An empirical analysis of the peseta's exchange rate dynamics

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Introduction

In the early 1980's Meese and Rogoff (1983) puzzled most economists by showing that despite the existence of several competing theories to explain freely floating exchange rates[2], none is able to reliably improve the forecasts from a simple random walk model. More than ten years later their results remain in place. In a recent survey, Frankel and Rose (1994) conclude that standard theoretical models still fail to predict future exchange rate changes in the short and medium term.

Empirical results are also disappointing regarding our ability to explain future exchange rate movements for currencies that belong to managed exchange rate regimes like the Exchange Rate Mechanism (ERM) of the European Monetary System (see Garber and Svensson, (1994), in spite of the convincing theoretical work pioneered by Krugman (1991).

The recent periods of turbulence in the foreign exchange markets have renewed interest in identifying the driving forces of exchange rate movements in the short and medium term. In this paper we estimate a model explaining the dynamics of the effective exchange rate of the peseta vis-à-vis the currencies of other OECD countries[3]. Our model takes into account that this exchange rate is neither under the direct control of the monetary authorities (as it includes bilateral exchange rates against currencies that are, or have been, outside the ERM) nor completely flexible (because it includes bilateral managed exchange rates). It also pays special attention to the role of the "jumps" in the exchange rate that we observe from time to time.

The empirical model relies, on the one hand, on the results in Pérez-Jurado and Vega (1994), who showed that purchasing power parity (PPP) holds in the long run when tradable-good prices are considered. On the other hand, the model builds on the work by Ayuso and Pérez-Jurado (1995) where unusual jumps in the exchange rates of ERM currencies are explained in terms of real exchange rate deviations from a reference value and different variables that determine the costs for the monetary authorities of maintaining a given exchange rate.

In particular, the starting point of the analysis is an error correction model (ECM) for the first difference of the peseta's (log) effective exchange rate. This model is enlarged with terms which take into account the possibility of a jump in the exchange rate. Following Ayuso and Pérez-Jurado (1995) the size of the jumps is assumed to be a function of PPP deviations. The probability of the jumps is also estimated using Probit models that allow us to investigate to what extent macroeconomic variables may help to predict such jumps.

According to the estimate of our modified ECM equation, exchange rate jumps act to accelerate the speed of adjustment to the long run equilibrium. On the other hand, although a number of macroeconomic variables can help to explain why exchange rates jump, their predictive power is rather low.

The structure of the paper is the following: after this introduction, Section 1 depicts the

1 We are grateful to W. Melick for his excellent discussion and to the participants at the meeting of central bank econometricians and model builders held at the BIS. We also thank O. Bover and J.J. Dolado for helpful comments.

2 Surveys on this topic are legion. See, for example, MacDonald and Taylor (1989).

3 See Bajo and Sosvilla (1993) for a survey on the empirical evidence on different theoretical models to explain the peseta's exchange rate dynamics.

basic model. Section 2 deals with the estimate of the modified ECM equation and Section 3 is devoted to estimating the jump probabilities. The final section summarises the main results in the paper.

1. Econometric framework

Our starting point is the work by Ayuso and Pérez-Jurado (1995). This paper decomposes the expected devaluation rate into the likelihood of a devaluation and its expected size and puts forward, in the context of the ERM, the following univariate model for the bilateral peseta-Deutschemark exchange rate:

$$s_t = k + \Gamma(L)s_{t-1} + d_t + \varepsilon_t$$
$$d_t = \begin{cases} d_t^* & \text{with prob } Pr_{t-1} \\ 0 & \text{with prob } 1 - Pr_{t-1} \end{cases} \tag{1}$$

where s_t is (the log of) the exchange rate; $\Gamma(L)$ is a general lag polynomial; d_t^* is the size of the exchange rate jump in the event of a devaluation; and Pr_{t-1} is the likelihood, at time $t-1$, of a devaluation occurring at time t.

It is also assumed that d_t^* depends on the vector of variables x_{t-1}^d and that a devaluation takes place when a given indicator c_t^* becomes positive. This indicator can be interpreted as the cost perceived by the government of maintaining the current parity. This cost depends on a vector of fundamentals x_{t-1}^c. Therefore:

$$d_t^* = \beta^d x_{t-1}^d + u_t^d \tag{2}$$

$$c_t^* = \beta^c x_{t-1}^c + u_t^c \tag{3}$$

$$Pr_{t-1} = prob.\left(u_t^c > -\beta^c x_{t-1}^c\right) \tag{4}$$

According to the results in Ayuso and Pérez-Jurado (1995), d_t^* depends exclusively on the deviations of the real exchange rate from a reference level, so that equation (2) can be rewritten as:

$$d_t^* = \beta(tcr_{t-1} - tcr*) + u_t^d = \lambda - \beta tcr_{t-1} + u_t^d \tag{2'}$$

Neither c_t^* nor d_t are observable. The only information available to the econometrician is whether or not a devaluation has occurred and, conditional on its occurrence and on an estimate of k and $\Gamma(L)$, its size $\left(d_t^*\right)$. However, by defining a binomial variable:

$$\omega_t = \begin{cases} 1, & if\, c_t^* > 0 \\ 0, & if\, c_t^* \leq 0 \end{cases} \tag{5}$$

the parameters β^c can be estimated from a probit model for ω_t. Given the probit estimates, β_d can also be obtained by including in equation (2) the well-known Heckman lambda. Nevertheless, Ayuso and Pérez-Jurado (1995) confined their attention to the direct estimation of β^d from a non-linear transformation of equation (2) which exploits the uncovered interest rate parity assumption and the information contained in the interest rate differentials.

In this paper the aforementioned framework is extended in a number of directions. First, a more general process for the exchange rate is allowed for by using the results in Pérez-Jurado and Vega (1994). In a multivariate-multicountry framework based on the Johansen procedure, Pérez-Jurado and Vega (1994) found evidence that in the long run prices in the tradable sector (as proxied by the industrial price index) in Spain, Italy, France, the United Kingdom, Germany and the United States, expressed in the same currency, tend to converge. This convergence implies that the bilateral and multilateral real exchange rates follow processes that tend towards a constant long-run equilibrium. Hence PPP holds in the long run when prices of non-tradable goods are excluded from the analysis.

This cointegration property allows us to extend equation (1) by estimating the following ECM:

$$\Delta s_t = \mu - \delta(\Delta p - p*)_t - \alpha tcr_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta s_{t-1} + \sum_{i=1}^{p} \beta_i \Delta^2 p_{t-1} + \sum_{i=1}^{p} \delta_i \Delta^2 p_{t-1}^* + u_t \tag{6}$$

where s_t, p_t and p_t^*, (all variables in logs) stand for respectively, the nominal exchange rate index vis-à-vis OECD countries (foreign currency/pesetas), the domestic industrial price index, and a weighted index of industrial prices in OECD countries and $tcr_t \equiv s_t + p_t - p_t^*$ is the real exchange rate. The following statistical properties of the data are implicit in the specification of equation (6)[4]:

$$\begin{aligned} p_t &\sim I(2) \quad , \quad p_t^* \sim I(2) \\ s_t &\sim I(1) \quad , \quad (p_t - p_t^*) \sim I(1) \\ \Delta(p - p*) &\sim I(0) \quad , \quad tcr_t \equiv s_t + p_t - p_t^* \sim I(0) \end{aligned}$$

The second extension is related to the concept of exchange rate jumps. Ayuso and Pérez-Jurado (1995) confined their analysis to official devaluations of the peseta - i.e. realignments - during the ERM period (1989:6 onwards). In this paper the analysis is extended to also including these cases where, although no devaluations occur, there are abrupt changes (both positive and negative) in the exchange rate. Such episodes will be labelled as jumps.

Because extended concept increases the number of observations on jumps, it allows us to include both depreciation and appreciation episodes and it is readily extended to the free-floating period. But it also presents some shortcomings. First, variable c_t^* must be reinterpreted as the short-term economic costs that agents, both public and private, perceive from maintaining a given level of the nominal exchange rate. Secondly, a problem of econometric identification arises as variable ω_t is no longer observable. In this latter respect the adoption of a fairly empirical approach is suggested by assuming that the exchange rate jumps whenever the absolute value of the residuals in equation (6) exceed some arbitrary critical value (θ %).

In accordance with the extended concept of a jump, two variables (Q_t and D_t) are defined:

$$Q_t = \begin{cases} 0, & if\ \hat{u}_t < \theta \\ 1, & if\ \hat{u}_t \geq \theta \end{cases}$$

$$D_t = \begin{cases} 0, & if\ \hat{u}_t > -\theta \\ 1, & if\ \hat{u}_t \leq -\theta \end{cases}$$

4 See Pérez-Jurado and Vega (1994) for a detailed description of unit root test results.

The first variable (Q_t) captures positive jumps, i.e. unusual appreciations of the exchange rate, while the second (D_t) captures negative jumps, i.e. unusual depreciations. These variables enable us to estimate two probit models in Section 3 relating the likelihood of jumps, both positive and negative, to economic fundamentals. Moreover, they make it possible to estimate the parameters in equation (2') explaining the size of the jumps[5].

Residuals from equation (6) can be decomposed into two components: one capturing abrupt changes in the exchange rate (d_t), and the other a homoscedastic innovation (v_t): $u_t = d_t + v_t$.

Noting further that $d_t = (D_t + Q_t) d_t^*$ and substituting equation (2') into equation (6) yields:

$$\begin{aligned} \Delta s_t &= \Phi^l Z_{t-1} - \alpha\, tcr_{t-1} + \lambda (D_t + Q_t) - \beta (D_t + Q_t)\, tcr_{t-1} + \eta_t \\ \eta_t &= (D_t + Q_t)\, u_t^d + v_t \end{aligned} \tag{6'}$$

where the vector Z_{t-1} groups all variables in (6) other than tcr_{t-1} and the residuals η_t are no longer homoscedastic. Instead:

$$E\left(\eta_t^2\right) = \begin{cases} \sigma_\eta^2 & if \ (D_t + Q_t) = 1 \\ \sigma_v^2 & if \ (D_t + Q_t) = 0 \end{cases}$$

In the next section we estimate the exchange rate equation by GLS[6] using monthly data over the sample 1974:7-1995:9. In order to test for asymmetries in the effects of positive and negative exchange rate jumps, we estimate a slightly different version of equation (6'):

$$\Delta s_t = \Phi^l Z_{t-1} - \alpha\, tcr_{t-1} + \lambda^- D_t + \lambda^+ D_t - \beta^- D_t\, tcr_{t-1} - \beta^+ Q_t\, tcr_{t-1} + \xi_t \tag{6''}$$

where:

$$E\left(\xi_t^2\right) = \begin{cases} \sigma_\xi^{2+} & if\ Q_t = 1 \\ \sigma_\xi^{2-} & if\ D_t = 1 \\ \sigma_v^2 & otherwise \end{cases}$$

2. Exchange rate dynamics

As described above, the proposed econometric strategy begins by estimating the error correction model for the changes in the (log) exchange rate given by equation (6). When this equation is estimated by OLS using monthly data spanning the period 1974:4-1995:9, the coefficient $\hat{\alpha} = -.046$ (t-ratio = –2.3), on the error correction term turns out to be consistent with the low speed of adjustment towards the PPP long-run equilibrium underlined in Pérez-Jurado and Vega (1994). More importantly, as expected, the estimated residuals, u_t, show strong signs of heteroscedasticity and non-normality. Conversely, no signs of autocorrelation or ARCH are detected.

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5 In Vlaar (1994), jump probabilities and jump effects on the exchange rate dynamics are jointly estimated inside the ERM. Nevertheless, he has to assume that jump sizes are constant.

6 Note that although $(D_t + Q_t)$, $(D_t + Q_t) tcr_{t-1}$ and η_t are different functions of $\hat{u}_t$, the chosen functional forms are such that neither regressor is correlated with the noise, thus making IV estimation unnecessary.

Chart 1 shows the scaled residuals from the estimation and Table 1 summarises some diagnostic tests on these residuals. The White (1980) HET test rejects unconditional homoscedasticity. The Doornik and Hansen (1994) N_2 statistic strongly rejects normality, indicating a distribution which is skewed to the left and has fatter tails than the normal distribution, i.e. extreme values are more common than in the normal distribution.

Chart 1
Scaled residuals from equation (6)

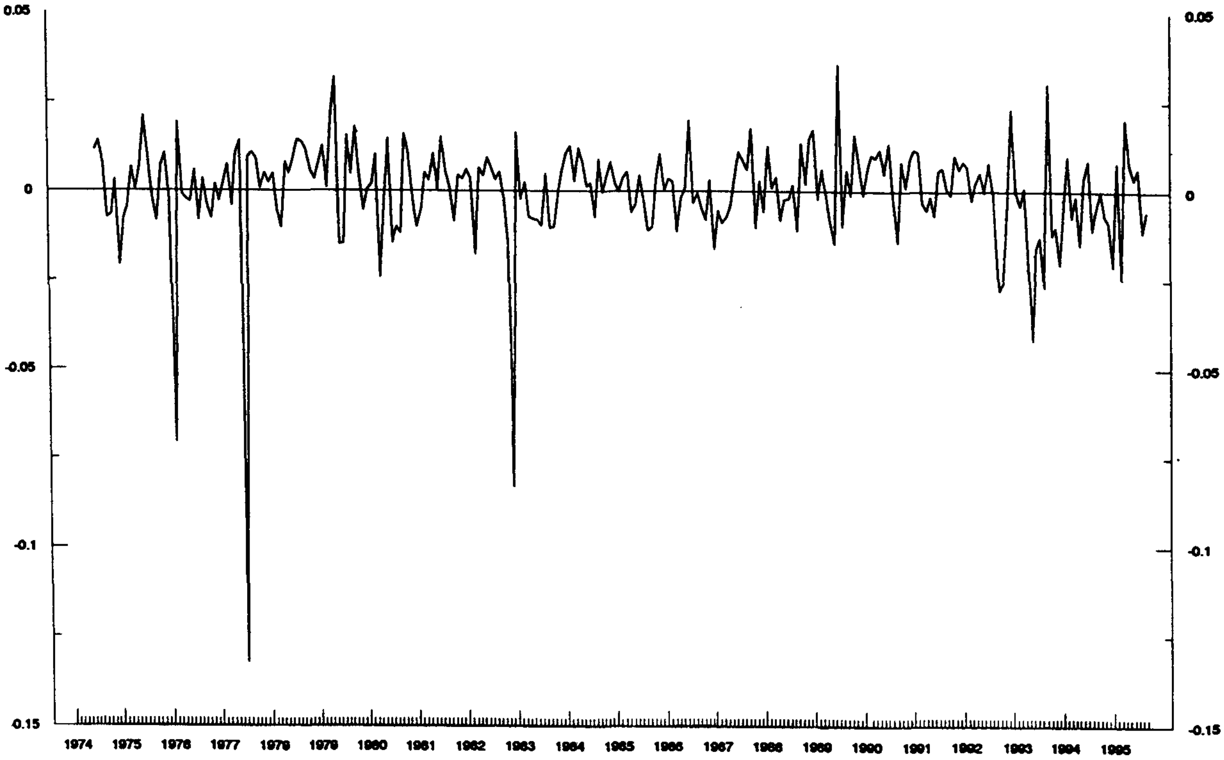


Table 1
Some diagnostic tests on the residuals from equation (6)

OLS estimates
Sample: 1974/7-1995/9

$LM_{12,216} = .892$ $ARCH_{7,214} = .058$ $HET_{41,186} = 1.545*$

$N_2 = 304.3**$ $Sk = -3.738$ $Ek = 27.144$

	Number of jumps (%)		
	Positive	**Negative**	**Total**
θ = 2.0%.............................	8 (3.1%)	12 (4.7%)	20 (7.8%)
θ = 1.75%...........................	11 (4.3%)	14 (5.5%)	25 (9.8%)
θ = 1.5%.............................	17 (6.7%)	17 (6.7%)	34 (13.4%)

Notes: See the Appendix for a description of test statistics. * and ** stand for, respectively, rejection at the 5% and 1% significance level.

The latter observation provides some support for the proposed decomposition of the residuals into two components: the first (d_t) capturing abrupt changes in the exchange rate -jumps-, and the second (v_t) a homoscedastic innovation. The bottom part of Table 1 shows the number of jumps in the sample depending on the empirical definition of jumps (θ): there are 20 jumps for θ=2%, 25 for θ=1.75% and 34 for θ=1.5%, representing, respectively, 7.8%, 9.8% and 13.4% of the sample.

The variables D_t and Q_t were defined as dummies which take values equal to one whenever there is a jump and zero otherwise. Again, depending on θ, we have three pairs (D_t, Q_t). Results for GLS estimates of the preferred specification of equation (6") are summarised in Table 2. The bottom part of the table reports some diagnostic tests on the transformed residuals that are shown in Chart 2.

Table 2
Estimation of (6") and some diagnostic tests

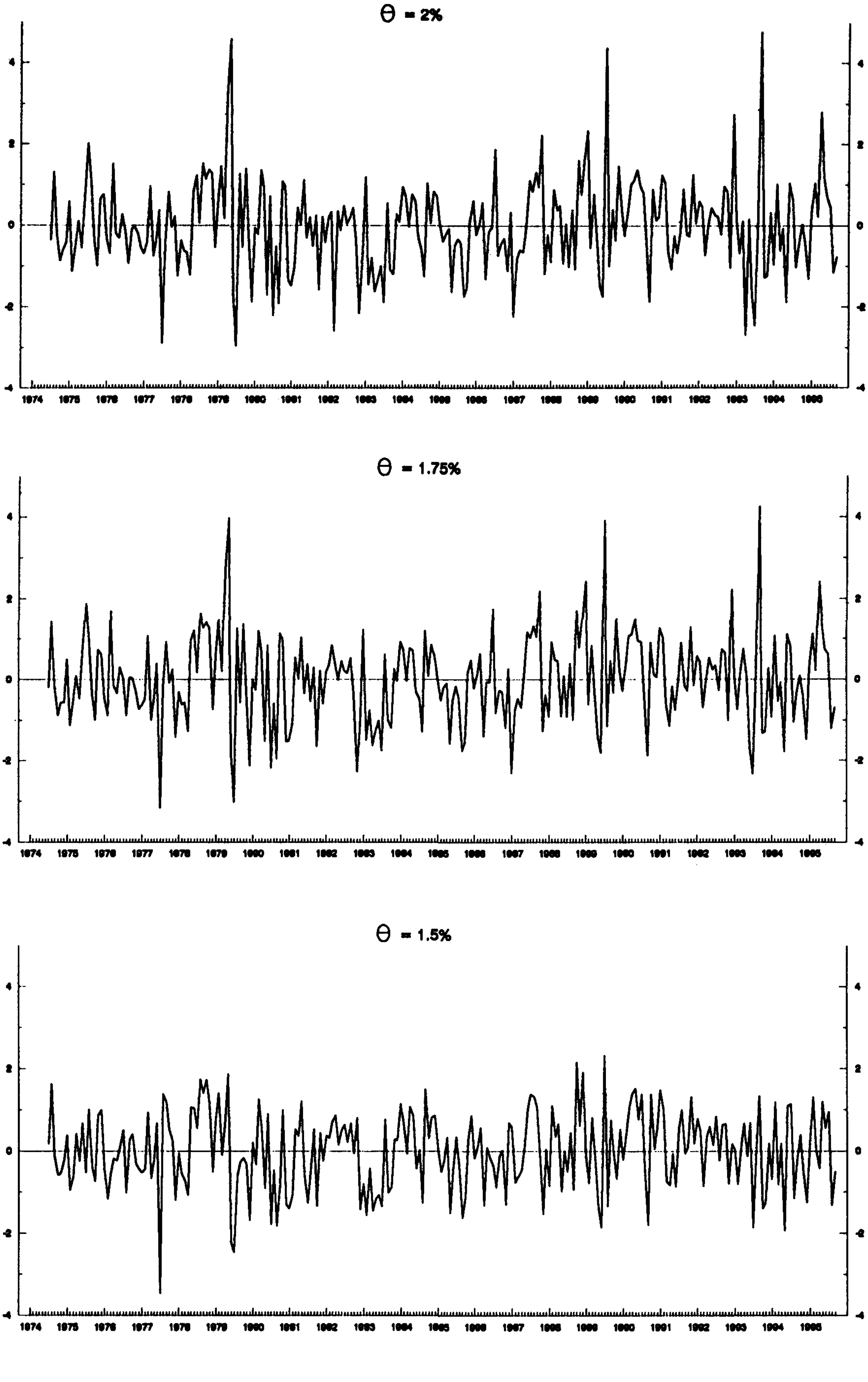
Exchange rate equation: GLS estimates
Sample: July 1974 - September 1995

$$\Delta s_t = \mu + \alpha_1 \Delta s_{t-1} + \alpha_2\left(\Delta^2 s_{t-1} + \Delta^2 s_{t-3}\right) + \alpha_3\left(\Delta^2 p_{t-1} + \Delta^2 p_{t-2}\right) + \delta\left(\Delta p - \Delta p*\right)_{t-1}$$
$$+ \alpha\, tcr_{t-1} + \lambda^- D_t + \beta^- D_t * tcr_{t-1} + \lambda^+ Q_t + \beta^+ Q_t * tcr_{t-1}$$
$$tcr_t \equiv s_t + p_t - p_t^*$$

	θ = 2%	**θ = 1.75%**	**θ = 1.5%**
μ	.1023 (2.09)	.0874 (1.97)	.1047 (2.68)
α_1	.1915 (4.37)	.2070 (5.36)	.2552 (6.71)
α_2	.0792 (3.35)	.0760 (3.48)	.0958 (4.81)
α_3	.1641 (2.22)	.1778 (2.62)	.2496 (4.19)
δ	−.2417 (2.07)	−.1958 (1.98)	−.2928 (3.29)
α	−.0225 (2.07)	−.0192 (1.96)	−.0232 (2.69)
λ^-	.8000 (1.42)	.6002 (1.40)	.5642 (1.53)
β^-	−.1879 (1.54)	−.1425 (1.48)	−.1331 (1.60)
λ^+	---	.1410 (0.66)	.2811 (1.77)
β^+	---	−.0265 (0.56)	−.0579 (1.65)
	R^2 = .58	**R^2 = .57**	**R^2 = .53**
	$LM_{12,234}$ = .63	$LM_{12,234}$ = .51	$LM_{12,232}$ = .53
	$ARCH_{7,232}$ = .98	$ARCH_{7,232}$ = .26	$ARCH_{7,230}$ = 1.19
	$HET_{16,228}$ = .36	$HET_{16,228}$ = .46	$HET_{18,225}$ = 1.01
	$RESET_{1,245}$ = 1.12	$RESET_{1,245}$ = 1.66	$RESET_{1,243}$ = 3.02
	N_2 = 5.20	N_2 = 5.01	N_2 = 3.42
	H^1 = .09	H^1 = .15	H^1 = .12
	H^2 = 2.39	H^2 = 2.31	H^2 = 2.62

Notes: See the Appendix for a description of test statistics. T-ratios in brackets.

Chart 2
Scaled residuals from equation (6")



Some features are worth mentioning. Firstly, the point estimate of α, the parameter that measures the speed of adjustment towards the long-run equilibrium in the absence of jumps, is somewhat above 2% (with t-ratios ranging from 2.0 to 2.7), and thus smaller than in equation (6). The remaining point estimates are quite similar to those of equation (6).

Secondly, exchange rate jumps act as an accelerator mechanism towards restoring the long-run equilibrium defined by PPP. For negative jumps - i.e. unusual depreciations - the parameter β^- that measures how much of the accumulated gain or loss in competitiveness is reverted when there is a jump is estimated between 13% and 19%, depending on the definition of jump: this is close to that estimated in Ayuso and Pérez-Jurado (1995) when the most restrictive definition is used (θ=2%). For positive jumps - i.e. unusual appreciations - this accelerator mechanism is weaker. The β^+ parameter ranges from 0, for the most restrictive definition of jump (θ=2%), to 6%, when θ equals 1.5%. In the intermediate case (θ=1.75%, λ, λ^+ and β^+), t-ratios are well below 1, although the point estimates imply that the normal speed of the adjustment towards PPP equilibrium is doubled. In general terms, the precision of these estimates is low because of the lack of degrees of freedom. This leads to low t-ratios, but the effects are economically meaningful.

Finally, diagnostic tests performed on the transformed residuals reveal no signs of autocorrelation, ARCH, unconditional heteroscedasticity or misspecification as reported, respectively, by the LM [Harvey, 1990], ARCH [Engle, 1982], HET [White, 1980] and RESET [Ramsey, 1969] tests. Normality is not rejected at standard confidence levels, even in columns 1 and 2 where only negative jumps are added to equation (6). The normality test statistic decreases[7] from more than 300 to values around 5. Also, H^1 and H^2 [Hansen, 1992] tests show no signs of within-sample parameter instability.

Overall, the results from estimating the exchange rate equation given by (6") seem quite satisfactory, especially when θ is equal to 1.5%. The estimates point to an exchange rate characterised by a slow adjustment towards the long-run equilibrium determined by relative prices in the tradable sector. Occasionally, unusual abrupt changes occur, acting as an accelerator mechanism of this adjustment process. This accelerator effect is stronger when the jump implies an unusual depreciation.

Exchange rate jumps, both positive and negative, take place when economic agents perceive that maintaining a given level of the nominal exchange rate is costly in the short run. Which macroeconomic fundamentals affect this perception is analysed below.

3. Jump probabilities

In this section we analyse to what extent fundamental macroeconomic variables can help anticipate future jumps in the peseta's effective nominal exchange rate.

The probability that agents assign to a future jump in the exchange rate plays an important role in explaining the credibility of exchange rate commitments like the ERM. Nevertheless, the literature has paid more attention to credibility indicators that take into account not only probabilities but also the expected size of the jump. Only a few papers have focused on estimating jump or realignment probabilities inside the ERM (see, for instance, Mizrach, 1993 and Gutiérrez, 1994) and they do not include the peseta. Recently, Ayuso and Pérez-Jurado (1995) estimated the probability of a realignment of the bilateral exchange rate of the peseta (and other ERM currencies) against the Deutschemark, using an empirical model that explains this probability in terms of the general performance of the ERM, a reputation effect, and a policy condition requiring an

7 It should be clear that our approach is a parsimonious modelling of jumps and does not involve the usual jump by jump intervention analysis.

interest rate level consistent with a country's position in the economic cycle. In any case, in all these papers jumps in exchange rates are associated with central parity realignments and always imply an unusual depreciation of the currency considered against the Deutschemark. Compared with that approach, jumps in the peseta's effective exchange rate are more difficult to define.

As explained in earlier sections of this paper, we define exchange rate jumps empirically and consider different critical sizes which allow for a reasonable number of jumps (between 8% and 14% of the sample size). In our case, jumps are both positive and negative and it is worth noting that jumps over the ERM period other than those associated with changes in central parities are included, as well as jumps over the non-ERM period that were not preceded by any official announcement.

We fit the probabilities of both an unusual depreciation, and an unusual appreciation in the exchange rate over the next month by estimating two probit models, one for positive jumps and the other for negative ones. This approach merits some comment. Strictly speaking, the exchange rate can show a positive jump, a zero jump or a negative jump at any time. Thus, we face a multinomial qualitative variable taking three possible values. However, as can be seen in McFadden (1984), multinomial qualitative response models are rather rigid and restrictive, like the multinomial Logit model, or have high computational requirements, like the multinomial Probit model. Instead, our approach relies on binomial Probit models that are both flexible and easier to implement. Nevertheless, it does not guarantee that the sum of negative and positive jump probabilities is below 1. Our results show, however, that this restriction has not been binding at any time in our sample.

Regarding the choice of the explanatory variables, we consider a relatively wide set of macroeconomic variables which, according to economic theory and to the results in the above-mentioned papers, could be arguments in the cost function described in Section 1 and, therefore, help to explain the probability of exchange rate jumps: real exchange rate, current-account deficit, inflation differential and variables capturing the relative position in the business cycle such as the unemployment rate, output growth, the real interest rate or the capacity utilisation index. Naturally, these variables are appropriately lagged in order to avoid simultaneity problems.

The maximum likelihood parameter estimates of the Probit models are shown in Tables 3 and 4. Charts 3, 4 and 5 show the fitted probabilities. The parameter estimates in Table 3 exhibit correct signs although, in several cases, they are only marginally significant. According to these estimates, the better the cyclical position (the higher the capacity utilisation is) the lower the probability of an unusual depreciation. On the other hand, the higher the accumulated real appreciation (over the last 12 months), the higher the negative jump probability, although this effect is less important after the entry of the peseta into the ERM. In the same vein, the higher the current-account deficit, the higher the probability of an unusual depreciation. This effect, however, also disappears after the peseta's entry into the ERM[8]. Finally, the exchange rate regime change in June 1989 increased the probability of an unusual depreciation and opened the door to a new variable capturing the policy requirement (or dilemma) that the domestic interest rate needs to be considered with the new exchange rate commitment as well as the cyclical position. The greater this dilemma, the greater the probability of an abrupt depreciation[9].

If we focus on the probability corresponding to months in which jumps have effectively occurred, the mean for these months is clearly higher than the mean probability for the remaining months. Histograms (not-provided) show that probabilities are distributed quite differently for the months in which jumps are observed. This is also the case for positive jumps.

Point estimates in Table 4 show, however, some wrong signs. This is the case for the cyclical position and for the accumulated real appreciation, during the period when the peseta was outside the ERM, although the first one is not statistically significant and the second is only marginally significant. After June 1989, however, both variables are correctly signed and are

8 To be more precise, the parameter changes its sign and is not statistically significant.

9 Other variables have t-ratios below 1 and, sometimes, the wrong sign.

significant: the probability of an unusual appreciation increases if the cyclical position improves or the real exchange rate has depreciated in the last 12 months. Contrary to Table 3, the entry of the peseta into the ERM reduced the probability of positive jumps. Again, the mean probabilities corresponding to months in which positive jumps have been observed are well above those for the remaining months.

Table 3

Probit model for the probability of an unusual exchange rate depreciation

$$Pr_{t-1}(D_t = 1) = \Phi\left(X_{t-1}^{D}\beta^{D}\right)$$

	Probability of a jump higher than		
	2%	**1.75%**	**1.5%**
Constant	6.74	11.40	9.82
	(.93)	(1.62)	(1.51)
Cyclical position [1]	–.13	–.19	–.15
	(–1.38)	(–2.08)	(–1.85)
Accumulated real appreciation [2]	17.03	19.61	8.67
	(2.12)	(2.41)	(2.15)
CA deficit [3]	.05	.05	.02
	(2.61)	(3.05)	(2.40)
ERM[4]	1.67	1.76	.46
	(2.08)	(2.19)	(1.04)
Accumulated real appreciation times ERM	–16.39	–16.17	–8.60
	(–1.87)	(–1.85)	(–1.40)
Policy dilemma time ERM [5]	.07	.06	.06
	(1.63)	(1.44)	(1.42)
pseudo-R^2	11%	13%	10%
RM [6]	5.16	5.08	3.53
RF [7]	4.5%	5.3%	6.5%

The model includes 246 observations corresponding to the period February 1975 to July 1995; t-ratios in brackets.

1 Capacity utilisation index.

2 Over the last 12 months.

3 As a percentage of GDP until May 1989, and 0 thereafter.

4 Dummy variable that takes unit value as from June 1989.

5 1-month interest rate differential divided by 12-month output growth differential (proxied by industrial output growth).

6 Ratio between mean probabilities in months with and without jumps.

7 Relative frequency of the corresponding jumps in the sample.

In Tables 3 and 4, results are very similar for jumps higher than 2%, 1.75% or 1.5%, although they are slightly better in the second case. Nevertheless, the pseudo-R^2 (see Estrella, 1995) range from 4% to 13% and are particularly poor for the positive jump models. The low predictive power of the Probit models is also confirmed by Charts 3, 4 and 5 which show that fitted probabilities are, in general, small[10], which relatively frequent peaks in periods in which the exchange rate has not jumped. Again, the picture is worse for positive than for negative jumps.

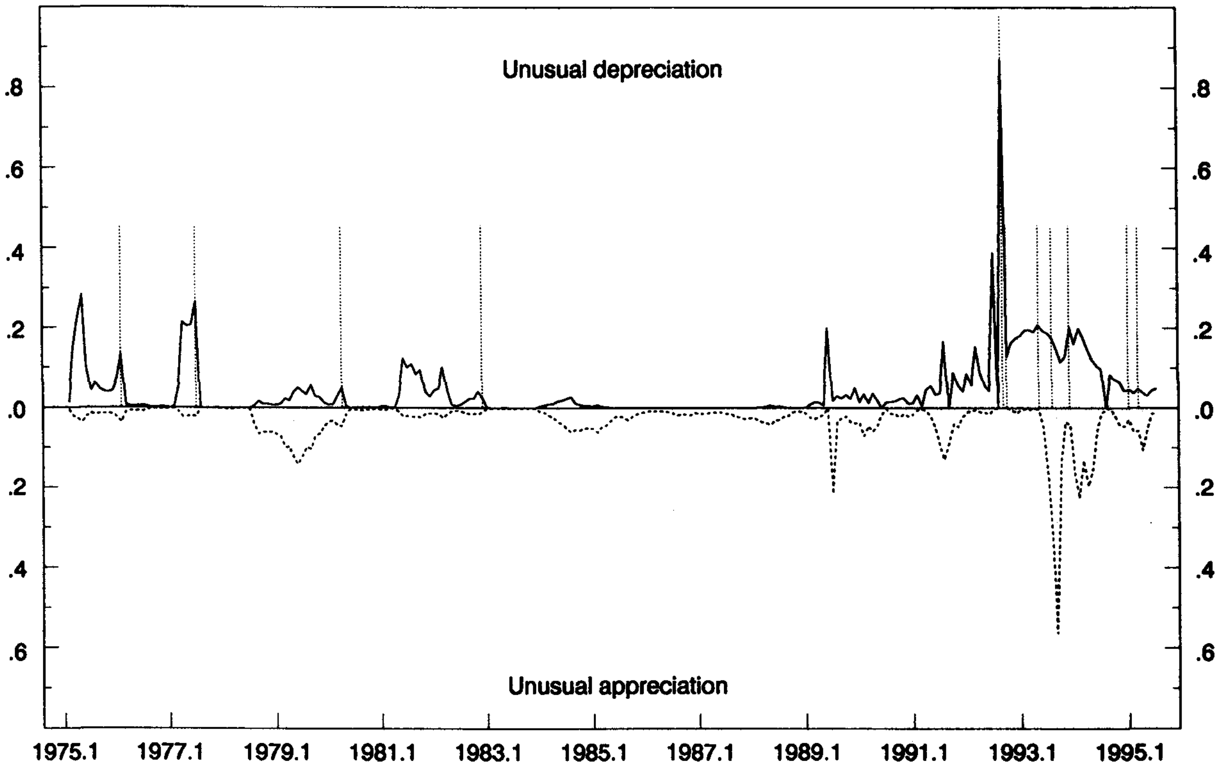
10 Over the ERM period, the estimated probability of an unusual depreciation is of the same order of magnitude as the realignment probability found in Ayuso and Pérez-Jurado (1995).

Table 4
Probit model for the probability of an unusual exchange rate appreciation

$Pr_{t-1}(Q_t = 1) = \Phi(X^Q_{t-1}\beta^Q)$			
	Probability of a jump higher than		
	2%	**1.75%**	**1.5%**
Constant	2.77	7.88	2.91
	(.22)	(-80)	(.40)
Cyclical position [1]	–.06	–.12	–.06
	(–.39)	(–.99)	(–.61)
Accumulated real appreciation [2]	7.73	7.11	4.09
	(1.83)	(2.04)	(1.63)
ERM [3]	–28.9	–34.0	–31.5
	(–1.56)	(–2.03)	(–2.08)
Accumulated real appreciation times ERM	–30.1	–29.5	–25.6
	(–2.78)	(–2.79)	(–2.59)
Cyclical position times ERM	.38	.44	.40
	(1.59)	(2.04)	(2.09)
pseudo-R^2	6%	5%	4%
RM [4]	4.95	2.65	1.94
RF [5]	3.3%	4.5%	6.9%

The model includes 246 observations corresponding to the period February 1975 to July 1995; t-ratios in brackets.
1 Capacity utilisation index.
2 Over the last 12 months.
3 Dummy variable that takes unit value as from June 1989.
4 Ratio between mean probabilities in months with and without jumps.
5 Relative frequency of the corresponding jumps in the sample.

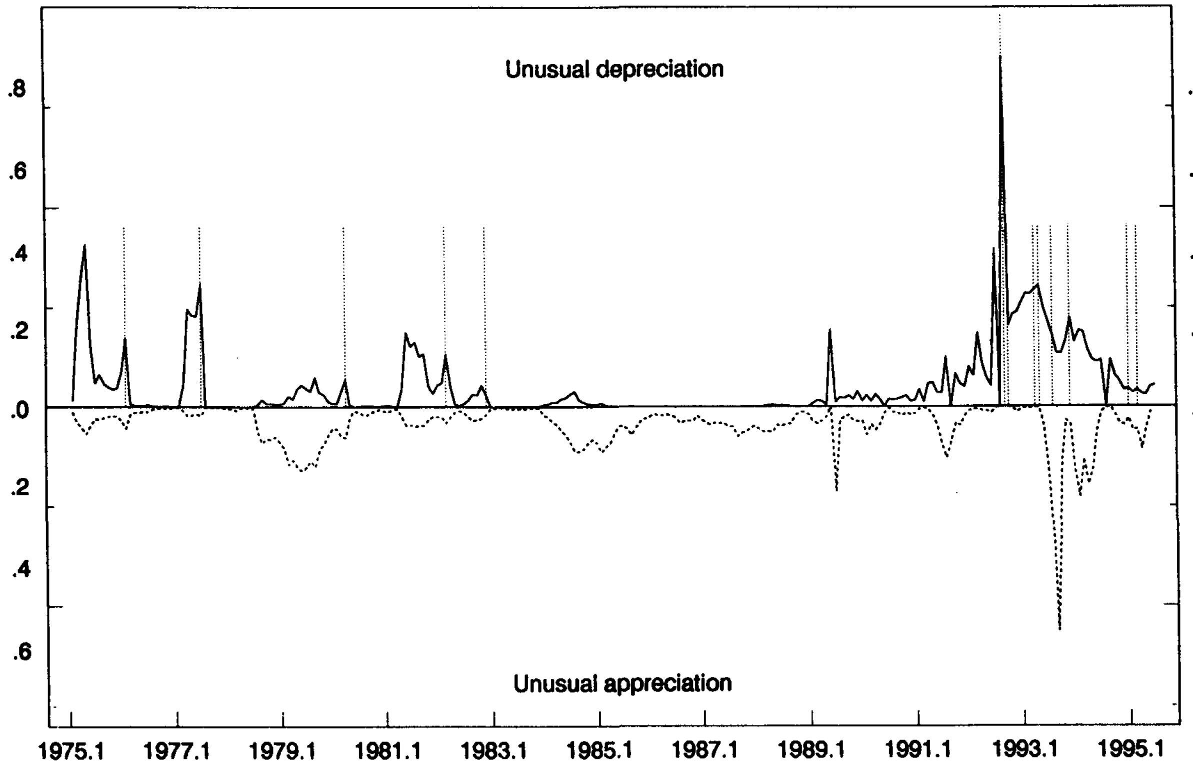
Chart 3
Fitted jump probabilities: jumps higher than 2%



Note: Vertical lines correspond to observed jumps.

Chart 4

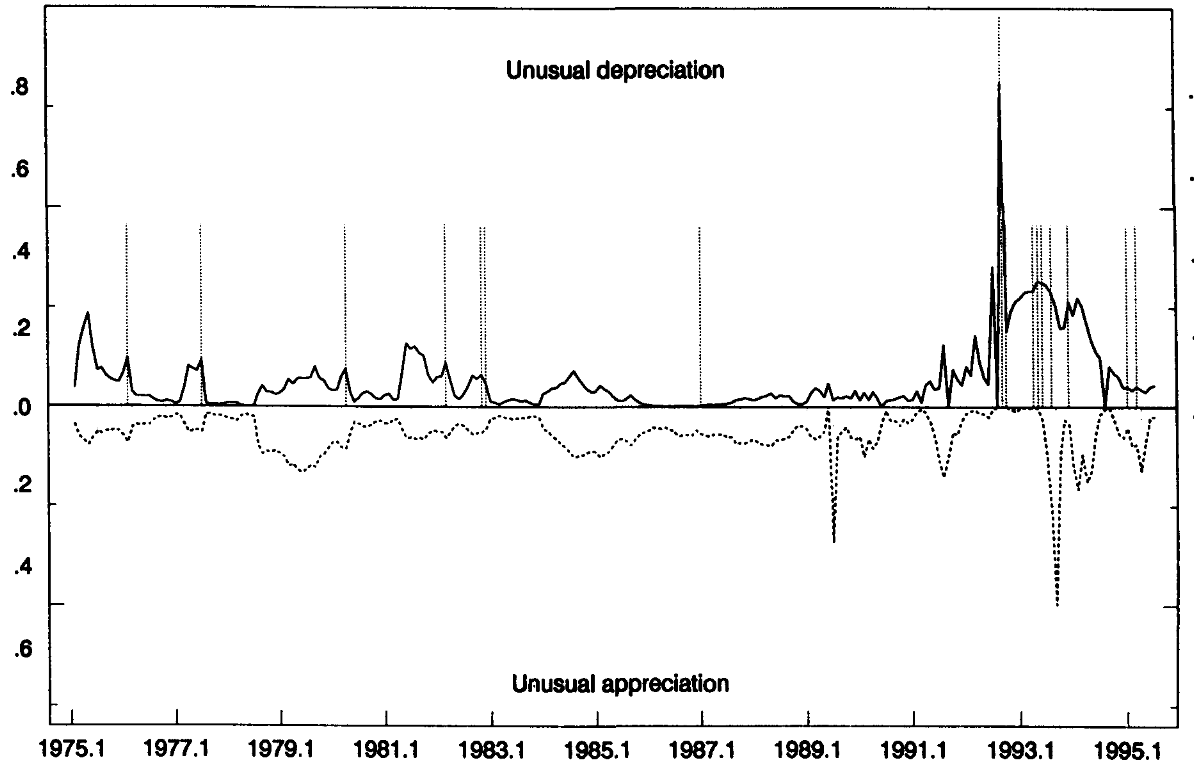
Fitted jump probabilities: jumps higher than 1.75%



Note: Vertical lines correspond to observed jumps.

Chart 5

Fitted jump probabilities: jumps higher than 1.5%



Note: Vertical lines correspond to observed jumps.

All in all, it can be said that according to our results, agents can hardly anticipate these unusual exchange rate jumps on the single basis of the macroeconomic fundamentals mentioned. This difficulty is especially clear when we look at the unusual appreciations. If agents were able to anticipate exchange rate jumps correctly, other factors such as expectations about political events or speculative bubbles should also play an important role. Unfortunately, these variables are difficult to measure and, therefore, difficult to include in a model like ours. Hence, not too much can be said about the timing of the exchange rate jumps, though some information is provided with respect to the macroeconomic fundamentals that may help to reduce this uncertainty.

Conclusion

In this paper we investigate the dynamics of the peseta's effective exchange rate vis-à-vis the currencies of other OECD countries over the period from January 1974 to September 1995. The proposed empirical model extends the results in Pérez-Jurado and Vega (1994) and Ayuso and Pérez-Jurado (1995). The former found that PPP holds in the long run when only prices in the tradable sector are considered. The latter estimated a model for the realignment probabilities inside the ERM and for the related jumps in the exchange rates. The results of both papers are embraced in our analysis by estimating an equation for exchange rate dynamics that combines the features of an ECM and the possibility of unusual jumps. The size and the probability of these jumps are also estimated.

Jumps are defined empirically and include not only "official" devaluations as in Ayuso and Pérez-Jurado (1995) but also other abrupt depreciations or even appreciations that are above a given threshold. Several thresholds are considered with a view to testing the robustness of the results.

The size of these unusual jumps depends on the deviation of the real exchange rate from its PPP value. Therefore, jumps enter the ECM as of 'accelerators' in the path towards the long-run equilibrium. In particular, negative jumps, i.e. unusual depreciations, multiply the speed of the adjustment process by a factor ranging from 10 (for the most restrictive definition of a jump) to 7 (for the least restrictive one). This accelerator effect is less clear for unusual appreciations. Only for the less restrictive definition of a jump is that effect significant, multiplying by 4 the speed of the adjustment.

Regarding the perceived probability of exchange rate jumps, two Probit models were estimated, one for each sort of jump. The results underscore that jump probabilities react to changes in certain fundamental macroeconomic variables: the current-account deficit (over the period when the peseta was outside the ERM), the accumulated real appreciation over the last twelve months and the position of the economy in the business cycle. Nevertheless, estimated probabilities are small and show relative peaks in periods in which exchange rate jumps have not occurred. Therefore, an important degree of uncertainty remains in predicting the timing of jumps.

Appendix

All the calculations in the paper have been made using TSP 4.2B and PcGive 8.0. The following is a list of the test statistics reported in Tables 1 and 2:

$LM_{i,j}$ = the Lagrange Multiplier F-test for residual autocorrelation up to i^{th} order. See Harvey (1990) for a description.

$ARCH_{i,j}$ = the Autoregressive Conditional Heteroscedasticity F-test reported in Engle (1982).

$HET_{i,j}$ = the White (1980) F-test for heteroscedasticity. In this test, the null is unconditional homoscedasticity, and the alternative is that the variance of the residual depends on the levels and squared levels of the regressors.

$RESET_{i,j}$ = the Regression Specification F-Test due to Ramsey (1969). This test may be interpreted as a test for functional form.

Sk = skewness.

Ek = excess kurtosis.

N_2 = the Doornik and Hansen (1994) χ^2-test for normality.

H_1 = the Hansen (1992) within-sample parameter instability statistic for the residual variance σ^2.

H^2 = the Hansen (1992) joint statistic for within-sample stability of all the parameters in the model.

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Comments on paper by J. Ayuso and J.L. Vega by W. Melick (BIS)

The paper "An Empirical Analysis of the Peseta's Exchange Rate Dynamics" represents an innovative and interesting attempt to realistically model variables such as exchange rates that are subject to "jumpy" behaviour. I would like to highlight the paper's strengths and contributions and offer two constructive criticisms.

The paper's insights really spring from one source. namely the authors use of a general definition of an exchange rate jump. The easy approach of defining a jump as a realignment of an official zone or parity is avoided, allowing for three significant contributions. First, this general definition of a jump allows, in the case of Spain, a longer time series to be analysed, not just the period over which Spain has participated in the ERM. Second, the general definition of a jump gives the paper a wider applicability. The modelling strategy developed here can be applied to countries with a floating regime as well as to those with a fixed or target regime. Therefore, the technique and results are of interest under any set of circumstances. Finally, the general definition of a jump allows for interesting tests when countries transition from one exchange regime to another, as was the case for Spain in 1989. To my mind the most interesting parts of the paper are the results from the probit estimations when comparing periods before and after June 1989. The disappearance of a current account effect after entry into the ERM is a finding worthy of further study.

Unfortunately, the general definition of a jump is not without problems. The general definition gives rise to an unobserved or latent variable (the jump) that complicates any estimation. The authors handle this problem using a two-stage estimation procedure. In the version presented at the December meeting, the procedure was somewhat flawed, resulting in biased and inefficient estimates, as pointed out in my comments at the meeting. In this revised version of the paper, a clever and simple modification of the two-stage procedure removes the bias in estimated coefficients. However, the inefficiency remains. I offer an alternative strategy. The model could be estimated using the regime switching technique of Hamilton, augmented with the assumption that transition probabilities (the jumps) are determined by fundamentals. That is, Markov switching variables could be defined, with the probability of being in a jump state determined by the fundamentals currently used in the probit estimation. Two such variations on the Hamilton technique have been developed, one by Diebold, et al (1994) and the other by Filardo (1994). This alternative strategy would allow for a simultaneous estimation of the model, avoiding the inefficiency problem.

Moving from econometrics to economics, my second constructive criticism involves the choice of variables used to explain the exchange rate. It seems somewhat restrictive to include only home and foreign prices as determinants of the exchange rate. It seems reasonable that there might be other short-run determinants of the exchange rate that ought to be included. I am curious if variables such as interest rates were part of an initial specification and rejected, or if they were not considered from the outset. Given the findings of some of the other papers presented at the meeting, it seems a longer list of determinants should be included or at least examined.

By way of conclusion, the paper provides a specification for exchange rates, be they fixed or floating, that allows for the jumps commonly seen in the data. Such a specification should be valuable and widely applicable. In the context of model building, the paper raises questions on the implication of such jumpy behaviour for the modelling of rational agents expectation formation.

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