A Non-parametric reassessment of target zone nonlinearities: The Spanish Peseta/Deutsche Mark exchange rate

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ABSTRACT
In this paper we present evidence concerning the existence of target zone nonlinearities in the Spanish Peseta/Deutsche Mark exchange rate using data with daily frequency for the period 1989-1996. Using a non-parametric technique, the Alternation Conditional Expectations (ACE) algorithm, we obtain evidence of the existence of non-linearities in both exchange rate and interest rate differential, with a functional form close to the non-linear effects given by the target zone model with realignment risk.

Keywords: Target zones, exchange rate, realignment risk, ACE algorithm

JEL classification: F31, F33.

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1 Introduction

It is well known that from standard models, the exchange rate is a function of the fundamentals, where the *fundamentals* can be thought of as a set of the most important driving variables in the economy. Particularly, in a target zone system, as the fundamentals depart from their equilibrium value, the exchange rate is proportionately less responsive, which implies a non-linear relationship between both *variables*. This is the so-called honeymoon effect (see Krugman, 1991). From that relationship, and assuming uncovered interest parity, it is also obtained a nonlinear relationship between the exchange rate and the interest rate differential.

One of the most important aspect of the adoption of a target zone, is that the stabilization of the exchange rate comes through an "expectational effect". In fact, the main characteristic of standard target zone models is the fact that agents firmly believe the declared policy of keeping the exchange rate within a fluctuation band. As a main consequence the target zone stabilizes exchange rate behavior as a function of its fundamentals, assuming interventions at the margins of the band. The existence of such a band is information that foreign exchange markets are aware of. If the monetary authority of a country following this system exhibits its capacity and determination to defend the band, the foreign exchange markets contribute by keeping the exchange rate within the band. The idea is straightforward: if a currency is close to its limit of depreciation, and the monetary authority has confidence in the preservation of the band, the exchange rate markets may only expect an appreciation of this currency, and this fact could reduce the cost, in terms of money supply changes or loss of reserves, of the maintenance of the exchange rate within the band.

However, most of the empirical analysis carried out on target zones only find a weak nonlinear relationship, if any, between a variety of exchange rates, interest rates and fundamentals and from those results it raises serious
doubts on the empirical validity of target zone models.

The aim of this paper is to investigate, for the case of the Spanish Peseta, the existence of stabilizing effects of the exchange rate associated with the membership of the Peseta to the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS), by looking for the existence of nonlinearities.

From standard target zone models, we obtain two important nonlinear behaviors: First, a nonlinear behavior of the exchange rate with respect to its fundamentals. As the exchange rate is closer to their limits of fluctuations, the exchange rate is proportionately less responsive. This is the well-known honeymoon effect, represented by a S-shaped relationship between the exchange rate and its fundamentals (Krugman, 1991). Second, a nonlinear behavior of the interest rate differentials. When the exchange rate is close to the lower edge of the band, since it can only depreciate, which implies a future intervention to increase money supply. This intervention in turn implies a decrease in the domestic interest rates above foreign interest rates, which implies the existence of a band for the interest rate differentials.

In this paper, we use a non-parametric technique, the Alternating Conditional Expectations (ACE) algorithm, in order to obtain the functional form of both variables (exchange rate deviations from the central parity and the interest rate differential) taking into account the existence of a nonzero probability of realignment. In computing the expected rate of realignment we use the drift adjustment method developed by Bertola and Svensson (1993). The idea is simple. Using the ACE algorithm, we estimate optimally the functional form of the explanatory variables in a linear regression model which links the exchange rate to the interest rate differential corrected by the devaluation risk. Particularly, we look for some kind of non-linear transformation of both variables and if these transformations are similar to the ones predicted by the model.

The results indicate the existence of important nonlinear behavior of both
the exchange rate and the corrected (by the devaluation risk) interest rate differential, as predicted by the target zone model. In fact, we obtain evidence of the existence of non-linearities with a functional form for the exchange rate close to the *S-shape* relationship given by the target zone model.

The structure of the paper is organized as follows. In Section 2 we present the theoretical target zone model with realignment risk. Section 3 presents the Alternating Conditional Expectations algorithm. Sections 4 shows the empirical results. Section 5 concludes.

## 2 Theoretical framework

We begin with the well known standard solution for the exchange rate,

\[ s_t = f_t + \alpha \frac{E_t(ds_t)}{dt} , \]  

where the exchange rate, \( s_t \), is equal to the fundamentals, \( f_t \), plus the expected rate of change of the exchange rate, \( E_t(ds_t)/dt \), and \( \alpha \) is the interest rate semi-elasticity. The fundamentals is a composite of the velocity shocks, \( v_t \) and the money supply, \( m_t \), (see Krugman, 1991).

It is assumed that \( f_t \) to follow a process with stochastic differential:

\[ df_t = dv_t + dm_t, \]  

where,

\[ dv_t = \mu_v dt + \sigma_v dZ_{v,t}, \]  

and where \( \mu_v \) is the drift of the process, \( \sigma_v \) the standard deviation and \( Z_{v,t} \) is a standard Wiener process. In the standard target zone model, changes in money supply only occur at the edge of the band. Therefore, inside the band \( df_t = dv_t \) given that \( dm_t = 0 \). The policy rule, defined by the money supply changes is:

\[ dm_t = dL - dU, \]
The money supply changes depend on the upper (U) and lower (L) regulators. The assumption of marginal interventions is justified by the effect of exchange rate expectations formed when a fluctuation band for the exchange rate is in place. The existence of such a band is information that foreign exchange markets take into account. If the monetary authority of a country following this system exhibits its capacity and determination to defend the band, the foreign exchange markets in effect contribute to the stabilizing effect by expecting the exchange rate to remain within the band. If a currency is close to its limit of depreciation, and the monetary authority has confidence in the preservation of the band, the exchange rate markets may only expect an appreciation of this currency, and this fact could reduce the cost, in terms of money supply changes or loss of reserves, of the maintenance of the exchange rate within the band.

However, the above assumptions rely on the fact of perfect credibility. If credibility is not perfect, we must include in the model the possibility of a change in the central parity. Following Bertola and Svensson (1993), the expected depreciation rate may be viewed as the sum of two components: the expected depreciation rate within the band and the expected rate of devaluation:

$$\frac{E_t(ds_t)}{dt} = \frac{E_t(dx_t)}{dt} + g_t$$

(5)

where $x_t = s_t - c_t$ is the exchange rate deviation from the central parity and $g_t$ is the expected rate of devaluation. Following Bertola and Svensson (1993), we assume that the expected rate of devaluation follows a Brownian motion process between realignments:

$$dg_t = \mu_g dt + \sigma_g dZ_t$$

(6)

Therefore, the exchange rate solution can be written as:

$$s(f, g) = f_t + \alpha g_t + \alpha \frac{E_t(dx_t)}{dt}$$

(7)
We define the new state variable:

\[ h_t \equiv f_t + \alpha g_t \]  

(8)

where \( h_t \) is a Brownian motion process with differential

\[ dh_t = \mu dt + \sigma dZ_t \]  

(9)

\[ \mu \equiv \mu_f + \alpha \mu_g, \quad \sigma = \sqrt{\sigma_f^2 + \alpha^2 \sigma_g^2 + 2 \alpha \rho \sigma_f \sigma_g} \]  

(10)

Applying Ito’s lemma to the exchange rate function we obtain:

\[ s_t = f(h_t) = h_t + \alpha \mu s'(h_t) + \frac{\alpha}{2} (\sigma^2) s''(h_t), \]  

(11)

and the general solution for \( s_t \) is

\[ s_t = h_t + \alpha \mu + A_1 \exp(\lambda_1 h_t) + A_2 \exp(\lambda_2 h_t), \]  

(12)

where \( \lambda_1 \) and \( \lambda_2 \) are the roots of the characteristic equation in \( \lambda \):

\[ \frac{\alpha}{2} (\sigma^2) \lambda^2 + \alpha \mu \lambda - 1 = 0, \]  

(13)

The solution for the exchange rate in a target zone can be obtained by applying the smooth pasting conditions\(^1\) to equation (12):

\[ s_t^{TZ} = \alpha (\mu_v + \alpha \mu_g) + h_t + \frac{\lambda_1 (e^{(\lambda_1 h_t + \lambda_2 h_t)} - e^{(\lambda_1 h_t + \lambda_2 h_t)}) + \lambda_2 (e^{(\lambda_1 h_t + \lambda_2 h_t)} - e^{(\lambda_1 h_t + \lambda_2 h_t)})}{\lambda_1 \lambda_2 (e^{(\lambda_1 h_t + \lambda_2 h_t)} - e^{(\lambda_1 h_t + \lambda_2 h_t)})}. \]  

(14)

Figure 1 shows the relationship between the fundamentals and the exchange rate, portraying the well-known S-shaped relationship between \( h \) and \( s \). As the realignment (devaluation) risk increases, the relationship shifts to the left.

\[ \text{[Insert here Figure 1]} \]

\(^1\)Smooth pasting conditions are boundary conditions which require the first derivative of the exchange rate to be zero at the limits of fluctuations.
2.1 The interest rate differentials

The presence of an exchange rate band also has implications for the behavior of the interest rates. The instantaneous interest rate differential should increase as the exchange rate approaches its upper boundary, that is, as the currency becomes weak and vice versa. Indeed, when a currency is close to the lower edge of the band, since it can only depreciate and not appreciate, expectations of a depreciation within the band presuppose a future intervention to increase the money supply. This intervention in turn implies a decrease in the domestic interest rates above foreign interest rates.

Assuming that there is no exogenous risk premium (Svensson, 1991), the interest rate differential is:

\[ d_t = i_t - i_t^* = \frac{E_t(d s_t)}{dt}. \]  

(15)

The interest rate differential is equal to the expected change of the exchange rate. In a target zone, we know that the exchange rate is given by the function \( s(f) \). From equations (1) and (20) the interest rate differential is given by:

\[ d(f) = \frac{(s(f) - f)}{\alpha}. \]  

(16)

Thus, the derivatives of the exchange rate and the interest rate differential are related according to:

\[ d'(f) = \frac{(s'(f) - 1)}{\alpha}. \]  

(17)

We know that \( s'(f) \) is less than one, because in a target zone system the exchange rate is less responsive to the fundamentals than in the free float exchange rate. Hence, the interest rate differential will be decreasing in the fundamentals, \( d'(f) < 0 \).

Given the existence of a nonzero realignment risk, the interest rate differential can be written as a function of \( h \) and \( g \):

\[ d(h, g) = \frac{E_t(dx_t)}{dt} + g_t \]  

(18)
By a similar argument to the solution of the exchange rate, the general solution to the interest rate differential is:

\[ d(h, g) = \mu_f + \alpha \mu_g + \frac{A_1 \exp(\lambda_1 h_t) + A_2 \exp(\lambda_2 h_t)}{\alpha}, \]  

(19)

which has the solution:

\[ d_T^Z_t = \mu_f + \alpha \mu_g + \frac{\lambda_1 (e^{(\lambda_1 h_t + \lambda_2 h_t)} - e^{(\lambda_1 \overline{h} + \lambda_2 \overline{h})}) + \lambda_2 (e^{(\lambda_1 h_t + \lambda_2 h_t)} - e^{(\lambda_1 \overline{h} + \lambda_2 \overline{h})})}{\alpha \lambda_1 \lambda_2 (e^{(\lambda_1 \overline{h} + \lambda_2 \overline{h})} - e^{(\lambda_1 \overline{h} + \lambda_2 \overline{h})})}. \]  

(20)

Therefore, at the same time that the monetary authority prevents both the fundamentals and the exchange rate from moving outside their bands, they also prevent the interest rate differential from moving outside its band. Target zone models imply a deterministic, non-linear inverse relationship between exchange rate deviations from its central parity and interest differentials. On the other hand, interest rate targeting is an operational procedure to control the exchange rate. The combination of foreign interest rate movements and the potential for exchange rate movements within the band translates into a target corridor for the nominal interest rate. Figure 2 shows the relationship between the interest rate differential and the exchange rate considering the existence of a positive expected rate of realignment. The existence of a nonzero expected rate of devaluation shifts up the instantaneous interest rate differential as a function of the exchange rate.

[Insert here Figure 2]

### 3 Non-parametric functional form estimation

In this section we describe and then implement a non-parametric technique to estimate optimally the functional form of the explanatory variables in a linear regression model which links the exchange rate to the interest rate differential taking into account the existence of a nonzero realignment risk. In
particular, we look for potentially non-linear transformation of both variables similar to those predicted by the model.

Previous attempts to estimate the target zone model have been carried out by Flood et al. (1991), Rose and Svensson (1995) and Flood and Rose (1995), among others. Flood, Rose and Mathieson (1991) assume uncovered interest parity and use the interest rate differentials as the unobserved exchange rate expectations to compute the fundamentals. They estimate the non-linear solution of the standard target zone model for the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) currencies by Linear Least Squares and conclude that there is little advantage in working with a non-linear, rather than a linear model of exchange rate determination. Rose and Svensson (1995) allow for risk by formalizing an expected realignment process which is assumed to follow an exogenously determined stochastic jump process. The expected rate of change in the exchange rate is thus now divided into two components: the expected rate of change of the exchange rate within the band plus the expected rate of change in the central parity, the devaluation risk. In addition to the interest rate differentials as a measure of the fundamentals, they use a term estimated using a cubic form of current and past values of the deviation of the exchange rate from its central parity. Flood and Rose (1995) estimate different measures of the fundamentals for the OECD countries using the monetary model in both the flexible-price and the sticky-price versions and find that the different measures of fundamentals implied do not vary much across exchange rate regimes.

Other authors such as Smith and Spencer (1992) do not attempt to estimate the fundamentals due to its apparent unobservability, and use the Method of Simulated Moments to test whether the statistical properties of the observed exchange rates are broadly compatible with those implied by the basic target zone model; they find little support for it. De Jong (1994) uses the Method of Simulated Moments and detects non-linearities for three out of six ERM currencies. For these currencies he argues that the presence
of a credible target zone has a significant effect on the stochastic behavior of the exchange rate within the band whereas the failure of the model to detect non-linearities in the other three currencies is explained by the presence of a narrower implicit target zone and the threat of intramarginal interventions. Lindberg and Soderlind (1994) also use the same method as well as Locally Weighted Regression in estimating and testing for non-linearities. Their results do not support the target zone model in the case of the Swedish exchange rate. Meese and Rose (1990) also use the Locally Weighted Regression technique to estimate a general non-linear model. They find only weak evidence of non-linearities and argue that if the exchange rate actually depends in a nonlinear way on exogenous macroeconomic fundamentals, linear exchange rate models may work poorly, even though the exchange rate is closely linked to fundamentals.

More recently, Iannizzotto and Taylor (1999), Taylor and Iannizzotto (2001) and Ma and Kanas (2000a,b) provided more evidence about target zone non-linearities. Ma and Kanas (2000a) examine whether there is a nonlinear relationship between fundamentals and exchange rates for three countries (Germany, The Netherlands and France), using two nonparametric nonlinear testing methodologies. The first approach is a nonlinear cointegration test aimed at examining the existence of a long-run nonlinear relationship and the second is a nonlinear Granger-causality test aimed at revealing a dynamic nonlinear relationship. The results suggest that there is a nonlinear cointegration among money, output and exchange rates for Netherlands and Germany, which can be interpreted as evidence of a long-run nonlinear relationship. For France-Germany they find nonlinear Granger causality from French money to FF/DM exchange rate, which can be interpreted as evidence of a dynamic nonlinear relationship between fundamentals and the exchange rate. They suggest that the existence of general type nonlinearities may distort possible target zone specific, S-shaped, nonlinearities. Ma and Kanas (2000b) present evidence that two ERM exchange rates(FF/DM and
Lit/DM) are Granger caused in a nonlinear fashion by the relative money supply. They interpret this result as evidence that the underlying relationship between relative money and exchange rate is nonlinear in a target zone, which is consistent with the target zone model. Moreover, their results suggest that the relative money plays a more important role that relative output in explaining nonlinearities in the fundamentals-exchange rate relationship.

3.1 The ACE algorithm

In this paper, we use a new method to study the possible existence of nonlinearities in the Spanish Peseta/Deutsche Mark exchange rate. The technique we use is known as the Alternating Conditional Expectations (ACE) algorithm by Breiman and Friedman (1985). Researchers seeking to understand a linear relationship between a set of explanatory variables, $x_i$, and a dependent variable, $y_i$, often replace $x_i$ and $y_i$ with transformation of the raw variables, denoted by $\phi(x_i)$ and $\theta(y_i)$.

Breiman & Friedman (1985) suggest a non-parametric way of estimating data transformations ($\phi(\cdot)$ and $\theta(\cdot)$) so as to minimize the expected mean squared error of the regression $\theta(y_i) = \beta \phi(x_i) + \epsilon_i$. $\phi(\cdot)$ is estimated conditionally for a given choice of $\theta(\cdot)$, then $\theta(\cdot)$ is estimated conditioning on the estimate of $\phi(\cdot)$. ACE operates iteratively: the transformation of all the variables except one are treated as fixed, and the optimal transformation for the variable in question is estimated with a non-parametric data smoothing technique. The algorithm then proceeds to the next variable; iterations continue until the equation mean squared error has been minimized.

The method estimates functions $\theta^*$ and $\phi^*$ that minimize

$$e^2 = \frac{E[(\theta(y) - \sum \phi(x))^2]}{Var[\theta(y)]}.$$  \hspace{1cm} (11)

The simplest way to understand the shape of the transformations is by means of the plot of the function versus the corresponding data values. In
practice, ACE is often used to produce scatter plots of the transformed and untransformed variables. Monte Carlo experimentation indicates that such plots are often highly suggestive of transformations and functional forms present in the data-generation process. The goal of this approach is to find those transformations that produce the best-fitting additive model. Knowledge of such transformations aids in the interpretations and understanding of the relationship between the response and predictors.

Meese and Rose (1991) applied this analysis to the monetary model of exchange rate in order to detect non-linearities between these variables (money supply, output and interest rates) and the exchange rate. They apply the above technique to five models of exchange rate. However, they obtained little evidence that inappropriate transformations of fundamentals were responsible for the poor performance of the models considered.

Here we apply the ACE algorithm to the exchange rate and the corrected interest rate differential in order to obtain an indicator of the functional relationship between both variables in a non-parametric way. The relationship we will estimate is,
\[ \theta(s_t) = \psi(d_t) + \epsilon_t. \] (12)

By cross-plotting the exchange rates and interest differential, \( s_t \) and \( d_t \), versus their transformations, \( \theta(s_t) \) and \( \psi(d_t) \), we can infer the kind of relationship existing between both variables. Then we compare the estimated transformations with the ones derived from the model.

4 Results

We use a data set of exchange rates and interest rates of daily frequency, with a total of 1,722 observations. We use 1 month euro-market interest rates for the Spanish Peseta and the Deutsche Mark. The sample period starts on November, 1989 to June, 1996. The initial bandwidth for the Spanish Peseta in the ERM was of ±6 percent. In August 2, 1993, the bandwidth was
widened to the ±15 percent. During the period, the Spanish Peseta suffered four devaluations: September 17, 1992, November 23, 1992, May 14, 1993 and March 6, 1995. Therefore, in the empirical analysis we consider the existence of six different regimes given the devaluations and the widening of the fluctuation band. Table 1 shows the sample period and the number of observations of each regime.

Table 1: Sample period and observations

<table>
<thead>
<tr>
<th>Regime</th>
<th>Sample Period</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>November 2, 1989-September 15, 1992</td>
<td>773</td>
</tr>
<tr>
<td>2</td>
<td>September 16, 1992-November 20, 1992</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>November 23, 1991, May 13, 1993</td>
<td>123</td>
</tr>
<tr>
<td>4</td>
<td>May 14, 1993-July 30, 1993</td>
<td>57</td>
</tr>
<tr>
<td>5</td>
<td>August 2, 1993-March 3, 1995</td>
<td>415</td>
</tr>
<tr>
<td>6</td>
<td>March 6, 1995-May 7, 1996</td>
<td>307</td>
</tr>
</tbody>
</table>

First, we compute the expected rate of devaluation (realignment) using the so-called drift adjustment method, developed by Bertola and Svensson (1993). This method is based on the decomposition of the expected rate of depreciation into two components: the expected rate of depreciation within the band plus the expected rate of change in the central parity. The last term can be calculated as the deviation of the expected depreciation within the band from the interest rate differential.2

2The estimated equation of the expected rate of depreciation is as follows:

\[
\left( x_{t+\tau} - x_t \right) \frac{264}{\tau} = \sum \alpha_j x_j + \beta x_t + \varepsilon_{t+\tau}
\]

where \( x_t \) is the exchange rate deviation with respect to the central parity and \( z_j \) is a dummy for regime \( j \). Since the maturity, \( \tau \), of the interest rate is one month, the expected change in the exchange rate is based on the same time interval. Therefore, the regressand is multiplied by \( 264/\tau \) in order to be annualized to maintain time consistency with the interest rate. Since we need to estimate the expected future exchange rate conditional upon no realignment, the observations within the time interval \( \tau \) before each realignment
In order to compare the results with the theoretical ones, we plot the exchange rate versus its transformation, whereas in the case of the interest rate, we plot the transformation versus the corrected interest rate differential. From the model we obtain that when the exchange rate approaches one of the limits of fluctuation, the exchange rate is proportionally less responsive. Therefore, the more direct way to see that honeymoon effect is by plotting the exchange rate versus its transformation. In the case of the interest rate differential, this variable is proportionally more responsive when the exchange rate approaches the limits of fluctuation. Therefore, to see graphically that effect, we plot the transformation versus the variable. In this way, we can directly compare the behavior of these variables with its theoretical behavior given by Figures 1 and 2.

In general, the results we obtain show the existence of important nonlinear behavior in both exchange rates and interest rate differentials. In most of regimes, we find a nonlinear behavior of both variables consistent with the theoretical target zone model with devaluation risk.

Figures 3-4 show the results for the first regime. As we can observe, we obtain a clear nonlinear transformation for both variables. The transformation for the exchange rate is similar to the one obtained in the theoretical model, with a pattern in which the exchange rate more stable as the exchange rate approaches it upper limit. Note that the nonlinear behavior appears when the exchange rate is close to its central parity. This is consistent with the result obtained by the model in which the existence of a positive probability of devaluation and/or a positive drift in the fundamentals process, shift to the left the relationship between the exchange rate and its fundamentals. This can be the reason why we find a nonlinear behavior of the exchange rate close are excluded. This corresponds to 22 observations, given that one month corresponds to about 22 daily data. The above equation was estimated using ordinary least-squares with standard errors computed using a Newey-West estimator of the covariance matrix which allow for heteroskedastic and serially correlated error terms. The results are available from the authors upon request.

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to the central parity. Note also that we do not find a similar behavior in the lower limit for the exchange rate, indicating that the honeymoon effect only appears when the currency depreciates. With respect to the interest rate differential, Figure 4, the obtained transformation indicates the existence of a non-linear behavior, but only in the lower limit for the interest differential band, or equivalently, in the upper limit for the exchange rate, which is consistent with the transformation obtained for the exchange rate plotted in Figure 3.

Figures 5-6 show the results for the second regime. This regime is a very short period between the first and the second devaluations of the Spanish Peseta in the ERM. In fact, this second devaluation, only 2 months later the first, was caused by an initial devaluation rate lower than the estimated by the market. In this case the nonlinearities are less important than in the previous regime. However, we can identify a similar pattern for both variables. The exchange rate exhibits a limited nonlinear behavior in the upper band of fluctuation. Also, the corrected interest rate differential shows a, also limited, nonlinear behavior in the upper band of fluctuation for the exchange rate.

Transformations for the third regime are plotted in Figures 7-8. In this case the patterns are not so clear as in the previous regimes, with estimated transformations of both variables with important non-linearities but not as expected.

The analysis of the fourth regime give us some impressive results (Figures 9-10). Both transformations fit extremely well the behavior of the variables generated by the theoretical model. In this case we obtain important stabilizing effects on both, the exchange rate and the interest rate differential. Contrary to the previous results, in this regime we obtained non-linear effects in both, the lower and the upper limits.

The last two regimes correspond to the period of a wide fluctuation band, so we expect that stabilizing effects of the target zone will be less important.
Figures 11-12 show the results for the fifth regime. In this case, nonlinear effects are weaker. Nevertheless, we find a non linear behavior of the interest rate differential in the lower limit of the band. However, with respect to the upper band, we find a linear behavior. So, from this results we can infer that the stabilizing effects in this regimes are small. This behavior can be a consequence of the widening of the fluctuation band to the $\pm 15$ percent at the beginning of this subsample. In fact, as the bandwidth increases, stabilizing effects are lower as the system is closer to a free float regime.

Finally, Figures 13-14 plot the transformations for the sixth regime. In this case, whereas the transformation for the interest rate differential is almost linear, in the case of the exchange rate we obtain a transformation close to the S-shape given by the model in both, the lower and the upper limits. As in the previous regime, the weak nonlinear behavior of both variables is influenced by the widening of the fluctuation band.

Therefore, our analysis shows the existence of important nonlinearities in the behavior of the Spanish Peseta during the period of the ERM, indicating the presence of significant stabilizing effects of the fluctuation band. From this results we can affirm that target zone model which account for the existence of a realignment risk are a good theoretical framework to explain the behavior of the exchange rate in the case of the Peseta/Deutsche Mark exchange rate.

5 Concluding remarks

In this paper we have presented a non-parametric analysis of nonlinearities in a target zone. Given the target zone model, we estimate the relationship between the exchange rate and the interest rate differential, taking into account the existence of a nonzero probability of realignment. To do that, we used a non-parametric technique which offered evidence of the functional form between the variables. The results support the target zone model for
the Peseta/Deutsche Mark, resulting in transformations of the variables quite similar to the behavior predicted by the model. Therefore, our results, contrary to previous empirical analyses, show the validity of target zone models in explaining the behavior of the exchange rate and the interest rate differentials when a band of fluctuation is in place. On the other hand, the results we obtain show that the existence of a band of fluctuation for the exchange rate have had important stabilizing effect on the behavior of the Spanish Peseta/Deutsche Mark exchange rate during the period studied.

We repeated the same analysis using exchange rate and interest rate differential without adjustment, that is, under the assumption of a zero realignment risk (perfect credibility). The results we obtain are quite different to the presented in this paper, and we are no able to obtain transformation which represent the stabilizing effects of the target zone. This result shows the importance of considering the existence of a nonzero realignment risk when estimating a target zone.

References


Figure 1: Exchange rate and the fundamentals with devaluation risk

Figure 2: Exchange rate and the interest rate differential with devaluation risk
Figure 3: Exchange rate versus transformation: First regime

Figure 4: Interest rate differential (corrected) versus transformation: First regime
Figure 5: Exchange rate deviation versus transformation: Second regime

Figure 6: Interest rate differential (corrected) versus transformation: Second regime
Figure 7: Exchange rate deviation versus transformation: Third regime

Figure 8: Interest rate differential (corrected) versus transformation: Third regime
Figure 9: Exchange rate deviation versus transformation: Fourth regime

Figure 10: Interest rate differential (corrected) versus transformation: Fourth regime
Figure 11: Exchange rate deviation versus transformation: Fifth regime

Figure 12: Interests rate differential (corrected) versus transformation: Fifth regime
Figure 13: Exchange rate deviation versus transformation: Sixth regime

Figure 14: Interest rate differential (corrected) versus transformation: Sixth regime