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A Model of the Currency Crisis of 1992: The Case of the British Pound and the Italian Lira (*)

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Abstract

The purpose of this paper is to develop a theoretical model of the attack on the Italian Lira and the British pound and the subsequent exit of these currencies from the ERM in September 1992. One element that has been crucial in the formulation of agents' expectations of future exchange rates, and hence the sustainability of the system, has been the degree of willingness of the Bundesbank to intervene and support the weak currencies of the System. The model will focus on this aspect and will provide a framework where the agents' uncertainty about the stance of the Bundesbank towards the 'weak' currencies of the System is reflected in increasingly high interest rate differentials between the 'weak' countries and Germany, a well known characteristics of the period immediately preceding the ERM crisis of 1992.

Keywords: ERM, speculative attacks; regime switches; peso problem
JEL Classification: F31, F33

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1 Introduction

The currency crisis that hit most of the ERM currencies and caused the exit of the Italian Lira and the British Pound from the System has been a crucial topic of research in the last few years. Several models have been proposed to explain the episode, each focusing on a different aspect of the crisis.

One strand of the literature (e.g. Masson 1994) has stressed the importance of the trade-off between exchange rate stability and unemployment facing a government and the opposite effect that high unemployment has on the credibility of the commitment of the government to defend the parity of its currency. Masson shows that a high unemployment level can have opposite implications for expectations of a future devaluation, and hence for the interest rate differential: on one hand it signals a 'tough' Government, strongly committed to defend its parity; on the other hand, if circumstances become too unfavourable, it makes the task too difficult, in such a way that also a government strongly committed to defend the parity is forced to realign.

Another strand of the literature (e.g. Ozkan and Sutherland 1994) has focused on the nature of the switch between a fixed and a floating exchange rate system as an optimising decision of the government, in order to loosen monetary policy and boost aggregate demand, and not as an action forced on the government. However, the agents in the foreign exchange market know the government's objective function and include the expectation of the switch of regime in their expectations, which are then reflected in the interest rate differential. The authors also show that the agents' knowledge of the government's objective function induces the regime switch to take place earlier than the time preferred by the government.

Several papers have also focused on the empirical aspects of the crisis (Rose 1993, Rose and Svensson 1993, Thomas 1994), but their results are far from being conclusive, on how and why the crisis took place.

The aspect which we want to analyse in this paper is the role of the willingness (or unwillingness) of the Bundesbank in supporting the currencies under attack for the agents' expectations of the future exchange rate and, hence, the viability of the system. A close reading of the financial press of the time stresses the fact that the agents used the stance of the German central bank as a signal on the viability and the sustainability of the system; although this element of the crisis has been raised before (Kenen 1994), there is no formal theoretical model which captures this aspect in the literature to date.

The degree of the willingness on the side of the Bundesbank to support the weak currencies is strongly linked to the implications of this manoeuvre on the level of the money supply and its growth for Germany if the manoeuvre remains unsterilized. The stance of the Bundesbank to contain money supply is well known and so it is not surprising that the market questioned the validity of the commitment on the side of the Bundesbank to intervene for any required amount.

This can be seen as the 'political economy' aspect of the framework proposed in this paper. There are two major differences with the models that focus on the political economic aspect of the crisis: first, the preferences of the 'strongest' country in the System, Germany, are not modelled in terms of a welfare function, but are taken into account as a dislike of an increase of the money supply beyond the target. Secondly, while in the models of the first type unemployment covers a major role, entering, either directly or indirectly, the government's welfare function, in the model proposed in this paper unemployment does not have any role to play. The reason for this is that the theoretical framework for our model is the monetary model of exchange rate determination with flexible prices, where it is assumed that output is set exogenously at the full employment level.

The models that focus on political economy issues, moreover, analyse the case of a switch between a fixed exchange rate system and a free float, while in this paper a switch between a two-sided target zone and a free float is examined. This seems closer to the nature of the ERM, where currencies are allowed to move within a fluctuation band.

The model proposed here is a modified version of the model of the gold standard proposed by Krugman and Rotemberg (1992) and Fella (1993).

The second section of the paper will outline the basic model of the gold standard by Krugman and Rotemberg and describe how the model can be extended to the target zone case. The third section is devoted to the description of our model and in the fourth section we will outline its empirical implications. The conclusion also contains the proposal for a further extension of the model.

2: The Krugman and Rotemberg Model of the gold standard and its extension to target zones

The basic target zone model, proposed by Krugman (1991a) and all the models of the so-called 'second generation' (Bertola and Caballero 1992, Bertola and Svensson 1993, Lindberg and Soderlind, 1993, and Tristani 1994) implicitly assume that the amount of reserves available in order to defend the parity of the currencies in the system is unlimited.

This assumption seemed compatible with the characteristic of the ERM, giving that the Act of Foundation of the EMS states that support to currencies which approach the weak edge of the band is unlimited ('...These interventions shall be unlimited at the compulsory intervention rates...', Document 8, Section 1, Article 2.2); moreover, with the Agreement of Basle-Nyborg in September 1987, it was agreed that the access to the Very Short Term Financial Facilities was extended in use and duration.

However, in December 1978, in a hearing to the Bundestag, the German Finance Minister stated that '...the Bundesbank has the responsibility to intervene *and the option not to intervene* if it is its opinion that it is not able to do so' (italics added).

The events of the Summer 1992 showed that the amount of reserves available for the countries whose currencies were subject to a speculative attack was actually an issue and that the central bank of the centre country, the Bundesbank, was not actually prepared to intervene for unlimited sums in defence of these currencies. For this reason, it seems necessary to extend the target zone model in order to incorporate limited reserves.

The issue of limited reserves has been studied extensively in the two-countries model of the gold standard proposed by Krugman and Rotemberg (1992) (henceforth KR).

In their model, the fixed exchange rate system is seen as a boundary between two one-sided target zones. The focus here is of course of the limited nature of the amount of reserves available to the two countries, whose sum is equal to the quantity of gold available in the system, and how this can cause a collapse of the fixed exchange rate system to a floating one. Each country has a fixed parity for the price of gold, and so the exchange rate between the two countries is fixed.

The model considers the behaviour of the exchange rate between the two currencies as one of the two countries runs out of reserves (which implies that the other countries owns almost all the gold in the system).

The agents know that once a country runs out of reserves, it cannot defend the parity of its currency any longer and is forced to float. The authors show that in the event the switch to a floating regime is a reversible one, this takes place for values of the velocity shock which differ compared to the case of an irreversible switch.

It is important to stress two characteristics of this model, which are going to be recalled later in the paper.

First, at the time of the switch from the fixed regime to the unilateral target zone A (where the domestic country holds all the gold) (B, where the foreign country holds all the gold) there is a discrete loss of reserves from the foreign (domestic) to the domestic (foreign) country. The reason for the loss of reserves is given by what follows: while under the gold standard the expected change of the exchange rate is equal to zero, under the target zone A (B) the exchange rate is expected to appreciate (depreciate) and hence at the edges of the gold standard there will be a sudden purchase (sale) of the domestic currency by means of a sale of gold reserves.

Secondly, the switch between the unilateral target zone and the gold standard can be seen as a state-contingent condition, i.e. the switch takes place once the velocity shock reaches a given and known value. As a consequence, in order to avoid the possibility of infinitely large gains, the exchange rate before and after the switch needs to be the same.

The framework proposed by Krugman and Rotemberg has been extended by Fella (1993) in order to analyse the issue of limited reserves in the framework of a fully credible two-sided target zone, instead than in a gold standard.

The free float lines, as well as the unilateral target zones are the same, and so have the same equations, as the ones in the Krugman and Rotemberg model. The difference lies in the state-contingent conditions of the switch between, in this framework, the two-sided and the one-sided target zone.

The two free float lines determine the area of sustainability of the two-sided target zone, in the case the switch to a floating exchange rate is irreversible. In the case of a reversible switch, the area of sustainability is narrower than the one corresponding to an irreversible switch.

The S-shaped curve (which characterises the two-sided target zone) position inside this area is given by the level of the relative money supply. The money supply, in turn, changes once one of the two boundaries of the fluctuation band is hit and the authorities are forced to intervene (when the country whose currency is weak looses gold in favour of the country whose currency is strong).

This framework has been extended by the same author to include the possibility for the country which has run out of reserves to borrow reserves from the other country in the system. This implies that the area of sustainability of the two-sided target zone is wider compared to the non-borrowing case.

As in the model by Krugman and Rotemberg, also in this framework the switch to the float is a state-contingent condition. This implies that, in order to satisfy the non-arbitrage condition, the exchange rate before the switch is either equal to the one prevailing after that or to the weighted average of the two possible level of the exchange rate which takes place after the attack, as it was said above.

The consequence of these assumptions and conditions is that, before the switch, the behaviour of the exchange rate is perfectly identical to the case where there is an unlimited amount of reserves available in the system and, hence, the target zone is sustainable for any value of the velocity shock. If this is true, also the interest rate differential (given by the vertical distance between the exchange rate along the S-shaped curve and the corresponding free float locus) will have exactly the same behaviour if reserves are either limited or unlimited.

3 A target zone model with an overdraft facility

The implications of the models outlined above, however, do not seem very consistent with the evolution of the interest rate differentials before the Italian Lira and the British Pound were forced to leave the European Monetary System. The interest rate differentials for the Italian lira started increasing rapidly after the no vote to Maastricht in Denmark in June 1992 and the ones for the British Pound increased towards the end of the summer. For these reasons, it seems important to formalise a model of the target zones, in the phases preceding its collapse, which generates positive interest rates differentials between Italy and Britain, on the one hand, and Germany, on the other hand, before the fall as an implication,

As it was mentioned in the introduction of this paper, one aspect of the crisis of the ERM which has been overlooked in the theoretical literature is the role of the attitude of the Bundesbank to intervene in defence of the weak currencies of the system as a signal of the sustainability of the system. The model will focus on this aspect. It is important to stress that the model proposed here can only offer a partial explanation of the ERM crisis. In particular, it is not possible to address issues related to the pressure on the exchange rate parities given by an appreciation of the real exchange rate, which Italy experienced before the crisis; this is due to the fact that our framework is based on the monetary model with flexible prices, which assumes that Purchasing Power Parity holds continuously. Furthermore, the model does not have anything to say on the role of unemployment, as it is assumed that output is fixed at full employment level.

It was shown above that by imposing a state-contingent condition (so that for given known values of the velocity shock there will be a switch of regime), it is necessary that the exchange rate after the switch (or its expected value) is equal to the exchange rate before the switch, in order to satisfy the non-arbitrage condition.

In order to relax this restriction without violating the non-arbitrage condition, it seems preferable to drop the state-contingent condition and view the switch to the float as a probabilistic event. This approach also implies the presence of a 'peso problem' (i.e. the expectation of an event which does not take place in-sample), before the fall, for the weak currency, which is obviously a very important factor before the lira and the pound were forced to float.

For reasons of simplicity, the model does not take into account the possibility of a realignment, but focuses on the switch of regime between the target zone and the free float. For the same reason, an irreversible switch is considered, in order to keep a simple analytical framework. It would be interesting to extend the model to an environment where realignments can take place and the switch to the float is reversible.

As in the KR framework, the model is a two-country one. It is also assumed that once the domestic country has run out of disposable reserves, the monetary authorities of the foreign country, Germany, agrees to grant a loan of, possibly, an unlimited amount. The loan, however, can be called back at any time, in other words an 'overdraft facility' is in place. If the loan is called back, the target zone becomes unsustainable and the exchange rate is forced to float; moreover, the relative money supply jumps to the level where the foreign country money supply equals its domestic credit and all the gold in the system, while the domestic country's money supply equals its domestic credit (as in the previous models, both D and D* are assumed to be constant).

It is assumed that the probability for the loan to being called back follows a Poisson process with (constant) arrival rate equal to p, so that in the time interval dt the loan will be recalled with probability pdt and it will be continued to be granted with probability (1 - pdt). Note that this is a simplification of the model. In reality, loans between central banks cannot be called back. However, the framework proposed in this paper can be reinterpreted as assuming that the loan has infinitesimal duration and that the probability of renewal follows a Poisson process, where p is the probability for the loan not to be renewed.

The model proposed in this paper has some similarities with the target zone model by Dumas et al. (1993), who model the probability of a realignment as a Poisson process; when the realignment takes place, the central parity is shifted upwards onto the free float line with the <u>same</u> money supply and the exchange rate is adjusted correspondingly; at the time of the realignment there is no change in the money supply of in the fluctuation limits of the fundamentals.

In our model, similarly to the models outlined above, the exchange rate behaviour can be expressed by the equation:

1) $$s(v) = (m - m^*) + v + \alpha E_t (ds/dt)$$

where s is the (log of) the exchange rate between the currencies of the two countries,
m (m*) is the log of domestic (foreign) money supply
v is a velocity shock, which follows a Brownian motion process (without drift)

2) $$dv = \sigma dz$$

α is the semi-elasticity of the money demand to interest rate
E_t (ds/dt) is the instantaneous expected change of the exchange rate, which is equal to zero in a fixed exchange rate system with no expectations of a future jump in the exchange rate
m (m*) can be written as:

3) $$m = \log (D + R)$$
$$(m^* = \log (D^* + R^*))$$

D (D*) is the level of domestic credit for the domestic (foreign) country
R (R*) is the level of reserves for the domestic (foreign) country.
The main difference with the models outlined in the previous section lies in the expression E_t (ds/dt). In the Krugman and Rotemberg model, when the gold standard prevails, the instantaneous expected change of the exchange rate is equal to zero; in the Fella model, the equation for the target zone is the same as the one of the original Krugman target zone model (where there is no concern for limited reserves) in the area between the two float loci, and so also the expected change of the exchange rate is the same as in the fully credible target zone.
In the model proposed in this paper, however, E_t(ds/dt) has two components, the first given by the expected change of the exchange rate inside the band, the seconf given by the expected change of the exchange rate if tje loan is called back, and so the exchange rate jumps to the free float value.
A further difference with the former models lies in the definition of the relative money supply, m - m*. Both Krugman and Rotemberg and Fella assume that the total amount of reserves in the system is constant and equal to the amount of
gold,

4) $$R + R^* = G$$

Given the characteristics of the modern international financial system, it seems more appropriate to specify national and foreign reserves, R and R*, as being the sun of two component: one, given by the minimum amount which each central bank wants to hold at all times, called R' and R'*, the second, given by the amount of reserves which each central bank is free to use in case of intervention, R" and R"*, so that:

5) $$R = R' + R''$$
$$R^* = R'^* + R''^*$$

The relative money supply corresponding to the free float locus after the jump will then be expressed as:

6) $$m - m^* = \frac{D + R'}{D^* + R^* + R''}$$

and the exchange rate after the jump to the free float locus equals:

7) $$s^{+}(v) = \ln \frac{D+R'}{D^*+R^*+R''} + v$$

(where the sign + indicates the after-collapse regime)
so the expected jump if the loan is called back equals:

8) $$s^{+}(v) - s(v) = \ln \frac{D+R'}{D^*+R^*+R''} + v - s(v)$$

Then, equation 1) will become (by ignoring the terms in dt^2 and rearranging):

9) $$s(v) = (m - m^*) + \alpha p \left[\ln \frac{D+R'}{D^*+R^*+R''} + v - s(v)\right] + v + (\alpha/2)\, \sigma^2 s_{vv}$$

and so:

10) $$s(v) = (1 + \alpha p)^{-1}((m - m^*) + \alpha p \ln \frac{D+R'}{D^*+R^*+R''} + v + (1+ \alpha p)^{-1} (\alpha/2)\, \sigma^2 s_{vv}$$

This equation is a second-order differential equation and has the following solution:

11) $$s(v) = (1 + \alpha p)^{-1}((m - m^*) + \alpha p \ln \frac{D+R'}{D^*+R^*+R''}) + v + A'_1 e^{r'v} + A'_2 e^{-r'v}$$

(where a ' indicates that the arbitrary constants and the roots of the characteristic equation refer to the target zone with an overdraft facility)
+/- r' are the roots of the characteristic equation:

12) $$(1 + \alpha p)^{-1}(\alpha/2)\, \sigma^2 r^2 - 1 = 0$$

and are equal to

13) $$r' = +/- (2\,(1 + \alpha p) / \alpha\sigma^2)^{1/2}$$

r' is greater, in absolute value, than the root of the characteristic equation for the basic Krugman model of a fully credible target zone (Krugman 1991), equal to

$r = +/-(2/\alpha\sigma^2)^{1/2}$.

Boundary conditions in the form of smooth pasting conditions at the boundaries of the fluctuation band for the velocity shock need to be imposed in order to determine the arbitrary constants A'_1 and A'_2.

As in this type of models it is assumed that interventions are of infinitesimal size, $\overline{v}'$ and $\underline{v}'$ are uniquely determined by the condition that:

14) $$s(\overline{v}') = \overline{s} \text{ and } s(\underline{v}') = \underline{s}$$

where $\overline{s}$ ($\underline{s}$) is the upper (lower) limit of the fluctuation band for s. Moreover, it can be shown that the exchange rate band is symmetric and so $\overline{s} = -\underline{s}$.

The family of curves corresponding to equation 11) has the well-known S-shaped form (see figure 1). The consequence of taking into account the possibility that the overdraft facility can be recalled at any time is both a shift of the curve to the left and a change of the curvature of the curve itself (see the appendix to this paper for a proof), compared to the fully credible target zone.

Note that given the assumptions of the model, the whole family of curves lies at the right of the free float locus where the exchange rate jumps if the loan is called back (line FF in figure 1), which is described by the equation

15) $$s^{+}(v) = \ln \frac{D+R'}{D^{*}+R^{*}+R''} + v$$

The line crosses the v-axis for

16) $$v_A = -\ln \frac{D+R'}{D^{*}+R^{*}+R''}$$

The fact that the whole family of curves OFTZ (overdraft facility target zone) lies at the right of the free float locus can be shown by making explicit the expression (m - m*), i.e. the relative money supply once the overdraft facility is in place, in equation 10 and 11

17) $$(m - m^{*})_{OFTZ} = \ln \frac{D+R'-L}{D^{*}+R^{*}+R''+L}$$

where L represents the loan in use at a given time.

Giving that L > 0, it follows that

18) $$(m - m^*)_{OFTZ} < (m - m^*)_{FCTZ}$$

18') $$\ln \frac{D+R'-L}{D^*+R^*+R''+L} < \ln \frac{D+R'}{D^*+R^*+R''}$$

i.e. under a target zone with an overdraft facility the relative money supply is smaller than under a fully credible target zone (FCTZ).

Note that s(v) will cross the v-axis at v_C, such that, by recalling equation 18'),

19) $$v_C = -(1+\alpha p)^{-1}\left[\ln \frac{D+R'-L}{D^*+R^*+R''+L} + \alpha p \ln \frac{D+R'}{D^*+R^*+R''}\right]$$

Moreover, v_C lies at the right of v_A, as:

20) $$v_C - v_A = (1+\alpha p)^{-1}\left[\ln \frac{D+R'}{D^*+R^*+R''} - \ln \frac{D+R'-L}{D^*+R^*+R''+L}\right] > 0$$

and so the family of 'Overdraft Facility Target Zone' (OFTZ) will lie to the right of the free float locus (see figure 1).

The fact that the money supply is smaller under an overdraft facility target zone, i.e. when the central bank of the domestic country is using up the loan granted by the foreign country, and that once the loan is called back the relative money supply increases (thus generating a devaluation) can be explained as follows:

suppose that the Bank of Italy (the domestic bank) intervenes to defend the lira by selling DM made available through a loan by the Bundesbank; this will, in absence of offsetting operations either in the foreign exchange or capital markets, have an equal effect of opposite sign in the money markets of the two countries: contractionary in Italy and expansionary in Germany (see Mastropasqua et al. 1988).

Conversely, when the loan is paid back, the money supply in Italy will increase and the one in Germany will decrease.

The size of the relative money supply after the loan is called back will be exactly the same as the one before the loan was started being used,

21) $$m - m^* = \ln \frac{D+R'}{D^*+R^*+R''}$$

Having established the characteristics of the target zone with an overdraft facility, we need to analyse how, as a consequence of cumulative velocity shocks, the system moves from a fully credible target zone (FCTZ) to a target zone with an overdraft facility

(OFTZ), recalling that the central bank of the foreign country agrees with certainty to make a loan to the central bank of the domestic country in order to defend its currency. The switch between the two will take place once the domestic country has completely run out of reserves, so that

22) $$m - m^* = \ln \frac{D+R'}{D^*+R^*+R''}$$

and the exchange rate hits the upper bound of the band, so that an intervention to keep it inside the band is needed. Let's call the value of the velocity shock that corresponds to this situation v**. (This can also be seen as a state contingent condition) (see figure 2).

In order to avoid the violation of the arbitrage condition, we need to impose the value matching condition between the exchange rate under a fully credible target zone and a target zone with an overdraft facility:

23) $$s_{FCTZ}(v^{**}) = s_{OFTZ}(v^{**})$$

Moreover, given that it is assumed that intervention takes place only at the boundary, it must also be true that:

24) $$\bar{s} = s_{FCTZ}(v^{**}) = s_{OFTZ}(v^{**})$$

Recall that under a FCTZ the equation for the exchange rate, when $v = v^{**}$, is:

25) $$s_{FCTZ}(v^{**}) = \ln \frac{D+R'}{D^*+R^*+R''} + v^{**} + (\alpha/2)\,\sigma^2\, s_{vv}$$

and that under a OFTZ the equation for the exchange rate is:

10') $$s_{OFTZ}(v^{**}) = (1+\alpha p)^{-1}\left[\ln\frac{D+R'-L^\circ}{D^*+R^*+R''+L^\circ} + \alpha p \ln\frac{D+R'}{D^*+R^*+R''}\right] + v^{**} + (1+\alpha p)^{-1}(\alpha/2)\sigma^2 s_{OFTZ,vv}$$

$$= \ln \frac{D+R'}{D^*+R^*+R''} + (1+\alpha p)^{-1}\left[\ln \frac{D+R'-L^\circ}{D^*+R^*+R''+L^\circ} - \ln \frac{D+R'}{D^*+R^*+R''}\right] + $$
$$+ \; v^{**} + (1+\alpha p)^{-1}(\alpha/2)\sigma^2 s_{OFTZ,vv}$$

where L° indicates the initial size of the loan.

Note that, as the curve for the OFTZ is steeper than the FCTZ,

PP' < PP"

(see figure 2)

but $PP' = -(1+\alpha p)\, s_{OFTZ,vv}$ and $PP'' = -s_{FCTZ,vv}$

hence:

26) $$-(1+\alpha p)\, s_{OFTZ,vv} < -s_{FCTZ,vv}$$

It then follows that if equation 23) has to hold, it is necessary that

27) $$\ln \frac{D+R'-L^\circ}{D^*+R^*+R''+L^\circ} < \ln \frac{D+R'}{D^*+R^*+R''}$$

so that at the time of the switch between the FCTZ and the OFTZ there is a discrete negative jump in the money supply. Given that the model assumes that D and D* are constant, the money supply can decrease only if the loan starts being used and if the initial loan is of discrete size.

Intuitively, the fact that at the time of the switch the initial loan needs to take a positive, discrete value can be explained by observing that at the time of the switch, the expected change of the exchange rate, which is negative under a fully credible target zone, becomes positive due to the presence of expected devaluation if the loan is called back. L° must be large enough so to compensate for the expected devaluation. Note that the size of the initial loan depends on the size of the probability p that the loan is called back: the higher p, the higher L° has to be in order for equation 23) to hold.

The distance $v_B - v_A$ is proportional to the initial size of the loan, L°, giving that, similarly to equation 20)

20') $$v_B - v_A = (1+\alpha p)^{-1} \left[\ln \frac{D+R'}{D^*+R^*+R''} - \ln \frac{D+R'-L^\circ}{D^*+R^*+R''+L^\circ}\right]$$

so that as L° increases also $v_B - v_A$ increases.

Note, however, that $v_B - v_A$ represents both the decrease in the money supply due to the initial loan, L° and the effect of the change in curvature and the expected devaluation, in case the loan is called back.

3.4 Implications of the target zone model with an overdraft facility

A crucial aspect of this model is the specification of the expected change of the exchange rate:

28) $$E_t\,(ds/dt) = (1/2)\sigma^2\, s_{vv} + p\,(\ln \frac{D+R'}{D^*+R^*+R''} + v - s(v))$$

The first component, $(1/2)\sigma^2\, s_{vv}$, reflects the expected movement of the exchange rate inside the band.

The second component is the expected devaluation, where the size is given by the difference between the freely floating exchange rate, which prevail if the loan is recalled, and the exchange rate inside the band, and the probability is given by the arrival rate of the Poisson process, p.

One assumption of the target zone model, which we need to recall here, is the one of validity of the Uncovered Interest Parity, $E_t(ds/dt) = i - i^*$, where i (i*) is the instantaneous domestic (foreign) interest rate on Eurodeposits (i.e. offshore financial assets).

The former specification of the instantaneous expected change of the exchange rate implies the presence of a 'peso problem' in the interest rate differential and, via the Covered Interest Parity, on the forward premium in case the loan is not recalled, and so there is no switch between the target zone and the free float.

If the agents form expectations rationally, then the actual future value, say at time t+dt, of the exchange rate equals the expected value of the exchange rate formed at time t, given the information available at time t plus a white noise disturbance which represent the news occurring after the expectations have been formed:

29) $$s_{t+dt} = E_t\, s_{t+dt} + u_{t+dt}$$

If, however, there is some probability, even small, of an event which does not materialise in the time interval considered, then:

29') $$s_{t+dt} \neq E_t s_{t+dt} + u_{t+dt}$$

The wedge between the LHS and the RHS of equation 29') is the measure of the 'peso problem' (the first mention of the 'peso problem' is contained in Krasker (1980); for a detailed explanation see Obstfeld (1987)).

In other words, even if the UIP holds, the realised change of the exchange rate will differ from the instantaneous interest rate differential plus a white noise disturbance.
The presence of the 'peso problem' in the behaviour of the interest rate differentials compared to the actual change of the exchange rate for the period preceding the exit of the British Pound and the Italian Lira from the ERM, has been widely recognised by the literature: with the exception of Italy and Spain, which had sizeable positive interest rate differentials with Germany for quite a long time, the interest rate differentials with respect to Germany remained subdued until late in the Summer of 1992, but at that time they increased very rapidly and reached very high levels (see Edison and Kole (1994), Rose (1994), Rose and Svensson (1994)). Therefore, any model which aims at explaining the behaviour of exchange rates and interest rates before the fall should generate this phenomenon: the model proposed in this paper has this characteristic.
In addition to generating a 'peso problem' in the phases anticipating a switch between a target zone and a free float, the model outlined here has another implication for the interest rate differential, which can be tested empirically and, again, focuses on the 'peso problem' component of the interest rate differential:

$$30)\ p(s^{+} - s(v)) = p(\ln\frac{D+R'}{D^{*}+R^{*}+R''} + v - s(v))$$

By looking at figure 1, it is possible to observe that the jump in the exchange rate at the time of the switch is not bounded and increases as the loan used by the domestic central bank to defend the parity of its currency increases. The FF locus can be seen as the free float 'shadow' exchange rate, in a similar fashion as in Flood and Garber (1984), i.e. as the exchange rate which would dominate in absence of the authorities' intervention and the presence of the loan, intervention which allows the domestic country to live on borrowed time. At the time of the switch the exchange rate 'rewinds' the effect of the cumulated shocks and jumps onto the shadow exchange rate locus. For this reason, the 'peso problem' component in the interest rate differential will show nonstationarity and so the interest rate differential.
Note that this is a very particular case and is caused by the jump of the money supply at the time the switch between a target zone and the free float takes place.
We will test for this empirical implication of the model for interest rate differentials in paper four.

3.5 Conclusion

This paper offers an explanation on one of the factors of the currency crisis which caused the exit of the British Pound and the Italian Lira from the ERM in September

1992. It focuses on the willingness of the Bundesbank to support the existing parity, and so the existing fluctuations band, for the above currencies, by granting respectively to the Bank of England and the Bank of Italy a loan which could become infinite in size. The willingness of the Bundesbank to do so, or the probability that it calls back the loan granted to the above central banks is a signal of the sustainability of the system: the model proposed in this paper shows how this feeds in the expectations of the future exchange rate from the agents in the foreign exchange market. This particular aspect of the crisis has not been considered until now in the theoretical literature on the topic. Note, however, that our model does not cover other significant elements of the crisis, such as the pressure coming from the real exchange rate appreciation and the consequent loss of competitiveness, which hit most notably Italy, and the influence of the increasing unemployment level on the governments' actions. These limits derive from the theoretical framework of our model, given by the monetary model of exchange rate determination with fully flexible prices, where it is assumed that Purchasing Power Parity holds continuously and that output is fixed at the level corresponding to full employment.

A particularly desirable implication of the model is the presence of a 'peso problem' in the interest rate differentials before the switch from the target zone and the free float takes place. It is a very well established fact that in the months immediately preceding the switch, the domestic interest rates rose considerably compared to the ones prevailing in Germany.

The model proposed here can be extended in a number of ways. Two, however, seem to be the most important extensions. First, it is possible to consider in the model not only the possibility that the loan is recalled and, hence, the exchange rate is forced to float, but also the possibility that the exchange rate can be subject to a realignment, despite the loan being granted. Secondly, it could be possible to express the arrival rate of the Poisson process for the recall of the loan as an increasing function of the amount of loan being used. We also noticed how an empirical implication of the model is that the interest rate differential when there is an expectation that the loan is recalled, and the domestic country is forced to float its currency, has a nonstationary component in it. We will investigate the empirical implication of the model in a paper to follow.

Appendix

In this appendix we will prove that the S-shape curve for a target zone with an overdraft facility (OFTZ) is steeper than the one for a fully credible target zone (FCTZ). Consider s_{FCTZ} and s_{OFTZ} and shift them so that:

a 1) $$s_{FCTZ}(0) = s_{OFTZ}(0) = 0$$

(i.e. they pass through the origin) (figure 3).

By making explicit the expressions for A'_1 and A'_2 it is possible to write $s_{FCTZ}(v)$ as:

a 2) $$s_{FCTZ}(v) = \frac{e^{rv}\left[e^{-r\bar{v}} - e^{r\underline{v}}\right] + e^{-rv}\left[e^{r\bar{v}} - e^{r\bar{v}}\right]}{r\left[e^{r(\bar{v}-\underline{v})} - e^{-r(\bar{v}-\underline{v})}\right]}$$

and similarly:

a 3) $$s_{OFTZ}(v) = \frac{e^{r'v}\left[e^{-r'\bar{\bar{v}}} - e^{r'\underline{\underline{v}}}\right] + e^{-r'v}\left[e^{r'\bar{\bar{v}}} - e^{r'\underline{\underline{v}}}\right]}{r'\left[e^{r'(\bar{\bar{v}}-\underline{\underline{v}})} - e^{-r'(\bar{\bar{v}}-\underline{\underline{v}})}\right]}$$

where:

a 4) $$|r'| > |r|$$

the root of the characteristic equation for the OFTZ is greater than the one for the FCTZ (see equation 3.22 in the main text)

and

a 5) $$\bar{v} = -\underline{v}\ ; \quad \bar{\bar{v}} = \underline{\underline{v}}$$

(where $\bar{v}$ ($\underline{v}$) is the upper (lower) limit for the FCTZ and $\bar{\bar{v}}$ ($\underline{\underline{v}}$) is the upper (lower) limit for the OFTZ) given to the symmetry of the two families of curves.

In order to prove that s_{OFTZ} is steeper than s_{FCTZ}, we need to prove that a 6) $$\bar{\bar{v}} < \bar{v}$$

We do this by exploiting the relationship:

a 7) $$s_{OFTZ}(\bar{\bar{v}}) = s_{FCTZ}(\bar{v}) = \bar{s}$$

and so

a 7') $$\bar{v} + \frac{2 - e^{2r\bar{v}} - e^{-2r\bar{v}}}{r\left[e^{2r\bar{v}} - e^{-2r\bar{v}}\right]} = \bar{\bar{v}} + \frac{2 - e^{2r'\bar{\bar{v}}} - e^{-2r'\bar{\bar{v}}}}{r'\left[e^{2r'\bar{\bar{v}}} - e^{-2r'\bar{\bar{v}}}\right]}$$

where the second term of both LHS and RHS is negative.

Suppose, now, that

a 8) $$\bar{\bar{v}} < \bar{v}$$

and such that:

a 9) $$r\bar{v} = r'\bar{\bar{v}}$$

the equality a 7) thus becomes:

a 7') $$\bar{v} - (B/r) = \bar{\bar{v}} - (B/r')$$

where:

a 10) $$B = B_{OFTZ} = B_{FCTZ} > 0$$

a11) $$B_{FCTZ} = \frac{-2 + \left(e^{2r\bar{v}} + e^{-2r\bar{v}}\right)}{\left[e^{2r\bar{v}} - e^{-2r\bar{v}}\right]} > 0$$

and

a 11') $$B_{OFTZ} = \frac{-2 + \left(e^{2r'\bar{\bar{v}}} + e^{-2r'\bar{\bar{v}}}\right)}{\left(e^{2r'\bar{\bar{v}}} - e^{-2r'\bar{\bar{v}}}\right)}$$

given a 4) and a 10), it follows that:

a 12) $$-(B/r') > -(B/r)$$

and the equality a 7') holds.

Suppose now, instead, that

a 8') $$\bar{\bar{v}} > \bar{v}$$

it then follows that:

a 13) $$r'\bar{\bar{v}} > r\bar{v}$$

This implies:

a 14) $$-(B_{OFTZ}/\,r') > -(B_{FCTZ}/\,r)$$

but this would violate condition a 7')!

Hence,

a 15) $$\bar{\bar{v}} < \bar{v}$$

and s_{OFTZ} (v) is steeper than s_{FCTZ} (v), as we intended to prove.

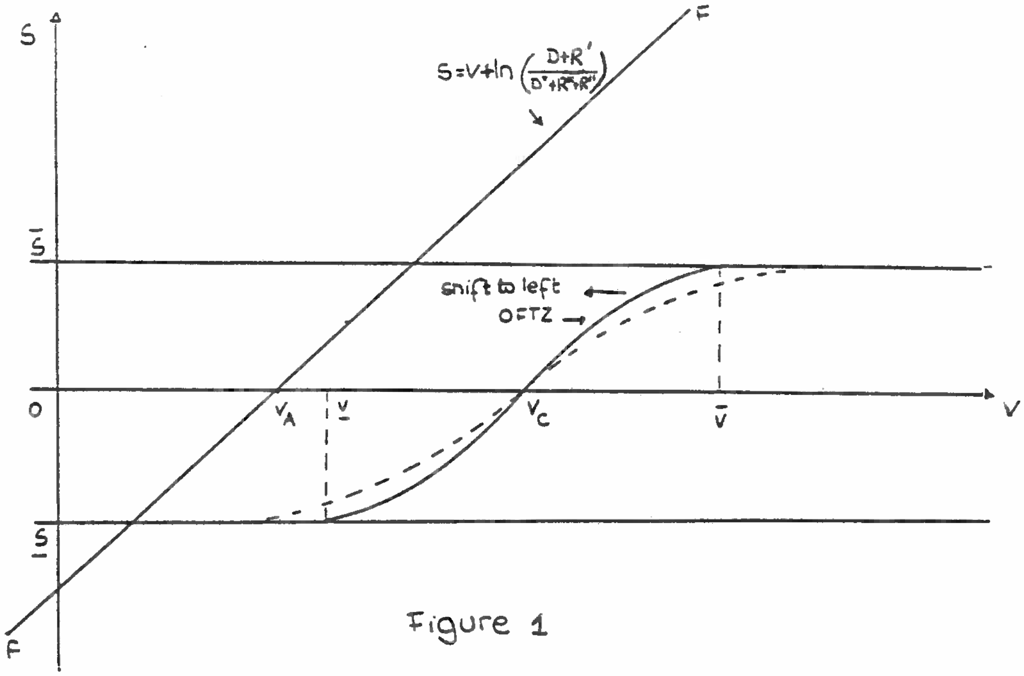
S
F
S=V+ln (D+R' / D"+R"+R")
S̄
shift to left
OFTZ
0
V_A
$\underline{V}$
V_C
$\bar{V}$
V
$\underline{S}$
F

Figure 1

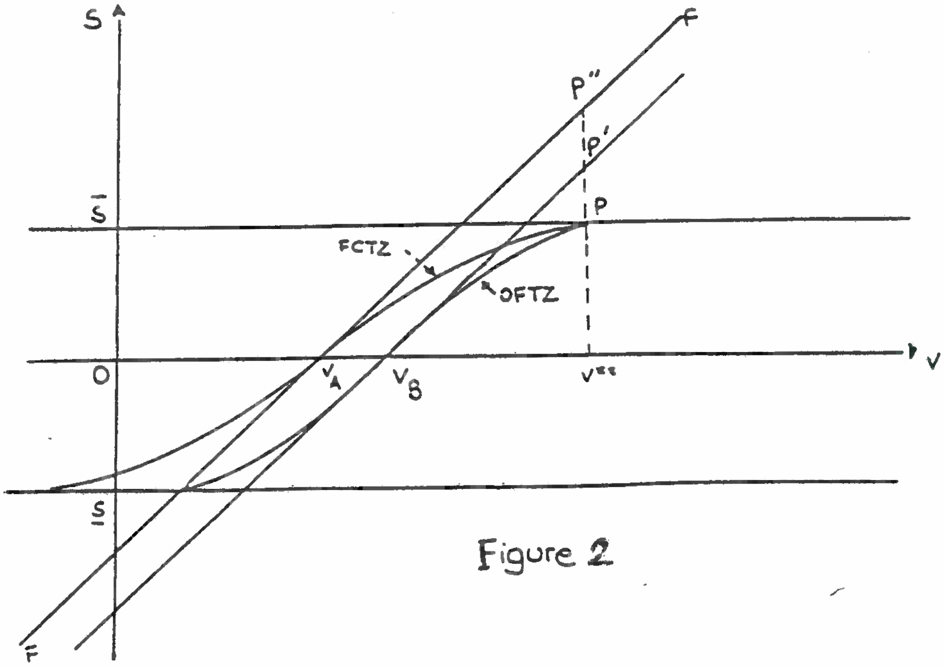

Figure 2

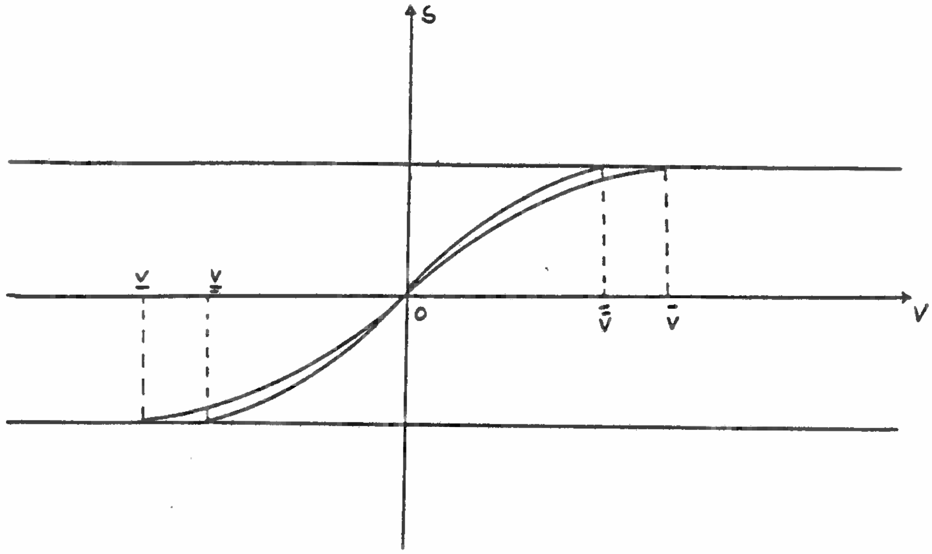

Figure 3

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