Testing for convergence: The Punt-Sterling relationship in the context of the EMS

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Abstract

This work seeks to analyze the stability of the exchange rate between the Irish and Sterling pounds. Towards this end, we work on a procedure, previously suggested by Haldane & Hall (1991), based on a regression with changing parameters and propose a statistical test of the null hypothesis of non-convergence versus the 'tendency towards convergence' alternative. The interest of the application rests in the fact that Ireland and the United Kingdom represent two countries that have traditionally maintained very strong commercial relationships, which forces them to maintain a very stable exchange rate in practice. With the coming of the EMS, both were subjected to the same discipline, thus making the maintenance of their traditional mutual stability easier. But the date the Sterling abandoned the EMS two interesting questions arose: which way would the Irish pound follow? and to what extent can Irish monetary policies make both concerns compatible?.

KEYWORDS: Unit Roots, Changing parameters,Kalman Filter, Monetary Stability, Exchange Rates.

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1 Introduction

With the creation first of the EEC and later on the EMS (European Monetary System) a new framework appears for the analysis of exchange rates in Europe. The EMS was born with the objective of creating a stable area within which the variability of exchange rates would be greatly reduced and internal trade would be made easier in order to provide a transition towards the European Union. The basic instrument to achieve this stability is the Exchange Rates Mechanism (ERM). The exchange rates are allowed to fluctuate as long as they stay confined within certain bands so that if any currency reaches one of the fluctuation limits, the central banks involved have to intervene in order to maintain their exchange rates within the limits of the bands. An abundant literature dedicated to analyze the credibility of the EMS has arisen in recent times (see, among others, Haldane & Hall (1991), Hall, Robertson & Wickens (1992), Caporale & Pittis (1993), Walsh (1993), Masson (1994), *etc.*).

In this paper we will first analyze the relationship among the exchange rates *Sterling-D-Mark* ($\pounds/DM$) and *Sterling-Dollar* ($\pounds/\$$), so as to confirm whether the Sterling detaches itself from the rest of currencies once it abandons the EMS. If such is the case, it can then be considered as an external reference to the system. Under this assumption the stability of the Irish *Punt* within the EMS is weighed up against its traditional relationship with the Sterling. This issue becomes particularly relevant from the moment the latter abandons the system.

Since exchange relationships do not stay constant along time, our starting point will be the work of Haldane & Hall (1991) who consider a system of equations with changing parameters in order to analyze the evolution of Sterling exchange rates with the Dollar and the D-Mark (($\pounds/\$$) and ($\pounds/DM$)). The conclusion that they reach —with daily exchange rates between January 1 1976 and August 31 1989— is that the ($\pounds/\$$) exchange rate weakens during that period at the same time as the ($\pounds/DM$) exchange rate acquires stability. Based on this result, the ERM plays in principle an important role as a stabilizing instrument, a role that must be affected when other interests —like in the case of the Irish *punt*— enter the scene.

The paper is organized as follows. In section 2 the idea of convergence in regional unions as well as its relationship with statistical concepts such as stationarity and cointegration is defined, using a external factor model with changing parameters. Section 3 sets up an statistical test of the null hypothesis of non-convergence versus the 'tendency towards convergence' alternative and studies its properties by means of Monte Carlo simulations. In section 4 the behavior of daily Sterling exchange rates to the D-Mark and the Dollar from January 1 1979 to August 31 1995 are analyzed with the purpose of checking whether the Sterling, after exiting from the EMS, can act as an external reference for the currencies within the system and in particular, for the Irish *punt*. Section 5 analyzes the time evolution of exchange rates between the Irish *punt*, the Sterling and the D-Mark ($\pounds^I/\pounds$ and $\pounds^I/DM$). Finally, section 6 summarizes the conclusions.

2 Convergence, cointegration and relative stationarity

Convergence is a particularly important concept in world economics. Even when its definition appears somewhat vague in the literature, the term convergence is generally used in situations where certain economic variables referring to different countries tend to come closer in the long term. Thus it is specially relevant in growth theory where, when speaking of developing countries, convergence often comes to imply a progressive approach to the levels of the more developed economies. In the context of regional unions of economic character (*e.g.* the European Union) the formal definition of the concept is even more elusive, coming to mean that the macroeconomic variables of the member countries tend to follow some certain common rules, possibly defined in terms of relative differences, *etc.*

At first sight, the convergence notion and the statistical concept of cointegration appear intimately bound to each other. Convergence implies that two series maintain certain 'equilibrium', not being able to deviate in the long term, so that they are cointegrated. More specifically, given a group of integrated variables of order one (not stationary), we say that there exists cointegration when there is at least one stationary linear combination between them. In general, the cointegrating vector can take any non trivial value, so that a cointegration analysis would give away the possible presence of 'convergence clubs' as well as of common trends whose study is very important in the analysis of convergence. Nevertheless, it must be kept in mind that convergence criteria are not usually defined in terms of multivariate relationships, but rather as relationships between *pairs* of variables (between any two countries, each country with regard to a leader or a given reference *etc.*). The *fulfilment* analysis is therefore restricted to relationships between pairs of variables and cointegrating vectors of the $(1, -1)$ type, which implicitly means the existence of one common trend only. That is to say, the cointegration concept is restricted in this case such that it implies stationary differentials between the variables involved.

Let $X_i(t)$ be a variable defining the convergence criterion with regard to country i, with $i \in \mathcal{U}$ where $\mathcal{U}$ represents a certain regional union (*e.g.* the European Union), and let $X_{\mathcal{U}}(t)$ be a reference measure corresponding to this criterion (*e.g.* a country considered leader within the union, an average of the three best countries, *etc.*).

Definition 1 (convergence) *It is said that country i has converged in terms of the X criterion when*

1. *the differential of country i in relation to the leader or reference*

$$y_i(t) = \log X_i(t) - \log X_{\mathcal{U}}(t) = \log \left(\frac{X_i(t)}{X_{\mathcal{U}}(t)} \right) \tag{1}$$

   follows a stationary process and

2. *the mean and the variance of the process are such that the probability of the interval defined by the criterion is sufficiently high.*

It is necessary to point out that, by virtue of our definition, the stationarity of the differentials is not only necessary to define a *state* of convergence but also during any *process* conducive to it. This contradicts the opinion of some authors (Hall et al. 1992, Caporale & Pittis 1993) that have come to point out that such stationarity is neither a necessary nor a sufficient requirement for convergence. In particular Caporale & Pittis (1993), in an article on inflation rates convergence within the EMS in which they criticize the work of Artis & Nachane (1990) supporting the German leadership thesis, affirm that the cointegration analysis carried out by the latter would be able to measure convergence only once this had been achieved, but that, during the important period of transition, 'convergence' is a gradual process that implies decreasing differentials and, therefore, the statistical tests would not detect any stationarity.

This position is not very clear since when one affirms that 'convergence' is a gradual process that implies decreasing differentials it is erroneous to conclude that the series of differentials must necessarily be non-stationary. In fact, the behavior of non-stationary processes, not having well defined moments, is characterized by its wandering about without opting for a concrete value. Therefore, since the differentials are not supposed to decrease without limit but tend to its stabilization around a certain value—zero usually— such decreasing differentials would be giving away its stationary nature even during the transition period.

Nevertheless, there is a doubt about whether the statistical tests will detect or not such stationarity in such circumstances, that is to say, during a transitory period in which they are forced to fall until being stabilized around, let us say, zero. The evidence encountered for the Dickey & Fuller (1979) test, by means of simulation, shows how an initial value different from the mean makes that the empirical distribution moves notoriously to the left of the position corresponding to an initial value equal to the mean of the process. The conclusion is clear: the usual unit root tests would easily detect the stationarity of the process when applied to a sample that decrease toward their zero mean even with relatively small sizes and roots close to one, thus seemingly contradicting the explanation of Caporale & Pittis (1993) attributing the lack of rejection of the null hypothesis of a unit root in the differentials to the existence of a transition period towards convergence.

Even when, for all the above mentioned, the stationarity of the differentials is a necessary condition of convergence, country-reference cointegration is not enough in itself since this only assures that differences from the norm are stationary without actually saying anything about their size. But this way the probability of ever achieving convergence may be insignificant if the mean or the variance of the process are not compatible with the interval determined by the criterion. Our definition 1 requires that the first two moments define an interval of moderate confidence compatible with the interval defined by the convergence criterion. Thus, we rule out the possibility of constant (and, therefore, stationary) differentials, as well as excessively volatile differentials (stationary, but with scarce probability of staying within the interval) from being taken as an indication of convergence.

2.1 The external factor model

Let $X_{\mathcal{W}}(t)$ be the criterion measure corresponding to an external factor to the regional union $\mathcal{U}$(*e.g.* a country considered a world leader outside the union, a world average, *etc.*). We define the differential of this external factor in relation to the union as

$$\begin{aligned} z(t) &= \log X_{\mathcal{W}}(t) - \log X_{\mathcal{U}}(t) \\ &= \log \left(\frac{X_{\mathcal{W}}(t)}{X_{\mathcal{U}}(t)} \right). \end{aligned}$$

In terms of definition 1 it only makes sense to speak of convergence within the regional union $\mathcal{U}$, therefore the differential $z(t)$ follows *necessarily* a non-stationary process, *e.g.* $z(t) \sim I(1)$. (If it were stationary the external factor would in some sense belong to the union, which implies a contradiction).

Given a certain period, the regression

$$y_i(t) = \alpha + \beta z(t) + u(t) \tag{2}$$

can be used to test the convergence hypothesis (H_0), since a $I(1)$ variable cannot be relevant in the explanation of a $I(0)$ variable. Under H_0 we have that the regressand is $I(0)$, therefore it is obvious that $\hat{\beta}_{OLS} \rightarrow \beta = 0$ since $z(t)$ is an irrelevant variable. Meanwhile, under the alternative, we have that the regressand will be $I(1)$ and, therefore, $\hat{\beta}_{OLS} \rightarrow c \neq 0$ since, in this case, either $\{y_i(t), z(t)\}$ form a cointegrated pair, in which case $z(t)$ is not irrelevant, or the regression is spurious, in which case β is inconsistently estimated by a $\hat{\beta}_{OLS} \neq 0$, (see *e.g.* Stock (1987)).

One of the main problems which we encounter when studying convergence phenomena by means of the typical statistical tests of integration and cointegration is derived from the static character of these tests. In fact, if a country is immersed in a convergence process towards a certain norm, the differences will become gradually smaller during the process: is this a consequence of the return to the mean characteristic of stationary series or a consequence of some structural change?. The behavior of the usual tests is different in such circumstances and, therefore, during that period of time it may give us an erroneous indication. If this convergence period is relatively important within the sample under study, it is not surprising that indications from static tests are doubtfully applicable to the whole sample. It is quite probable that this might start right from the creation of the convergence criterion itself, but, anyway, the duration of the adjustment may not be evident.

Haldane & Hall (1991) sketch a procedure based on a model of changing parameters which, without constituting a proper statistical test, allows a dynamic visualization of the possible convergence process. A reinterpretation of this procedure in agreement with our own objectives will be described in what follows.

As in the previous section, let $\{y_i(t)\}$ be our variable of interest and let $\{z(t)\}$ be a variable known to be generated by a $I(1)$ process. Typically $z(t)$ will correspond to the probable specific cause of the lack of stationarity in $y_i(t)$ under the alternative hypothesis. Let us now consider a variant of the external factor model (2) with changing parameters

$$y_i(t) = \beta_t \, z(t) + u(t), \tag{3}$$

where we will allow $\{\beta_t\}$ to behave as a random walk process, while $\{u_t\}$ follows a Local Level Model (LLM) (Harvey 1989), independent of $\{\beta_t\}$, with the purpose of capturing other non-stationary effects not attributable to $z(t)$

$$\begin{array}{lcl} u(t) & = & \alpha_t + \varepsilon_t \\ \alpha_t & = & \alpha_{t-1} + \eta_t \\ \beta_t & = & \beta_{t-1} + \zeta_t \end{array} ; \qquad \begin{pmatrix} \varepsilon_t \\ \eta_t \\ \zeta_t \end{pmatrix} \sim \text{iid} \left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \sigma^2 \begin{pmatrix} 1 & & \\ & q_\eta & \\ & & q_\zeta \end{pmatrix} \right]. \tag{4}$$

In a static context, it is clear that if $\{y_i(t)\}$ is $I(0)$ then $\{\alpha_t = \alpha\}$and $\{\beta_t = 0\}$ for all t (that is to say, $q_\eta = q_\zeta = 0$, $\alpha_0 = \alpha$ and $\beta_0 = 0$). This implies that if $\{y_i(t)\}$ is 'becoming' a $I(0)$ process then $\{\alpha_t\}$ will tend to a constant while $\{\beta_t\}$ will tend to zero. On the other hand, remember that if $\{y_i(t)\}$ were $I(1)$ (alternative hypothesis true) then, either $\{y_i(t), z(t)\}$ form a cointegrated system, in which case $\{\alpha_t = \alpha\}$ and $\{\beta_t = \beta \neq 0\}$ so that $z(t)$ represents the specific alternative (probable cause of lack of stationarity), or the relationship is spurious, in which case the estimate of β is inconsistent. From all this we have that graphic inspection of the time evolution of the coefficient β_t can be an interesting instrument when visualizing if the series of interest seems to tend or not to something stationary.

When studying convergence both $y_i(t)$ and $z(t)$ are differentials (in logarithms or percentual) of the country in relation to two references, one internal (typically determined by the criterion to follow, *e.g.* Maastrich) and other external (typically USA) respectively. Thus, for example, we will use inflation differentials (measured as logarithmic increments of the ratios of their respective price indexes) when studying convergence in prices, differentials of interest rates (measured as logarithmic increments of the ratios of their respective bonds) when studying the convergence in long term bond values, *etc.*In the same manner, when studying the stability of the Sterling within the EMS, in this article we will use logarithms of exchange rates

$$y = \log \frac{£}{DM} \qquad z = \log \frac{\$}{DM} \sim I(1).$$

In which case, if £ and DM have already converged then $\{y(t)\} \sim I(0)$ and we will observe that $\{\beta_t = 0\}$ while if £and DM are converging then $\{\beta_t\}$ it will tend to zero. On the other hand, if £ and DM are not converging in any way then we will observe that $\{\beta_t\}$ does not tend to zero.

Of course, certain arbitration exists between the three variable $X_i(t), X_{\mathcal{U}}(t), X_{\mathcal{W}}(t)$ that define the two differential y, z in (3). In fact, defining the differential of the country i in relation to the external reference as

$$y_i^*(t) = \log X_i(t) - \log X_{\mathcal{W}}(t) = \log \left(\frac{X_i(t)}{X_{\mathcal{W}}(t)} \right)$$

we have that

$$y_i^*(t) = (\beta_t - 1)z(t) + u(t),$$

with β_t and $u(t)$ as in (4).

3 Testing for convergence

Let us consider model (3) with $\beta_t \equiv 0$

$$\begin{array}{rcl} y(t) & = & \alpha_t + \varepsilon_t \\ \alpha_t & = & \alpha_{t-1} + \eta_t \end{array} \qquad ; \qquad \begin{pmatrix} \varepsilon_t \\ \eta_t \end{pmatrix} \sim \left[\begin{matrix} 0 \\ 0 \end{matrix}, \sigma^2 \begin{pmatrix} 1 & \\ & q \end{pmatrix} \right]$$

where $\{y(t)\}$ typically represents the differential of some country in relation to the relevant reference given by a certain convergence criterion. Thus $y(t)$ follows an LLM that depends on a signal/noise ratio (q) whose maximum likelihood estimator (MLE) has received some attention in the time series literature (Shephard & Harvey (1990), Fernández Macho (1996)). In particular, the model implies a $I(1)$ behavior in general, except if $q = 0$, when it will reflect a $I(0)$ behavior around a deterministic level. This, evidently, does not allow transition situations like those that are now of interest but, nevertheless, this circumstance can be easily built in by allowing the signal/noise ratio to evolve in time according to the following equation

$$q_t = (1 + \mathrm{e}^{-\theta})^{-1} q_{t-1} \qquad ; \quad q_0 = q. \tag{5}$$

It is evident that with $\theta \to \infty$ one extreme case is obtained in which $q_t = q$ for all t, thus reproducing the previous model; but for any finite value of θ we have an infinite range of possibilities in which $q_t \to 0$; that is, if $\{y(t)\}$ represents the differential between two series, then both series must be, strictly speaking, converging since this differential will become stationary in a sufficiently long period of time. The value of θ determines the speed of the transition to the stationary situation.

The complete model can be expressed in *state space* form as

$$\begin{array}{rcl} y(t) & = & z'\mu_t + \varepsilon_t \\ \mu_t & = & \Phi\mu_{t-1} + \eta_t^{\mu} \end{array} \tag{6}$$

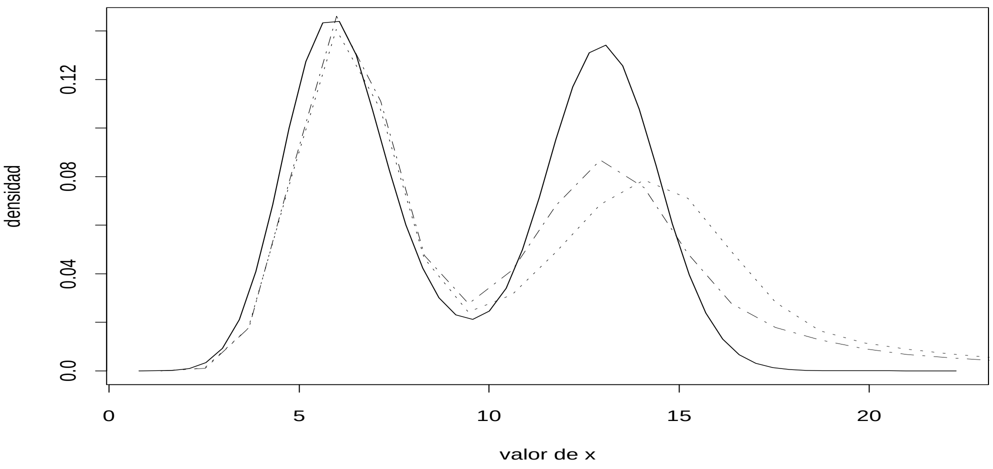
with

$$\begin{array}{rcl} \mu_t' & = & [\alpha_t \qquad q_{t+1}] \\ [z \qquad \Phi] & = & \left[\begin{array}{c|cc} 1 & 1 & 0 \\ 0 & 0 & (1+\mathrm{e}^{-\theta})^{-1} \end{array}\right] \\ \begin{pmatrix} \varepsilon_t \\ \eta_t^{\mu} \end{pmatrix} & \sim & \mathrm{nid}\left[0, \sigma^2 \begin{pmatrix} 1 & & \\ & q_t & \\ & & 0 \end{pmatrix}\right] \end{array}$$

which ensures its statistical treatment (especially the construction of the likelihood) by means of the Kalman filter (Harvey 1989).

Finally, we can build a dynamic convergence test based on a function of the MLE of the speed parameter θ, which will take relatively high values under the null hypothesis of non-convergence, *i.e.* $\{y(t)\} \sim I(1)$. The test will reject such a hypothesis when the value calculated for the statistic is smaller than the corresponding critical value (see table 2) in favor of the alternative that the series whose difference is measured by $y(t)$ 'tend towards convergence'.

Figure 1: ML estimator of θ: density



3.1 Empirical distributions

With the purpose of approaching the distributions of some statistics based on the MLE of θ under the non-convergence hypothesis, we have carried out several Monte Carlo simulation experiments. In each of these, 10,000 random samples of 180 observations each have been generated by means of an LLM

$$\begin{aligned} y(t) &= \alpha_t + \varepsilon_t, \qquad V(\varepsilon) = \sigma^2, \\ \alpha_t &= \alpha_{t-1} + \eta_t, \qquad V(\eta) = \sigma^2 q_0, \end{aligned}$$

which corresponds to the limit with $\theta \to \infty$ in model (6), so that under the null hypothesis the differential $\{y(t)\}$ refers to two series that are not converging.

For each one of the replications the MLE of the two parameters of the model ($\hat{\theta}$ and $\hat{q}_0$) has been calculated using the `maxlik` routine in the **GAUSS** package.

We carried out three experiments of this type with different values of q_0 with the purpose of checking whether the statistic of interest ($\hat{\theta}$) depended or not on their value. Figure 1 compares the estimated densities for these statistics in the three cases (sees also the moments table 1). The distribution is considerably bimodal but, fortunately, the distribution of this statistic does not seem to be affected by the value of q_0, which facilitates the tabulation of its critical values.

Table 1: ML estimator of θ: moments

	mean	median	modes		trough	std dev
$q_0 = 1$	9.51	9,37	6.06	13.07	9.56	3,59
$q_0 = 5$	11.07	10.82	5.98	14,07	9.45	5,39
$q_0 = 10$	10.83	10.26	5.99	12.92	9.46	5,77

Table 2: Critical values of statistic

	significance level							
	0.1%	1%	5%	10%	25%	50%	75%	90%
$\hat{\theta}$	4.4486	4.8133	5.2063	5.4681	6.1291	10.1488	13.7577	10.2475

3.2 Critical values

Under the assumption that the value of q_0 does not affect the corresponding distribution, the critical values of the empiric distribution of the $\hat{\theta}$ statistic have been obtained from the simulations described in the previous section (table 2).

Table 3 presents percentages of rejection of the non-convergence hypothesis that would be obtained with these critical values in each one of the Monte Carlo experiments. The results for the $\hat{\theta}$ statistic are satisfactory, and can be used with a certain degree of reliability in the applications.

Table 3: ML estimator of θ: rejection percentages

	nivel de significación							
	0.1%	1%	5%	10%	25%	50%	75%	90%
$q_0 = 1$	0.58	2.8	9.37	15.17	29.58	50.93	88.35	99.8
$q_0 = 5$	0.04	0.57	3.55	8.1	22.37	48.31	67.48	84.81
$q_0 = 10$	0.02	0.5	3.02	7.34	23.03	49.7	76.28	88.17

3.3 Examples

In order to show the performance of the dynamic convergence test, in this section we show five examples using simulated data, all of them of 180 observations (see table 4).

In the first of these examples a random walk observed with white noise error was generated with the signal/noise ratio kept constant ($q = 5$) during the whole sample. It is then the typical IMA(1,1) case (with an unit root) for which the test statistic would be expected to take relatively big values so that the null hypothesis that the series is an integrated variable is not rejected.

For the second example we generated an autoregression h($\phi = 0.8$) polluted with white noise error where the signal/noise ratio ($q = 5$) was also kept constant during the whole sample. It is then the typical ARMA(1,1) stationary case, for which the test statistic would be expected to take relatively small values, even negative, so that the null hypothesis that the series is an integrated variable is clearly rejected in favor of the 'tendency towards convergence' hypothesis.

The rest of the examples are heteroscedastic variations of the random walk plus noise model of example 1. In the third example the variance of the signal falls with time so that the signal/noise ratio $q_t = 0.8\, q_{t-1}$. That is, starting from a non-stationary initial situation, the evolution of the series is such that it tends to become stationary in the long term; in practice once Δq_t is sufficiently small. We can then expect the test statistic to take relatively small values that reject the null hypothesis in favor of the hypothesis of 'tendency towards convergence'.

In example number four, the variance of the signal remains constant during the first half of the sample, while it falls with time (so that the signal/noise ratio $q_t = 0.8\, q_{t-1}$) in the second half. It is then a mixed case, and we should expected the test statistic to take values somewhat bigger than before but, nevertheless, still reject the null hypothesis in favor of the hypothesis of 'tendency towards convergence'.

The fifth and last example represents the opposite case: during the first half the signal falls slowly with time (so that the signal/noise ratio $q_t = 0.99\, q_{t-1}$) going from an initial value 5 to a value 2.024 in $t = 90$, after which it is kept constant for the rest of the sample.

Table 4: Dynamic convergence test: examples of 180 data (*)

	ej_1	ej_2	ej_3	ej_4	ej_5
$\hat{\theta}$	7,7421	**-3,2608**	**1.0887**	**3,4041**	5,6524

(*) **bold type:** convergence is accepted with 99,9% confidence.

It is then also a mixed case, but now the initial tendency towards convergence seems to have been aborted. The test should capture this situation with the statistic taking relatively big values so that the null hypothesis, that implies non-convergence, is not rejected.

The graphics of the evolution of $\hat{q}_t$ in each case are quite illustrative of what happens in each example (see figure 2). It can be clearly appreciated how in examples 2 y 3 $\hat{q}_t$ becomes zero very quickly (2 and 30 observations respectively) thus showing that either the series is already stationary (case 2) or the series tends to stationary (case 3). In example 4 q_t tends clearly to zero, even detecting that the series does not become approximately stationary until well within the second half of the sample. On the other hand, in examples 1 y 5 q_t does not end up being zero, showing that the series never ends up approaching a stationary behavior.

Finally, the values shown in table 4 indicate clearly the good performance of the $\hat{\theta}$ statistic in these cases. With it we would reject clearly (with a significance level of one in a thousand) the non-convergence hypothesis in examples 2, 3 and 4, but we would not reject examples 1 and 5 even at the 10% significance level. (On the other hand, the behavior of the statistic $t(\hat{\theta})$ has also been studied by means of a similar experiment. The results, however, were not very satisfactory since this statistic was only able to reject the non-convergence hypothesis in the stationary example number 2, not being able to detect the tendency towards convergence of the examples 3 y 4. These cases are very illustrative of what happens in practice, being easily detected by the $\hat{\theta}$ statistic).

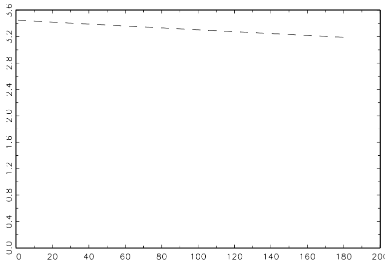
4 The Sterling versus the D-Mark and the Dollar

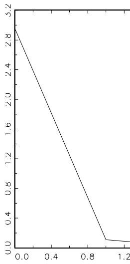
In accordance with section 2, the relationship of the Sterling with the D-Mark and the Dollar can be analyzed by means of a model of changing parameters of the type (3)

$$log(\pounds/DM)(t) = \beta_t \, log(\$/DM)(t) + u(t),$$

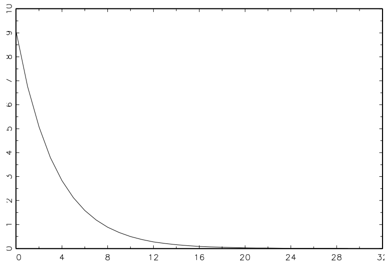
Figure 2: Evolution of $\hat{q}_t$: examples

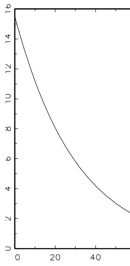
Example 1:





Example 3:





where β_t and $u(t)$ are stochastic processes generated as in (4).

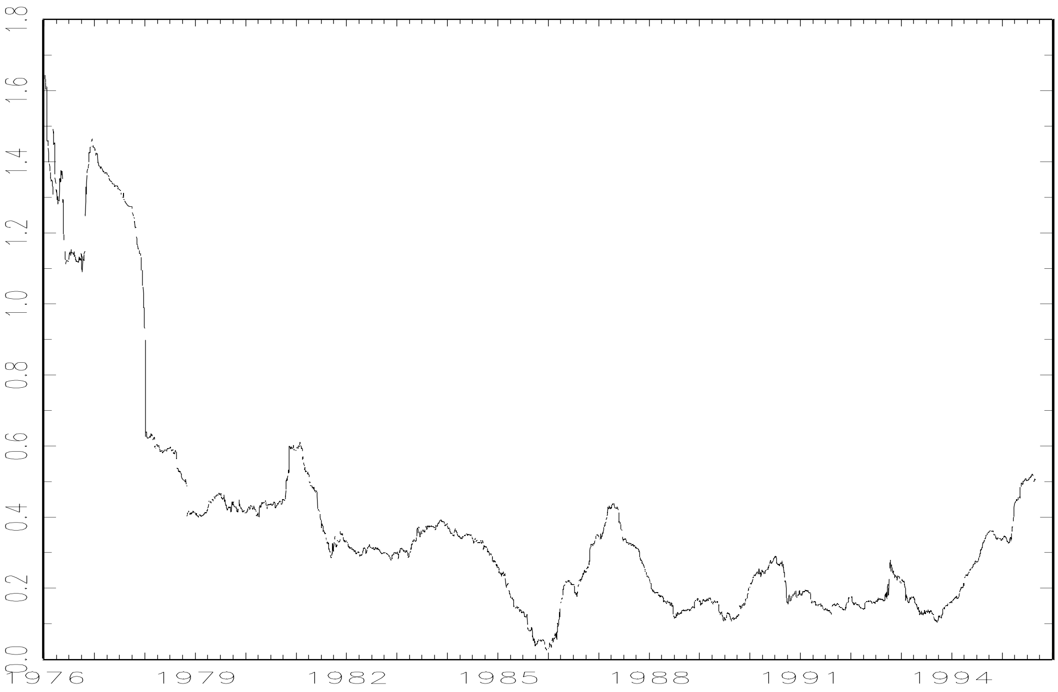
This way, the D-Mark would be the internal reference, considered as the most stable currency within the EMS, and the Dollar would be the external reference since it has been traditionally considered the standard currency in the international trade.

The considered variables are daily exchange rates (data recorded at the closing of business). The sample comprises 4813 observations (once Saturdays and holidays are removed) between January 1 1976 and August 31 1995.

Figure 3 shows the time evolution of the estimated value for β_t where three different phases can clearly be made out.

- 1976–1987. This first phase coincides with much of the period studied previously by Haldane & Hall (1991). Along this period it is observed that $\widehat{\beta_t} \rightarrow 0$, although the estimate is not close to 0 in any moment. This improvement in the stability of the $(£/DM)$ exchange rate can be explained due to the fact that, on one hand, the UK enters to be part of the EEC in 1973, therefore adapting its policies to the guidelines

Figure 3: Sterling: evolution of $\widehat{\beta_t}$.



of the Community and, on the other hand, the EMS starts operating in March of 1979 (although initially the UK stays out of the system). We may observe that starting from 1986 the (£/DM) exchange rate is more and more stable (the estimate of β_t gets nearer to 0).

- 1988–1993. In this phase the (£/DM) exchange rate is more or less stabilized, (the estimated value for β_t fluctuates between 0.1 and 0.3). Remember that the Sterling enters the EMS in 1990 but abandons it at the end of 1992.

  In this period two important upturns are observed in the evolution of $\widehat{\beta_t}$:

  - The first of them takes place in the last quarter of 1989 and lasts until mid 1990 only to fall sharply then. This behavior is due to the new EMS on one hand and on the other due to the strong uncertainty that the markets suffer as a consequence of the Iraqi invasion of Kuwait in August of 1990.
  - The second takes place at the end of 1992 and lasts until the first quarter of 1993. During the previous months numerous speculative tensions are the cause

of successive realignments when the exchange rates of the currencies involved are driven to the limits of fluctuation allowed in the system. These tensions entail the abandonment by the UK of the discipline imposed by the EMS in September of 1992. From that point onwards the $(£/DM)$ exchange rate will show clear indications of uncertainty.

- 1994–August 1995. We observe that the estimated value of β_t begins to grow, that is, the Sterling clearly detaches itself from the D-Mark in favor of the Dollar. Remember also that in November of 1993 the Treaty of Maastricht goes into effect.

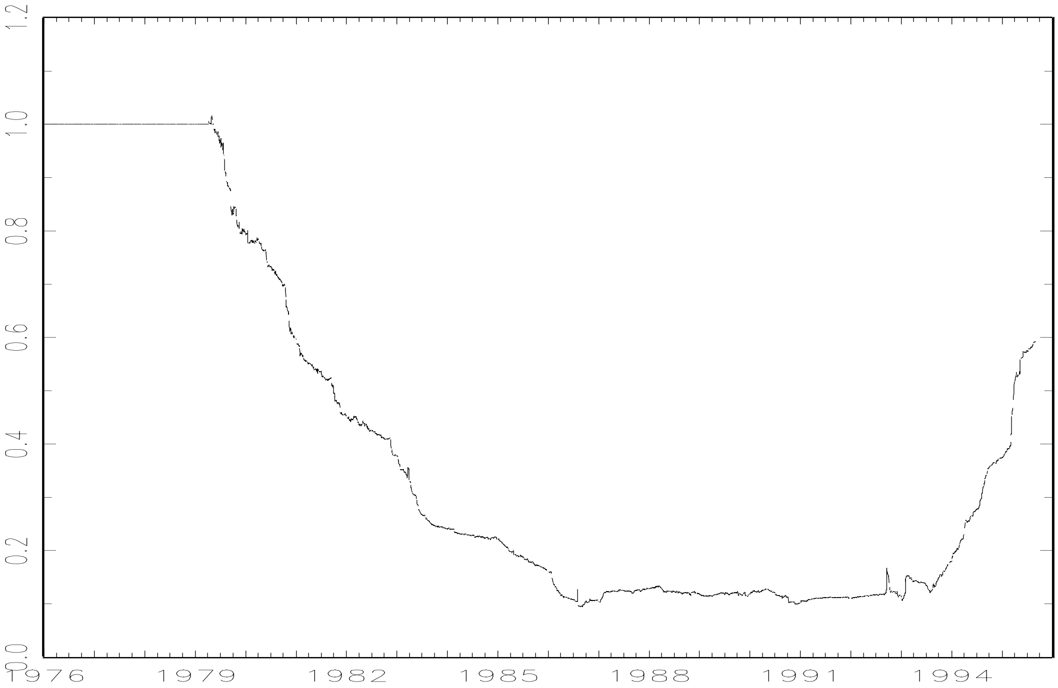
Application of the test discussed in section 3 comes to offer statistical evidence on the lack of convergence with the D-Mark. Remember that the null hypothesis under this test is non-convergence versus the 'tendency towards convergence' alternative. Carrying out the test on the complete sample, the value that we obtain for the statistic is 7.7712. This value is notoriously bigger than the critical values for the usual significance levels (see table 2). Therefore we accept the null hypothesis of non-convergence with the D-Mark, which is consistent with the behavior of $\widehat{\beta_t}$ towards the end of the sample (see figure 3).

To summarize, we may observe that the $(£/DM)$ exchange rate stayed quite stable while the Sterling was subjected to the discipline of the EMS. But such stability disappeared the moment the discipline was abandoned. For this reason, the Sterling can now be regarded as an external reference when studying the evolution of the Irish pound within the EMS.

5 The Irish Punt versus Sterling and the D-Mark.

In this section we seek to analyze the stability of the Irish *punt* versus the Sterling and the D-Mark. Is this the case of two countries, UK and Ireland, that have traditionally maintained very close relationships, particularly of a commercial nature? (see Thom (1993) and Thom (1995)). Nevertheless, while the Sterling has experienced a turbulent and uncomfortable relationship with the EMS, Irish monetary politicy has preferred, for diverse politico-economic reasons, to maintain its currency within the discipline of the system. Thus, an interesting case study is set up to test the relative strengh of the EMS (that would force the Irish pound to follow the D-Mark closely) against the traditional knots (that would impel the Irish pound

Figure 4: Irish *punt*: Evolution of $\widehat{\beta_t}$.



to follow the Sterling), as well as to discover until what point both interests can be made compatible for the Irish monetary authorities.

We will consider the following equation

$$\log(\pounds^I/DM)(t) \; = \beta_t, log(\pounds/DM)(t) \; + u(t),$$

that is, the German D-Mark is, for the reasons already exposed, again considered as the internal reference, while the external reference will now be the Sterling. In this context, remember that if $\beta_t = 0$, the D-Mark and the Irish *punt* would have reached convergence, while if $\beta_t = 1$ the convergence would have taken place between the Sterling and Irish pounds.

Figure 4 shows the time evolution of the estimate of β_t. In view of this we may distinguish three phases:

- A first phase that goes from the beginning of the sample until the first quarter of 1979, in which $\widehat{\beta_t} = 1$ and the $u(t)$ estimates are zero. These results are not surprising, since in this period the ($£^I/£$) exchange rate is practically fixed, so that it could be said that both currencies would be in a 'state of convergence' between themselves.

- A second phase that goes from the first quarter of 1979 to May 1993. During this phase we may observe how the estimate of β_t falls continuously. This does not stop until the second quarter of 1986, moment at which the coefficient estimate becomes stabilized around 0.1. This evolution indicates that the ($£^I/DM$) exchange rate gains in stability.

  It must be taken into account that from the creation of the EMS (March of 1979) the exchange discipline forced the Irish *punt* to fluctuate within narrow margins (2.5%), but as from May,13 1993, after numerous speculative tensions, the EMS decided to enlarge this fluctuation band up to the actual 15%.

- A third phase that goes from the last quarter of 1993 to the end of the sample. We may observe how $\widehat{\beta_t}$ begins to rise continuously until it reaches the value of 0.6. It is interesting to see how although the Irish *punt* is still subjected to the EMS, it does not maintain the stability of its exchange rate with the D-Mark achieved in the previous period. In fact, the ($£^I/DM$) exchange rate loses stability due to the abandonment by the Sterling of the EMS discipline.

As in the previous section, we will formally test for dynamic convergence by means of the statistic introduced in section 3. We consider three periods of interest:

- Whole sample.
- January,1 1976 to May,13 1993: narrow band period for exchange rate fluctuation (2.5%).
- May,14 1993 to August,31 1995: wider band period (15%).

The results appear in table 5 where we see that the null hypothesis of non-convergence is not rejected in any of the cases (the critical value for $\hat{\theta}$ at which the null hypothesis of non-convergence is rejected at the 5% confidence level is 5.2), although important differences are observed in the value that the $\hat{\theta}$ statistic takes depending on the period under study.

Table 5: $\pounds^I/DM$: convergence dynamic test

Period	Jan 1,76–Aug 31,95	Jan 1,76–May 13,93	May 14,93–Aug 31,95
θ	7.2289	6.9976	15.2714

For the complete sample, the null hypothesis of non-convergence with the D-Mark is not rejected, which is actually what we advanced by observing the evolution of $\widehat{\beta_t}$. However, when considering the different subperiods for the series ($\pounds^I/DM$) a very different behavior is observed. For the period between January,1 1976 and May,13 1993 —during which we could think that the Irish *punt* might be converging with the D-Mark— the result of the test does not confirm this categorically, although the value that it takes it is indeed smaller than the one obtained for the whole sample. Meanwhile, in the period between May 14, 1993 and August 31, 1995 the statistical evidence clearly reflects the lack of convergence.

In view of all this it can be said that the Irish *punt* appears more stable with the D-Mark while the Sterling is linked to the EMS and the maximum limits of fluctuation for its exchange rate were at the narrow band of 2.5%. But the moment the fluctuation margins were widened to the actual 15% and the Sterling abandoned the EMS the relationship of greater stability is once again with the Sterling, although the Irish *punt* continues in principle to be linked to the EMS. The thesis, therefore, is that Ireland's efforts, in spite of its commitment to the EMS but provided that the bands are wide enough to allow it, will be centered on following the UK rather than Germany, because the existent commercial relationships between both countries are very strong and it is not in Ireland's interest to maintain a weak trading position with the UK.

6 Conclusions

The EMS was born with the objective of reducing the variability of exchange rates between European currencies establishing some maximum limits of fluctuation so as to provide them with a stable trading framework. From this point of view, and since the D-Mark is usually considered the reference currency within the EMS, it would be observed along time that currencies belonging to the EMS maintain stable exchange rates with the D-Mark but not with the Dollar, the external reference.

We have analyzed the behaviors of the Sterling and the Irish *punt* exchange rates with the D-Mark with the purpose of checking whether some type of convergence takes place between them.

First, we have checked that the Sterling can now be considered as an external reference to the system and has been so since the day it abandoned the discipline of the EMS. In second place, we have analyzed the behavior of the Irish *punt* in the following terms: Ireland and the UK are two countries that traditionally have maintained important commercial relationships and an almost fixed exchange rate. While both countries were under the discipline of the EMS, both were actually converging with the D-Mark, but now the question is: what happens once the Sterling abandons the EMS?; will the Irish *punt* follow the D-Mark or the Sterling?.

The results obtained mean that the main objective of the EMS is fulfilled only partly due to the Irish paradox: the $(\pounds^I/DM)$ exchange rate gets destabilized the moment the UK is not subjected to the EMS discipline any more. And this in spite of Ireland still being subjected to the discipline of the system.

If the Irish *punt* maintains an stable exchange rate with the D-Mark and the Sterling maintains it in relation to the Dollar, an appreciation of the latter would result in potentially serious imbalances in the Irish balance of payments by way of the imports coming from the UK. On the other hand, a depreciation of the Dollar would cause that Irish products would be less competitive in the British mrkets. This way, the Irish *punt* will try to continue linked to the Sterling provided that the width of the EMS bands (enlarged in May of 1993 from 2.5% to 15%) allows it . These bands enable the Irish Central Bank to maintain two objectives —to continue belonging to the EMS while their currency continues linked to the Sterling— seemingly incompatible in principle, providing an ampler maneuvering space for the application of those policies meant to force movements in the Irish *punt* exchange rates in relation to the Sterling and the D-Mark (see Thom (1995)).

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