudo*. Differences on banking supervision between Catroga and Beleza, who had succeeded Moreira in May 1992, led to the replacement of most of the board and the appointment of Antonio de Sousa as governor in June 1994. This drastic move was well accepted, for it was clear that the tension did not originate in monetary policy. Just like the ERM code of conduct moved the *escudo* into the euro, the *Treaty on European Union* and the *Banking Law* (Decree Law º 298/92 of 31 December) which introduced the single market in financial services and called for greater supervision and competition, forced the central bank to adjust. Further changes have thus been introduced to the statutes of the central bank to make it more independent from the government, to introduce some accountability in parliament and to improve the regulation and supervision procedures.

Another reflection of the continuity of the MAFAS is that the PCR proposed in 1993 extended the expenditure ceilings into 1997 and remained the basis for the excessive deficit procedures until a *Convergence, Stability and Growth Program* from 1998 to 2000 was approved by the ECOFIN in May 1997 where it was presented by Sousa Franco, minister of finance since October 1995. Franco then presented a *Stability and Growth Program* for 1999-2001 shortly after the *escudo* joined the euro at a rate of 200,482[6]. The MAFAS continues listing structural reforms, especially in the public adminsitration but unfortunately has dropped nominal ceiling on non-interest expenditures. Moreover, structural reforms are not likely to be started in the run-up to the 1999 elections. The opportunity for sustained structural change afforded by the euro and the associated improvement in fiscal discipline could therefore be lost and public administration would remain incapable of reforming itself in areas such as justice, home affairs, social welfare, education and others. The absence of structural reforms is especially grave in what pertains to the enlarged public sector and the discretionary regulation of private enterprise. This is why the rule-based exchange rate regime, coupled with a credible MAFAS, was such a decisive signal of the change in economic regime. As it turned out, the 1993 recession and the (general and local) election

[6] The current minister/governor pair, lasting over three years, has appeared as durable and uneventful as the first one, certainly relative the other five: Beleza/Moreira (almost two years), Macedo/Beleza and Catroga/Sousa (about eighteen months), Macedo/Moreira and Catroga/Beleza (about six months). Braga de Macedo (1997) reports results on the decomposition of real interest rate differentials relative to the dollar and the D-mark according to the mandates of ministers and governors. Results updated to late 1998 by Miguel Rocha de Sousa are available from the author upon request. See also Rocha de Sousa (1997).

cycles have hindered the implementation of public sector reform - including social security. In Braga de Macedo (1997), this is called “euro hold-up”.

Cabinet reshuffles involving the minister of finance and major spending ministers took place around the time of local elections, which have been falling in the middle of the parliamentary term. As a consequence, they had an uncanny role in the regime change and its reversals[7]. The implementation of a MAFAS and of a PPERR between 1989 and 1992 was identified with the prime minister, but different faces were needed to alternatively stress international and domestic objectives. The four finance ministers either implemented structural reforms with high external visibility or were instead required to hold the line domestically, rather than pressing on unpopular reforms. A rather extreme example is the *Banking Law* Several drafts had been discussed between treasury and central bank since Cadilhe/Moreira but operating procedures did not begin to change until Catroga/Sousa, so that six of the minister/ governor pairs were involved[8]. A cabinet reshuffle was also carried out at the time of the 1997 local elections, when a broad EMU was becoming fully credible, but Franco did not have to go in order for the new prime minister to sell stability at home. The pattern of alternating between international and domestic objectives in macroeconomic policy making may thus remain associated with a task which appears now completed, that of moving the *escudo* into the euro. The failure to carry out structural reforms - or even to make a credible announcement thereof - threatens the benefits to people and to business of being again endowed with a stable and convertible currency, however. If the awareness of the threat rises, the pattern may re-emerge and bring about the "euro hold-up".

3. ESTIMATING VOLATILITY STATES

The six exchange rate regimes defined in Section 1 will now be ranked in terms of the volatility of *escudo* DMark exchange rate. The data consists of 614 observations on the average value of the spot exchange rates during each week published by Banco de Portugal from January 7, 1987 until October 15, 1998. Due to the nonstationarity of the data we will work with the first differences of the series. The log difference in the weekly rate expressed in percent, denoted by y_t, exhibits serial correlation, time dependent variances and heavy tails[9]. A specification that captures the autocorrelation in y_t is the AR(1) process:

$$(1) \qquad y_t = \alpha + \phi \; y_{t-1} + u_t,$$

where the residuals are normal and identically and independently distributed,

$$u_t \text{ i.i.d. } N(0, \sigma^2),$$

[7] There were major differences between the two mid-term cabinet reshuffles. The 1990 allowed a second wind for the social democratic party to win the 1991 elections while the 1993 did not. True, the fact that the new economic regime was in place in 1993 made it less costly for the prime minister to halt reforms and simply attempt to finish his term, once he explicitly announced in February 1995 that he was not running for prime minister in the October general election.

[8] The *Foreign Exchange Law* or the *Statute of the Central Bank* are other examples of structural reforms prepared by Cadilhe but passed during Beleza’s term as minister. Tax administration procedures, and the solution of disputes involving the privatisation of Banco Totta and of Petrogal, are similar examples for Catroga’s term.

[9] Appendix Figure 1. The heavy tails can be detected by a kurtosis three times larger than the normal The Ljung-Box test statistics suggests that there is serial correlation in the series and in the squared residuals though the test has less power due to the high value of the kurtosis. The ARCH tests also indicate the presence of strong heteroskedasticity in the data. See Appendix Table 1.

In addition, there is a condition for covariance stationarity, $|\phi|<1$. This implies that y_t has a constant (conditional and unconditional) variance given by $\sigma^2/(1-\phi^2)$. If $|\phi|\geq 1$ then y_t will diverge and its (conditional and unconditional) variance will be infinite. Therefore the assumption about the error term is too restrictive to capture the clear clustering of volatility over time which is apparent in the data. The standard models to deal with this problem are the generalized autoregressive conditional heteroskedasticity (GARCH) specifications where the conditional variance of the residual depends linearly on past realizations. A Gaussian GARCH(1,1) process for the residual u_t is widely used. It is characterized by:

(2) $u_t = h_t v_t$

v_t i.i.d. N(0,1)

(3) $h_t^2 = \kappa + \delta h_{t-1}^2 + \beta u_{t-1}^2$.

It is clear from (2) that the conditional variance of u_t is now given by h_t^2 rather than the constant σ^2. According to (3) this conditional variance at time t depends on the past conditional variance and the squared past residual. This specification by itself does not ensure that the estimated model satisfies the non-negativity of h_t^2. A sufficient condition for the variance not to be negative is $\kappa \geq 0$, $\delta \geq 0$, $\beta \geq 0$ and the process is covariance stationary if $\delta + \beta < 1$. Otherwise the unconditional variance of the error will be infinite. Also, a measure of the persistence of errors on future volatility is given by $\delta + \beta$. If this quantity is equal to zero, future volatility is not affected by any shock, so that the variance is constant and equal to κ (or σ^2 in the earlier specification). As $\delta + \beta$ approaches one, the effect of shocks on future volatility persist longer. When the sum equals one, any shock to volatility will be permanent. The case when the above sum is greater than one would imply an exploding variance in the presence of any shocks.

The usual procedure to estimate the unknown parameters of the model is the method of maximum likelihood. The sample log-likelihood function can be written as the sum of the log conditional densities:

(4) $L = \Sigma \ln f(y_t \mid y_{t-1}, y_{t-2}, \ldots)$

where the above sum goes from t=1 to t=T. Because we have assumed that v_t is normally distributed, each of the terms in the sum is given by:

$\ln f(y_t \mid y_{t-1}, y_{t-2}, \ldots) = -0.5\ln(2\pi h_t^2) - 0.5(y_t - \alpha - \phi y_{t-1})^2 / h_t^2$.

The BFGS (Broyden, Fletcher, Goldfarb, and Shanno) algorithm for numerical maximization was used to find the vector of parameters that maximize L. Given an initial set of parameter values, $(\alpha, \phi, \kappa, \delta, \beta)$, this procedure finds the maximum of L by iteration. In this case, however, an additional restriction must be imposed on κ, to avoid negative values of h_t^2. When κ is set at its optimal value, the sum of the estimated values of δ and β is greater than one[10]. None of these results was consistent with the short lived surges in volatility observed in the weekly percent change of the *escudo* DMark rate. A possible explanation for the failure of the

[10] Appendix Figure 2 graphs the maximum log-likelihood for several non-negative values of κ, showing that the optimal value of κ is zero. With κ fixed at zero, Appendix Table 2 shows that the estimated values of δ and β do not satisfy the covariance stationarity condition. These conditions fail to hold under several other GARCH and ARCH models estimated for the same data.

GARCH specification to model volatility in our case, is that these models are not appropriate in the presence of structural changes in the series. Both poor forecasting results and spurious high estimated persistences result from the GARCH specification, and consequently Hamilton and Susmel (1994) propose an alternative parsimonious model, called the SWARCH model, that allows for structural change in the scale of the conditional variance specification. The location of the regimes is estimated by the model itself, given the number of states K.

Consider a model where the residual u_t follows a K-state Markov switching ARCH(2) process:

(5) $u_t = g_{st}^{0.5} e_t$

The variable s_t takes a value in {1, 2, 3, …,K} and denotes the state that the process is in at date t. The g_{st} denote how the scale of the process differ over the different states. The variance factor for state 1 is normalized at unity, $g_1=1$, with $g_j>1$, for j=2,3,…,K. From (5), it can be seen that $e_t^2 = u_t^2 / g_{st}$. Now e_t follows the traditional ARCH(2) model where, unlike the GARCH model in (3), past variances do not appear on the right hand side; only squared residuals lagged one and two periods:

(6) $e_t = h_t v_t$

v_t i.i.d. N(0,1)

(7) $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 e_{t-2}^2$.

The variance of the residual u_t given the current and past states is:

(8) $E[u_t^2|s_t, s_{t-1}, s_{t-2}, u_{t-1}, u_{t-2}] = g_{st} \{\alpha_0 + \alpha_1 (u_{t-1}^2/ g_{st-1}) + \alpha_2 (u_{t-2}^2/ g_{st-2})\}$.

When there is just one state (s_t is always equal to 1, g_{st} is also equal to 1 and $e_t = u_t$), (8) simplifies to the ARCH(2) model:

(9) $E[u_t^2| u_{t-1}, u_{t-2}] = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2$.

It is assumed that s_t follows a Markov-switching process with transition probabilities given by a KxK matrix P. The row j, column i element of P represents the probability of going from state i to state j:

(10) $p_{i\,j} = Prob(s_{t+1} =j, s_t =i)$,

for i, j = 1,2,3,4. To ensure consistency, each column of P should sum to one.

In the SWARCH model, the sample log-likelihood function can also be written as the product of the log conditional densities as in (4) above. To compute each of these terms, a recursive process described in the appendix is used to compute the probabilities of being in each of the K states. Given values of all the parameters of the model - α, ϕ, α_0, α_1, α_2 , the K-1 variance factors g; and the elements in P - the likelihood function can be evaluated by this recursive method. The maximum likelihood estimator of these parameters can then be computed by using a numerical optimization algorithm, such as in the GAUSS code kindly provided by Hamilton. Using the maximum likelihood estimator of the parameters, Hamilton (1994) describes a procedure to estimate the probabilities about the particular state the process s_t was

in at any date t using the full sample t=1,2,...,T. In the notation of the appendix, these 'smoothed probabilities' for j=1,2,3,…,K can be written as:

$$p(s_t=j \mid y_T, y_{T-1}, \ldots)$$

In previous studies of the *escudo* exchange rate using the SWARCH model, the maximum number of states allowed was three. Braga de Macedo (1997) reports preliminary results of joint work with Catela Nunes, using daily data on the *escudo*-DM rate until April 19, 1997. Re-estimating this model with the new data did not prove possible as the maximization procedure did not converge. Covas (1998) used weekly data for the rates of the *escudo*, the *peseta*, the punt, the *lira* and the *markka* against the dollar until May 1998. However, as a broad EMU became fully credible in late 1997, a new regime with nearly zero volatility seem to have emerged. This was to be expected from approximate measures of the likelihood of EMU beginning on time and the list of countries most likely to be included gathered from how strongly expectations of interest rate equalization were held by market makers. Goldman Sachs has used the difference between the forward rates on ECU instruments and its component currencies to evaluate EMU and J.P. Morgan has produced a calculator using swaps of floating into fixed interest rate instruments to draw the probabilities of individual currencies. According to these estimates, the probability of EMU rose from 80% during most of 1997 to 100% in mid October when the probability of the *escudo* moving into the euro reached 95%, the highest among eight non-core European currencies.

Table 1 here

The results of the estimated models are compared to the constant variance case, even though there is no nesting of the hypotheses underlying the GARCH(1,1) and SWARCH specifications. Some of the SWARCH models have been simplified by imposing a coefficient of zero for those probabilities in matrix P that were almost zero. The value of the likelihood function did not change significantly. A SWARCH(5,2) model was also estimated, but a corner solution was obtained for the α_2 parameter in (7), therefore leading to the SWARCH(5,1) model reported. In the first column of Table 1, the percentage improvement in mean square error (MSE), which Hamilton and Susmel (1994) compare to an R^2., is reported. This MSE is obtained from one-step ahead forecasts. The SWARCH(2,2) model shows very little improvement over the misspecified GARCH(1,1) model, and one week ahead forecasting performance is 11% worse than that of a constant variance model. With more than two states, the SWARCH models all lead to increasing improvements in the forecasting performance. The SWARCH(4,2) model is however worse than SWARCH(3,2) in terms of mean absolute error and the SWARCH(5,1) shows almost no improvement in the log-likelihood function[11]. The second column reports the variance factor for the highest volatility state (5, 4, 3 or 2) under the presumption that it is set to one even in the GARCH(1,1) model. The differences in the scale of volatility are quite significant, going higher than 800 for the SWARCH(4,2) model.

Table 2 here

[11] The MSE and MAE in Appendix Table 3 are the loss functions measuring one-step ahead forecast performance described in Hamilton and Susmel (1994), who also present the appropriate measure of persistence, following the solution of the second order difference equation for the conditional variance implied by the ARCH(2) component of the SWARCH model in equation (7). The degrees of persistence suggested by the estimated SWARCH models are clearly less than the large persistence suggested by a GARCH(1,1) model. Also, as the number of states increases, the persistence decreases. This result suggests that the problems with the GARCH(1,1) specification may be due to the presence of neglected states.

In the first column of Table 2, the average standard deviations over the six regimes estimated by the SWARCH (5,1) model are ranked from very low to very high volatility states[12]. It shows a conditional volatility of 0.3% and 0.43% per week in the first and second sub-periods respectively. A priori an inconvertible currency, not being market determined, would tend to reveal a lower volatility than a convertible one. Yet, the opposite is true: during two sub-periods after the widening of the ERM bands, separated by the last realignment, the estimated standard deviation was 0. 28% and 0.4% per week respectively. During the ERM crises it reaches 0.47% whereas it falls to 0.08% per week after October, 1997. The second column of Table 2 shows the average smoothed probabilities in each regime, arranged to underscore the correspondence between states and regimes. This correspondence is clearest in the *EMU* regime and it provides a measure of the credibility of the final year of transition to stage three, since the "own" probability is highest at 86%. The *crises* regime corresponds to both the high and very high volatility states, with probabilities of 54% and 39% respectively but the *wide* and the *DM* regimes both correspond the the high volatility state with a probability of about 70%. Then the medium volatility regime corresponds to the *peseta* and the *crawl* regimes with probabilities around 50%. The fact that the low volatility state has no strong correspondence with any one of the more stable regimes reflects the fact that both four and five states are adequate models.

The estimated matrix of transition probabilities for the SWARCH(5,1) model reveals that the very low volatility state is the most stable (97.5%) while the very high volatility state is the least stable (84.5%). The low volatility state is less stable (93.3%), it allows a 2.6% probability of going to the very low volatility state and a 4.1% probability of going to the medium volatility state. States 3 and 4 dominate most of the sample period. However, only state 4 is interrupted by switches to the very high volatility state with probability 3.4%[13]. Table 3 shows how a fully credible EMU came about by steadily declining smoothed probabilities of the medium and then the low volatility states as the probability of the very low volatility state rises to 100% in March 1998 (not shown). From September 1996 until June 1997 the medium volatility state drops monotonically, and then it drops from 87% to 70%. The probability of the low volatility state begins then to rise until it reaches 100% in November 1997, only to fall abruptly from 97% to 16% in late December. Tables 4a and b in the next Section show the chronology of the *crises* regime.

Table 3 here

Results for the SWARCH(4,2) model are very similar, except that it is possible to identify the *EMU* subperiod in the sample as belonging to a regime completely separate from the past. State 4 is now the very high volatility state, and the most short-lived (79.1%). States 2 (low volatility) and 3 (high volatility) alternate during most of the sample. The low volatility state which obtained before EMU is fully credible was also very stable (97.6%) but it allows a 0.8% probability of going to the high and a 1.2% probability of going to the very low volatility state. The high volatility state has a own-probability of 95.6% and the transition to the high volatility state is 2.9%, larger than that of going to the low volatility state (1.6%). The model with three states shows a variance factor for the medium volatility state that is almost the same as the low state in the model with four states. The smoothed probabilities are also very close to the those obtained in the previous model. The high volatility state is now a mixture of the high and very high volatility states in the SWARCH(4,2) model.

[12] Appendix Figure 2 plots this conditional standard deviation for the whole sample period.

[13] Appendix Tables and Figures 4-7 report the average smoothed probabilities (Panel A) and the conditional standard deviation (panel B) for each one of the regimes and for the mandates of the three central bank governors (Panel C). Appendix Figures 4-7 plot the smoothed probabilities for various SWARCH models.

Therefore, a model with three states still identifies the *EMU* but not the *crises* regime. As mentioned, there is no appropriate model with less than three states: in the estimated SWARCH(2,2) model, the low volatility state at the end of the sample period is no longer defined separately from other low volatility states and it is less stable than the high volatility state.

4. ERM CRISES: A CLOSER LOOK

Paradoxically, the stability culture was recovered in Portugal at a time of system instability. This paradox may explain domestic neglect of ERM membership. It seems, however, that the central rate the *escudo* kept after the realignment of the *peseta* in March 1995 would have been difficult to reach without the benefit of the ERM code of conduct. In this Section we try to provide evidence to this effect, by stressing some episodes of domestic controversy which coexisted with the ERM crises and therefore provide early tests for the credibility of Portugal's policy.

Table 4a here

The restoration of full convertibility by the central bank on 16 December, 1992 turned out to be extremely difficult to bring about, as the board reluctantly agreed to have controls renewed for shorter and shorter periods. The elimination was not announced until 13 August, 1992, under the threat that legislative action would be taken to withdraw the central banks' power to issue *avisos*. The effect in Table 4a is a jump in volatility. The virtual rule on policy-making Moreira's board enjoyed in 1990-91 made it even more difficult for Beleza to accept that the restoration of full currency convertibility could be carried out before the derrogation to the 4th Brussels directive negotiated by Greece and Portugal expired, in 1995 instead of asking for a renewal until 1993 or 1994 (which is when Greece finished its liberalization). Macedo had introduced several procedures which could have helped establish a two-way dialog between the treasury and the bank[14]. On March 3, 1993, he publicly urged the central bank to adjust to the time of full currency convertibility and to pay attention to the accumulating evidence that the recession was hitting the domestic economy. Two implications of convertibility which had been raised in the sessions with the bank's board were not made explicit in his plea: allowing for greater banking competition and lowering money market rates even if it meant letting the *escudo* slide towards the middle of the 6% ERM band rather than being glued to the top. Better banking supervision would lead to a decline in the cost of credit without the need to change the stance of monetary policy. Flexibility within the top of the band would reflect the benefit of the ERM code of conduct relative to opaque DMark shadowing. Some days later, *Reuters* aired rumours that Beleza was to resign in the footsteps of a vice-governor who had been an outspoken advocate of the hard *escudo* policy. While the rumours did not materialise, the adjustment to convertibility was depicted as a crisis rather than as a natural adaptation to greater financial reputation. Thus, the socialist opposition, who was openly questioning the stability-oriented policy contained in Q2 and calling instead for a slower disinflation and an autonomous depreciation of the currency, pretended to see the independence of the central bank threatened by an "authoritarian" government. To the social-democratic business elite, still under the shock of ERM entry, the pressure on the monetary authority suggested a reversal in the orientation of macroeconomic policy. Domestic controversy contributed to slow down the learning process for firms and citizens about the benefits to be derived from

[14] Both teams meet regularly (and minutes were kept, but not published), and the ministry team also convened an informal council including a dozen former ministers of finance, where four other past governors who had also been ministers (Pinto Barbosa before the revolution, Silva Lopes, Victor Constancio and Beleza thereafter) were able to debate the state of the economy and the progress of convergence.

financial reputation but there were no negative international effects and ERM partners believed the code of conduct would be upheld. This can be gathered from Table 4b, where nothing happens.

Table 4b here

In the turbulence which followed ERM entry, the lack of credit familiarity with Portugal also had to be overcome. Yet, the central bank, along with favoring capital controls, discouraged international borrowing, which it still associated to situations of looming payments crises rather than to the promotion of the nation's credit abroad. Exceptionally high foreign exchange reserves where another inheritance from the past, and therefore were not used to boost the Treasury's credit rating: Portugal's external debt issues had been assigned a rating of A1 by Moody's Investors Services in late 1986 and A by Standard and Poor's two years later. The divergence between the two agencies remained until late 1991, when Standard and Poor's upgraded to A+ . As soon as the currency was fully convertible, therefore, a strategy of making the treasury known in international markets was designed, involved a planned return to international borrowing, successively in yen, marks and dollars. The upgrading of Portugal's foreign debt to AA- was decided by Standard and Poor's in May 1993, even though the previous upgrade had been decided less than 18 months earlier. International investors were ready to believe then that economic policy in Portugal would retain a medium term orientation also because this was the first such move since Ireland had been upgraded in 1989. Nevertheless, the strategy was ignored domestically. Shortly after the global dollar issue of September 1993, the deterioration in the deficit, whilst keeping non-interest expenditure at the nominal amount included in Q2, increased the deficit and had a much greater impact domestically than the credibility earned abroad [15].

The ERM crises were felt by the *lira* and sterling who left the grid on 17 September, 1992 when the *peseta* also realigned but the *escudo* did not. The opinion at the central bank was to deny the "geographic fundamentals" and to stick to DM shadowing, while recognising that exchange rate policy was a competence of the government. Exporters, on the other hand, were impressed by the bilateral rate with the *peseta* and had been pressing for a devaluation of the *escudo* relative to the *peseta*. As it turned out, the realignment of 23 November was matched and those on 14 May, 1993 and 6 March, 1995 were followed in part, without ever facing the loss in financial reputation associated with initiating a realignment. In Table 4a, the probability of the very high volatility state jumps from 40% to 90%, but nothing elese moves. Quarterly data on capital flows confirm that external credibility was achieved in late 1992 and remained unperturbed by subsequent *peseta* realignments. As there was no memory of speculative attacks against the escudo, the domestic turbulence of March 1993 may just reflect the tension between treasury and central bank, or echo fears about the liberalisation of capital movements on the part of the banking community. On the other side, the more flexible policy of following the realignments of *peseta* would probably not have been possible to enforce as smoothly without the required change in the bank's operating procedures.

The very low volatility state which otherwise only occurred near the end of the full sample, is also identified just ahead of the first realignment of the *escudo*, from 7 October to 4 November, 1992, switching to high volatility in the week of 11 November, while the conditional standard deviation drops from .65% to .06% per week. Table 4a shows this episode of what might be called "false stability", where a strong market intervention by the

[15] *Euromoney* credited Macedo when nominating Portugal "The Borrower of the Year 1993". Note that previous practice had the minister/ governor pair directly involved in foreign debt issuing.

central bank was able to maintain the rate glued to the top of band before adjusting the central rate. While this interpretation of response of the central bank to speculative attacks should be further tested using appropriate intervention data, it is consistent with the presumption from Section 2 that the decision to enter the ERM could not have been taken much later than April 1992 and that, given the absence of the prerequisite MAFAS and PPERR, an earlier entry date would not have been credible either. Indeed, the reason why the specification with five states appears more adequate than the model with four states is that the latter allows the identification of the very low volatility state 1 with the *EMU* regime, ruling out the instance of "false stability" uncovered above[16].

5. CONCLUSION

When, two years and a half years after Portugal joined the European Community, the 1987 general elections brought a durable government, the national environment was still inflationary. Nevertheless, thanks to the efforts of successive minister of finance/central bank governor pairs, the criteria for EMU were met and the seventh pair saw the euro conversion rate be set at 200 *escudos*. The agreed rate represents a depreciation of some 16% over the one at which the *escudo* entered the ECU basket in 1989. As the change in regime towards stability-oriented macroeconomic policies was completed when the parity grid of the ERM was under severe stress, *escudo* depreciations were agreed upon at realignments initiated by the *peseta*.

The understanding by the Portuguese authorities of the ERM code of conduct as they prepared to join after the 1991 general elections made it possible to acquire financial reputation very quickly. This understanding was made clear by the priorities of the Portuguese presidency of the ECOFIN in the first semester of 1992, during which public communiqués of multilateral surveillance were introduced. But the enhanced national credibility abroad caused tension within several minister/governor pairs, especially with respect to the timing of ERM entry, the speed at which to move to full currency convertibility and whether the *escudo* should respond to *peseta* realignments. Moreover, both the opposition and the governing party initially resisted the stability-oriented policy, stalling structural reforms and allowing the opposition to win the 1995 general elections on a reformist platform. As a consequence, the stability-oriented policy was maintained until EMU qualification but there were no other major reforms, rasing the threat of a "euro hold-up".

The weekly *escudo*-DMark rate reveals widely different volatility states which were accompanied by six successive exchange rate regimes. Before entering the ERM, a crawling peg was discreetly replaced by DMark shadowing with reinforced controls on capital inflows at the beginning of first stage of EMU. Yet, the *escudo*-DMark rate, even allowing for the last realignment, was more stable in the ERM than when it was inconvertible and the central bank controlled the currency. The comparison excludes the subperiod of crises before widening the bands and the one after volatility in prospective EMU qualifying currencies subsided. Even though an inconvertible currency, not being market determined, would tend to reveal a lower volatility than a convertible one, the results show the opposite. The conditional volatility is 0.3% and 0.43% per week in the first and second sub-periods respectively, whereas during two sub-periods after the widening of the ERM bands, separated by the last realignment, it is 0. 28% and 0.4% per week respectively. During the ERM crises the volatility reaches 0.47% whereas it falls to 0.08% per week after October, 1997.

[16] Jeanne and Masson (1998) use similar techniques to predict realignments of the French franc in the ERM.

SWARCH models with more than three states capture all regimes. The specification with five states is favored because it suggests the nature of the response of the central bank to speculative attacks during the crises regime. Thus in November 1992, central bank intervention was so strong it induced "false stability". Another conclusion pertains to the pattern of alternating between international and domestic objectives in macroeconomic policy making, which was associated with the task of moving the *escudo* into the euro. This pattern may re-emerge if the awareness of the threat of a "euro hold-up" rises, perhaps as a consequence of turbulent world financial markets. The research agenda on the stochastic properties of the *escudo*-DMark rate includes robustness tests, returning to daily data, to the effect of the dollar-DMark rate, of central bank intervention and of "news" (such as those of financial panics outside the euro area)[17].

Appendix

Keeping the equation numbering in the text for convenience, the probabilities of being in each of the states at times t, t-1 and t-2, given values for the parameters of the model are computed as:

(11) $p(s_t, s_{t-1}, s_{t-2} \mid y_t, y_{t-1}, \ldots)$.

The recursion begins at t=0 with these probabilities given by the ergodic probabilities obtained as a function of the elements in the transition matrix P.

The procedure involves multiplying the probabilities in (11) by the probabilities of moving from one regime to another, given by the elements in P, as in (10), to obtain:

(12) $p(s_{t+1}, s_t, s_{t-1}, s_{t-2} \mid y_t, y_{t-1}, \ldots)$.

Conditioned on the values s_{t+1}, s_t, s_{t-1} denote the distribution function of y_{t+1} by:

(13) $f(y_{t+1} \mid s_{t+1}, s_t, s_{t-1}, s_{t-2}, y_t, y_{t-1}, \ldots)$.

The expression in (13) is simply the usual normal density function for the AR(1)-ARCH(2) model given by (1) with the variance of the residual given by (8). Multiplying the expressions in (12) and (13), we obtain the likelihood of observing y_{t+1} and of being in each of the states at times t-2 through time t+1:

(14) $p(s_{t+1}, s_t, s_{t-1}, s_{t-2}, y_{t+1} \mid y_t, y_{t-1}, \ldots)$.

Summing the expression in (14) over all possible values of $s_{t+1}, s_t, s_{t-1}, s_{t-2}$, we finally obtain the likelihood of observing y_{t+1} conditional on current and past values of y:

(15) $f(y_{t+1} \mid y_t, y_{t-1}, \ldots)$.

The recursive procedure continues using as the new initial condition the probabilities of being in each of the states at times t+1, t and t-1:

(16) $p(s_{t+1}, s_t, s_{t-1} \mid y_{t+1}, y_t, \ldots)$.

[17] When the SWARCH (5,1) and (4,2) models are re-estimated until end-December 1998, the ranking in Table 2 is preserved but the range of variance factors rises; conditional volatility in the *EMU* regime falls to 1/3 but remains the same in the *crises* regime. Fornari et al (1998) have a model for the Italian *lira* with news.

The probabilities in (16) are obtained by summing the probabilities obtained in (14) over all possible values of s_{t-2}, and dividing the result by the conditional density in (15). Note that (11) is (16) lagged one period.

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References

Bliss, Christopher and Jorge Braga de Macedo, editors, **Unity with Diversity in the European Economy: The Community's Southern Frontier**, Cambridge: Cambridge University Press, 1990.

Braga de Macedo, Jorge, *Crises? What crises?* Escudo *from ECU to EMU*, Nova Economics Working Paper nº 313, December 1997

Covas, Francisco, *Regime Switching in Exchange Rates*, unpublished paper, FEUNL, July 1998

Fornari, Fabio, Carlo Monticelli, Marcello Pericoli and Massimo Tivegna, *The impact of news on the lira exchange rate and long-term interest rates*, paper presented at the LINK World Conference in Rio de Janeiro, Brazil, September 1998.

Hamilton, James, **Time Series Analysis**, Princeton: Princeton University Press, 1994.

Hamilton, James and Raul Susmel, Autoregressive Conditional heteroskedasticity and changes in regime, **Journal of Econometrics**, 64 (1994), 307-333.

Jeanne, Olivier and Paul Masson, *Currency Crises, Sunspots and Markov-switching regimes*, CEPR Discussion Paper nº 1990, October 1998

Rocha de Sousa, Miguel, *Real Interest rate Differentials and Regime Change in Portugal 1989-1997*, unpublished paper, FEUNL, June 1997

Table 1

Comparisons relative to constant variance model

Model description	MSE	Hghst vr factor
GARCH(1,1)	**-1%**	**1**
SWARCH(2,2)	**-11%**	**23**
SWARCH(3,2)	**1%**	**236**
SWARCH(4,2)	**4%**	**823**
SWARCH(5,1)	**10%**	**725**

Source: Appendix tables 2 and 3

Table 2

Average Standard Deviation and Probabilities of states in regimes

Av condit sd (%pw)	Regime label	Average smoothed probabilities of five states (%) very low	low	medium	high	very high
0.08	EMU	**86**	**14**	0	0	0
0.28	peseta	0	**14**	**54**	**30**	2
0.30	crawl	0	7	**49**	**43**	1
0.40	wide	0	0	**17**	**70**	**12**
0.43	Dmark	0	0	5	**71**	**24**
0.47	crises	7	0	0	**54**	**39**

Source: Appendix Table 3b panels A and B

Table 3
Chronology of a fully credible EMU

Date	Mn Rtrn (% pw)	Cond sd (% pw)	Smoothed probs very low	low	med	high
04/02/97	-0.07	0.22			**97%**	3%
04/09/97	-0.29	0.20			**97%**	3%
04/16/97	-0.06	0.23			**96%**	4%
04/23/97	0.29	0.21			**95%**	5%
04/30/97	-0.15	0.24			**94%**	6%
05/07/97	0.18	0.24			**93%**	7%
05/14/97	**0.20**	0.24			**92%**	8%
05/21/97	-0.01	0.23			**91%**	9%
05/28/97	0.44	0.22			**89%**	11%
06/04/97	-0.11	0.28			**88%**	12%
06/11/97	0.20	0.26			**87%**	12%
06/18/97	-0.35	0.26			**87%**	13%
06/25/97	0.08	**0.31**		21%	**70%**	9%
07/02/97	-0.05	0.28		**54%**	42%	4%
07/09/97	0.05	0.25		**74%**	24%	1%
07/16/97	-0.01	0.24		**85%**	14%	
07/23/97	0.01	0.22		**90%**	9%	
07/30/97	0.09	0.19		**93%**	7%	
08/06/97	0.16	0.19		**94%**	6%	
08/13/97	0.09	0.19		**96%**	4%	
08/20/97	0.09	0.16		**96%**	4%	
08/27/97	0.07	0.15		**97%**	3%	
09/03/97	**-0.12**	0.13		**96%**	4%	
09/10/97	0.16	0.15		**97%**	3%	
09/17/97	0.13	0.17		**97%**	3%	
09/24/97	0.03	0.15		**98%**	2%	
10/01/97	0.19	0.13		**98%**	2%	
10/08/97	-0.02	0.16		**98%**	2%	
10/15/97	-0.09	0.15		**99%**	1%	
10/22/97	0.03	0.14		**99%**	1%	
10/29/97	0.18	0.12		**99%**	1%	
11/05/97	0.09	0.15		**99%**	1%	
11/12/97	-0.06	0.13		**100%**		
11/19/97	0.03	0.13		**100%**		
11/26/97	0.10	0.11		**100%**		
12/03/97	0.01	0.12	2%	**98%**		
12/10/97	-0.03	0.11	2%	**98%**		
12/17/97	0.11	0.10	3%	**97%**		
12/29/97	0.02	0.12	**62%**	38%		
12/31/97	0.02	0.10	**84%**	16%		
01/07/98	-0.01	0.10	**90%**	10%		
01/14/98	-0.03	0.09	**93%**	7%		
01/21/98	0.03	0.08	**95%**	5%		
01/28/98	0.08	0.08	**95%**	5%		
02/04/98	-0.01	0.09	**97%**	3%		
02/11/98	0.03	0.08	**98%**	2%		
02/18/98	-0.01	**0.07**	**98%**	2%		

Source: Calculations summarised in Appendix Table 3a
Note: "very high" volatility state was zero throughout.
Probabilities may not add to 100 due to rounding.

Table 4a

Chronology of the ERM crises regime
(from entry to the first realignment)

Date	Mn Rtrn	Cond sd	Smoothed probabilities		
	(% pw)	(% pw)	very low	high	very high
04/08/92	-0.53	0.19		**85%**	13%
04/15/92	0.06	0.38		**82%**	17%
04/22/92	-0.80	0.33		**71%**	29%
04/29/92	-1.08	0.55		**71%**	29%
05/06/92	-0.68	0.62		**81%**	18%
05/13/92	-0.65	0.53		**87%**	13%
05/20/92	0.00	0.51		**92%**	7%
05/27/92	-0.21	0.43		**94%**	5%
06/03/92	0.06	0.40		**94%**	5%
06/11/92	0.32	0.37		**92%**	7%
06/17/92	-0.27	0.37		**88%**	11%
06/24/92	-0.03	0.39		**82%**	18%
07/01/92	0.49	0.35		**63%**	37%
07/08/92	0.72	0.41		45%	**55%**
07/15/92	1.22	0.44		27%	**73%**
07/22/92	0.22	0.65		31%	**69%**
07/29/92	-0.42	0.51		28%	**72%**
08/05/92	0.41	0.52		24%	**76%**
08/12/92	0.35	0.52		19%	**81%**
08/19/92	1.30	0.44		5%	**95%**
08/26/92	0.72	0.78		20%	**80%**
09/02/92	0.30	0.65		27%	**73%**
09/09/92	0.00	0.54		25%	**75%**
09/16/92	0.70	0.45		15%	**85%**
09/23/92	-0.13	0.57		12%	**88%**
09/30/92	0.78	0.49		4%	**96%**
10/07/92	0.28	0.65	89%	4%	6%
10/14/92	0.12	0.49	94%	5%	1%
10/21/92	0.01	0.31	95%	5%	
10/28/92	0.02	0.15	94%	6%	
11/04/92	0.03	0.08	85%	15%	
11/11/92	-0.32	0.06		**100%**	
11/18/92	0.12	0.36		**98%**	2%
11/25/92	0.59	0.36		**96%**	4%

Source: Calculations summarised in Appendix Table 3a

Note: "low" and "medium" volatility states were negligible.

Probabilities may not add to 100 due to rounding.

Table 4b

Chronology of the ERM crises regime
(from the first realignment to the widening of the bands)

Date	Mn Rtrn (% pw)	Cond sd (% pw)	Smoothed probs high	Smoothed probs very high
12/02/92	0.09	0.42	**95%**	5%
12/09/92	-0.39	0.37	**92%**	8%
12/16/92	0.22	0.40	**89%**	11%
12/23/92	0.88	0.39	**81%**	19%
12/30/92	0.39	0.54	**85%**	15%
01/06/93	-0.55	0.42	**84%**	16%
01/13/93	-0.40	0.54	**90%**	10%
01/20/93	0.37	0.45	**92%**	8%
01/27/93	0.35	0.47	**94%**	6%
02/03/93	0.17	0.41	**95%**	5%
02/10/93	0.16	0.37	**93%**	7%
02/17/93	0.84	0.35	**87%**	13%
02/24/93	0.70	0.52	**90%**	10%
03/03/93	-0.23	0.46	**92%**	8%
03/10/93	0.44	0.45	**94%**	6%
03/17/93	0.22	0.46	**96%**	3%
03/24/93	0.40	0.39	**97%**	3%
03/31/93	-0.15	0.39	**97%**	3%
04/07/93	0.14	0.38	**96%**	3%
04/14/93	0.04	0.36	**95%**	4%
04/21/93	-0.27	0.34	**90%**	9%
04/28/93	0.16	0.36	**81%**	19%
05/05/93	-0.10	0.35	**61%**	39%
05/12/93	0.89	0.34	10%	**90%**
05/19/93	2.08	0.59		**100%**
05/26/93	-0.13	0.87		**100%**
06/02/93	0.92	0.73		**100%**
06/09/93	-1.43	0.76		**100%**
06/16/93	0.32	0.86	2%	**98%**
06/23/93	-0.38	0.73	4%	**96%**
06/30/93	0.48	0.67	4%	**96%**
07/07/93	-0.01	0.67	4%	**96%**
07/14/93	1.29	0.56		**100%**
07/21/93	1.72	0.80		**100%**
07/28/93	3.00	0.80		**100%**
08/04/93	1.00	0.98	43%	**57%**

Source: Calculations summarised in Appendix Table 3a
Note: other volatility states were negligible.
Probabilities may not add to 100 due to rounding.

Table 1. Summary statistics for yt

Observations	613
Mean	0.050
Variance	0.151
Skewness	1.288
Kurtosis	8.481

Autocorrelation Tests (Ljung-Box tests)

lags	test	sig.
1	61.97	0.00
4	79.34	0.00
12	103.01	0.00
24	107.85	0.00
squared residuals		
lags	**test**	**sig.**
1	65.79	0.00
4	82.41	0.00
12	165.35	0.00
24	174.25	0.00

ARCH tests

lags	test	sig
1	65.93	0.00
4	66.44	0.00
12	114.32	0.00
24	125.25	0.00

Table 2. Estimated parameters for GARCH(1,1) model

Parameters	Estimates	Std. err.	Est/se
alpha	0.0070	0.0050	1.407
phi	0.3059	0.0437	6.994
kappa	0.0000	.	.
delta	0.8374	0.0367	22.843
beta	0.1977	0.0568	3.483

Table 3. Comparative results for estimated models

Model	No. Param	Log.-Lik.	MSE	MAE	Persistence
Constant variance	2	-1661.61	1452.72	16.15	0.00
GARCH(1,1) with	4	-1515.05	1464.00	16.45	1.04
SWARCH(2,2)	8	-1513.24	1630.96	16.37	0.82
SWARCH(3,2)	11	-1486.48	1439.27	14.68	0.46
SWARCH(4,2)	16	-1475.55	1401.32	14.81	0.39
SWARCH(5,1)	18	-1474.64	1316.53	14.38	0.08

Table 4a. Estimation results for the SWARCH(5,1) model

Constant term in regression: 0.0074
Autoregressive coefficient in regression: 0.3043
Constant term in ARCH process: 0.00083
Coefficients on lagged e squared in ARCH process: 0.0836

States:	very low	low	medium	high	very high
Variance factors:	1	10	48	127	725

Matrix of Transition Probabilities (%):

very low	97.5	2.6	0	0	1.5
low	0	93.3	0.9	0.3	0
medium	0	4.1	96.7	1.4	0
high	2.5	0	2.4	94.9	14
very high	0	0	0	3.4	84.5

Ergodic Probabilities (%):

	12	6	27	46	10

Table 4b. Summary results for the SWARCH(5,1) model

Panel A

Average Probabilities of states in Periods (%)

	very low	low	medium	high	very high
01/28/87-07/04/90	0	7	49	43	1
07/11/90-04/08/92	0	0	5	71	24
04/15/92-04/08/93	7	0	0	54	39
08/11/93-03/08/95	0	0	17	70	12
03/15/95-11/05/97	0	14	54	30	2
11/12/97-10/14/98	86	14	0	0	0

Panel B

Standard Deviation in Periods and their description

01/28/87-07/04/90	0.30	Crawling peg
07/11/90-04/08/92	0.43	DM shadowing cum capital controls
04/15/92-04/08/93	0.47	ERM 6% and system instability
08/11/93-03/08/95	0.40	ERM 15% before PTE realigment
03/15/95-11/05/97	0.28	ERM 15% after PTE realigment
11/12/97-10/14/98	0.08	Before EMU

Panel C

Governors of Central Bank

Average Probabilities of states in Periods (%)

	very low	low	medium	high	very high	
Jan87-May92	0	4	33	53	9	Moreira
Jun92-Jun94	4	0	0	65	31	Beleza
Jul94-Oct98	18	12	40	28	2	Sousa

Standard Deviation in Periods and their description

Jan87-May92	0.34	Moreira
Jun92-Jun94	0.47	Beleza
Jul94-Oct98	0.25	Sousa

Table 5a. Estimation results for the SWARCH(4,2) model

Constant term in regression: 0.0058
Autoregressive coefficient in regression: 0.259
Constant term in ARCH process: 0.00076
Coefficients on lagged e squared in ARCH process:
0.088
0.119

States:	very low	medium	high	very high
Variance factors:	1	36	124	823

Matrix of Transition Probabilities (%)

very low	99.5	0.4	0.0	0.0
medium	0.0	97.6	1.6	0.0
high	0.2	0.8	95.6	20.9
very high	0.3	1.2	2.9	79.1

Ergodic Probabilities (%):

	21	28	43	8

Table 5b. Summary results for the SWARCH(4,2) model

Panel A

Average Probabilities of states in Periods (%)

	very low	medium	high	very high
01/28/87-07/04/90	0	53	45	2
07/11/90-04/08/92	0	6	73	20
04/15/92-08/04/93	0	1	70	29
08/11/93-03/08/95	0	25	67	9
03/15/95-11/05/97	0	68	31	1
11/12/97-10/14/98	88	12	0	0

Panel B

Standard Deviation in Periods and their description

01/28/87-07/04/90	0.31	Crawling peg
07/11/90-04/08/92	0.42	DM shadowing cum capital controls
04/15/92-08/04/93	0.50	ERM 6% and system instability
08/11/93-03/08/95	0.39	ERM 15% before PTE realigment
03/15/95-11/05/97	0.29	ERM 15% after PTE realigment
11/12/97-10/14/98	0.09	Before EMU

Panel C

Governors of Central Bank

Average Probabilities of states in Periods (%)

	very low	medium	high	very high	
Jan87-May92	0	36	55	9	Moreira
Jun92-Jun94	0	1	77	22	Beleza
Jul94-Oct98	19	54	25	2	Sousa

Standard Deviation in Periods and their description

Jan87-May92	0.35	Moreira
Jun92-Jun94	0.47	Beleza
Jul94-Oct98	0.25	Sousa

Table 6a. Estimation results for the SWARCH(3,2) model

Constant term in regression: 0.0051
Autoregressive coefficient in regression: 0.261
Constant term in ARCH process: 0.00067
Coefficients on lagged e squared in ARCH process:
0.209
0.118

States:	very low	medium	high
Variance factors:	1	40	236

Matrix of Transition Probabilities (%)

very low	99.5	0.3	0.0
medium	0.0	97.0	2.6
high	0.5	2.7	97.4

Ergodic Probabilities (%):

	21	37	42

Table 6b. Summary results for the SWARCH(3,2) model

Panel A

Average Probabilities of states in Periods (%)

	very low	medium	high
01/28/87-07/04/90	0	70	30
07/11/90-04/08/92	0	20	80
04/15/92-08/04/93	0	3	96
08/11/93-03/08/95	0	28	72
03/15/95-11/05/97	0	71	29
11/12/97-10/14/98	88	12	0

Panel B

Standard Deviation in Periods and their description

01/28/87-07/04/90	0.31	Crawling peg
07/11/90-04/08/92	0.40	DM shadowing cum capital controls
04/15/92-08/04/93	0.49	ERM 6% and system instability
08/11/93-03/08/95	0.39	ERM 15% before PTE realigment
03/15/95-11/05/97	0.29	ERM 15% after PTE realigment
11/12/97-10/14/98	0.08	Before EMU

Panel C

Governors of Central Bank

Average Probabilities of states in Periods (%)

	very low	medium	high	
Jan87-May92	0	52	48	Moreira
Jun92-Jun94	0	3	97	Beleza
Jul94-Oct98	19	57	25	Sousa

Standard Deviation in Periods and their description

Jan87-May92	0.34	Moreira
Jun92-Jun94	0.47	Beleza
Jul94-Oct98	0.25	Sousa

Table 7a. Estimation results for the SWARCH(2,2) model

Constant term in regression: 0.0071
Autoregressive coefficient in regression: 0.259
Constant term in ARCH process: 0.00284
Coefficients on lagged e squared in ARCH process:
0.2714
0.4461

States:	low	high
Variance factors:	1	23

Matrix of Transition Probabilities (%)

	low	high
low	90	3
high	10	97

Ergodic Probabilities (%):

25	75

Table 7b. Summary results for the SWARCH(2,2) model

Panel A

Average Probabilities of states in Periods (%)

	low	high
01/28/87-07	18	82
07/11/90-04	17	83
04/15/92-08	8	92
08/11/93-03	11	89
03/15/95-11	29	71
11/12/97-10	100	0

Panel B

Standard Deviation in Periods and their description

01/28/87-07	0.32	Crawling peg
07/11/90-04	0.41	DM shadowing cum capital controls
04/15/92-08	0.51	ERM 6% and system instability
08/11/93-03	0.39	ERM 15% before PTE realigment
03/15/95-11	0.30	ERM 15% after PTE realigment
11/12/97-10	0.12	Before EMU

Panel C

Governors of Central Bank

Average Probabilities of states in Periods (%)

	very low	medium	
Jan89-May	17	83	Moreira
Jun92-Jun9	6	94	Beleza
Jul94-Oct9	43	57	Sousa

Standard Deviation in Periods and their description

Jan89-May	0.35	Moreira
Jun92-Jun9	0.47	Beleza
Jul94-Oct9	0.27	Sousa

Figure 1. Percent changes in the weekly escudo-DM rate

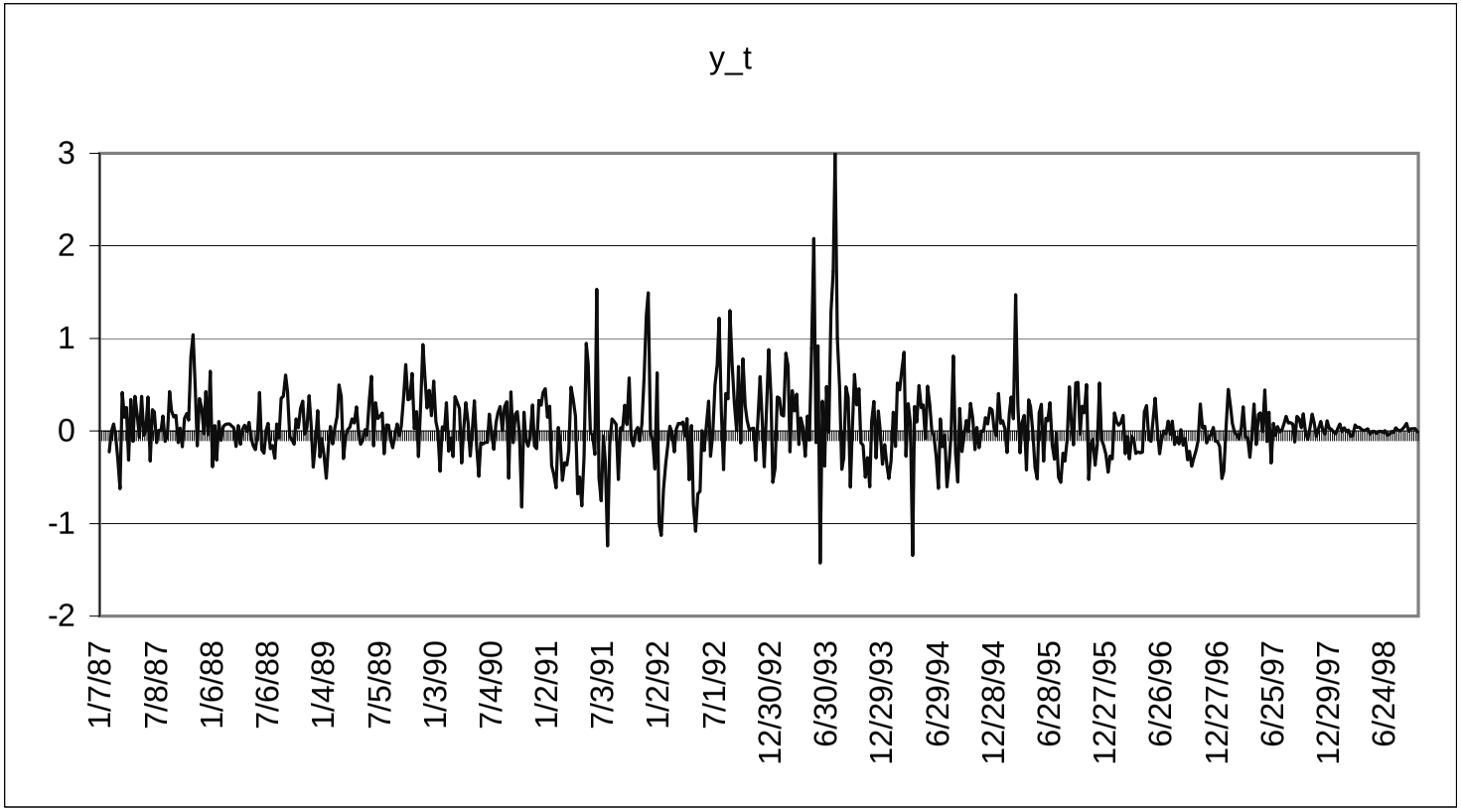


Figure 2. Graph of maximized log-likelihood for different values of k

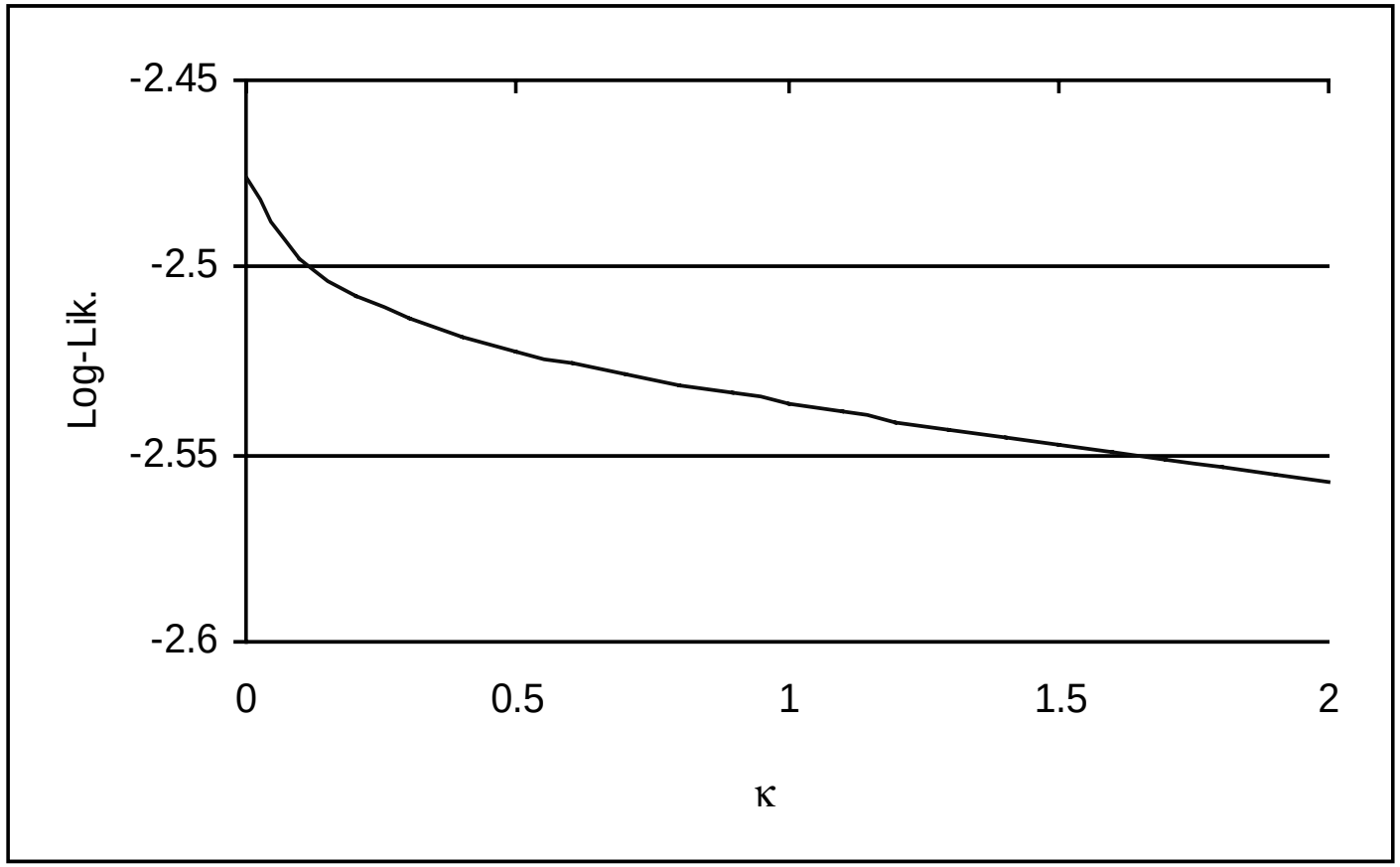


Figure 3. Conditional volatility for the SWARCH(5,1) model

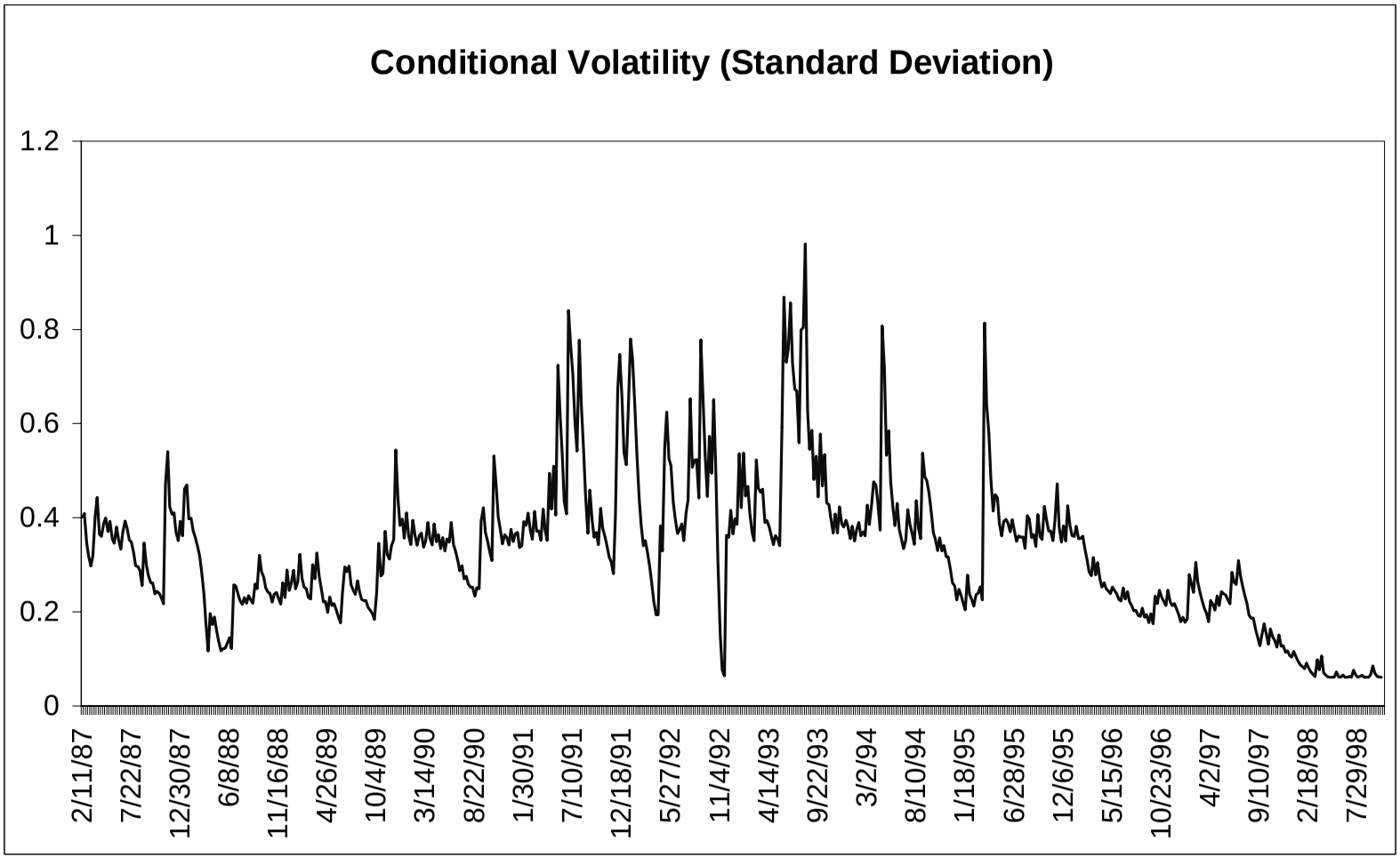


Figure 4. Probabilities of being in each of the five states in the SWARCH(5,1) model

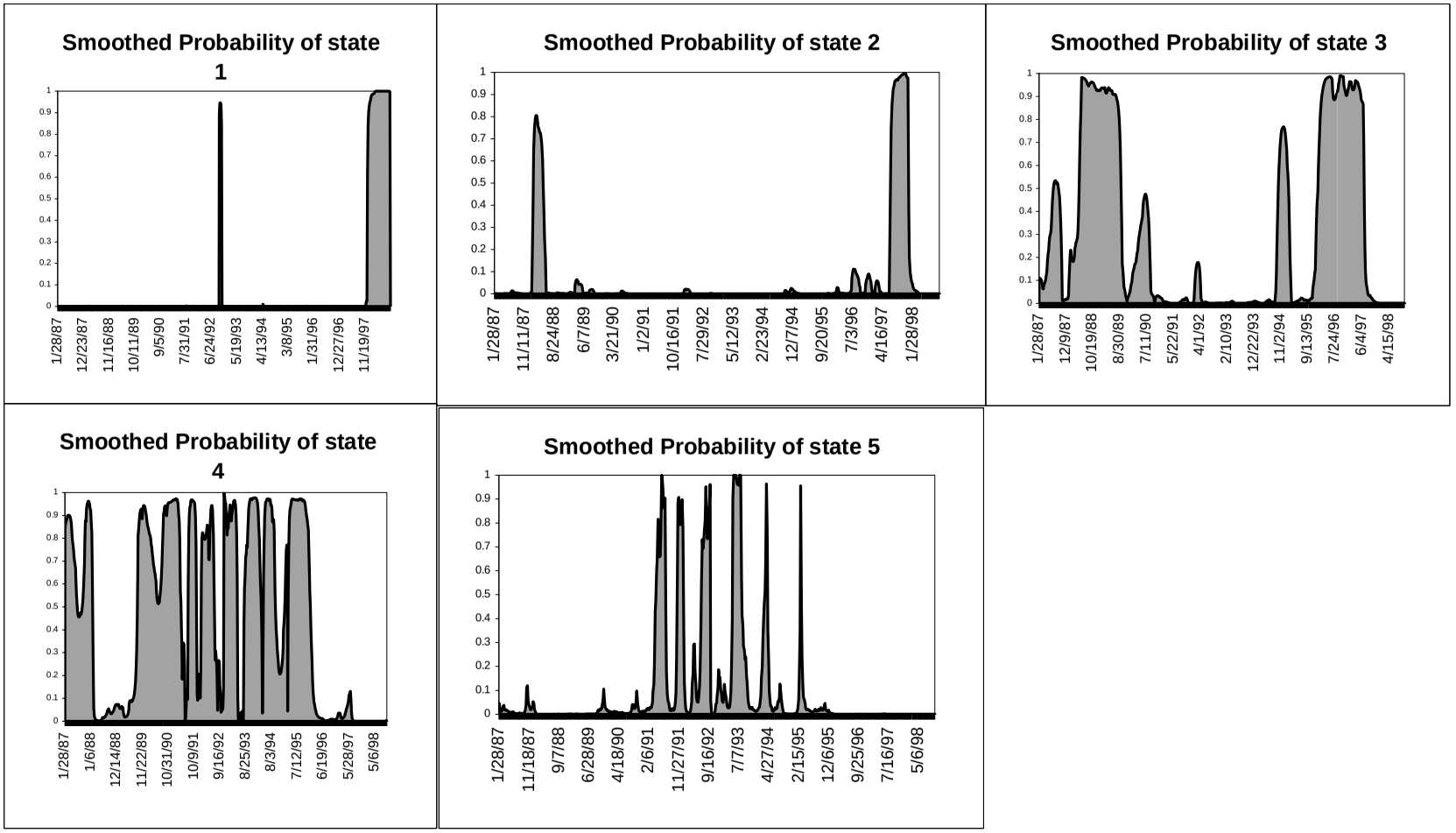


Figure 5. Probabilities of being in each of the four states in the SWARCH(4,2) model

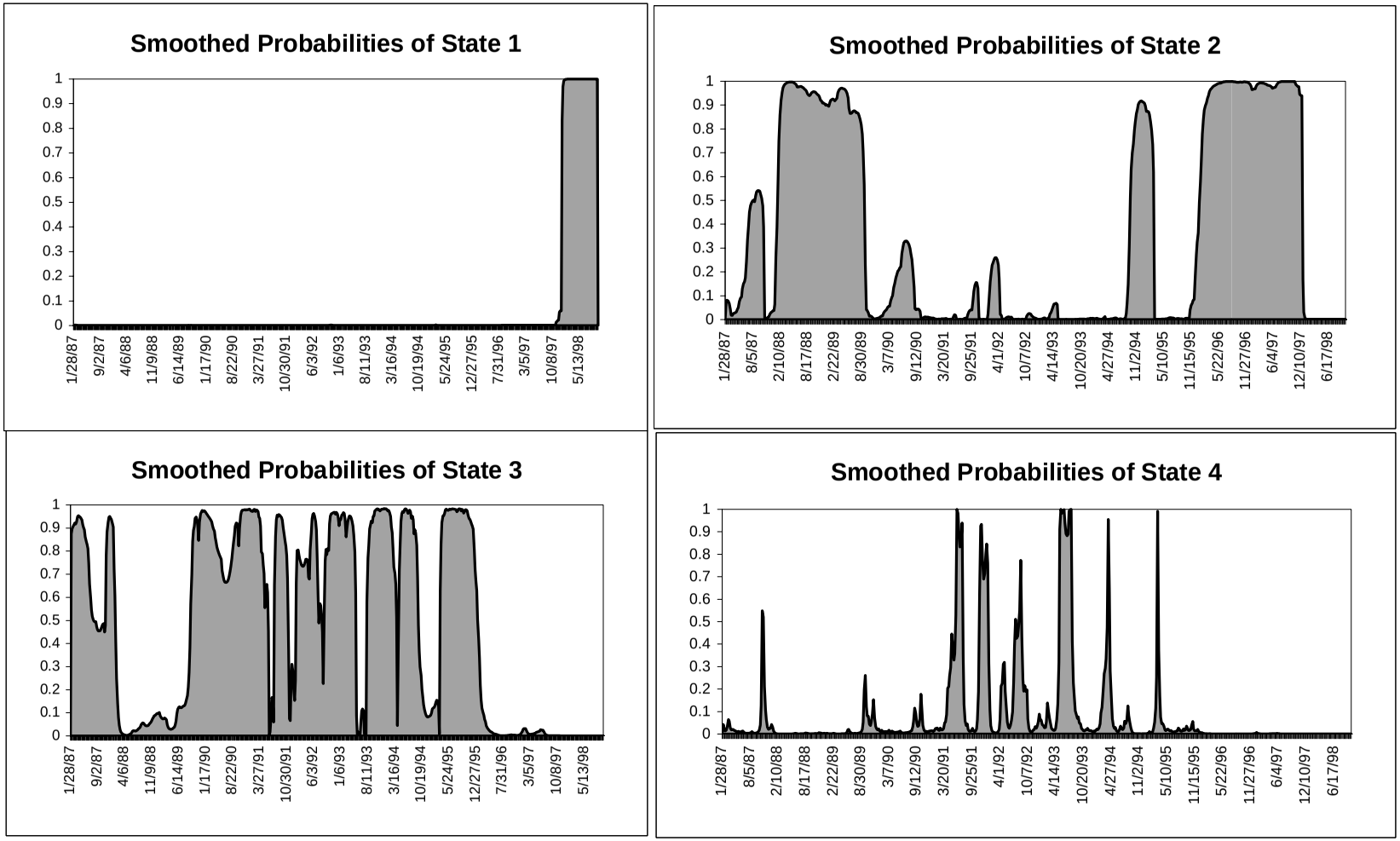
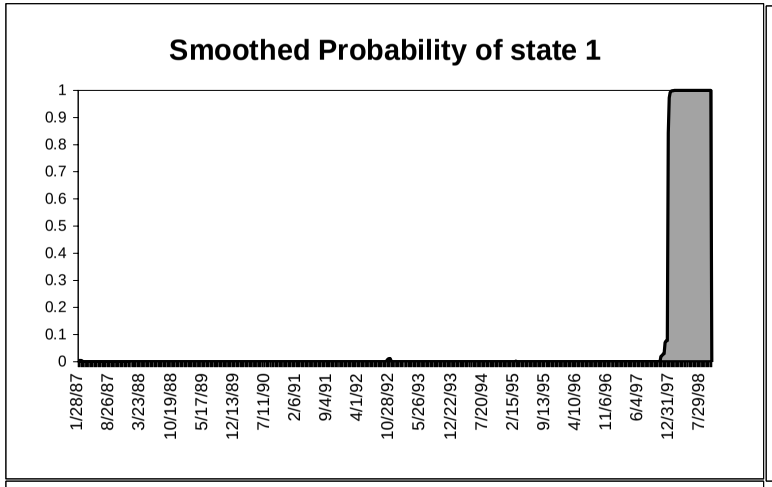
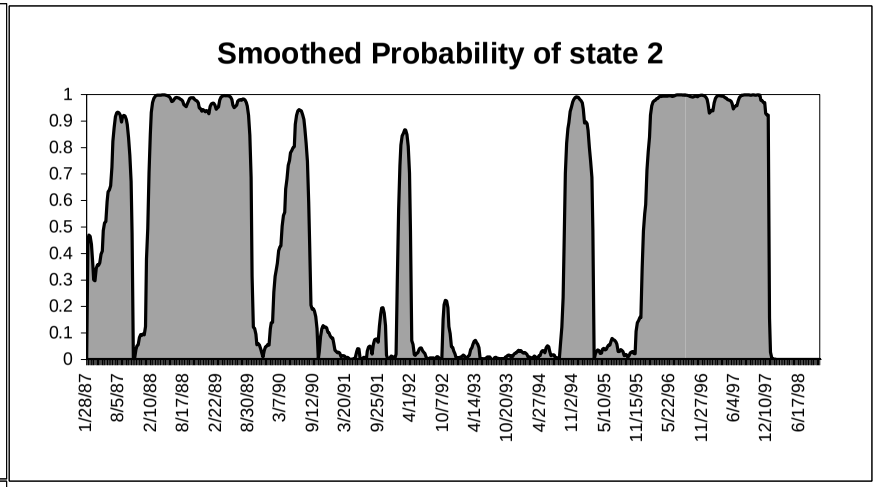


Figure 6. Probabilities of being in each of the three states in the SWARCH(3,2) model





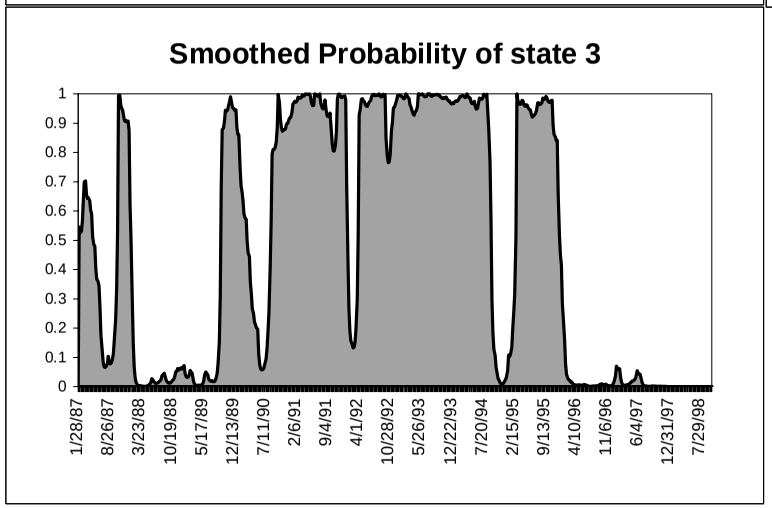


Figure 7. Probabilities of being in each of the two states in the SWARCH(2,2) model