

**EXCHANGE RATE DYNAMICS.
COINTEGRATION AND ERROR CORRECTION MECHANISM.***

M^a Amparo Camarero**

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ABSTRACT

This paper aims to analyse the factors affecting exchange rate determination for the Spanish peseta. Nevertheless, this is not its only objective. Two different models have been estimated using the cointegration methodology. One of them includes Spanish variables and aggregate variables corresponding to the countries participating in the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS). The other model refers only to Spanish and German variables. As the aggregate model results having more explanatory power than the simple one, this gives us an indirect argument for economic policy coordination among the European countries: the evolution of exchange rate would depend on the variables of the whole system.

RESUMEN

El propósito de este trabajo es examinar los factores que afectan al tipo de cambio de la peseta. No obstante, éste no es su único objetivo. Se ha procedido a estimar dos modelos diferentes utilizando la técnica de la cointegración. El primero incluye como variables explicativas las españolas así como variables agregadas formadas por las correspondientes a los países integrantes del Mecanismo de Cambio e Intervención del Sistema Monetario Europeo. El otro modelo incluye solamente variables españolas y alemanas. El hecho de que el modelo agregado resulte ser más explicativo que el modelo más simple nos proporciona un argumento indirecto a favor de la coordinación de políticas económicas entre los países europeos de la CEE, ya que el tipo de cambio dependía de las variables del sistema en su conjunto.

1. INTRODUCTION.

This paper aims to estimate an exchange rate model for the pta/DM. Nevertheless, its principal objective is to give an empirical support to the proposal of some authors as Berx and Tullio (1989) or Russo and Tullio (1988). They think that if a larger degree of integration is to be achieved, further coordination in the determination of economic policies should be promoted.

The exchange rate is a clue variable for all EC member countries. The first stage of coordination has started in the European Monetary System. The objective is to achieve exchange rate stability. But this objective would be impossible to maintain in the future with all countries participating, free movements of capital and smaller margins of fluctuation without effective rules of functioning for monetary policy, and even fiscal or budgetary policy.

The main problem is which country should decide which are the objectives and how to fix them. The hypothesis to test is whether the leading country should be Germany alone or the decisions should be taken in a more coordinate way as a compromise among all the member countries. In order to test this hypothesis, two exchange rate models for the peseta/DM will be estimated: one including the "fundamentals" of Germany and Spain, and other using Spanish data and the aggregate variables for the countries being part of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS). A greater explanatory power of the latter model will be an indirect argument for policy coordination in the EMS.

This paper has 5 chapters. Chapter 2 is a brief introduction to the subject of coordination in the EMS. Chapter 3 presents the basic theoretical and methodological aspects of the models. Chapter 4 presents the empirical results. Finally, chapter 5 summarizes the conclusions.

2. THE EMS: COOPERATION vs. LEADERSHIP.

In the seventies, the problems affecting the International Monetary System since the failure of Bretton Woods led to an implicit "non-system" arrangement. Floating exchange rates were adopted at the beginning, as a means of protecting the economies from the external shocks that were occurring. The consequences of the second oil crisis over the stability of exchange rates and external relationships turned out to be more disruptive than in 1973. From then on, the leading countries have progressively understood their mutual interdependence. Therefore, explicit or implicit coordination has been a feature defining international monetary settlements. But the only institutional arrangement that succeeded was the European Monetary System.

According to McKinnon (1984), currency substitution implies that the demand for any particular currency is unstable but the world demand for currencies is stable. Hence, any attempt to control the stock of a particular currency is destined to fail¹; only coordinated attempts at controlling the total world stock of currencies can succeed.

At the EMS level, Russo and Tullio (1988) proposed some rules of conduct. They think that a properly functioning exchange rate system needs rules governing inflation and rules guaranteeing smooth balance of payments adjustment. They concluded that member countries should expand the domestic component of the monetary base according to the targeted inflation rate and the potential output growth. This would assure symmetry in the system². Intra-EMS international flows should not be sterilized. Therefore, a degree of asymmetry would be necessary in response to other shocks, involving the use of fiscal policy in a coordinated fashion as well.

¹ This description can be also applied to the EC in stages of highly integrated capital markets.

² Symmetry as opposed to the consequences of German leadership, that de facto obliges weak currencies to intervene intra marginally more frequently. Asymmetry in the distribution of the burden of adjustments in the real functioning of the system is one of the most important critiques that can be made of the actual EMS.

The performance of the EMS has been satisfactory: average inflation has fallen; the difference between the highest and the lowest inflation rate has narrowed; and, despite high unemployment still remaining, trade relationships within the Community have not been infected by protectionist pressures.

Thus, the acceptance of the objectives and principles of the system has reinforced policy cooperation both among member countries and within countries.

This is true, however, that the successful performance owed something to the help of special factors and circumstances: the strong dollar attenuated intra-EMS pressures by diverting financial flows away from DM-denominated assets; capital controls reduced the exchange rate pressures associated with the higher inflation rates of France and Italy; the recognition of the need to give priority to the reduction of inflation has made easy the acceptance of the policy leadership of Germany. The problem appears now that the circumstances have changed.

However, it would be erroneous to think that hegemony is a necessary characteristic of a well-functioning monetary system. If hegemonic systems are studied carefully, they reveal that the amount of coordination needed for smooth functioning was substantial. Moreover, the appearance of hegemony can sometimes result as much from common objectives as from asymmetries in economic size or reputation among countries. Recent developments in the EMS have been a clear example of these outcomes.

At this moment, some analysts argue that given both the progress already made on inflation, and the high unemployment rate in some EMS countries, it is time to give greater weight to objectives other than inflation.

A new challenge to the system has appeared: capital controls are being lifted and all the remaining non-tariff barriers on the trade of goods and services are removed as a consequence of fulfilling the programme set by

the Single European Act. The Community seeks to achieve the impossible task of reconciling: free trade, full capital mobility, fixed exchange rate and national autonomy in the conduct of monetary policy. Padoa-Schioppa (1987) has defined these four incompatible objectives as the inconsistent quartet. The four elements cannot coexist. Nevertheless, the full effects of the inconsistency have not yet been felt, because capital mobility is still incomplete.

The question has been whether the EMS mechanisms were adequate to allow the system to survive and to perform as affectively as before. The Delors' Report and its proposal for an Economic and Monetary Union is a response to this question.

A key point, a required change in attitude, consists in not considering pressures in the exchange markets as a sufficient condition for a realignment. The only effective instrument to counter financial disturbances is a defense of the exchange rate through enhanced cooperation among monetary authorities and the willingness to subordinate domestic goals to exchange rate stability when circumstances so require.

However, in the long term, the only solution for the inconsistency is to complement the internal market with a monetary union (and economic).

What is really needed for a monetary union to exist, according to Padoa-Schioppa (1987) is one monetary policy and hence one monetary authority, entrusted with the necessary decision making powers and operational instruments. This means that the supply money for the whole Community should be based upon the same monetary base, as proposed by Russo and Tullio (1988).

Hence, it seems that the EC approach to the EMU is, at the same time, a proposal for further cooperation versus leadership.

3. THEORETICAL BACKGROUND.

3.1. EXCHANGE RATE DETERMINATION THEORY.

Much of the work on floating exchange rates goes under the name of "MONETARY" or "ASSET" view; the exchange rate is viewed as moving to equilibrate the international demand for stock of assets, rather than the international demand for flows of goods, as under more traditional view³. Within the asset view there are two different approaches, which have conflicting implications in particular for the relationship between the exchange rate and the interest rate.

The first approach can be called the "CHICAGO" theory because it assumes that prices are perfectly flexible. As a consequence, changes in the nominal interest rate reflect changes in the expected inflation rate. When the domestic interest rate rises relative to the foreign interest rate, it is because the domestic currency is expected to lose value through inflation and depreciation. Demand for the domestic currency falls relative to the foreign currency, which causes it to depreciate instantly. This is a rise in the exchange rate, defined as the price of foreign currency. Thus, we get a positive relationship between the exchange rate and the nominal interest differential.

The second approach can be called the "KEYNESIAN" theory because it assumes that prices are sticky, at least in the short run. As a consequence of this assumption, changes in the nominal interest rate reflect changes in the tightness of monetary policy. When the domestic interest rate rises relative to the foreign rate it is because there has been a contraction in the domestic

³ We are going to follow an article by Frankel (1979) in which he presents the Real Interest Differential Theory of Exchange Rate Determination but, at the same time, he allows for other approaches of exchange rate determination to be tested depending on the value of the estimated parameters.

money supply relative to domestic money demand without a matching fall in prices. The higher interest rate at home than abroad attracts a capital inflow, which causes the domestic currency to appreciate instantly. Thus, we get a negative relationship between the exchange rate and the nominal interest differential.

The Chicago theory is a realistic description when variation in the inflation differential is large, whereas the Keynesian theory is a realistic description when variation in the inflation differential is small.

The paper of Frankel (1979) develops a model which is a version of the asset view of the exchange rate, in that it emphasizes the role of expectations and rapid adjustment in capital markets. The change is that it combines the Keynesian assumption of sticky prices with the Chicago assumption that there are secular rates of inflation. Thus, it turns out that the exchange rate is negatively related to the nominal interest differential, but positively related to the expected long-run inflation differential.

This theory yields an equation of exchange rate determination in which the spot rate is expressed as a function of the relative money supply, relative income level, the nominal interest differential (with the sign hypothesized negative), and the expected long-run inflation differential (of positive sign). Then, one can test these hypotheses and decide which is the exchange rate determination approach that is better explained by the data.

3.1.1. The real interest differential theory of exchange rate determination.

Two are the assumptions that support this theory:

1. INTEREST RATE PARITY holds, associated with efficient markets in which the bonds of different countries are perfect substitutes:

$$d = r - r^* \quad (1)$$

where r is the short-term domestic interest rate, r^* is the foreign rate and d is considered to be the forward discount, then (1) is a statement of covered interest parity. Under perfect capital mobility, covered interest parity must hold exactly. However, d is defined as the expected rate of depreciation; then (1) represents the stronger condition of uncovered interest parity. If there is no uncertainty the forward discount is equal to the expected rate of depreciation, and (1) follows directly. If there is uncertainty, then the assumption that there is no risk premium is a strong one.

2. THE EXPECTED RATE OF DEPRECIATION IS A FUNCTION OF THE GAP BETWEEN THE CURRENT SPOT RATE AND AN EQUILIBRIUM RATE, AND THE EXPECTED LONG-RUN INFLATION DIFFERENTIAL BETWEEN THE DOMESTIC AND FOREIGN COUNTRIES:

$$d = -\theta(e - \bar{e}) + \pi - \pi^* \quad (2)$$

where e is the logarithm of the spot rate; π and π^* are the current rates of expected long-run inflation at home and abroad, respectively. The logarithm of the equilibrium exchange rate \bar{e} is defined to increase at the rate $\pi - \pi^*$ in the absence of new disturbances. Equation (2) says that in the short run the exchange rate is expected to return to its equilibrium value at a rate that is proportional to the current gap, and that in the long run, when $e = \bar{e}$ it is expected to change at the long run rate $\pi - \pi^*$. The justification of this

equation is that it is a reasonable form for expectations to take form in an inflationary world.

If we combine the two equations we get:

$$e - \bar{e} = -\frac{1}{\theta} [(r - \pi) - (r^* - \pi^*)] \quad (3)$$

The expression in brackets is the *real interest differential*. In the long run, when $\bar{e} = e$, we must have $\bar{r} - \bar{r}^* = \pi - \pi^*$, where \bar{r} and \bar{r}^* denote the long run, short-term interest rates. Thus, the expression in brackets is equal to $[(r - r^*) - (\bar{r} - \bar{r}^*)]$. When a tight domestic monetary policy causes the nominal interest differential to rise above its long-run level, an incipient capital inflow causes the value of the currency to rise proportionately above its equilibrium level.

In order to get the complete equation of exchange rate determination, it remains only to explain \bar{e} . Assume that in the long run, *purchasing power parity holds*:

$$\bar{e} = \bar{p} - \bar{p}^* \quad (4)$$

where \bar{p} and \bar{p}^* are defined as the logarithms of the equilibrium price levels at home and abroad, respectively.

If we assume a conventional *money demand equation*:

$$m = p + \phi y - \lambda r \quad (5)$$

where m , p , and y are defined as the logarithms of the domestic money supply, price level, and output. A similar equation holds for abroad. Let us take the difference between the two equations:

$$m - m^* = p - p^* + \phi(y - y^*) - \lambda(r - r^*) \quad (6)$$

Using bars to denote equilibrium values and remembering that in the long run $e=\bar{e}$, $\bar{r}-\bar{r}^*=\pi-\pi^*$, we obtain:

$$\begin{aligned}\bar{e} &= \bar{p} - \bar{p}^* = \\ &= \bar{m} - \bar{m}^* - \phi(\bar{y}-\bar{y}^*) + \lambda(\pi-\pi^*)\end{aligned}\quad (7)$$

This equation illustrates the monetary theory of exchange rate, according to which the exchange rate is determined by the relative supply and demand for the two currencies. In full equilibrium, a given increase in the money supply inflates prices and thus rises the exchange rate proportionately, and that an increase in income or a fall in the expected rate of inflation raises the demand for money and thus lowers the exchange rate.

Substituting (7) into (3), and assuming that the current equilibrium money supplies and income levels are given by their current actual levels, we obtain a complete equation of spot rate determination:

$$e = m - m^* - \phi(y-y^*) - 1/\theta(r-r^*) + (1/\theta + \lambda)(\pi-\pi^*)\quad (8)$$

3.1.2. Testable alternative hypotheses.

We can rewrite equation (8) by adding an error term:

$$e = m - m^* - \phi(y-y^*) + \alpha(r-r^*) + \beta(\pi-\pi^*) + u\quad (9)$$

where $\alpha = (-1/\theta)$ is hypothesized negative and $\beta = (1/\theta + \lambda)$ is hypothesized positive and greater than α in absolute value.

The alternative hypotheses turn out to be very interesting.

* DORNBUSCH APPROACH (1976) is an incarnation of the Keynesian approach, in which secular inflation is not a factor. In fact, the model

developed by Frankel (1989) is the same as the Dornbusch model in the special case where $\pi - \pi^*$ equals zero. The testable hypothesis is $\beta = 0$.

* CHICAGO THEORY of the exchange rate, which is attributed to Frenkel (1976) and Bilson (1978). The variant presented by Bilson begins by a money demand equation like (5). Subtracting the foreign version yields (6). Bilson then assumes that PPP always holds:

$$e = p - p^* = (m - m^*) - \phi(y - y^*) + \lambda(r - r^*) \quad (10)$$

An increase in the domestic interest rate lowers the demand for domestic currency and causes a depreciation. In terms of equation (9), α , the coefficient of the nominal interest differential, is hypothesized to be positive rather than negative.

The interest differential ($r - r^*$) is viewed as representing the relative expected inflation rate ($\pi - \pi^*$), either because international investment flows equate real rates of interest or because interest rate parity insures that the interest differential equals expected depreciation, and PPP insures that depreciation equals relative inflation. Thus, the expected inflation differential can be put in (10) instead of the nominal interest rate differential:

$$e = (m - m^*) - \phi(y - y^*) + \lambda(\pi - \pi^*) \quad (11)$$

In terms of equation (9), α is hypothesized to be zero and β to be positive, if we use a good proxy for ($\pi - \pi^*$). Or, more generally, the hypothesis can be represented $\alpha + \beta = \lambda > 0$, $\alpha \geq 0$, $\beta \geq 0$. The relative size of α and β would depend on how good a proxy we have for the expected inflation differential.

Indeed Frenkel assumes a Cagan-type money demand function, which uses the expected inflation rate rather than the interest rate. He uses the expected rate of depreciation as reflected in the forward discount in place of the unobservable expected inflation differential, which, in well-functioning

bond markets would be the same as using the nominal interest differential.

Thus, the Frenkel-Bilson theory could be viewed as a special case of the real interest differential theory where the adjustment to equilibrium is assumed instantaneous: θ is infinite, that is, α is zero.

This theory was tested for the German hyperinflation, being relevant when the inflation is very high and variable, Dornbusch's theory being relevant in the polar case, when inflation differential is very low and stable.

Frankel (1979) pretends that his theory is relevant for moderate inflation periods, as existing in the first six years after the generalized floating in 1973.

The various alternative hypotheses can be summarized as follows:

KEYNESIAN MODEL (DORNBUSCH 1976)	$\alpha < 0$	$\beta = 0$
CHICAGO MODEL:* BILSON	$\alpha > 0$	$\beta = 0$
* FRENKEL	$\alpha = 0$	$\beta > 0$
REAL INTEREST DIFFERENTIAL MODEL	$\alpha < 0$	$\beta > 0$

3.2. THE AGGREGATION ISSUE.

The models and the estimations developed in this paper take as a reference the model appeared in 1989 from Bekx and Tullio.

They focus on the determination of the DM/\$ exchange rate. They had three main objectives:

1.- To show that the institutional change introduced by the creation of the EMS in 1979 has altered the determinants of the DM/\$ rate and cannot be neglected.

2.- To show that to explain the DM/\$ exchange rate since mid-78, the variables determining the exchange rate have to be aggregated across the countries participating in the ERM and that German variables alone have less explanatory power.

3.- By taking into account currency substitution in the demand for money, the explanatory power of the exchange rate equation improves.

It is based on the fact that in between realignments the DM is linked to the other currencies participating in the ERM. Therefore, in between realignments, the DM/\$ rate is not reflecting changes in German fundamentals but changes in ERM fundamentals. They have run a model following the monetary approach.

So, it is possible to specify a model as if the system (EMS) were flexible instead of fixed. With fixed exchange rates and perfect mobility of capital, the monetary policy would be ineffective to achieve economic policy objectives and the aggregation would not make sense. The money supply would be endogenous. The explanation consists in the fact that in between realignments, the currencies fluctuate within the bands. Thus, the fundamentals of all the member countries influence the exchange rate of the others.

Their main conclusion is that since the creation of the EMS, the DM/\$ exchange rate is determined by economic developments in the whole ERM area and in each member country: as convergence of inflation improves and realignments become more infrequent, the ERM tends towards a system in which national inflation rates are determined more by the aggregated money stock of the ERM than by the national money stock. We should point out the relationship between this result and the conclusions of the article by Russo and Tullio

(1988). Coordination in monetary policy (and other economic policies) is the indirect outcome of both articles.

J.J.M. Kremers and T.D. Lane (1990) have followed Bekx and Tullio (1989) and studied money demand. They have introduced some comments and critiques to the article of Bekx and Tullio. There are two points that are particularly important:

- To introduce dynamics in the model. They use the cointegration approach and estimate the error correction mechanism.
- To use the PPP as the transformation exchange rate to aggregate ERM currencies.

The models estimated in this paper follow the model of Bekx and Tullio but try to introduce the first critique of Kremers and Lane (1990). The model has been applied to the case of the exchange rate peseta/DM for the period 1980-1988, when the EMS was functioning but the Spanish peseta was not still obliged by its discipline. We have used the cointegration methodology.

3.3. COINTEGRATION THEORY.

3.3.1. Introduction. Some Definitions.

Economic Theory generally deals with *equilibrium relationships*. Most empirical econometric studies are an attempt to evaluate such relationships using statistical analysis. To apply standard inference procedures in a dynamic time series model, we need the various variables to be stationary. Until recently, this assumption was rarely questioned, and econometric analyses proceeded as if the economic time series were stationary, at least around some deterministic trend function which could be appropriately removed.

Integrated variables are a specific class of non-stationary variables with important economic and statistic properties. These are derived from the presence of unit roots which give rise to stochastic trends, as opposed to pure deterministic trends, with innovations to an integrated process being permanent instead of transient.

The underlying idea is that a vector of variables, all of which achieve stationarity after differencing, may have linear combinations which are stationary without differencing. Engle and Granger (1987) formalise the idea of variables sharing an equilibrium relationship in terms of cointegration between time series, providing us with tests and an estimation procedure to evaluate the existence of equilibrium relationships.

The procedure consists of finding a stable relationship (or steady state) among the original variables as suggested by Economic Theory representing their long run behaviour. These relationships used to be written in levels.

The residuals of this relationship are the deviations from the long run and contain the non-explained part of the model. The dynamic specification of the model will try to capture the short-run information about the adjustment process. This technique is the Error Correction Mechanism. Let us formalise this definition:

x_t and y_t are two stochastic processes. If they are linked by the long term relationship:

$$y = a + b.x \quad (1)$$

Then, the short-run relationship is said to be characterised by an error correction mechanism if

$$\Delta y_t = \alpha_1 \Delta x_t + \alpha_2 (y_{t-1} - b x_{t-1}) \quad (2)$$

Additional lags may be added.

It can be interpreted as a *static long-run relationship* if x and y are constant in the long run. If the variables grow at a constant rate, the relation is one of a *steady state*. This requires the variables to be the natural logarithm of the original variables.

3.3.2. A strategy for applying the cointegration method.

Once we have explained the basics of this approach, the stages to apply this method should follow. First, we will test for unit roots to determine which is the order of integration of each variable. Then, we will formulate the feasible long-run relationships given the previous results (because all the variables involved must have the same order of integration). And last, an error correction specification will try to reflect the short run elements that adjust.

First of all, in order to specify a good general model representing the Data Generating Process, the order of integration (that is, the number of unit roots), d , is to be analysed, as well as the feasible cointegration relationships.

As mentioned above, Box-Jenkins methodology allows us to transform non-stationary series into stationary ones by differencing. But this is not enough when studying long-run relationships. Cointegration allows us to complete the model with the long-run well specified relationship.

Thus, cointegration is a step forward from both traditional Econometrics and ARIMA models.

The steps to test $I(d)$ can be summarised as follows:

(i) To start with the tests:

I(2) vs. I(1), then

I(1) vs. I(0)

by using the simple Dickey-Fuller statistics, Fuller (1976) and likelihood ratio statistics, Dickey and Fuller (1981).

(ii) To test the significance of the trend and the drift under the null hypothesis of the series being I(d), in order to use the normal distribution tables if necessary.

(iii) To complete it with further analysis:

- Augmented Dickey-Fuller

- Non-parametric corrections (Phillips and Perron, 1988; Phillips, 1987; Perron, 1990).

- Traditional methods: exam of the Autocorrelation Function (ACF) of the series, Partial Autocorrelation Function (PACF), graphs...⁴

Second, once we know the order of integration of the series, we proceed to estimate the cointegration relationships. We can define cointegration, as explained above, in the following way: one group of variables is cointegrated if,

a) all them are I(d) and

b) there exists a linear combination of them that is I(d-b), where $b > 0$.

For X_t and Y_t it would mean that there exists a constant, α , which:

⁴ Nevertheless, we started the analysis by looking at the graphs and ACF and PACF. The reason is that we think it is better to observe first which is the behaviour of the data and the pattern of the graph. This information can be very useful and gives us a rather clear idea of which kind of series we have.

$$Z_t = X_t - \alpha Y_t \quad \text{where } Z_t \text{ is } I(0). \quad (11)$$

This relationship means that the factors that determine the growth of the variable along time cancel out. They generate a stationary series. Z_t assures a stochastic equilibrium between X_t and Y_t , because no permanent deviations occur.

So, we shall now look for the cointegration relationship. Ordinary Least Squares can be used. Estimators are biased but consistent, and converge to their true value quicker than the classical estimators. This property is called "superconsistency" (Dolado, 1989).

Some statistics can be used to test for cointegration:

(a) The DURBIN-WATSON statistic of the regression between the reference variables. This test is called CRDW and it is due to Sargan and Bhargava (1983).

(b) TO TEST FOR A UNIT ROOT IN THE RESIDUALS.

In order to complete the analysis, unit root tests are used to improve the accuracy of the conclusion. These tests, also due to Dickey and Fuller, are different from those applied to find out the order of integration. While the latter are run over the original data, the former use the residuals of the long run regression. They test whether Z_t is white noise, as cointegration theory pretends.

ADF can be used to deal with the problems of simple DF, similar to those of the CRDW statistic. The critical values can be found in Dolado (1989).

(c) The ERROR CORRECTION MECHANISM is also a test for cointegration.

Cointegration exists if an ECM representation can be found. Thus, this is a further test for cointegration.

In the estimation strategy, once we have selected the long-run relationship(s) we are interested in, dynamics should be added to the model. This aims to reflect the impacts or temporary phenomena that affect the explanatory variables and deviate them from their long-run path. It can be expressed either by the growth rate of these variables (first difference) or by their velocity (second differences).

4. EMPIRICAL RESULTS.

4.1. INTRODUCTION.

We will proceed in the following pages to present the empirical results of the analysis. The description of the variables can be found in ANNEX 2. We must point out the difficulties in founding the quarterly data for Spanish GDP. This information is not currently available in official statistics. So, we have used a recent study of F.J.Goerlich (1990) who updates the series already elaborated by staff-people of the Bank of Spain.

4.2. ORDER OF INTEGRATION OF THE VARIABLES.

4.2.1. Description of the variables.

We will start the empirical part of the paper by describing first the series we use.

In figure 2.1 appears the endogenous variable ER in original data. 2.2 represents the series in logarithms. It is quite clear from the graphs that a change in the upwards trend is produced after 1985. Thus, it may be quite difficult to find an appropriate ARIMA model to fit such DGP. A change in trend might have also important consequences for the cointegration of ER with the other variables (segmented trends).

Figures 1.1. through 1.4 show the exogenous variables. Money supply ratios are presented in graph 1.1. Both have a downwards trend. No change in trend seems to be evident. As the Spanish money supply appears in the denominator, the downwards trend means that the growth of Spanish money tends to be faster relative to ERM and German money. This tends to depreciate the exchange rate.

Graph 1.2. shows GDP ratios. Once more, segmented trends may appear. More or less the change occurs in 1985-86, when the slope of the series changes dramatically. Spanish GDP is on the numerator of the ratio. Thus, its growth relative to ERM and German GDP has increased substantially. It also provokes appreciation movements in the pta./DM exchange rate.

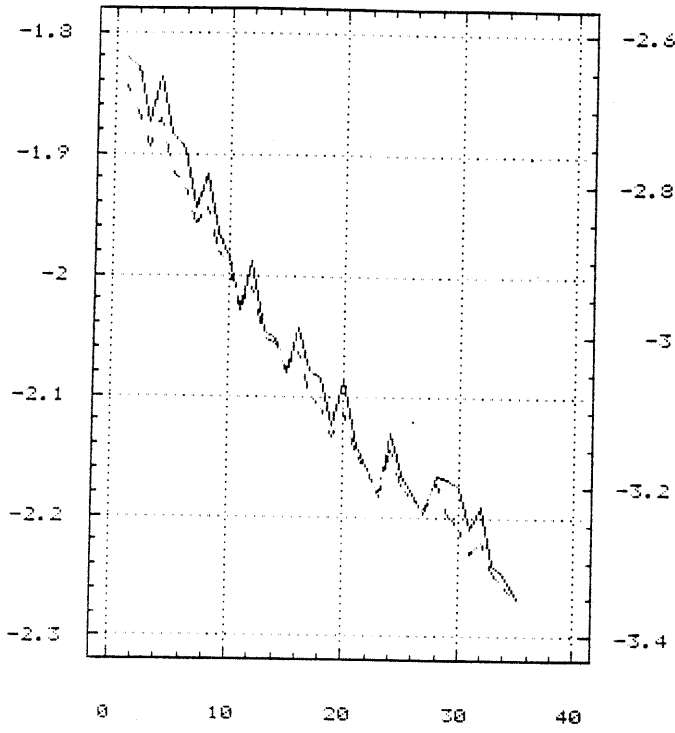
Interest rate differential (graph 1.3.) does not present any clear pattern. These series may be stationary in levels. From 1984 to the beginning of 1987 the interest differential seemed to decrease. The economic overheating suffered by the Spanish economy enlarged this magnitude from 1987 until now. Tight monetary policy as the sole instrument to control prices has endangered both internal and external equilibria. When comparing the series, the interest rate differential has always been larger between Spain and Germany than relative to the weighted average of ERM countries.

For the inflation differential (graph 1.4.) things are different. Two periods can be distinguished. From 1987 until 1988 both differential have been very similar. This reflects the progressive convergence of inflation rates all around the ERM of the EMS. In previous years, the differential relative to Germany was wider. The anchor role of Germany seems to be quite evident.

FIGURE 1

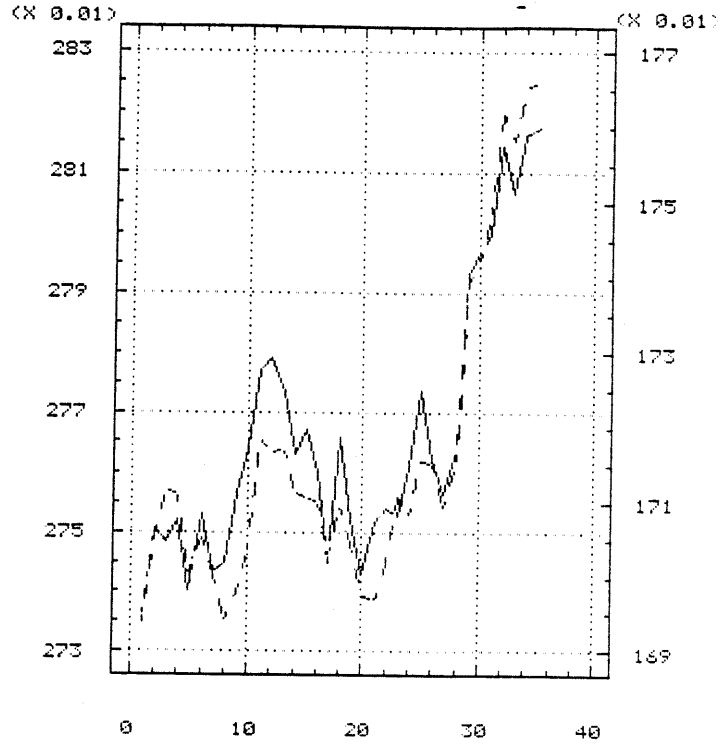
1.1.

LM1
LM2



1.2.

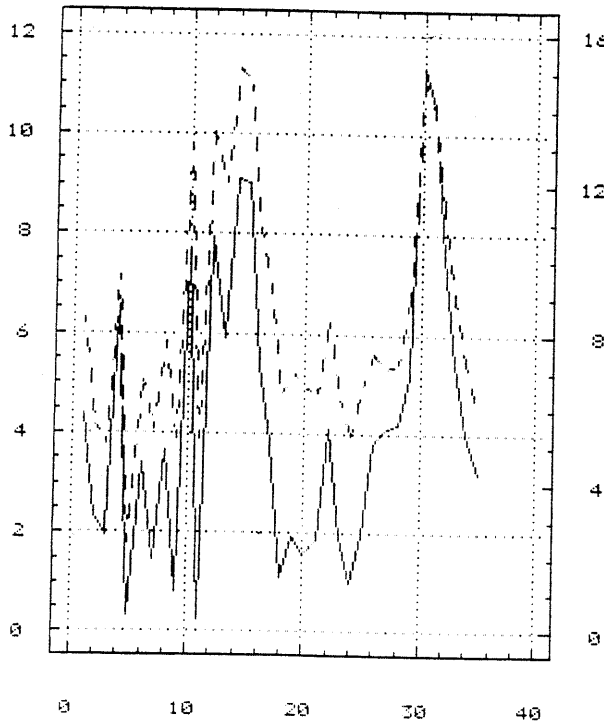
LYG
LYERM



1.3.

Time

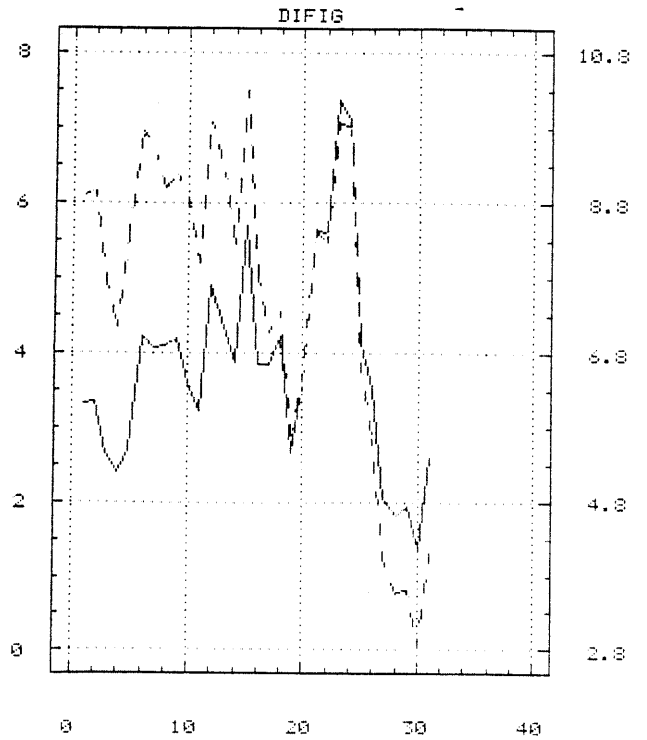
DIFRERM
DIFRG



1.4.

Time

DIFIERM
DIFIG

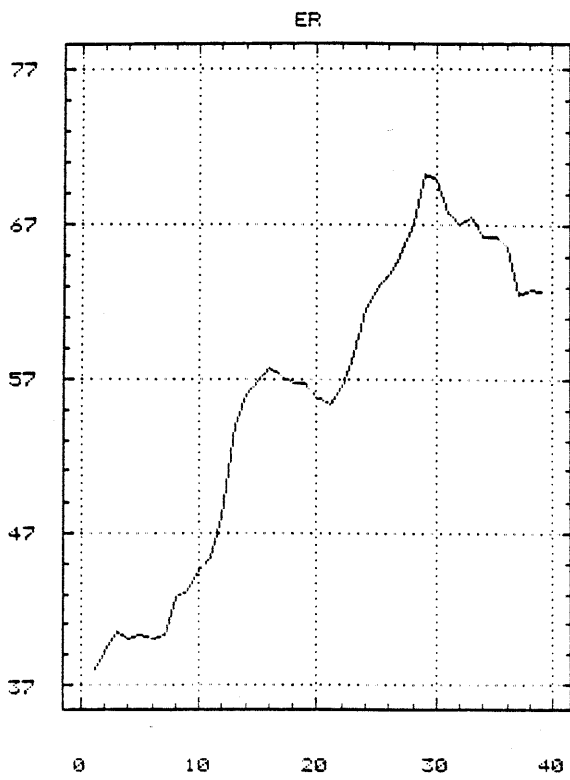


Time

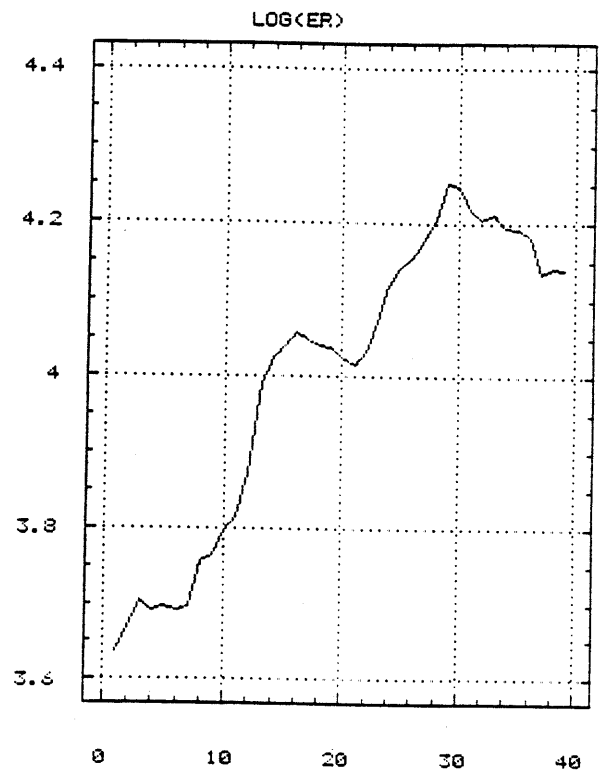
Time

FIGURE 2

2.1.

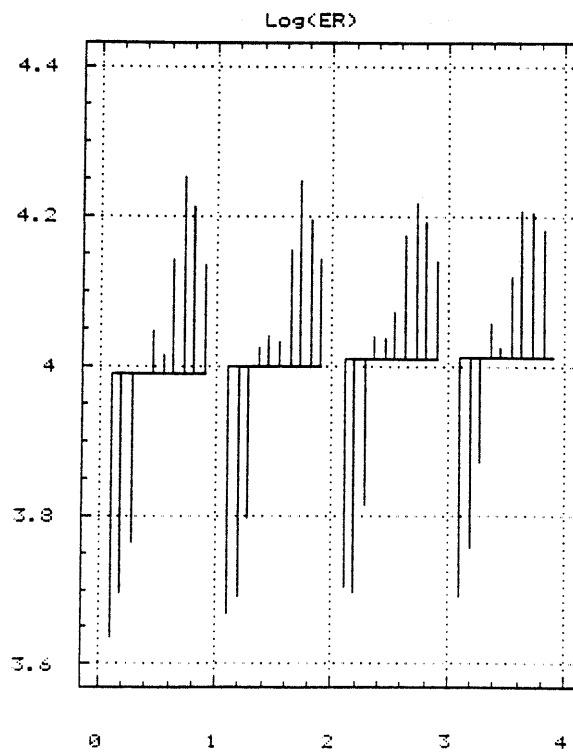


2.2.



2.3.

Seasonal Subseries Plot



4.2.2. Order of integration of the series.

We are going to present them in a table where we specify which are the test we use, which are the statistics and the hypotheses and the value of the statistic.

The general form that adopts the regression we run is the following:

$$(1-L)^d x_t = \alpha + \beta (1-L)^{d-1} (t-T/2) - a(1)(1-L)^{d-1} x_{t-1} + \sum_k \beta_k (1-L)^d x_{t-k} + \varepsilon_t$$

$$H_0: a(1)=0 \quad [x_t \approx I(d)]$$

$$H_1: a(1)>0 \quad [x_t \approx I(d-1)]$$

(A) EXCHANGE RATE in logarithms (LER).

TESTS FOR UNIT ROOTS.

	CASE 1 : d = 2		CASE 2 : d = 1	
TEST	STATISTIC	VALUE	STATISTIC	VALUE
DF	$t(\rho-1): \alpha=\beta=0$	-2.98	$t(\rho-1): \alpha \neq 0, \beta=0$	-1.85
LR-DF	-	-	ϕ_1	7.16
PP	$Z(t(\rho-1))$	-2.93	$Z(t(\rho-1))$	-1.49
PP-LR	-	-	$Z(\phi_1)$	4.46
DW		2.00		1.13

where DF is the simple Dickey-Fuller statistic (Fuller 1976, critical value for $\alpha=\beta=0$ is -1.95; for $\alpha \neq 0, \beta=0$ is -3.0); LR-DF is the Likelihood Ratio Statistic of DF (Dickey and Fuller, 1981, critical value of ϕ_1 is 5.18 for 25 observations and 95%); PP is the Phillips Perron non-parametric correction and the critical values are the same as the corresponding DF; PP-LR is the Phillips Perron correction for the Likelihood Ratio Statistic; DW is the

Durbin Watson statistic.

For case 1, the null hypothesis is rejected in both cases. Thus, I(2) is rejected. In the second case I(1) can only be rejected in DF, but the other statistics allow us to accept I(1), the Phillips Perron statistics being a nonparametric correction of DF statistic when the sample is small. This could be the reason to reject it. Nevertheless, the pattern of the variable and the existence of two means in its first difference allow us to think of segmented trends. As the ARIMA analysis⁵ does not allow us to reject the I(1) hypothesis, as a general conclusion, Log (ER) is I(1).

(B) LM1 (ERM-SPAIN RATIO OF MONEY SUPPLY).

TESTS FOR UNIT ROOTS.

	CASE 1 : d = 2		CASE 2 : d = 1	
TEST	STATISTIC	VALUE	STATISTIC	VALUE
DF	$t(\rho-1):\alpha=\beta=0$	-8.15	$t(\rho-1):\alpha\neq 0,\beta=0$	-1.19
LR-DF	-	-	ϕ_1	3.73
PP	$Z(t(\rho-1))$	-7.71	$Z(t(\rho-1))$	-1.25
PP-LR	-	-	$Z(\phi_1)$	10.06
DW		1.71		3.15

The tests, the statistics and the critical values are the same as in the previous case. All the statistics except for $Z(\phi_1)$ indicate that the series is I(1). Thus, the Phillips Perron correction of the likelihood ratio allows us to reject I(1). Once more, the analysis should be extended to segmented trends.

⁵ It is available upon request to the author.

(C) LYERM (SPAIN-ERM GDP RATIO).

TESTS FOR UNIT ROOTS.

	CASE 1 : d = 2		CASE 2 : d = 1	
TEST	STATISTIC	VALUE	STATISTIC	VALUE
DF	$t(\rho-1):\alpha=\beta=0$	-5.09	$t(\rho-1):\alpha=0,\beta=0$	1.68
PP	$Z(t(\rho-1))$	-5.12	$Z(t(\rho-1))$	1.59
DW		2.05		1.79

In this case there is no doubt: the critical values being the same as before, we can reject I(2) but we cannot reject I(1). Thus, there is a unit root.

(D) DIFIERM (INFLATION DIFFERENTIAL RELATIVE TO THE ERM).

TESTS FOR UNIT ROOTS.

	CASE 1 : d = 2		CASE 2 : d = 1	
TEST	STATISTIC	VALUE	STATISTIC	VALUE
DF	$t(\rho-1):\alpha=\beta=0$	-5.64	$t(\rho-1):\alpha=0,\beta=0$	-0.83
PP	$Z(t(\rho-1))$	-5.66	$Z(t(\rho-1))$	-0.77
DW		1.96		2.08

The null hypothesis of I(2) can be rejected in the first case. For I(1) we cannot reject that the series has a unit root.

(E) DIFRERM (INTEREST RATE DIFFERENTIAL RELATIVE TO ERM).

TESTS FOR UNIT ROOTS.

TEST	CASE 1 : d = 2		CASE 2 : d = 1	
	STATISTIC	VALUE	STATISTIC	VALUE
DF	$t(\rho-1):\alpha=\beta=0$	-10.41	$t(\rho-1):\alpha=0,\beta=0$	-1.95
PP	$Z(t(\rho-1))$	-10.39	$Z(t(\rho-1))$	-1.81
DW		1.85		2.77

As occurred with the Box-Jenkins analysis, the conclusion is not clear for the case of I(1) we can reject two unit roots, but for one unit root the DF statistic is just at the limit for rejection. The Phillips Perron correction does not allow us to reject the null. Thus, we conclude that the series has a unit root, because the PP statistic introduces a correction in the results of simple DF.

(F) LM2 (GERMANY-SPAIN RATIO OF MONEY SUPPLY).

TESTS FOR UNIT ROOTS.

TEST	CASE 1 : d = 2		CASE 2 : d = 1	
	STATISTIC	VALUE	STATISTIC	VALUE
DF	$t(\rho-1):\alpha=\beta=0$	-6.74		
ADF	-	-	$T(P-1):\alpha\neq 0,\beta=0$	-1.45
LR-ADF	-	-	Φ_1	1.77
PP	$Z(t(\rho-1))$	-6.77	$Z(t(\rho-1))$	-1.73
PP-LR	-	-	$Z(\phi_1)$	23.92
DW		1.86		3.17

The critical values are still the same. For case 2 we have used ADF (augmented Dickey-Fuller) instead of the simple one. The critical values do not change. We reject I(2) and cannot reject I(1). Nevertheless, the value of the Phillips Perron correction for ϕ_1 allows us to reject the existence of a unit root.

(G) LYG (SPAIN-GERMANY GDP RATIO)

TEST FOR UNIT ROOTS.

TEST	CASE 1 : d = 2		CASE 2 : d = 1	
	STATISTIC	VALUE	STATISTIC	VALUE
DF	$t(\rho-1):\alpha=\beta=0$	-6.51	$t(\rho-1):\alpha=0,\beta=0$	1.30
PP	$Z(t(\rho-1))$	-6.48	$Z(t(\rho-1))$	1.54
DW		2.00		2.28

Once more, having the same critical values and testing the same hypothesis, we can reject I(2) but we cannot reject the existence of a unit root.

(H) DIFIG (INFLATION DIFFERENCE RELATIVE TO GERMANY).

TEST FOR UNIT ROOTS.

		CASE 1 : d = 2		CASE 2 : d = 1	
TEST	STATISTIC	VALUE	STATISTIC	VALUE	
DF	$t(\rho-1):\alpha=\beta=0$	-5.53	-	-	
ADF(k=5)	-	-	$t(\rho-1):\alpha=0,\beta=0$	-1.50	
PP	$Z(t(\rho-1))$	-5.54	$Z(t(\rho-1))$	-1.02	
DW		1.94		1.95	

In the ADF k indicates the number of lags we have included in the regression. We can reject I(2) but we cannot reject I(1). Thus, a unit root has been found.

(I) DIFRG (INTEREST RATE DIFFERENTIAL RELATIVE TO GERMANY).

TEST FOR UNIT ROOTS.

		CASE 1 : d = 2		CASE 2 : d = 1	
TEST	STATISTIC	VALUE	STATISTIC	VALUE	
DF	$t(\rho-1):\alpha=\beta=0$	-10.35	$t(\rho-1):\alpha=0,\beta=0$	1.21	
PP	$Z(t(\rho-1))$	-10.09	$Z(t(\rho-1))$	1.02	
DW		1.83		2.92	

We can reject I(2) while it is not possible to reject the null hypothesis of I(1) for the second case.

4.3. COINTEGRATION TESTS OF THE VARIABLES.

As explained in the theoretical section of the paper, we are going to present what are the long-run relationships among the variables and the presence of cointegration. We shall apply the tests that we have already specified.

Some more information is needed about the regressions we are going to run in the case of DF and ADF of the residuals to find out if they have a unit root.

The critical values for 50 data are presented in the next table:

n	CRDW	DF	ADF
2	0 . 7 8	-3 . 67	-3 . 29
3	0 . 8 9	-4 . 11	-3 . 75
4	1 . 1 0	-4 . 35	-3 . 98
5	1 . 1 0	-4 . 76	-4 . 15

This table has been obtained from Dolado (1989). n is the number of variables included in the long-run regression.

The results for the models we have tried are included in the table below. This table summarizes the results.

The endogenous variable is the logarithm of exchange rate: LER. We have to point out that the value of the t-statistics of the long-run relationship is not important at this stage of the analysis. They appear under the estimated parameter. We will only pay attention to the t-statistics of the

long-run relationship in the Error Correction Mechanism that we will estimate later.

The relationships of the interest rate differential and inflation differential with LER are not presented but their results are of non-cointegration. We should also point out that we only have 35 observations. The critical values correspond to 50 variables; thus, we have been more exigent.

As a preliminary conclusion, we can say that our most important variables are cointegrated. The long-run relationship suggested by the monetary theory seems to work with the data we have.

TESTS FOR COINTEGRATION USING ERM VARIABLES

(Period 1980:1 1988:4)

Dependent variable: LER							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.94 (5.5)	-6.46 (-2.8)	0.21 (0.2)	1.34 (1.3)	-1.29 (-0.9)	0.74 (3.2)	0.98 (6.5)
LM1	-1.47 (-18)	-	-1.42 (-13)	-1.44 (-15)	-1.34 (-8.2)	-1.54 (-14)	-1.42 (-19.4)
LYERM	-	6.08 (4.6)	0.48 (0.72)	-0.23 (-0.3)	1.4 (1.5)	-	-
DIFRERM	-	-	-	0.01 (2.99)	-	-	0.01 (3.12)
DIFIERM	-	-	-	-	0.02 (2.15)	0.01 (1.46)	-
R²	0.90	0.39	0.90	0.92	0.89	0.88	0.92
CRDW	0.82*	0.10	0.80	1.02	1.02	0.98*	0.98*
CRDF	-2.78	-1.36	-2.67	-3.30	-2.95	-2.95	-3.12
CRADF	-5.12*	-1.52	-5.02*	-3.03	-3.28	-4.10*	-3.06

The sign * means that the result of the test allows us to accept cointegration among the analyzed variables.

TEST FOR COINTEGRATION USING GERMAN VARIABLES

(Period 1980:1 1988:4)

Dependent variable: LER							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	1.02 (6.99)	-11.9 (-3.7)	1.03 (0.7)	2.48 (1.84)	-1.59 (-0.8)	0.46 (1.75)	1.02 (7.9)
LM2	-0.97 (-20)	-	-0.97 (-14)	-0.98 (-17)	-1.08 (-13)	-1.11 (-14)	-0.94 (-22)
LYG	-	5.7 (4.9)	-0.004 (-0.007)	-0.57 (-1.8)	0.77 (1.14)	-	-
DIFRG	-	-	-	0.009 (3.34)	-	-	0.008 (3.15)
DIFIG	-	-	-	-	0.17 (2.47)	0.01 (2.19)	-
R²	0.92	0.42	0.92	0.93	0.91	0.91	0.94
CRDW	0.62*	0.18	0.62	0.94	1.00	0.91*	0.80*
CRDF	-2.29	-1.49	-2.29	-3.14	-2.93	-2.79	-2.80
CRADF	-5.43*	-1.46	-5.43*	-3.28	-3.73	-3.91*	-3.41

The sign * means that the result of the test allows us to accept cointegration among the analyzed variables.

4.4. DYNAMICS AND ERROR CORRECTION MECHANISM.

4.4.1. The strategy of the estimation.

As mentioned above, once we have estimated the long-run relationships, we have to choose the models that could be cointegrated. The last stage of the cointegration approach to econometric modeling consists of finding out the dynamics of the model. This represents the short-run process of adjustment of the variables. Nevertheless, the long-run model is contained in it, and this takes the form of the ERROR CORRECTION MECHANISM.

From the Granger's Representation Theorem, it follows that a cointegration relationship has its corresponding Error Correction Representation. Thus, the strategy is to find this Error Correction Mechanism in order to get a more accurate representation of the adjustment process to the equilibrium relationship.

4.4.2. The monetary theory hypothesis.

As mentioned above, we aim to apply the idea of Berx and Tullio (1989) to the Spanish case. In order to formulate a model as general as possible, we followed the real interest differential model of Frankel (1979), that allows for a particular hypothesis to be tested.

Equation (9) of section 2.1. was written in the following way:

$$e = (m - m^*) - \phi(y - y^*) + \alpha(r - r^*) + \beta(\pi - \pi^*) + u_t$$

The different monetary hypotheses to be tested⁶ can be represented as follows:

⁶ This opens new possibilities for further study. When data is available, all the hypotheses presented in the article by Frankel (1979) will be able to be tested.

KEYNESIAN MODEL: DORNBUSCH (1976)	$\alpha < 0$	$\beta = 0$
CHICAGO MODEL: BILSON	$\alpha > 0$	$\beta = 0$
CHICAGO MODEL: FRENKEL	$\alpha = 0$	$\beta > 0$
REAL INTEREST DIFFERENTIAL MODEL	$\alpha < 0$	$\beta > 0$

We have to point out that we cannot take into account the expected inflation differential because these data are not available now. The variables we call DIFIERM, DIFIG are different from the variables that Frankel recommends using. DIFIERM and DIFIG are the Consumer Price Index differentials between Spain and the ERM and Germany, respectively, while $(\pi - \pi^*)$ is the long-term bonds interest rate differential.

Thus, we assume $\beta = 0$ and can only test the first two models: the Keynesian and the Chicago Model by Bilson.

4.4.3. The selected long-run relationships.

The next step is to select the long-run relationships that are cointegrated. From section 4.4. we will choose the relationships that pass the cointegration tests. We will distinguish ERM models from German models.

* ERM DATA.

The results can be summarized in the following way: the dependent variable (LER) is cointegrated with LM1; it is not cointegrated with the GDP variable separately (LYERM); but if we run the joint regression, LER vs. LM1, LYERM, they are cointegrated. We also find cointegration between LER and LM1, DIFRERM and LER and LM1, DIFIERM. The relationship LER vs. LM1, LYERM and DIFRERM, that is the relevant from the economic point of view, is not cointegrated at 5% of significance. Nevertheless, it could be accepted at 10%.

In order to decide whether to accept this relationship, we have tried estimating the Error Correction Mechanism. If this model can be estimated, from the Granger's Representation Theorem, the variables will be cointegrated. We have found that these variables are cointegrated. We have also tried estimating other ECM. Only one other (more simple model) was a well-specified model. We will present both and then we will compare the ERM-simple model with the German one.

The cointegration relationship is the following:

$$e = (m - m^*) - \phi(y - y^*) + \alpha(r - r^*) + u_t$$

In terms of the variables we have defined:

$$LER = - LM1 - \phi LYERM + \alpha DIFRERM + RESIDS$$

we have to point out that the sign of LM1 should be negative because we have defined this variable as the inverse of $(m - m^*)$:

$$(m - m^*) = 1/LM1$$

Thus, the equation (7) in section 4.4. is the following:

$$\begin{aligned} LER_t = & 1.346 - 1.449 LM1_t - 0.236 LYERM_t + \\ & (1.37) \quad (-15.3) \quad (-0.36) \\ & + 0.0106 DIFRERM_t + RESIDS7_t. \\ & (2.99) \end{aligned}$$

Consequently, the signs that present the estimated variables are coherent with the Chicago Theory by Bilson⁷. The relationship between exchange rate and LM1 is negative: when Spanish money supply grows more rapidly than

⁷ We have to point out that the t-values are not important at this stage of the analysis. Later we will see that in the ECM all the parameters are significantly different from zero.

the corresponding ERM variable, the exchange rate depreciates (that is, $LM1^{\downarrow} \rightarrow LER^{\uparrow}$). An increase in domestic income over the foreign increase of this variable causes an appreciation of the exchange rate. And an increase in the domestic interest rate lowers the demand for domestic currency and causes a depreciation.

The Error Correction Mechanism is the following:

$$\begin{aligned}
 (1-L) LER_t = & 3.806 + 0.468(1-L)LM1_{t-1} + 2.51(1-L)LYERM_{t-1} + \\
 & \quad (4.81) \quad (3.53) \quad (3.64) \\
 & + 1.97(1-L)LYERM_{t-2} + 2.32(1-L)LYERM_{t-3} + 2.58(1-L)LYERM_{t-4} - \\
 & \quad (3.38) \quad (3.44) \quad (4.72) \\
 & - 0.005(1-L)DIFRERM_{t-1} - 0.004(1-L)DIFRERM_{t-2} + \\
 & \quad (-2.46) \quad (-2.5) \\
 & + 0.003(1-L)DIFRERM_{t-4} + 0.01(1-L)DIFIERM_{t-3} + \\
 & \quad (2.7) \quad (4.66) \\
 & + 0.01(1-L)DIFIERM_{t-4} - 0.4895 LER_{t-1} - 0.76 LM1_{t-1} - \\
 & \quad (3.43) \quad (-6.67) \quad (-5.6) \\
 & - 2.01 LYERM_{t-1} + 0.008 DIFRERM_{t-1} \\
 & \quad (-3.9) \quad (3.54)
 \end{aligned}$$

$R^2 = 0.910$	$F(15,10) = 6.67 (0.0022)$
DW = 1.866	
RESET test:	$F(1,9) = 2.14 (0.17)$
SERIAL CORRELATION:	$F(1,9) = 0 (0.99)$
ARCH TEST:	$F(1,8) = 0 (0.89)$
NORMALITY:	$X^2(2) = 0.32 (5.99)$ (level of significance).

All the parameters are significantly different from zero. The determination coefficient is very high if we compare it with the results achieved in previous estimations. We also find that the joint significance of the parameters is also accepted (the F-test allows us to reject the joint nullity). First-order autocorrelation is also rejected (DW is situated within the limits). The cointegration parameter is that corresponding to the variable

LER in levels: -0.4895, which is significant. It also passes all the mis-specification tests⁸.

Once we have a well-specified model, let us compare the long-run relationship we can derive from it, with the cointegration relationship (7). If we are talking in terms of long run, $t=t-1$ and then $(1-L)X_t = X_t - X_{t-1} = 0$. We will eliminate all the variables in differences from the equation. The result is:

$$\text{LER} = 7.76 - 1.55 \text{ LM1} - 4.18 \text{ LYERM} + 0.016 \text{ DIFRERM}$$

While the cointegration relationship was (7):

$$\text{LER} = 1.34 - 1.449 \text{ LM1} - 0.23 \text{ LYERM} + 0.010 \text{ DIFRERM}$$

From the results we can see that all the parameters remain stable in both relationships, except for those corresponding to LYERM. We also found that LER was not cointegrated with this variable, and we know that it was difficult to transform annual Spanish GDP data into quarterly data. Thus, this variable seems to present some problems, but the results, jointly, are quite satisfactory.

* "GERMAN" DATA.

First of all, the results we have obtained with these data are much poorer than the previous ones: those corresponding to ERM data.

Some cointegration relationships were found: LER vs. LM2; LER vs. LM2 and LYG; LER vs. LM2, DIFIG. It is important to point out that LER is not cointegrated with the interest rate differential, which makes it impossible to

⁸ We could not test for homoskedasticity because we had not enough degrees of freedom.

find an Error Correction Representation including DIFRG and even an ECM with the GDP variable: LYG. Once more, we have problems with this variable.

The model that we have estimated is the following:

$$\begin{aligned}
 (1-L) LER_t = & 0.37 + 0.62 (1-L) LER_{t-1} + 0.37 (1-L)LM2_{t-1} + \\
 & (3.8) \quad (4.3) \qquad \qquad \qquad (2.67) \\
 & + 0.31 (1-L)LM2_{t-4} + 0.81 (1-L)LYG_{t-4} - 0.25 LER_{t-1} - \\
 & (2.29) \qquad \qquad \qquad (2.3) \qquad \qquad \qquad (-3.2) \\
 & - 0.21 LM2_{t-1} \\
 & (-2.3)
 \end{aligned}$$

$$\begin{aligned}
 R^2 = & 0.626 & F(6,23) = & 6.42 \quad (0.0004) \\
 DW = & 2.007
 \end{aligned}$$

RESET TEST:	F(1,22)= 2.55 (0.12)
SERIAL AUTOCORRELATION:	F(3,20)= 0.38 (0.76)
HOMOSKEDASTICITY:	F(12,10)= 0.6 (0.799)
ARCH TEST:	F(3,17)= 0.45 (0.71)
NORMALITY:	X ² (2)= 2.81 (5.99) (level of significance).

The cointegration parameter (-0.25) is significant and the model passes all the mis-specification tests. Nevertheless, its explanatory power is reduced.

The long-run solution of the ECM is the following:

$$LER = 1.47 - 0.84 LM2.$$

Compared to the cointegration relationship obtained in section 4.4. and model (2):

$$LER = 1.02 - 0.97 LM2.$$

We have tried to compare the models of Germany with the model for the ERM. Nevertheless, it was not possible to use the encompassing analysis because we did not have enough degrees of freedom. Therefore, the comparison should be made taking into account the results we have obtained. It is evident that the ERM model is more complete than the German one. It includes all the relevant variables and gives us results with economic significance. We can conclude that the ERM model is better than the German one.

5. CONCLUSIONS.

From the results of this paper some interesting conclusions can be derived. And, more important, it opens the scope for related economic questions to be studied.

We have applied the model of Bekx and Tullio (1989) to the pta./DM exchange rate for the period 1980-1988 using quarterly data. The purpose of the model is to compare the explanatory power of two different kinds of variables: first, one monetary model including Spanish and German fundamentals, and second, the same monetary model but using instead of German fundamentals the aggregate variables of the countries being part of the ERM in the EMS. The aggregation was possible and relevant because in between realignments, the exchange rates are not perfectly fixed, but fluctuate within the boundaries of the bands. So, the fundamentals of the ERM countries will influence the behaviour of the DM.

We have found that we cannot reject that all the variables are $I(1)$. So, we can proceed to estimate the cointegration relationships as well as the error correction representation. These estimations result, for the aggregate

variables, in a Bilson model, that is, the sign of the parameter for the interest rate differential is positive. This model passes all the mis-specification tests and has a high (91%) explanatory power. For the German variables alone, the only ECM we have found includes the money supply as a exogenous variable, but the interest rate differential and the GDP variable do not appear. Its explanatory power is small compared with the aggregate model.

This conclusion is very important for the coordination issue in the EMS: it is an indirect argument to promote the coordination of monetary and fiscal policies, because we have just found the relationship among their fundamentals. It is a clue conclusion especially when the EC authorities are discussing deeper degrees of integration. Having common objectives implies that coordinating economic policies is the only way to achieve common goals in terms of reference variables, for example the exchange rate.

ANNEX : DESCRIPTION AND SOURCES OF THE DATA.

All them for the period 1980:1 1988:4.

VARIABLES

SOURCE

* MONEY:

.M: money	IMF, IFS, line 34.
.QM: quasi money	IMF, IFS, line 34.
.MII = M + QM	
.ALP: wide money	Banco de España, Boletín Estadístico.
. LM1 = $\log \left(\frac{\Sigma MI I_{ERM}}{ALP} \right)$	ERM: aggregate DM-86 of the variable for ERM
. LM2 = $\log \left(\frac{MI I_G}{ALP} \right)$	

* GDP

. GNP : Gross Domestic Product 1985 prices.	Cronos for Germany, France and Italy; F.J.G. for Spain and IMF, IFS for the rest.
. LYERM = $\log \left(\frac{GDPE}{\Sigma GDP_{ERM}} \right)$	
. LYG = $\log \left(\frac{GDPE}{GDP_G} \right)$	

VARIABLESSOURCE

* INTEREST RATES

.CMRE: call money rate
of Spain.(3 months)

IMF, IFS, line 60b.

.CMRG: call money rate
of Germany.
(The same for the rest).

IMF, IFS, line 60b.

.CMRERM = $\Sigma (w_i \text{CMR}_i)$

w_i : weight of currency i in
a revised ECU without
the Pound, Lux.F and
Greek Drachma.

.DIFRERM = CMRE - CMRERM
interest rate differential

.DIFRG = CMRE - CMRG

* INFLATION

.CPI: consumer prices
index.
.IRE, IRG = inflation
rate of Spain, Germany.

IMF, IFS.

.IRERM = $\Sigma (w_i \text{IR}_i)$

.DIFIG = IRE - IRG
inflation differential

.DIFIERM = IRE - IRERM

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