BANCO DE ESPAÑA

THE EFFECTS OF THE PESETA JOINING THE ERM ON THE VOLATILITY OF SPANISH FINANCIAL VARIABLES

Juan Ayuso

SERVICIO DE ESTUDIOS
Documento de Trabajo nº 9106

THE EFFECTS OF THE PESETA JOINING THE ERM ON THE VOLATILITY OF SPANISH FINANCIAL VARIABLES

Juan Ayuso

Banco de España. Servicio de Estudios
Documento de Trabajo n.º 9106

In publishing this series, the Banco de España seeks to diffuse worthwhile studies that help acquaint readers better with the Spanish economy.

The analyses, opinions and findings of these studies represent the views of their authors; they do not necessarily coincide with those of the Banco de España.

ISBN: 84-7793-092-9
Depósito legal: M. 13704 - 1991

Imprenta del Banco de España

ABSTRACT

This paper seeks to determine whether the incorporation of the peseta into the exchange rate mechanism of the European Monetary System has been accompanied by a reduction in the volatility of the exchange rate against the Deutschemark (DM), the system's pivotal currency. It is also asked whether there have been significant changes in the volatility of other relevant financial variables, such as the interest rate, changes in central bank foreign reserves, the money supply and exchange rates against non-EMS countries, particularly against the dollar ($).

By separating the unexpected part of the series pursuant to univariate ARIMA modelling and by analysing its variance under GARCH methodology, it can be seen that the volatility of the peseta/DM exchange rate has diminished substantially, as has -at the same time- that of the interest rate. Market intervention by the Bank of Spain addressing the peseta can also be seen to have decreased, and no increase in the volatility of the peseta/$ exchange rate has been detected. However, an increase in the volatility of the money supply has been noted.

The proximity in time between the peseta's entry into the ERM and changes to the short-term conduct of monetary policy, coupled with the presence of major portfolio shifts by agents and the restructuring of capital controls during the period under study, mean that the findings should be interpreted with care.

I. INTRODUCTION.

On June 19 1989, the peseta joined the exchange rate mechanism of the European Monetary System, adopting a wide fluctuation band. This followed a fairly extensive period in which there had been "frequent conflict between quantitative monetary targets and the pursuance of exchange rate benchmarks". The aim, among others, was to secure "the advantages of creating the necessary conditions of stability and certainty for obtaining all the benefits of European integration" (Malo de Molina and Pérez (1990)).

Indeed, to echo the words of its founders, the EMS championed as one of its goals the establishment of an area of "monetary stability". However, there is no broad agreement on the specific meaning of "monetary stability". Empirical research in this area (Ungerer et al. (1983, 1986), Rogoff (1985), Artis and Taylor (1988) and Fratianni and von Hagen (1990)) interpreted stability as lower volatility in exchange and interest rates. They were particularly concerned with testing for the presence or absence of a problem of volatility transfer from exchange rates to interest rates.

Against this background, a little more than a year after entry, this paper seeks to analyse empirically the course of Spanish financial stability before and after June 1989. However, unlike the above-mentioned research, the focus here is on a broader set of monetary and financial variables.

Specifically, the paper addresses two questions. First, it is asked whether full EMS entry has led to a significantly different reduction in the volatility of the exchange rate against the other EMS countries than against the rest of the world (non-EMS countries). Second, assuming an affirmative reply to the first question, a response is sought to whether such reduction has been accompanied by a significant increase in the volatility of interest rates, the money supply or Bank of Spain intervention on the foreign exchange market.

The paper is thus structured as follows: section 2 develops a simple theoretical model of the financial sector in an open economy in order to establish formally the different directions the possible transfer or trade-off of volatilites may take; section 3 addresses the selection of the data;

section 4 details the main empirical findings; and section 5 summarises and concludes the research.

II. A SIMPLE THEORETICAL MODEL OF THE FINANCIAL SECTOR.

This section presents a simple theoretical model which illustrates, from a formal standpoint, the variety of forms the trade-off of volatilities referred to in the introduction can take. This requires consideration of changes in the volatility not only of exchange and interest rates, but also of other financial variables such as foreign reserves and the money supply.

In accordance with the ultimate aim of the paper, the model presented is in keeping with the basic principles of the so-called "portfolio models" associated with Branson (1977), Branson and Halttunen (1979) and Branson, Halttunen and Masson (1977). These models adopt a financial equilibrium approach in the analysis of the exchange rate.

Specifically, the model focusses on the financial sector of a small but open economy, disregarding the goods and services section. Accordingly, the model is understood to be defined in a framework in which markets adjust with sufficient flexibility, in contrast to the habitual inertias and rigidities of goods markets. The main advantage of this approach is that special emphasis is placed on the joint setting of equilibrium exchange and interest rates. It also gives an overall wiew of an integrated financial system.

Its main features are the following.[1]

There are two countries, the domestic country and the rest of the world, and we will always speak from the standpoint of the former. There are also three relevant financial assets:

- Fiat money, which shall be represented by M and the nominal yield on

---

[1]The model is drawn from Cuddington and Viñals (1985).

which is nil[2]

- Domestic bonds, B, with nominal yield i.

- Rest-of-the-world bonds, which shall be referred to as currency, D, with nominal yield i^*

The domestic country is small in relation to the rest of the world so that i^* is considered to be exogenous for it. It is likewise assumed that M is not internationally marketable [3].

There are three market agents: the resident public, the monetary authority and financial investors from the rest of the world.

The public decide the distribution of their financial wealth, W, denominated in domestic currency, among the three above-mentioned financial assets. Their behaviour is characterised by the following aggregate demand functions (also expressed in domestic currency):

$$\text{Money:} \quad \underset{(-)}{l(i,} \; \underset{(-)}{i^*,} \; \underset{(+)}{W)} + Z_l$$

$$\text{Domestic bonds:} \quad \underset{(+)}{b(i,} \; \underset{(-)}{i^*,} \; \underset{(+)}{W)} + Z_b$$

$$\text{Currency:} \quad \underset{(-)}{d(i,} \; \underset{(+)}{i^*,} \; \underset{(+)}{W)} + Z_d$$

The different z variables depict the effect of other variables such as changes in preference or precise changes in expectations. The absence of the expected rate of appreciation among the arguments for demand functions deserves additional comment. The assumption here is that foreign exchange markets are efficient and that agents' expectations are rational. This

[2]The entire model is expressed in nominal terms given the implicit assumption of constant prices for goods and services.

[3]Note that as M is fiat money, items such as deposits, which are internationally marketable in the real world, would be included under B and not under M.

translates into the characterisation of exchange rates as random walks and, therefore, into a zero rate of expected appreciation[4].

Additionally, occasional changes in expectations that might, for instance, warrant the taking of speculative positions, would be included in the appropriate z. The z variables thus enable different changes exogenous to financial markets to be modelled, and through these the potential stabilising effect of the move to a fixed exchange rate system will be studied.

In accordance with the budgetary restriction of the public, it must be ensured that the partial derivatives of each demand function with repect to i, partial derivatives with respect to i^* and disturbances amount to zero, and that partial derivatives with respect to W amount to unity.

It has also been assumed that the three assets are normal ones, not Giffen and gross substitute assets.

If e is taken to be the (nominal) exchange rate expressed as domestic currency units per rest-of-the-world unit, the financial wealth of the public would be given by:

$$W = M + B + e. D$$

Hereafter, D will be assumed to be positive, whereby a depreciation increases, all other things being equal, the financial wealth of the public.

The monetary authority monopolises the money supply as a counterpart of its holdings of domestic bonds, B_c, and currency, D_c,:

$$M = B_c + e. D_c$$

and pursues a target be it in quantity terms or in interest rate terms. B_c and D_c are thus control variables for the monetary authority.

[4]As will later be seen, the empirical evidence does not contradict this assumption.

Foreign investors demand domestic bonds, which they "pay for" with currency. The appropriate demand function, expressed in rest-of-the-world currency, is:

$$b^{*}\underset{(+)}{(i,}\ \underset{(-)}{i^{*},}\ \underset{(+)}{W^{*})} + Z_b^{*}\ .$$

Lastly, it is assumed that there is an exogenous supply of domestic bonds, BN, and a currency stock which has arisen from previous goods and services transactions not modelled here, DN.

In all, the conditions of equilibrium for the financial sector of this economy are as follows:

$$e.D_c + B_c = M = l(i,W) + Z_l \qquad (1)$$

$$BN - B_c - e.b^{*}(i) - e.z_b^{*} = B = b(i,W) + z_b \qquad (2)$$

$$e.DN + e.b^{*}(i) + e.z_b^{*} - e.D_c = e.D = d(i,W) + Z_d \qquad (3)$$

$$W = M + B + e.D \qquad (4)$$

where i^{*} and W^{*} have been removed by virtue of the small-country assumption, so as not to make the notation excessively complex.

The model thus comprises seven equations, six endogenous variables (e, i, W, M, B and D), two control variables (D_c and B_c), and eight exogenous variables (the four z's, DN, BN, i^{*} and W^{*}) of which two have been eliminated in the set of equations (1) to (4). The Walras Law implies that only six of the above seven equations are linearly independent; accordingly, the system is well defined as regards the number of equations and unknows.

Note that (4) and the first eqivalences in (1), (2) and (3) imply that:

$$W = BN + e.DN \tag{5}$$

Substituting (5) in (1), (2) and (3) and eliminating (2) under the Walras Law, the equilibrium solution for this economy can be characterised as the pair (e, i) satisfies:

$$e.D_c + B_c = l(\underset{(-)}{i}, \underset{(+)}{e.DN + BN}) + Z_l \tag{6}$$

$$e\ [DN + \underset{(+)}{b^*\ (i)} + Z_b^* - D_c] = d(\underset{(-)}{i}, \underset{(+)}{e.DN + BN}) + Z_d \tag{7}$$

Nex it is assumed that:

$$D_c - l_w \quad DN < 0 \tag{8}$$

$$D_c - b^*\ (i) - (1-d_w)\ .\ DN < 0 \tag{9}$$

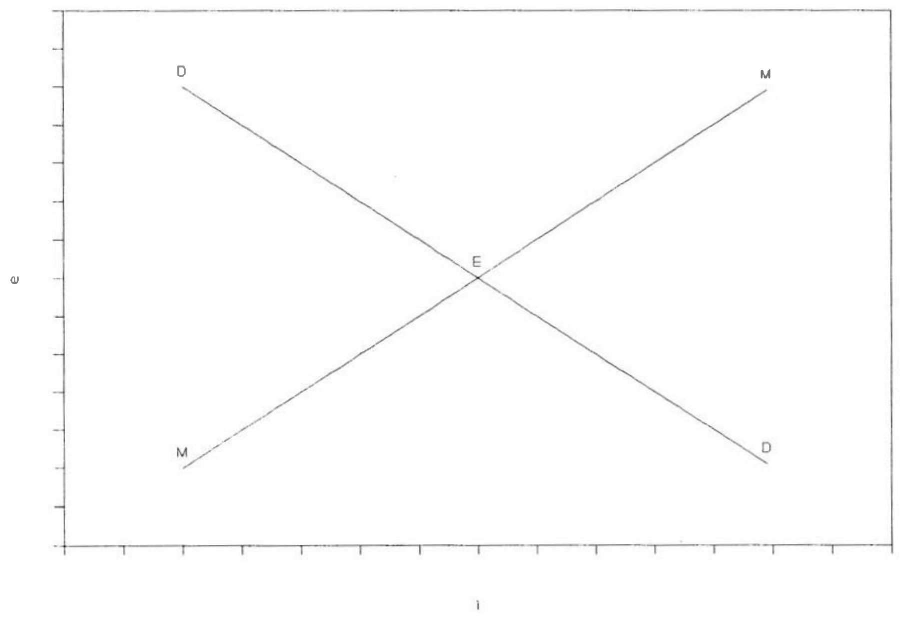
where the subindices under the functions denote the partial derivatives thereof with respect to the argument addressed by said subindex.

(8) is tantamount to assuming that the demand for money is more sensitive to the exchange rate, through the wealth effect it entails, than the supply of money. In turn, (9) implies that it is the supply of, as opposed to the demand for, currency which is most sensitive to the exchange rate.

Drawing on these assumptions, the system made up of the equations (6) and (7) is depicted with axes e and i in Chart 1.

CHART 1.

EQUILIBRIUM IN THE FINANCIAL SECTOR.



where MM is the set of money-market equilibrium pairs, DD that of equilibrium pairs in the currency market and E overall equilibrium in the financial sector. Note that the aforementioned assumptions guarantee the sign of the slopes of both curves. Indeed, starting from an equilibrium situation, an increase in the interest rate causes excess supply in the currency market (excess demand in the money market). The greater sensitivity of supply (demand) to the exchange rate implied by condition (9) ((8)) ensures that a reduction (increase) in the exchange rate will restore equilibrium.

Further, thanks to (8) and (9), the model produces two results which, intuitively, should be expected to emerge: an expansive monetary policy reduces the interest rate and such reduction is accompanied by a depreciation via capital outflows.

Based on Chart 1, and considering different disturbances modelled by means of the z variables, it is possible to analyse how the choice of a fixed exchange rate system affects the volatility of relevant financial variables. To be precise, insofar as the aforementioned model is deterministc, "volatility" in these circumstances will be identifiable by the size of the change in a variable in the presence of a given disturbance. This enables the type of questions raised in this section to be answered without having to resort to the painstaking and complex analysis that a stochastic context would entail.

Appendix A analyses the effects of the different types of exogenous changes: a disturbance in domestic markets:

$$(Z_l = -Z_b > 0;\ Z_d = Z_b^* = 0)$$

and a disturbance in bond markets[5]:

$$(Z_d = -Z_b > 0;\ Z_l = Z_b^* = 0)$$

Both cases are analysed in turn under two alternative control outlines: target in terms of M and target in terms of i. Table 1 summarises the main results.

---

[5]Insofar as attention will not be paid to the domestic bonds market, the second of the disturbances analysed coincides, in its effects, with a disturbance of a strictly external nature, i.e. $Z_b^* > 0$; $Z_l = Z_b = Z_d = 0$.

TABLE 1

EFFECTS OF THE MOVE TO A FIXED EXCHANGE RATE SYSTEM ON THE DEGREE OF VARIATION OF THE VARIABLES.			
	Control of M	Control of i	
		Via bond swaps	Via open market
Disturbance in domestic markets ($Z_l=-Z_b$)	e => (-) i => (+) D_c => (+)?	e => (-) M => (+)? D_c => (-)	e => (=) M => (=) D_c => (=)
Disturbance in bond markets ($Z_b=-Z_d$ ó $Z_b^*>0$)	e => (-) i => (-) D_c => (+)?	e => (=) M => (=) D_c => (=)	e => (-) M => (-) D_c => (+)?

NOTES: - (-), (+) and (=) signify volatility reduction, increase and maintenance, respectively.
- The sign "?" next to brackets denotes that some additional assumption should be posited in view of the presence of opposing effects.

As Table 1 sohws, this analysis highlights the different directions the so-called "transfer of volatility" may take, thereby justifying the focus on a broader set of variables than the simple sum of exchange and interest rates.

Furthermore, it should be remembered that exchange rate and monetary targets are set in terms of bands, which gives an extra dimension to the matters considered in Table 1.

All told, it is necessary to tackle the empirical study of financial stability in Spain following entry into the ERM from a wide perspective. Together with the variables traditionally considered -exchange and interest rates- this perpective should at least consider changes in the volatility of some monetary aggregate and Bank of Spain interventions in the peseta market. Further, beyond the context of just two countries, the exchange rate of the peseta against the non-EMS rest of the world should be addressed in order both to test the differential nature of changes in the exchange rate against the EMS and to check out a further possible direction for the likely trade-off in volatilities.

III. THE DATA.

The preceding section established the set of variables of interest to the study. This section specifies which series of the Spanish economy will represent them.

First, as far as sample frequency is concerned, data of daily frequency will be used. Specifically, Monday-to-Friday series are used for the different variables, the figure for the previous day being repeated on days on which there was no market for any of the variables.

The sample period covers from the beginning of January 1984 to the end of June 1990, signifying a total of 1,695 data for each series. One exception here is the monetary aggregate, for which the available information dates from July 1984. The number of data in this case falls to 1,565.

For this paper the following series have been chosen.

The exchange rate against the EMS is characterised by the official PTA/DM foreign exchange selling rate. The D-Mark has been chosen for two reasons: first, its pivotal role in the EMS; and second, due to the fact that since 1988 (officially) and prior thereto (unofficially), the Bank of Spain's short-term exchange rate policy was expressed in terms of specific fluctuation bands vis-à-vis the PTA/DM exchange rate. The choice of the selling rate is unimportant in view of the parallel course of the buying rate (see Chart B1 in Appendix B).

The selected interest rate is the three-month interbank rate [6]. The time span of the model of the previous section and the depth and extent of development of the interbank deposits market are the reasons for the use

---

[6] In particular, the annual compound capitalisation of the quarterly rate.

of this series, which is shown in Chart B2 of Appendix B.

For Bank of Spain interventions in the peseta market, the "interventions: changes in the net foreign currency position" series is used, expressed in dollars.

The selection of the monetary aggregate entailed further difficulty. Although the aggregate made up of "liquid assets held by the public" (ALP) was the obvious candidate for Spain, the problem resides in the differing frequency with which data on the various ALP components become available. In particular, it is not possible to reconstruct the series with daily frequency. Accordingly, use is made of a monetary aggregate made up as follows: bank and savings banks' exigible liabilities, except convertible pesetas (seasonally adjusted), cash (seasonally adjusted), Treasury notes and bills held by the public both outright and undes repurchase agreement and repos on government debt. Excluded from the aggregate are certain components of ALP (insurance transactions, asset transfer certificates, other deposits and liabilities of credit co-operatives). However, these alterations are relatively minor. As a result, based on the monthly frequency for which all the information is available, the aggregate in question acounts for a percentage of ALP ranging from 90% to 94%. This series is shown in Chart B3 of Appendix B.

Lastly, the official PTA/$ foreign exchange selling rate is used as a representative series of the exchange rate against the non-EMS rest of the world. The choice of the dollar is self-evident. Chart B4 in Appendix B highlights that it is possible to opt for the selling rate in the case of the D-Mark.

IV. EMPIRICAL RESULTS.

A brief review of the different papers that have studied the problem of the transfer volatility evidences considerable progress in how the concept of volatility of a financial series is understood and measured[7].

---

[7]In this connection, Wyplosz (1989) offers an excellent summary.

In line with the approach by Rogoff (1985), the present paper the volatility of a financial series is calculated on the bais of the variance of the unexpected component. The underlying idea here is that the principal component of risk in financial markets is associated with fresh information that reaches such markets, i.e. the surprises.

Naturally, there are several ways of separating the expected and unexpected components of a series and, likewise, of measuring the variance of the latter. Here, we will use the univariate ARIMA[8] and GARCH[9] methodologies, respectively, estimating jointly the parameters for the mean and for variance by means of the maximum likelihood method.

The virtual non-existence of structural models which, with daily frequency, explain the behaviour of the variables it is sought to analyse here and the "minimum outcome" nature of the univariate modelling of a series support the use of this approach. The advantage of GARCH methodology is that it addresses continuous changes over time in variance and detects some of the typical features that emerge in empirical analyses of exchange and interest rates, as is the case with lepto-kurtosis[10].

Changes in central bank foreign reserves alone will not be analysed under this outline. The reason for this lies in the singularity of this series which, since early 1988 and following a change in the Bank of Spain's participation in the peseta market[11], may be identified as a variable strictly for control. Events such as the concentration of more than 70% of the series in value 0 since January 1988, even though the sample mean of the series is non-zero, prevent classical univariate analysis of the series. Accordingly, we have resorted in this case to the simple use of descriptive statistics in the hope of finding a somewhat more sophisticated method for

---

[8]Box and Jenkins (1986).

[9]Engle (1982) and Bollerslev (1986, 1988).

[10]Hsieh (1988).

[11]As set forth in Leyva (1988), the Bank of Spain moved onto a secondary plane to market forces as regarded exchange rate setting. In short, this led to a sharp reduction in the number of days on which the Bank intervened on the foreign exchange markets and to a sizable increase in the scale of such interventions when any were actually made.

studying the volatility of this series.

To analyse the effects of full EMS entry, a test was made for a structural change in June 1989 in the models addressing the behaviour of the different series. In addition, the above-mentioned change in the Bank of Spain's role in the foreign exchange market necessitated the introduction of another structural change in January 1988. The main results of the different estimates as far as volatility is concerned are given in Tables 2 and 3 and in Chart 2. Apprendix C includes the original estimates and the different tests of the goodness of fit.

Specifically, Chart 2 shows changes over the sample period in the different conditional variances that have beer estimated. Table 2 complements this Chart and depicts changes in what may be called the conditional variance "threshold", i.e. the value toward which such variance trends when market innovations or news are nil over a fairly extensive period[12].

Table 3 details a pair of sample statistics that illustrate changes in the number of Bank of Spain interventions in the peseta market and the average size thereof. The reason for this differential treatment was discussed in the preceding section.

---

[12]In terms of GARCH modelling (see Appendix C), this threshold relates to the value $\alpha_0 / (1-\beta)$

CHART 2.1.

ESTIMATED CONDITIONAL VARIANCES: PTA/DM EXCHANGE RATE

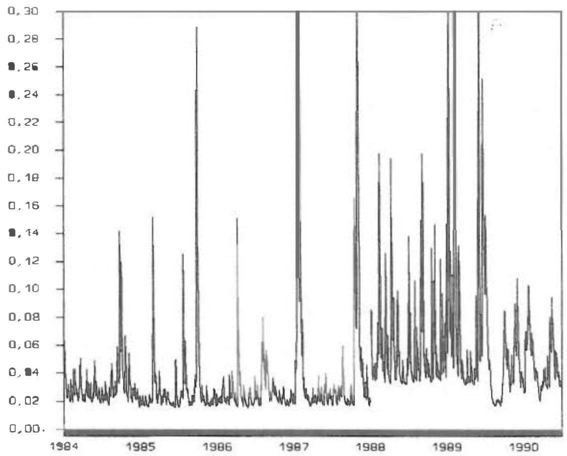


CHART 2.2.

ESTIMATED CONDITIONAL VARIANCES: INTEREST RATE.

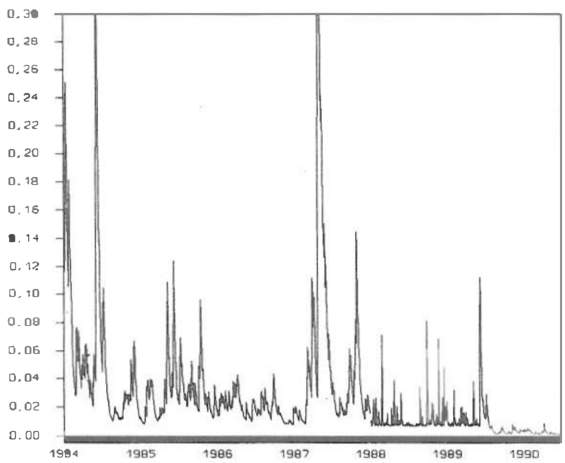


CHART. 2.3.

ESTIMATED CONDITIONAL VARIANCES: MONEY SUPPLY.

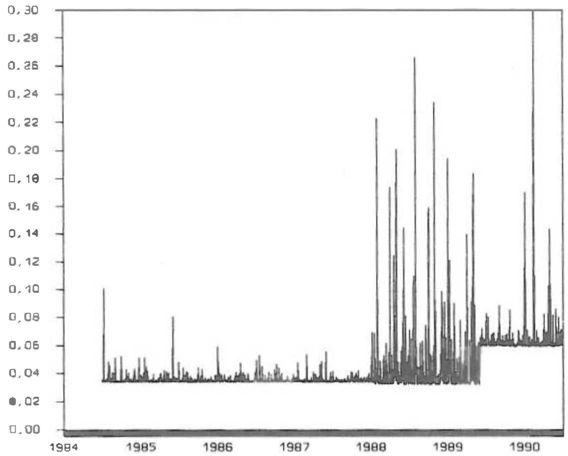


CHART. 2.4.

ESTIMATED CONDITIONAL VARIANCES: PTA/$ EXCHANGE RATE.

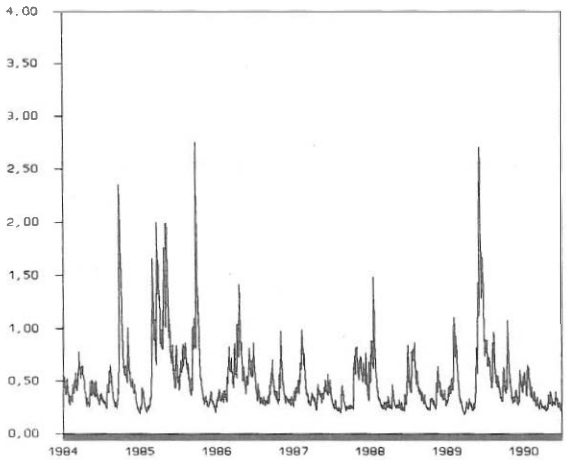


TABLE 2.

ESTIMATED CONDITINAL VARIANCE THRESHOLDS.					
	Sample period			% increase	
	1/84–12/87 (1)	1/88-5/89 (2)	6/89-6/90 (3)	(2) over (1)	(3) over (2)
Series					
Pta/Dm	.015	.032	.013	113.3	-59.4
i	.006	.007	.001	16.7	-85.7
M	.034	.032	.059	-5.9	84.4
pta/$	No structural change detected.				

TABLE 3.

INTERVENTIONS BY THE BANK OF SPAIN IN THE PESETA MARKET.			
	Sample period		
	1/84-12/87	1/88-5/89	6/89-6/90
Parameters			
S_1	92.5%	32.9%	22.9%
S_2	.011	.036	.042

S_1 = percentage accounted for by intervention days with respect to the total period.

S_2 = sum of the square of interventions divided by the number of days on which the Bank of Spain intervenes.

Further to these tables and charts, a series of results may be highlighted.

First, the change that took place in 1988 can be seen, as was foreseeable, to have led to a decrease in the volatility (taken, in this case, as the number of interventions) of movements in central bank foreign reserves and to an increase in that of the exchange rate against the D-Mark. The absence of any structural change in the PTA/$ rate will be discussed later in this paper. Further, the effect on the volatility of the monetary aggregate, albeit minor, is of the expected sign if interventions could not be sterilised in their entirety.

As far as the June 1989 change (on which this paper is centred) is concerned, a sizable reduction in the volatility of the exchange rate against the D-Mark is observable. This reduction is not accompanied by a similar pattern for the rate against the dollar. At the same time, a considerable reduction in the volatility of the interest rate and in the frequency of Bank of Spain interventions in the foreign exchange market is detectable. The monetary aggregate also shows an appreciable increase with respect to its volatility.

Referring back to the questions posed in the introduction, this set of results would indicate that, with full entry into the EMS, the volatility of the exchange rate against EMS countries decreased; the volatility of the exchange rate against non-EMS countries has not varied significantly; and the cost, in terms of volatility, of full EMS entry has been a decrease in the short-term stability of the money supply. However, this would leave unexplained the considerable reduction detected in the volatility of the interest rate (see the different theoretical results set out in Table 1).

The problem here is the coincidence in time of full entry into the EMS and two phenomena which are fairly important with a view to changes in the volatility of some of the series under analysis.

On the one hand, since the mid-eighties a process -which has probably quickened since June 1989- has been under way to modify the design of short-term monetary policy. Underpinning this modification has been "more flexible implementation, assigning to interest rates a more important role as an instrumental variable of monetary policy and relegating bank reserves to the role of a simple leading indicator (...). This new conception reflects greater concern to reduce the volatility of interest rates" (Malo de Molina and Pérez (1990)). At the same time exceptional quantitative restrictions on domestic credit have been imposed. However the effect of such restrictions on the variables concerned is of a complexity beyond the scope of this research.

On the other hand, 1988 and 1989 also saw strong portfolio-reallocation movements by agents. These shifts occurred between ALP and non-ALP elements and between elements intrinsic to ALP. In the first case, an increase in the volatility of the series selected here as a monetary aggregate is foreseeable.

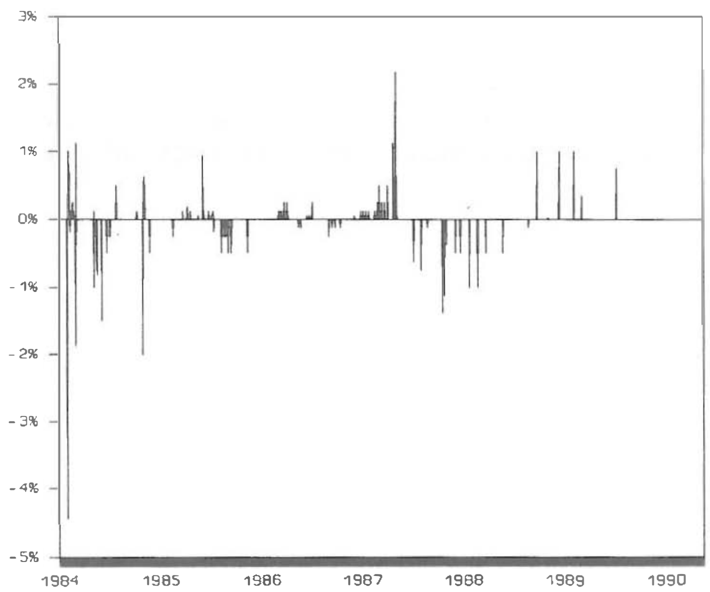
In any event, together with full EMS entry a series of phenomena[13] have been recorded. These point first, to a trade-off in volatility, at least in the short run, from interest rates to the money supply; and second, to an additional increase in the volatility of the monetary aggregate.

Unfortunately, it is as yet impossible to disaggegate effects from one another. In any event, Chart 3 highlights the acceleration of the aforementioned change in the short-term implementation of monetary policy after June 1989; as can be seen, swings in the Bank of Spain intervention rate have been even further reduced.

[13] For different details on these phenomena, see Escrivá (1989, 1990) and Sanz (1988).

CHART 3.

CHANGES IN THE BANK OF SPAIN INTERVENTION RATE.

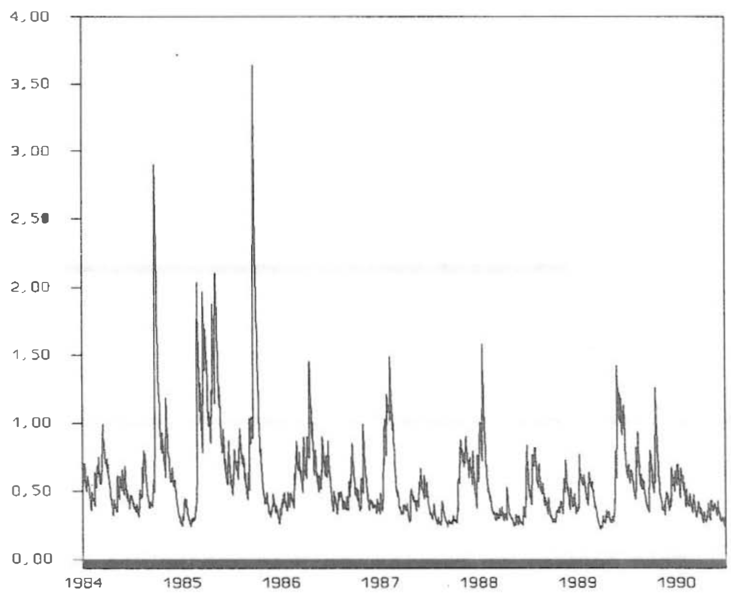


This section on results would be incomplete were no consideration given to the characterisation of full EMS entry as a move from a system of flexible exchange rates to one of fixed exchange rates.

Prior to June 1989, Spanish exchange rate policy was actually closer to the so-called "dirty float" system than to full exchange rate flexibility. Moreover, the D-Mark has increasingly adopted the role of "benchmark currency", to the detriment of the dollar, owing to the growing relative weight of the "DM zone" (namely the EC) in Spanish international trade[14]. Admittedly, the absence of structural changes in the volatility of the PTA/$ rate and the parallel course thereof with the volatility of the DM/$ rate -which can be deduced from the overall viewing of Charts 2 and 4 and from the comparison of the results of the stimates for both rates that are featured in Appendix C- reinforce, from an empirical standpoint, the above considerations[15].

CHART 4.

ESTIMATED CONDITIONAL VARIANCE OF THE DM/$



---

[14]The exchange rate target used to be set in terms of an index constructed on the basis of different bilateral rates weighted, inter alia, by the relative volume of trade with the country in question. From 1986 onwards, the target was in terms of bilateral rates with the major EC countries.

[15]Further empirical support can be found in Hevia (1990) for this increasing weight of the D-Mark as a benchmark currency for Spanish exchange rate policy.

Under these conditions, the peseta joining the ERM places on a substantially official footing certain commitments that were already working unofficially. Expressed otherwise Spanish entry is largely, though not entirely, the move from a system of "de facto" fixed exchange rates to one of "de jure" fixed exchange rates, though that should not detract from the importance of the move. Indeed, it should be stressed that in the case of "de facto" fixed rates, a government might, at a given moment and faced with excessive upward or downward pressure, feasibly allow its exchange rate to move freely. However, the "de jure" fixed exchange rates underpinning the ERM mean there are rules preventing countries from unilaterally changing the central parity of their currency.

Seen in this light, it is possible to bring about an overall reduction in the volatility of the different series as a result of the credibility effect vis-à-vis financial-sector agents entailed by full EMS entry. This effect has led, for instance, to fewer disturbances such as speculative movements in favour of or against the peseta, or changes in the demand for financial instruments associated with mistrust over the maintenance of monetary policy targets. Unsurprisingly, these were among the arguments originally raised on the desirable and desired effects of the peseta joining the ERM[16]. In terms of the model in section 2, full EMS entry would reduce the absolute value of the noise components vector z, thereby reducing the volatility of all the relevant financial variables.

In the absence of a quantitative disaggregation of the effects of the phenomena discussed earlier, there can be no clear, unequivocal interpretation of the result obtained. Unfortunately, such disaggregation is not easy. Nonetheless, it should be remebered that, in terms of Table 1, the result of greater volatility in M and less volatility on the other variables is associated with the predominance of disturbances in domestic markets over that arising in the currency markets. One indirect way of tackling the problem could be to test the most frequent origin of financial disturbances in Spanish markets.

However, even if it were possible to attribute the increase in the volatility of M to the phenomena mentioned earlier, one unresolved problem

[16] See Malo de Molina and Pérez (1990).

would remain. And at the very least, such problem should advise against unrestrained optimism about the stabilising effect of ERM entry. We refer here to the effects that capital controls, and controls on credit, may have had on the volatility of the different series. There is enough controversy (at least in the empirical field) surrounding this issued to warrant a detailed study beyond the scope of the goals of this paper.

5. CONCLUSIONS

The principal aim of this paper was, as explained at the outset, to analyse the effect the peseta joining the ERM had on the stability of the financial sector. To this end, the relevant set of variables were defined with the help of a simple theoretical model.

Throughout the paper, evidence was presented supporting the view that ERM entry has been accompanied by a considerable reduction in the volatility of the exchange rate of the peseta against the system's pivotal currency, the D-Mark. This reduction is not detectable in the exchange rate against the dollar, thus apparently discarding the possibility that such reduction is in response to general conditions in international financial markets.

With regard to the other variables, a parallel reduction in the volatility of the interest rate and in the frequency of Bank of Spain interventions in the peseta market was also detectable. On the other hand, an increase in the volatility of the money supply was noted.

However, part of the reduction in interest rate volatility and of the increase in money supply volatility may be attributable to the changes to short-term monetary policy implementation since the mid-eighties, which quickened in pace in June 1989. Such changes led to a keener focus on the interest rate than on bank reserves, which has translated into a decrease in the volatility of the interest rate, and an increase in that of the money supply.

In the period under study, significant portfolio shifts were also recorded. These translated into the replacemente of assets outside ALP. These phenomena muy have led to an additional increase in the volatility of the monetary aggregate in the short run.

Exchange rate policy prior to June 1989 was closer to a dirty-float system with the D-Mark as the key benchmark currency than to a fully flexible system. Accordingly, ERM entry largely represented a move from a "de facto" system of fixed (though adjustable) exchange rates to a "de jure" system, a by no means insignificant change. Indeed, commitment to the ERM entails renouncing an option that is always open in a dirty-float system: permitting unilaterally the exchange rate to drift when upward or downward pressure proves excessive.

From this standpoint, the favourable effects of entry may be highlighted. It has reinforced the credibility of monetary policy for private agents and reduced, as a result, a series of disturbances bearing adverse effects for financial stability (e.g. speculative attacks against or in favour of the peseta).

Lastly, the presence of capital controls and the setting of limits on the growth of bank credit during the period under study are relevant. The difficulties of analysing (at least from an empirical standpoint) both their effectiveness and, where appropriate, their effects on the daily volatitily of the series warrant caution against excessive optimism over the stabilising effects of ERM entry considered in isolation.

APPENDIX A. COMPARATIVE STATIC ANALYSIS OF THE MODEL IN SECTION 2.

CASE 1. Disturbance in domestic assets markets:

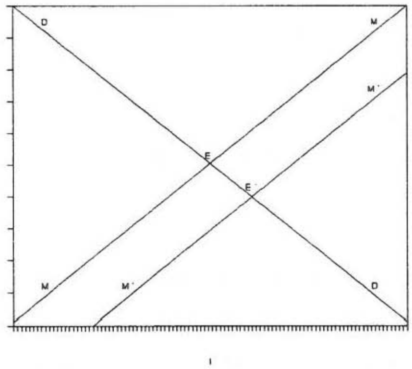
$$Z_1 = -Z_b > 0; \quad Z_d = 0$$

1.1. The monetary authority controls the money supply.

1.1.a Flexible exchange rate.

CHART A1.

FLEXIBLE EXCHANGE RATE



With regard to movements in foreign reserves:

$$dD_c = (1/e) \;.\; \{ DN \,[\, g + (1 - d_w) - l \,]\; de + (e \,.\, b_i^* - d_i)\; di \}$$

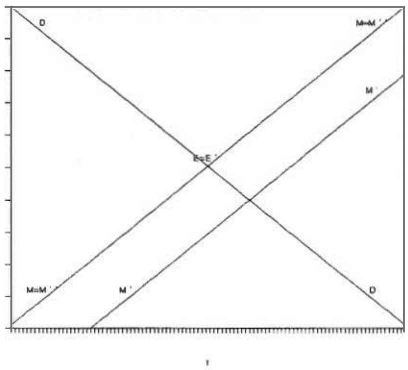
Where g is the ratio of $b^*(i)$ and DN; 1, the ratio of D_c and DN; and the subindices under the different functions denote partial derivatives with respect to the argument that such subindex represents.

The first term depicts a disaccumulation effect owing to the fall in e; the second the accumulation effect associated with the increase in i.

1.1.b. Fixed exchange rate (strict).

CHART A2.

FIXED EXCHANGE RATE (STRICT).



With regard to the movement in reserves.

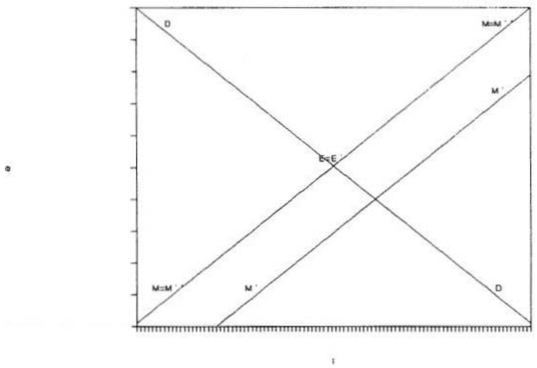
$$dD_c = (1/e).[(e.b_i^* - d_i)di]$$

1.2. The authority controls interest rate i.

1.2.a. Flexible exchange rate and implementation via open market operations (B versus M).

CHART A3.

FLEXIBLE EXCHANGE RATE AND IMPLEMENTATION VIA OPEN MARKET (B VERSUS M).



With regard to the movement in the money suply and foreign reserves:

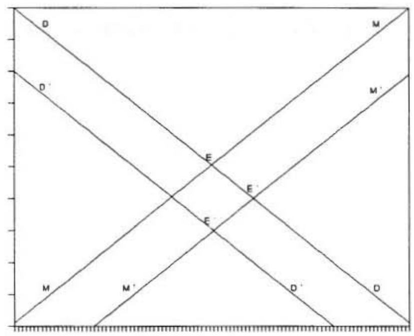
$$dM = dB_c = Z_1$$

$$dD_c = 0$$

1.2.b. Flexible exchange rate and implementation via bond swaps (B versus D).

CHART A4.

FLEXIBLE EXCHANGE RATE AND IMPLEMENTATION VIA BOND SWAPS (B VERSUS D)



$$dM = 1_w \,.\, DN \,.\, de + Z_1$$

$$dD_c = (1/e) \,.\, D_c \,.\, [-1 + (1-d_w) + g] \,.\, de$$

1.2.c. Fixed exchange rate.

In this case, the analysis coincides with section 1.2.a.

CASE 2. Disturbance in the bond markets:

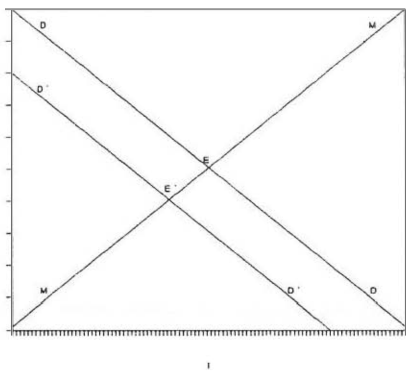
$$Z_b = -Z_d > 0; \quad Z_I = 0$$

2.1. The authority controls the money suply.

2.1.a. Flexible exchange rate.

CHART A5.

FLEXIBLE EXCHANGE RATE.



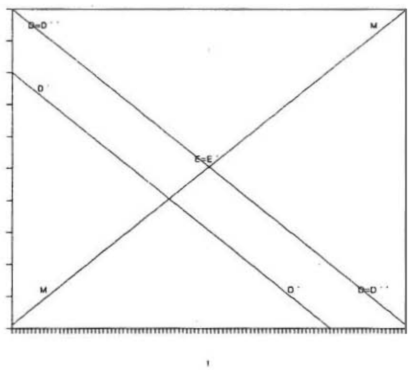
$$dD_c = (1/e)\ \{ DN\ [\ -l + (1 - d_w) + g\ ]\ de + (e.b_i^* - d_i)\ di - Z_d \}$$

The first two terms depict the disaccumulation due to the change in the pair (e,i), and the third the accumulation due to the disturbance.

2.1.b. Fixed exchange rate.

CHART A6.

FIXED EXCHANGE RATE



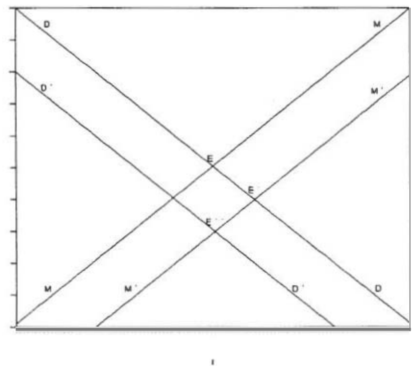
$$dD_c = (1/e) \cdot (-Z_d)$$

2.2. The monetary authority controls i.

2.2.a. Flexible exchange rate and implementation via open market in domestic assets.

CHART A7.

FLEXIBLE EXCHANGE RATE AND IMPLEMENTATION VIA OPEN MARKET IN DOMESTIC ASSETS.



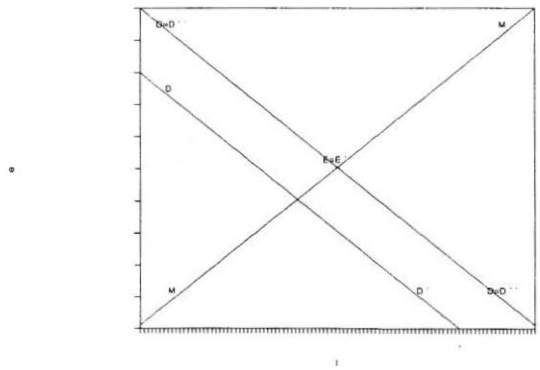
$$dM = l_w \,.\, DN \,.\, de$$

$$dD_c = (1/e)\ \{\ DN\ [-l + (1 - d_w) + g\ ]\ de - Z_d\ \}$$

2.2.b. Flexible exchange rate and implementation via bond swaps.

CHART A8.

FLEXIBLE EXCHANGE RATE AND IMPLEMENTATION VIA BOND SWAPS.



$$dM = 0$$

$$dD_c = (1/e) \cdot (-Z_d)$$

2.2.c.Fixed exchange rate.

In this case the results of section 2.2.b. recur.

APPENDIX B. CHARTS OF THE DIFFERENT VARIABLES.

CHART. B1. PTA/DM Exchange rate (pesetas per D-Mark).

CHART B11.

SELLING RATE

CHART B12.

BUYING RATE.

CHART B2.

3-MONTH INTERBANK RATE.

CHART B3.

MONETARY AGGREGATE (PTA bn)

CHART. B4. PTA/$ Exchange rate (pesetas per $).

CHART B41.

SELLING RATE.

CHART B42.

BUYING RATE.

APPENDIX C. ADDITIONAL RESULTS TO THE ESTIMATIONS OF SECTION 4.

This appendix includes a series of results additional to those furnished in section 4. In particular, for each relevant variable, except Bank of Spain interventions in the peseta market, the following are given:

1. Specific model and results of the estimation.

2. Simple and partial autocorrelation functions of the squared standardised residuals to test for the presence of additional GARCH-type heteroskedasticity (see Bollerslev (1988)).

3. Simple and partial autocorrelation functions of the standardised residuals to test for the presence of serial correlation therein.

4. Percentage of extreme observations that must be eliminated so that the Bera-Jarque test (Bera and Jarque (1982)) does not reject the normality of the standardised residuals. The reason for such a presentation lies in the sensitivity of the test to the presence of extreme values. Since this percentage is considerable in certain cases, a test is also incorporated for the presence of the fourth-order momentum of the standardised residuals which, in the case of a GARCH (1,1) process takes the following form:

$$3.\alpha_1^2 + 2.\alpha_1 \beta + \beta^2 < 1$$

Were this momentum to exist, the results pertaining to the consistency and asymptotic normality of the estimators would be maintained, though with some variations in the variance and co-variance matrix (see White (1982) and Weiss (1982)).

C.1 PTA/DM EXCHANGE RATE.

ESTIMATED MODEL:

$$(1 - \phi . B)\nabla \log(pta/DM)_t = \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N\ (0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 . \epsilon^2_{t-1} + \beta . h_{t-1}$$

ESTIMATION RESULTS:

Parameters	Sample period 1/84-12/87	1/88-6/89	6/89-6/90
ϕ	.15 (.03)	.04 (.05)	.06 (.06)
α_0	.0045 (.0000)	.0161 (.0000)	.0021 (.0000)
α_1	.18 (.00)	.29 (.00)	.12 (.00)
β	.69 (.00)	.50 (.00)	.84 (.00)
$\alpha_0/1-\beta$	.015	.032	.013
$\alpha_1/1-\beta$	.57	.59	.77
T	1043	371	278

Notes: - Standard errors in brackets.

- Structural change tests:

$$LR=46.17\ (X^2_8(.05)=15.5)$$

ADDITIONAL RESULTS:

SUBSAMPLE 1/84-12/87:

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.007	0.062	0.007	0.062
2	-0.020	0.062	-0.020	0.062
3	0.009	0.062	0.009	0.062
4	-0.024	0.062	-0.024	0.062
5	0.019	0.062	0.020	0.062
6	-0.002	0.062	-0.003	0.062
7	-0.011	0.062	-0.010	0.062
8	-0.011	0.062	-0.012	0.062
9	0.067	0.062	0.068	0.062
10	0.108	0.062	0.106	0.062
11	-0.030	0.062	-0.029	0.062
12	0.012	0.062	0.014	0.062
13	-0.020	0.062	-0.020	0.062
14	-0.020	0.062	-0.017	0.062
15	0.014	0.062	0.008	0.062

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.032	0.062	0.032	0.062
2	0.049	0.062	0.048	0.062
3	0.036	0.062	0.034	0.062
4	0.101	0.062	0.097	0.062
5	0.094	0.062	0.087	0.062
6	0.021	0.062	0.007	0.062
7	0.061	0.062	0.047	0.062
8	0.010	0.062	-0.008	0.062
9	0.076	0.062	0.055	0.062
10	-0.041	0.062	-0.058	0.062
11	0.032	0.062	0.017	0.062
12	0.041	0.062	0.031	0.062
13	0.019	0.062	0.005	0.062
14	0.003	0.062	-0.005	0.062
15	0.017	0.062	0.017	0.062

t-ratio residual mean equal to 0 ... -0.28

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 1.44

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.82

SUBSAMPLE 1/88 - 6/89

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.083	0.104	0.083	0.104
2	0.078	0.104	0.071	0.104
3	-0.012	0.104	-0.025	0.104
4	-0.028	0.104	-0.031	0.104
5	0.002	0.105	0.009	0.104
6	-0.035	0.105	-0.032	0.104
7	0.061	0.105	0.065	0.104
8	0.005	0.105	-0.001	0.104
9	-0.007	0.105	-0.019	0.104
10	-0.045	0.105	-0.044	0.104
11	-0.027	0.105	-0.014	0.104
12	0.004	0.106	0.012	0.104
13	0.021	0.106	0.026	0.104
14	-0.016	0.106	-0.028	0.104
15	0.072	0.106	0.072	0.104

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.015	0.104	0.015	0.104
2	0.014	0.104	0.014	0.104
3	0.035	0.104	0.034	0.104
4	-0.028	0.104	-0.030	0.104
5	-0.012	0.105	-0.012	0.104
6	-0.053	0.105	-0.054	0.104
7	-0.002	0.105	0.002	0.104
8	0.021	0.105	0.022	0.104
9	0.095	0.105	0.098	0.104
10	0.099	0.105	0.094	0.104
11	0.070	0.105	0.064	0.104
12	-0.026	0.106	-0.040	0.104
13	0.021	0.106	0.017	0.104
14	0.058	0.106	0.063	0.104
15	0.079	0.106	0.101	0.104

t-ratio residual mean equal to 0 ... 0.25

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 7.82

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.80

SUBSAMPLE 6/89 - 6/90

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.018	0.120	-0.018	0.120
2	-0.032	0.120	-0.032	0.120
3	-0.033	0.121	-0.035	0.120
4	-0.025	0.121	-0.027	0.120
5	0.066	0.121	0.063	0.120
6	0.026	0.121	0.026	0.120
7	-0.043	0.121	-0.040	0.120
8	0.040	0.122	0.043	0.120
9	0.010	0.122	0.014	0.120
10	0.093	0.122	0.091	0.120
11	0.012	0.122	0.014	0.120
12	-0.010	0.123	0.004	0.120
13	-0.013	0.123	-0.009	0.120
14	0.027	0.123	0.027	0.120
15	-0.036	0.123	0.045	0.120

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.008	0.120	0.008	0.120
2	0.012	0.120	0.012	0.120
3	0.051	0.121	0.051	0.120
4	0.065	0.121	0.065	0.120
5	-0.095	0.121	-0.097	0.120
6	-0.027	0.121	-0.030	0.120
7	-0.041	0.121	-0.045	0.120
8	0.084	0.122	0.092	0.120
9	0.077	0.122	0.095	0.120
10	0.128	0.122	0.129	0.120
11	0.097	0.122	0.089	0.120
12	0.090	0.123	0.061	0.120
13	-0.100	0.123	-0.121	0.120
14	-0.057	0.123	-0.079	0.120
15	0.004	0.123	0.017	0.120

t-ratio residual mean equal to 0 ... 0.01

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 2.52

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.96

C.2 INTEREST RATE.

ESTIMATED MODEL:

$$\nabla \log(1+r)_t = \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N\ (0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 . \epsilon^2_{t-1} + \beta . h_{t-1}$$

ESTIMATION RESULTS:

	Sample period		
Parameters	1/84-12/87	1/88-6/89	6/89-6/90
α_0	.0009 (.0000)	.0051 (.0000)	.0002 (.0000)
α_1	.12 (.00)	.28 (.00)	.13 (.00)
β	.87 (.00)	.25 (.00)	.81 (.00)
$\alpha_0/1-\beta$	.006	.007	.001
$\alpha_1/1-\beta$	.92	.38	.70
T	1043	370	280

Notes: - Standard errors in brackets.

- Structural change tests:

$$LR=142.83\ (X^2_8(.05)=15.5)$$

- In subsample 1/88-6/89 the ARIMA model is:

$$\underset{(.05)}{(1-.15\ B)}\nabla \log(1+r)_t=\epsilon_t$$

ADDITIONAL RESULTS:

SUBSAMPLE 1/84 - 12/87

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.042	0.062	0.042	0.062
2	-0.001	0.062	-0.003	0.062
3	0.003	0.062	0.003	0.062
4	-0.015	0.062	-0.014	0.062
5	-0.014	0.062	-0.013	0.062
6	0.004	0.062	0.005	0.062
7	-0.026	0.062	-0.027	0.062
8	0.006	0.062	0.009	0.062
9	-0.020	0.062	-0.021	0.062
10	-0.005	0.062	-0.003	0.062
11	-0.029	0.062	-0.029	0.062
12	-0.017	0.062	-0.015	0.062
13	-0.026	0.062	-0.025	0.062
14	-0.012	0.062	-0.012	0.062
15	0.005	0.062	0.006	0.062

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.028	0.062	0.028	0.062
2	0.017	0.062	0.016	0.062
3	0.061	0.062	0.060	0.062
4	0.031	0.062	0.027	0.062
5	-0.004	0.062	-0.008	0.062
6	0.083	0.062	0.079	0.062
7	0.058	0.062	0.051	0.062
8	0.020	0.062	0.015	0.062
9	0.031	0.062	0.020	0.062
10	0.034	0.062	0.022	0.062
11	-0.029	0.062	-0.035	0.062
12	0.015	0.062	0.007	0.062
13	-0.028	0.062	-0.040	0.062
14	-0.027	0.062	-0.030	0.062
15	0.057	0.062	0.055	0.062

t-ratio residual mean equal to 0 ... 0.28

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 9.30

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.92

SUBSAMPLE 1/88 - 6/89

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.010	0.104	0.010	0.104
2	0.034	0.104	0.034	0.104
3	-0.050	0.104	-0.050	0.104
4	-0.003	0.104	-0.005	0.104
5	-0.005	0.105	-0.002	0.104
6	0.012	0.105	0.010	0.104
7	-0.053	0.105	-0.053	0.104
8	-0.024	0.105	-0.026	0.104
9	0.033	0.105	0.038	0.104
10	0.007	0.105	0.004	0.104
11	-0.024	0.105	-0.030	0.104
12	0.043	0.106	0.046	0.104
13	-0.050	0.106	-0.046	0.104
14	-0.006	0.106	-0.014	0.104
15	-0.038	0.106	-0.035	0.104

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.042	0.104	0.042	0.104
2	0.034	0.104	0.032	0.104
3	0.020	0.104	0.017	0.104
4	0.052	0.104	0.050	0.104
5	0.028	0.105	0.023	0.104
6	0.065	0.105	0.060	0.104
7	0.028	0.105	0.020	0.104
8	0.116	0.105	0.109	0.104
9	-0.055	0.105	-0.070	0.104
10	0.062	0.105	0.055	0.104
11	0.017	0.105	0.007	0.104
12	-0.020	0.106	-0.038	0.104
13	0.011	0.106	0.009	0.104
14	-0.002	0.106	-0.019	0.104
15	-0.063	0.106	-0.065	0.104

t-ratio residual mean equal to 0 ... -0.07

Extreme values to eliminate to satisfy the Bera-Jarque test (percentage) ... 11.08

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.38

SUBSAMPLE 6/89 - 6/90

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.057	0.120	0.057	0.120
2	-0.016	0.120	-0.020	0.120
3	-0.012	0.121	-0.010	0.120
4	-0.021	0.121	-0.020	0.120
5	-0.020	0.121	-0.018	0.120
6	-0.004	0.121	-0.003	0.120
7	-0.015	0.121	-0.016	0.120
8	-0.005	0.122	-0.005	0.120
9	-0.002	0.122	-0.004	0.120
10	0.005	0.122	0.004	0.120
11	-0.014	0.122	-0.016	0.120
12	0.007	0.123	0.008	0.120
13	-0.014	0.123	-0.016	0.120
14	-0.017	0.123	-0.016	0.120
15	-0.014	0.123	-0.013	0.120

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.031	0.120	-0.031	0.120
2	0.021	0.120	0.020	0.120
3	0.092	0.121	0.093	0.120
4	0.039	0.121	0.045	0.120
5	0.038	0.121	0.037	0.120
6	0.087	0.121	0.080	0.120
7	0.540	0.121	0.052	0.120
8	0.075	0.122	0.069	0.120
9	-0.038	0.122	-0.052	0.120
10	0.113	0.122	0.093	0.120
11	0.020	0.122	0.008	0.120
12	-0.065	0.123	-0.077	0.120
13	0.042	0.123	0.008	0.120
14	-0.051	0.123	-0.071	0.120
15	0.011	0.123	0.009	0.120

t-ratio residual mean equal to 0 ... -0.82

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 6.79

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.70

C.3 MONEY.

ESTIMATED MODEL:

$$((1 - \phi_1 . B - \phi_2 . B^2)/(1 - \theta . B))\nabla \log(ALP)_t = c + \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N(0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 . \epsilon^2_{t-1}$$

ESTIMATION RESULTS:

Parameters	Sample period 7/84-12/87	1/88-6/89	6/89-6/90
ϕ_1	.87 (.06)	.80 (.04)	.70 (.14)
ϕ_2	-.12 (.04)	-.14 (.06)	-.15 (.07)
θ	.85 (.06)	.88 (.05)	.75 (.13)
c	.075 (.006)	.121 (.011)	.087 (.006)
α_0	.034 (.001)	.032 (.002)	.059 (.003)
α_1	.05 (.00)	.33 (.00)	.09 (.00)
T	914	370	280

Notes: - Standard errors in brackets.

- Structural change tests:

$LR=64.6$ $(X^2_{10}(.05)=18.3)$

ADDITIONAL RESULTS:

SUBSAMPLE 7/84-12/87:

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.010	0.066	-0.010	0.066
2	-0.008	0.066	-0.008	0.066
3	-0.028	0.066	-0.028	0.066
4	-0.035	0.066	-0.036	0.066
5	0.014	0.066	0.013	0.066
6	-0.039	0.066	-0.040	0.066
7	-0.007	0.066	-0.010	0.066
8	-0.003	0.066	-0.005	0.066
9	-0.002	0.066	-0.004	0.066
10	0.047	0.067	0.043	0.066
11	-0.048	0.067	-0.047	0.066
12	-0.016	0.067	-0.019	0.066
13	-0.031	0.067	-0.031	0.066
14	0.000	0.067	-0.002	0.066
15	0.100	0.067	0.095	0.066

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.001	0.066	-0.001	0.066
2	0.029	0.066	0.029	0.066
3	-0.013	0.066	-0.013	0.066
4	-0.017	0.066	-0.018	0.066
5	0.019	0.066	0.020	0.066
6	-0.015	0.066	-0.014	0.066
7	-0.075	0.066	-0.077	0.066
8	0.029	0.066	0.030	0.066
9	0.011	0.066	0.016	0.066
10	0.062	0.067	0.057	0.066
11	0.035	0.067	0.033	0.066
12	0.042	0.067	0.043	0.066
13	-0.009	0.067	-0.012	0.066
14	0.008	0.067	0.003	0.066
15	-0.062	0.067	-0.058	0.066

t-ratio residual mean equal to 0 ... 0.04

Extreme values to eliminate to satisfy the Bera-Jarque test (percentage) ... 3.39

SUBSAMPLE 1/88 - 6/89

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.059	0.104	-0.059	0.104
2	0.029	0.104	0.025	0.104
3	-0.030	0.104	-0.026	0.104
4	0.004	0.104	0.000	0.104
5	0.056	0.105	0.058	0.104
6	0.008	0.105	0.014	0.104
7	-0.027	0.105	-0.029	0.104
8	0.061	0.105	0.061	0.104
9	-0.054	0.105	-0.046	0.104
10	0.012	0.105	-0.002	0.104
11	-0.064	0.105	-0.059	0.104
12	-0.036	0.106	-0.044	0.104
13	-0.065	0.106	-0.073	0.104
14	-0.028	0.106	-0.034	0.104
15	0.016	0.106	0.018	0.104

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.013	0.104	-0.013	0.104
2	0.004	0.104	0.004	0.104
3	0.030	0.104	0.030	0.104
4	0.007	0.104	0.008	0.104
5	-0.121	0.105	-0.121	0.104
6	0.021	0.105	0.017	0.104
7	0.006	0.105	0.007	0.104
8	0.062	0.105	0.070	0.104
9	0.005	0.105	0.007	0.104
10	0.047	0.105	0.031	0.104
11	0.034	0.105	0.036	0.104
12	0.004	0.106	0.005	0.104
13	0.038	0.106	0.052	0.104
14	0.045	0.106	0.043	0.104
15	-0.189	0.106	-0.186	0.104

t-ratio residual mean equal to 0 ... 0.28

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 2.97

SUBSAMPLE 6/89 - 6/90

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.067	0.120	0.067	0.120
2	0.023	0.120	0.018	0.120
3	0.005	0.121	0.002	0.120
4	-0.039	0.121	-0.040	0.120
5	0.019	0.121	0.024	0.120
6	-0.025	0.121	-0.027	0.120
7	-0.016	0.121	-0.013	0.120
8	-0.020	0.122	-0.019	0.120
9	-0.016	0.122	-0.010	0.120
10	-0.028	0.122	-0.028	0.120
11	0.014	0.122	0.019	0.120
12	-0.044	0.123	-0.047	0.120
13	-0.019	0.123	-0.014	0.120
14	-0.014	0.123	-0.014	0.120
15	-0.004	0.123	0.000	0.120

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.021	0.120	-0.021	0.120
2	0.022	0.120	0.021	0.120
3	-0.066	0.121	-0.066	0.120
4	-0.071	0.121	-0.075	0.120
5	0.006	0.121	0.006	0.120
6	-0.040	0.121	-0.042	0.120
7	-0.016	0.121	-0.030	0.120
8	0.007	0.122	0.003	0.120
9	0.060	0.122	0.057	0.120
10	0.013	0.122	0.007	0.120
11	0.124	0.122	0.122	0.120
12	0.034	0.123	0.050	0.120
13	0.071	0.123	0.081	0.120
14	0.044	0.123	0.069	0.120
15	-0.101	0.123	-0.074	0.120

t-ratio residual mean equal to 0 ... 0.24

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 2.86

C.4 PTA/$ EXCHANGE RATE.

ESTIMATED MODEL:

$$\nabla \log(pta/\$)_t = \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N(0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 . \epsilon^2_{t-1} + \beta . h_{t-1}$$

ESTIMATION RESULTS:

Parameters	Sample period 1/84-6/90
α_0	.020 (.000)
α_1	.10 (.00)
β	.86 (.00)
$\alpha_0/1-\beta$	.14
$\alpha_1/1-\beta$	.73
T	1043

Notes: - Standard errors in brackets.

- Structural change tests:

1/88: LR=1.28 ($X^2_3(.05)=7.81$)

6/89: LR=0.00 ($X^2_3(.05)=7.81$)

ADDITIONAL RESULTS:

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	0.003	0.049	0.003	0.049
2	-0.028	0.049	-0.028	0.049
3	-0.031	0.049	-0.031	0.049
4	0.025	0.049	0.024	0.049
5	-0.004	0.049	-0.006	0.049
6	0.020	0.049	0.021	0.049
7	0.048	0.049	0.049	0.049
8	-0.015	0.049	-0.015	0.049
9	0.015	0.049	0.019	0.049
10	-0.022	0.049	-0.021	0.049
11	0.042	0.049	0.040	0.049
12	-0.036	0.049	-0.036	0.049
13	-0.038	0.049	-0.040	0.049
14	-0.024	0.049	-0.024	0.049
15	0.113	0.049	0.108	0.049

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.016	0.049	-0.016	0.049
2	-0.010	0.049	-0.010	0.049
3	0.031	0.049	0.031	0.049
4	0.025	0.049	0.026	0.049
5	0.016	0.049	0.017	0.049
6	0.032	0.049	0.032	0.049
7	0.001	0.049	0.001	0.049
8	0.008	0.049	0.007	0.049
9	0.056	0.049	0.054	0.049
10	0.001	0.049	0.000	0.049
11	0.003	0.049	0.003	0.049
12	-0.011	0.049	-0.016	0.049
13	0.034	0.049	0.031	0.049
14	-0.006	0.049	-0.008	0.049
15	0.023	0.049	0.020	0.049

t-ratio residual mean equal to 0 ... 0.31

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 1.18

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.95

C.5 DM/$ EXCHANGE RATE.

ESTIMATED MODEL:

$$\nabla \log(DM/\$)_t = \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N\ (0.h_t)$$

$$h_t = \alpha_0 + \alpha_1 . \epsilon^2_{t-1} + \beta . h_{t-1}$$

ESTIMATION RESULTS:

Parameters	Sample period 1/84-6/90
α_0	.021 (.000)
α_1	.09 (.00)
β	.87 (.00)
$\alpha_0/1-\beta$	.17
$\alpha_1/1-\beta$	.73
T	1043

Notes: - Standard errors in brackets.

ADDITIONAL RESULTS:

ACF and PACF of squared standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.011	0.049	-0.011	0.049
2	-0.009	0.049	-0.009	0.049
3	-0.031	0.049	-0.031	0.049
4	0.034	0.049	0.034	0.049
5	-0.012	0.049	-0.012	0.049
6	0.014	0.049	0.014	0.049
7	0.024	0.049	0.026	0.049
8	-0.025	0.049	-0.025	0.049
9	0.017	0.049	0.020	0.049
10	-0.022	0.049	-0.022	0.049
11	0.045	0.049	0.042	0.049
12	-0.041	0.049	-0.039	0.049
13	-0.036	0.049	-0.040	0.049
14	-0.016	0.049	-0.013	0.049
15	0.127	0.049	0.121	0.049

ACF and PACF of standardised residuals:

Lag	ACF Coeff.	2-sigma	PACF Coeff.	2-sigma
1	-0.009	0.049	-0.009	0.049
2	-0.001	0.049	-0.001	0.049
3	0.048	0.049	0.048	0.049
4	0.035	0.049	0.036	0.049
5	0.019	0.049	0.020	0.049
6	0.021	0.049	0.019	0.049
7	0.004	0.049	0.001	0.049
8	0.016	0.049	0.013	0.049
9	0.067	0.049	0.064	0.049
10	0.010	0.049	0.010	0.049
11	0.002	0.049	0.000	0.049
12	-0.015	0.049	-0.023	0.049
13	0.027	0.049	0.021	0.049
14	-0.015	0.049	-0.019	0.049
15	0.046	0.049	0.045	0.049

t-ratio residual mean equal to 0 ... 0.41

Extreme values to eliminate to satisfy
the Bera-Jarque test (percentage) ... 1.30

$3.\alpha_1^2 + 2.\alpha_1.\beta + \beta^2$ 0.95

REFERENCES

ARTIS, M. and M. TAYLOR (1988) "Exchange Rates, Interest Rates, Capital Controls and the EMS: Assessing the Track Record", in F. Giavazzi and others (eds.), The European Monetary System, CUP.

BERA, A. and C. JARQUE (1982) "Model Specification Tests: A Simultaneous Approach", Journal of Econometrics, 20, 59-82.

BOLLERSLEV, T. (1986) "Generalized Autoregressive Conditional Heteroskedasticity", Journal of Econometrics, 31, 307-327.

(1988) "On the Correlation Structure for the Generalized Autoregressive Conditional Heteroskedasticity Process", Journal of Time Series Analysis, 9-2, 121-131.

BOX, G.E.P. and J.M. JENKINS (1976) Time Series Analysis: Forecasting and Control. San Francisco, Holden day.

BRANSON, W.H. (1977) "Asset Markets and Relative Prices in Exchange Rate Determination", Sozialwissenschaftliche Annalen , 1, 69-89.

BRANSON, W.H. and H. HALTTUNEN (1979) "Asset Market Determination of Exchange Rates: Initial Empirical and Policy Results", in Martin, J.P. and A. Smith (eds.), Trade and Payments Adjustments under Flexible Exchange Rates, London: Macmilan.

BRANSON, W.H., H. HALTTUNEN and P. MASSON (1977) "Exchange Rate in the Short Run: the Dollar-Deutschemark Rate", European Economic Review, 10, 303-324.

CUDDINGTON, J. and J.VIÑALS (1985) Lecture Notes. Unpublished.

ENGLE, R.F. (1982) "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK Inflation", Econometrica, 50, 987-1008.

ESCRIVA, J.L. (1989) "La Instrumentación de la Política Monetaria en España y la Variabilidad de los Tipos de Interes", Boletín Económico del Banco de España, June, 31-42.

(1990) "Tendencias Básicas en la Fijación e Instrumentación de los Objetivos Monetarios en España", Papeles de Economía, 43.

FRATIANNI, M. and J. von HAGEN (1990) "The EMS Ten Years After", in A. Meltzer and C. Plosser, Carnegie Rochester Conference Series, 32.

GROS, D. and N. THYGESEN (1988) "The EMS: Achievements, Current Issues and Direction for the Future". Mimeo.

HEVIA, J. (1990) "Cuantificación de la Importancia Relativa del Tipo de Cambio pta/DM en la Política Cambiaria". FEDEA, Working Paper 90-13.

HSIEH, D.A. (1988) "The Statistical Properties of Daily Foreign Exchange Rates: 1974-1983", Journal of International Economics, 24, 129-145.

LEYVA, M.L. (1988) "La Reforma del Sistema de Intervención del Banco de España en el Mercado de Cambios", Boletín Económico del Banco de España, February, 21-25.

MALO DE MOLINA, J.L. and J. PEREZ (1990) "La Política Monetaria Española en la Transición hacia la Unión Monetaria Europea", Papeles de Economía, 43.

ROGOFF, K. (1985) "Can Exchange Rates Predictability be Achieved without Monetary Convergence?", European Economic Review, 28, 93-115.

SANZ, B. (1988) "Los Agregados Monetarios y su Calidad como Objetivos Intermedios", Boletín Económico del Banco de España, December, 25-49.

UNGERER ET AL. (1983) "The EMS: The Experience 1979-1982", International Monetary Fund, Occasional Paper nº 19.

(1986) "The EMS: Recent Developments", International Monetary Fund, Occasional Paper nº 48.

WEISS, A.A. (1982) "Asymptotic Theory for ARCH Models: Stability, Estimation and Testing", University of California, San Diego, Discussion Paper 82-36.

WHITE, H. (1982) "Maximum Likelihood Estimation of Misspecified Models", Econometrica, 50, 1-25.

WYPLOSZ, C. (1990) "EMS Puzzles", Revista Española de Economía, vol.7, nº1, 33-66.

DOCUMENTOS DE TRABAJO (1):

8601 **Agustín Maravall:** Revisions in ARIMA signal extraction.
8602 **Agustín Maravall and David A. Pierce:** A prototypical seasonal adjustment model.
8603 **Agustín Maravall:** On minimum mean squared errorestimation of the noise in unobserved component models.
8604 **Ignacio Mauleón:** Testing the rational expectations model.
8605 **Ricardo Sanz:** Efectos de variaciones en los precios energéticos sobre los precios sectoriales y de la demanda final de nuestra economía.
8606 **F. Martín Bourgón:** Indices anuales de valor unitario de las exportaciones: 1972-1980.
8607 **José Viñals:** La politica fiscal y la restricción exterior. (Publicada una edición en inglés con el mismo número).
8608 **José Viñals and John Cuddington:** Fiscal policy and the current account: what do capital controls do?
8609 **Gonzalo Gil:** Política agricola de la Comunidad Económica Europea y montantes compensatorios monetarios.
8610 **José Viñals:** ¿Hacia una menor flexibilidad de los tipos de cambio en el sistema monetario internacional?
8701 **Agustin Maravall:** The use of ARIMA models in unobserved components estimation: an application to spanish monetary control.
8702 **Agustin Maravall:** Descomposición de series temporales: especificación, estimación e inferencia (Con una aplicación a la oferta monetaria en España).
8703 **José Viñals y Lorenzo Domingo:** La peseta y el sistema monetario europeo: un modelo de tipo de cambio peseta-marco.
8704 **Gonzalo Gil:** The functions of the Bank of Spain.
8705 **Agustín Maravall:** Descomposición de series temporales, con una aplicación a la oferta monetaria en España: Comentarios y contestación.
8706 **P. L'Hotellerie y J. Viñals:** Tendencias del comercio exterior español. Apéndice estadistico.
8707 **Anindya Banerjee and Juan Dolado:** Tests of the Life Cycle-Permanent Income Hypothesis in the Presence of Random Walks: Asymptotic Theory and Small-Sample Interpretations.
8708 **Juan J. Dolado and Tim Jenkinson:** Cointegration: A survey of recent developments.
8709 **Ignacio Mauleón:** La demanda de dinero reconsiderada.
8801 **Agustin Maravall:** Two papers on arima signal extraction.
8802 **Juan José Camio y José Rodriguez de Pablo:** El consumo de alimentos no elaborados en España: Análisis de la información de Mercasa.
8803 **Agustín Maravall and Daniel Peña:** Missing observations in time series and the «dual» autocorrelation function.
8804 **José Viñals:** El Sistema Monetario Europeo. España y la politica macroeconómica. (Publicada una edición en inglés con el mismo número).
8805 **Antoni Espasa:** Métodos cuantitativos y análisis de la coyuntura económica.
8806 **Antoni Espasa:** El perfil de crecimiento de un fenómeno económico.
8807 **Pablo Martín Aceña:** Una estimación de los principales agregados monetarios en España: 1940-1962.
8808 **Rafael Repullo:** Los efectos económicos de los coeficientes bancarios: un análisis teórico.
8901 **M.ª de los Llanos Matea Rosa:** Funciones de transferencia simultáneas del indice de precios al consumo de bienes elaborados no energéticos.
8902 **Juan J. Dolado:** Cointegración: una panorámica.
8903 **Agustin Maravall:** La extracción de señales y el análisis de coyuntura.
8904 **E. Morales, A. Espasa y M. L. Rojo:** Métodos cuantitativos para el análisis de la actividad industrial española. (Publicada una edición en inglés con el mismo número).
9001 **Jesús Albarracín y Concha Artola:** El crecimiento de los salarios y el deslizamiento salarial en el periodo 1981 a 1988.
9002 **Antoni Espasa, Rosa Gómez-Churruca y Javier Jareño:** Un análisis econométrico de los ingresos por turismo en la economia española.
9003 **Antoni Espasa:** Metodología para realizar el análisis de la coyuntura de un fenómeno económico. (Publicada una edición en inglés con el mismo número).
9004 **Paloma Gómez Pastor y José Luis Pellicer Miret:** Información y documentación de las Comunidades Europeas.

9005 **Juan J. Dolado, Tim Jenkinson and Simon Sosvilla-Rivero:** Cointegration and unit roots: a survey.
9006 **Samuel Bentolila and Juan J. Dolado:** Mismatch and Internal Migration in Spain, 1962-1986.
9007 **Juan J. Dolado, John W. Galbraith and Anindya Banerjee:** Estimating euler equations with integrated series.
9008 **Antoni Espasa y Daniel Peña:** Los modelos ARIMA, el estado de equilibrio en variables económicos y su estimación. (Publicada una edición en inglés con el mismo número).
9009 **Juan J. Dolado and José Viñals:** Macroeconomic policy, external targets and constraints: the case of Spain.
9010 **Anindya Banerjee, Juan J. Dolado and John W. Galbraith:** Recursive and sequential tests for unit roots and structural breaks in long annual GNP series.
9011 **P. Martínez Méndez:** Nuevos datos sobre la evolución de la peseta entre 1900 y 1936. Información complementaria.
9101 **Javier Valles:** Estimation of a growth model with adjustment costs in presence of unobservable shocks.
9102 **Javier Valles:** Aggregate investment in a growth model with adjustment costs.
9103 **Juan J. Dolado:** Asymptotic distribution theory for econometric estimation with integrated processes: a guide.
9104 **José Luis Escrivá y José Luis Malo de Molina:** La instrumentación de la política monetaria española en el marco de la integración europea. (Publicada una edición en inglés con el mismo número).
9105 **Isabel Argimón y Jesús Briones:** Un modelo de simulación de la carga de la deuda del Estado.
9106 **Juan Ayuso:** Los efectos de la entrada de la peseta en el SME sobre la volatilidad de las variables financieras españolas. (Publicada una edición en inglés con el mismo número).

(1) Los Documentos de Trabajo anteriores a 1986 figuran en el catálogo de publicaciones del Banco de España.

Información: Banco de España
Sección de Publicaciones. Negociado de Distribución y Gestión
Teléfono: 338 51 80
Alcalá, 50. 28014 Madrid