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Pierpaolo Benigno, New York University and CEPR
Alessandro Missale, Università di Firenze

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Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

High Public Debt in Currency Crises: Fundamentals *versus* Signalling Effects*

This Paper examines how public debt, government credibility and external circumstances affect the probability of exchange rate devaluations in a three-period, open economy version of the Barro-Gordon (1983) model with nominal public debt. Public debt creates a link between current and future policy actions: resisting a crisis may enhance or undermine the sustainability of the exchange rate regime depending on whether the government's reputation or fundamentals – i.e. the level of public debt – are critical for sustainability. The focus is on the impact of public debt, debt maturity and government credibility on the expected devaluation for the current and future periods. This allows us to identify factors affecting the short-term interest rate and the forward rate and hence to derive predictions on the level and the slope of the term structure of interest rates.

JEL Classification: E58, F31, F33, H63
Keywords: credibility, fixed exchange rates, nominal debt maturity and yield curve

Pierpaolo Benigno
Department of Economics
New York University
269 Mercer Street (7th floor)
New York, NY 10003
USA
Tel: (1 212) 998 8958
Fax: (1 212) 995 4186
Email: pierpaolo.benigno@nyu.edu

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Alessandro Missale
Dip. Studi sullo Stato
Università di Firenze
Via S Caterina d'Alessandria 3
50129 Firenze
ITALY
Tel: (39 055) 4622 920
Fax: (39 055) 472 102
Email: missale@unifi.it

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NON-TECHNICAL SUMMARY

The credibility of a fixed exchange regime depends on the government's reputation (Backus-Driffil 1985a, 1985b) and on economic fundamentals (Dornbusch 1986). A strenuous defence of the fixed parity can signal the government commitment and thus improve its credibility, but it also deteriorates fundamentals, making the economy more vulnerable to unfavourable shocks. If the reputation of the government is not an issue, then resisting a currency crisis may reduce – rather than enhance – the credibility of the exchange rate regime. As shown by Drazen and Masson (1994), with persistence in the unemployment rate, maintaining the fixed parity leads to higher future unemployment thus decreasing the possibility that the currency peg will be maintained in the future. In this Paper we study the same mechanism but in a context where the link between present and future actions is given by the accumulation of nominal public debt. We identify the relative importance of public debt, debt maturity and governments' credibility in determining the *ex ante* probability (as perceived by the private sector) of an exchange-rate devaluation.

We examine a three-period stochastic version of the Barro-Gordon (1983) model, where the decision to devalue or maintain the fixed parity depends on the realization of an output shock. Because of uncertainty, inflation may turn out to be higher than expected and increase output, both through a standard price-output effect and through a reduction of distortionary taxes associated with public debt servicing. Devaluation in the current period reduces the real value of the debt and thus the government's need for future devaluation. This makes it uncertain whether the exchange-rate regime gains or loses credibility after a successful defence of the fixed parity. On the one hand, resisting a crisis enhances the credibility of the government and – to the extent that the debt is rolled over at lower interest rates – it improves the future sustainability of the exchange regime. This effect is important if there is substantial uncertainty about governments' preferences and the level of debt is low. We call it the 'signalling effect'. On the other hand, defending the fixed parity and refraining from inflationary financing increases the debt burden and thus, the likelihood of having to resort to future devaluation. Therefore, with nominal debt, devaluation may enhance, instead of reduce, the credibility of a fixed exchange regime. This effect is important if the level of debt is high and there is little uncertainty about governments' preferences. We call it 'the debt burden' effect. Which effect prevails depends on the importance of fundamentals relative to the government's credibility, i.e. of debt burden relative to signalling effects.

When governments' preferences are publicly known only fundamentals matter; a current devaluation always increases the probability that a future defence of the new parity will succeed. In this case the probability of a first-period devaluation increases with the level of public debt and, more interestingly, with the share of short-term debt. A short maturity makes it more likely that the fixed parity will be abandoned since a large share of debt will, then, be rolled over at lower than expected interest rates. That a short maturity impairs the government's ability to defend the exchange rate is a main result in the literature on self-fulfilling crises (e.g. Giavazzi and Pagano, 1990; Obstfeld, 1994). We show that the argument in favour of long-term debt can be made without relying on intrinsic uncertainty: long-term debt eliminates the temptation to exploit the lower interest rate that follows devaluation.

When the cost that the government assigns to a devaluation is not known to the private sector, the decision to devalue may reveal a weak government, thus leading to inflationary expectations which, in turn, increase the likelihood of a future devaluation. With asymmetric information there is an incentive to defend the fixed parity both for a tough government, in order to signal its type, and for a weak government in order to disguise itself as tough and exploit lower interest rates. Therefore, reputation motives increase the probability that the fixed parity will be maintained.

The analysis offers a theory of the term structure of interest rates for high-debt countries vulnerable to currency crises. This is possible since, unlike in Drazen and Masson (1994), the expected devaluation is derived for both the current and the future period. A greater uncertainty about government's preferences, that is, a greater difference in the devaluation costs of the two governments – for any given expected cost – reduces the probability that the private sector assigns to a first-period devaluation. By contrast, the probability of a second-period devaluation does not depend on reputational considerations. Hence, the perception of a government's incentive to resist the crisis and enhance its credibility helps to contain the expectations of an imminent devaluation but has no effect on the long-run sustainability of the exchange regime. Reputational incentives thus lower the short-term interest rate, but have no impact on the forward rate, as the latter only depends on fundamentals.

Debt burden and signalling effects thus play a key role in determining the slope of the yield curve. For any given level of debt, a greater uncertainty about governments' preferences implies lower short- (and long-) term interest rates and a steeper yield curve. In any case where the debt-burden effect prevails, and all those where the government's cost of devaluation is known, a higher level of debt should be associated with higher interest rates and a flatter (or more downward sloping) yield curve. If, however, reputational considerations are more important than fundamentals, a higher debt may reinforce the signalling effect of a defence of the fixed parity and thus lead to a steeper yield curve.

1. Introduction

The credibility of a fixed exchange regime depends on the government's reputation (Backus-Driffil 1985a, 1985b) and on economic fundamentals (Dornbusch 1986). A strenuous defense of the fixed parity can signal the government commitment and thus improve its credibility, but it also deteriorates fundamentals making the economy more vulnerable to unfavorable shocks. If the reputation of the government is not an issue, then resisting a currency crisis may reduce instead of enhancing the credibility of the exchange-rate regime. As shown by Drazen and Masson (1994), with unemployment persistence maintaining the fixed parity leads to higher future unemployment thus mining the possibility that the currency peg will be maintained in the future. In this paper we study the same mechanism but in a context where the link between present and future actions is given by the accumulation of nominal public debt. We identify the relative importance of public debt, debt maturity and government's credibility in determining the ex-ante probability (as perceived by the private sector) of an exchange-rate devaluation.

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Debt-burden and signaling effects thus play a key role in determining the slope of the yield curve. For any given level of debt, a greater uncertainty about governments' preferences implies lower short- (and long-term) interest rates and a steeper yield curve. When the government's cost of devaluation is known and, in any case, when the debt-burden effect prevails, a higher level of debt should be associated with higher interest rates and a flatter (or more downward sloping) yield curve. However, if reputational considerations are more important than fundamentals, a higher debt may reinforce the signaling effect of a defense of the fixed parity and thus lead to a steeper yield curve.

The paper is organized as follows. Section 2 presents evidence from EMS realignments which suggests the importance of the debt burden effect. This effect is examined in Section 3 by restricting the attention to the case when government's preferences are publicly known. Asymmetric information is introduced in Section 4, where the credibility of the exchange-rate regime is shown to depend on both fundamentals and signaling effects. Implications for the term structure of interest rates are discussed in Section 5. The same section examines the effects of debt and debt maturity on the expected devaluation. Section 6 concludes.

2. Evidence from EMS realignments

A high debt with a short maturity is a potential source of self-fulfilling speculative attacks in second-generation models of currency crises. Following the seminal contribution by Calvo (1988), the role of debt composition and maturity has been emphasized by Giavazzi and Pagano (1990), Obstfeld (1994) and Sachs, Tornell and Velasco (1998), among others. Quoting Obstfeld (1996 p.1045): "Highly indebted governments with mostly short-term or floating-rate nominal debt will find their fiscal burden increased sharply if market expectations of a depreciation drive up domestic interest rates. This may induce devaluation of domestic-currency debt."

The devaluation of the Italian lira in September 1992 is perhaps the clearest episode where a short maturity debt makes a defense of the fixed parity a too costly option. At the end of August, on the eve of the speculative attack, the Italian debt had reached 110% of GDP while the 3-month interest rate was at 6 points above the German rate.[1] With one-third of the debt with a less than 1-year maturity and another third indexed to short-term interest rates, the Italian public finances were indeed vulnerable to any further increase in debt servicing costs. As the speculative attack was launched on September 1^{st} and the 3-month Italian rate was raised up to 19% in a vane attempt to maintain the peg, the cost of debt roll-over became unsustainable. On September 14^{th} the Italian lira was devalued by 7% and four days later it was floated.

As argued by Obstfeld (1996), the 1992 crisis presents self-fulfilling features, but the substantial fall in interest rates that took place in the following months, leading the spread on German rates to 5% in November and to 3% in March 1993 and thus below the 5% pre-crisis level (see Figure 1) also points to substantial benefits for the Italian fiscal position from the decision to devalue. Insofar as a devaluation allows to roll-over the debt at interest rates that are lower than expected, a short maturity provides a strong incentive to abandon the peg. A fall in interest rates is possible since a devaluation, by reducing the real value of the debt (and restoring competitiveness), reduces the need for further future devaluations.

Therefore, a short maturity debt increases the probability of a currency crisis, not only because it makes the fiscal position vulnerable to expectations-driven increases in interest rates, but also because it makes the budget sensitive to changes in interest rate which depends on the decision to devalue. This mechanism has so far been neglected in the literature on debt crises, since the analysis is usually confined to a two-period framework. However, the rapid fall of interest rates after a currency devaluation (often to levels lower than in the pre-crisis period) should deserve a greater consideration, if anything, because it appears an important feature of a number of realignment episodes in the late stage of the Exchange Rate Mechanism (ERM) of the EMS. Indeed, looking at the EMS experience, we can distinguish two periods. While until 1985 realignments were typically accompanied by an increase in the spread between domestic and German interest rates, in the second period they were often followed by a fall of interest-rate

[1] Data on interest rates are daily euro-currency middle rates taken from Datastream.

spreads to pre-crisis levels. This pattern is shown in Figures 1, 2 and 3 for the 3-month spread of Italy, Ireland and France, respectively; i.e. three of the long-term participants to the ERM.[2]

In the case of Ireland the fall of the interest-rate spread after the 10% devaluation of January 1993 is striking, but it is also evident after the realignment of January 1987. Then, the 3% devaluation of the Irish punt against the Deutsche mark led to a substantial decline in the spread; from 9 % at the beginning of January, to 7% at the end of April and to 4.5% in October; i.e. at a level even lower than the previous realignment. Figure 1 shows a similar dynamics of the interest rate in two Italian episodes of the late 1980s. In April 1986 the Italian lira was devalued by 3% against the Deutsche mark and two months later the interest-rate spread stood at 7% compared to 11% at the beginning of April and to 8% in August 1985. The Italian realignment of January 1990 also led to a decline in the interest spread.

Interestingly, during the same period the dynamics of interest rates in France, a country with no debt problems was different. Indeed, Figure 3 shows that the spread between French and German rates actually increased after both the realignments of April 1986 and January 1987. The interest-rate spread also widened in Italy and Ireland after the 10% devaluation of the Italian lira in July 1985 and the 8% devaluation of the Irish punt in August 1986.[3] A possible explanation for such a different behavior is that while the former episodes involved all ERM participants, the latter Irish and Italian devaluation were against all other ERM currencies. It is likely that such unilateral realignments caused a loss of credibility in the government anti-inflationary stance. Indeed, Rose and Svensson (1994) presents clear evidence suggesting the importance of cooperative behavior for the credibility of the ERM.

In the following sections we examine the importance of fundamentals and government's credibility in affecting the probability that the exchange rate will be maintained. In the next section we focus on the role of fundamentals showing that a short maturity impairs the government ability to withstand a crisis, independently of self-fulfilling mechanisms.

3. The government problem

To study the role of fiscal fundamentals in currency crises we consider a three-period open economy version of the Barro-Gordon (1983) model where the unexpected inflation that follows a devaluation increases output both through a standard price-output effect and through a tax-reduction effect. The model extends the analysis of Drazen and

[2]Similar evidence is presented by Rose and Svensson (1994). We do not report interest-rate spreads for 1-month and 1-year maturity, since they follow the same pattern. Evidence for Belgium, Denmark and the Netherlands is also not informative because realignments were minor and infrequent. The Dutch guilder was actually revalued along with the Deutsche mark, while the size of Belgian franc devaluations in the 1986 and 1987 episodes was smaller than for weak currencies. The Danish krona behaved in the same way in the 1986 episode.

[3]The Italian spread also increased after the realignment of January 1987.

Masson (1994) to the consideration of public debt. As in Velasco (1996), we assume that levying taxes (in the last period) to service the public-debt is costly. These distortions increase the incentive to devalue. However, we focus on domestic instead of foreign debt and explicitly consider the role of debt maturity. We assume that output is stochastic to take into account that the government's decision to devalue depends on external circumstances in addition to the relative cost of devaluation and output deviations from target. The approach is based on Obstfeld's (1997) model of escape clauses and captures the idea that even a reliable policymaker, fully committed to the fixed parity, will devalue if the economy is hit by unusually-large shocks.

The sequence of events is as follows. At the beginning of period 0, the government inherits a given stock of public debt made of one-period and two-period fixed-rate bonds denominated in the domestic currency. The interest payments on both types of debt are determined by (rational) inflation expectations. In period 1, after the realization of the output shock, the government decides whether to devalue or maintain the fixed parity and then rolls-over one-period debt. In period 2, after the realization of a second shock, the government decides whether to devalue and finally repays the debt by levying distortionary taxes.

The decision to devalue determines whether inflation takes place and the nature of the inflation process. In case of a devaluation in period 1 the country undergoes an inflation spell which is halted by subsequent re-pegging. When devaluation takes place in both periods the country can be thought as going on "float".

We make two simplifying assumptions. First, as in Giavazzi and Pagano (1990) and Obstfeld (1994), we assume that taxes are levied only in the last period. Second, unlike in the literature on currency crises, we take the size of a devaluation as given, i.e. not depending on the magnitude of the shock. Therefore, the government's choice is between the rule of a fixed parity and the alternative of a devaluation of a fixed size. This simplifies the analysis since it avoids the explicit consideration of a fixed cost of devaluation.[4] The consequences of both assumptions are discussed in Section 3.2 after we derive the basic insights from the present framework.

The government weighs the cost of devaluation against the output deviation from the target y^* according to the following loss function:

$$E_0 L = E_0[\theta \pi_1^2 + (y_1 - y^*)^2] + \beta E_0[\theta \pi_2^2 + (y_2 - y^*)^2] \tag{1}$$

where θ measures the cost of devaluation relative to output and $0 < \beta < 1$ is the discount factor. π_i denotes the rate of devaluation in period $i = 1, 2$ and can take two values: 0, if the fixed parity is maintained, and -d- in case of devaluation.

A devaluation increases output and reduces the cost of debt stabilization, since it leads to unexpected inflation. We make the simplifying assumption that the inflation

[4]Following Drazen and Masson (1994), for the exchange-rate mechanism of the EMS, a defense of this assumption can be based on informal evidence that the size of realignments were not the sole discretion of the single countries.

rate is equal to π_i, the rate of devaluation.[5] Output rises in both periods because of a standard price-output effect and, in the second period, also because of the reduction in the real value of nominal debt that allows for lower taxes and tax distortions:

$$\begin{aligned} y_1 &= y^* + (\pi_1 - E_0\pi_1) - k - u_1 \quad (2) \\ y_2 &= y^* + (\pi_2 - E_1\pi_2) - k - T - u_2 \quad (3) \end{aligned}$$

The output deviation from target depends on goods (or labor) market distortions k, on unexpected inflation, $\pi_i - E_{i-1}\pi_i$, and on taxes (or tax distortions), T, which are levied in the second period to repay the debt.

Output is affected by first- and second-period shocks, u_i, which are independently and uniformly distributed over the interval $[-v, v]$. We assume that output shocks are publicly observed. Although this assumption complicates the analysis, we feel uncomfortable with the idea that the private sector is unable to observe macro variables.

Taxes are derived from a linearization of the government budget constraint. Since nominal interest rates reflect expected devaluation (and inflation), and the foreign interest rate is assumed equal to zero, the value of taxes to be levied at the end of period 2, is given by[6]

$$\begin{aligned} T &= (1 + E_0\pi_1 + E_0\pi_2 - \pi_1 - \pi_2)B_2 + (1 + E_0\pi_1 + E_1\pi_2 - \pi_1 - \pi_2)B_1 \\ &= [1 - (\pi_1 - E_0\pi_1) - (\pi_2 - E_0\pi_2)](B_1 + B_2) + (E_1\pi_2 - E_0\pi_2)B_1 \quad (4) \end{aligned}$$

where B_1 and B_2 denote the real value, as of period 0, of one-period and two-period debt, respectively. Finally, we assume that $0 \leq d \leq 0.5$. This restriction is implicitly required by the linearization of the budget constraint, in order to avoid an inflation tax on public debt which exceeds the debt value.[7]

Substituting the real value of taxes into the output equation (3) yields

$$y_2 - y^* = (\pi_2 - E_0\pi_2)m + (\pi_1 - E_0\pi_1)B - (E_1\pi_2 - E_0\pi_2)S - K - u_2 \quad (5)$$

where $B = B_1 + B_2$ is the real value of total debt at period 0, $m = 1 + B$, $S = 1 + B_1$ and $K = k + B$ is the expected deviation of output from target.

The output effect of a revision in expectations depends on the term $S = 1 + B_1$ which increases with short-term debt, B_1. If a devaluation leads to an upward revision in the interest rate, then the government is worse off the shorter the maturity of its debt (the higher S), because short-term debt is refinanced at higher-than-expected interest rates.

[5]Within the present framework purchasing power parity can be assumed without any loss of generality since the debt is denominated in domestic currency and with a devaluation of a fixed size its cost θ can always be re-normalized to account for the difference between devaluation and inflation rates.

[6]Note that T can be interpreted as the output loss from taxation once B is taken as the product of debt repayments and their impact on output.

[7]In general the linearization of the budget constraint would reduce the likelihood of multiple equilibria (see e.g. Calvo 1988 and Obstfeld 1994). However, in the present model multiple equilibria are already ruled out by the assumption that the rate of devaluation is of fixed size (see Section 3.2).

This is the case if the devaluation leads to the expectation of a further depreciation of the exchange rate. On the other hand, if interest rates turn out to be lower than expected, the benefits of a devaluation increase with short-term debt. This happens if the inflation that follows a devaluation reduces the debt burden and thus the need for future devaluation. For the same reason, however, a short-maturity debt creates an incentive to devalue, thus giving rise to unfavorable expectations about the government's resolution to resist a currency crisis. This effect of debt maturity is studied in the next section.

3.1 When only fundamentals matter

In this section we examine how public debt and debt maturity affect the probability of devaluation when the cost of devaluation, θ, is known to the private sector. Since the government's credibility is not an issue in forming expectations, the credibility of the exchange-rate regime just depends on fundamentals.

The timing of decisions is as follows. In period 0 the private sector forms expectations about inflation in period 1 and 2 which determine the short- and long-term interest rates on the nominal bonds issued by the government. At the beginning of period 1 the output shock, u_1, is observed and the government decides whether to devalue or maintain the fixed parity. At the end of the same period the private sector revises its expectations about second-period inflation and thus determines the interest rate at which the maturing debt, B_1, is refinanced. Finally, in period 2 a new output shock, u_2, is observed which makes the government devalue or maintain the fixed parity.

To derive the probability of devaluation in periods 1 and 2, we first examine the impact of a first-period devaluation on the probability of a second-period devaluation and then go back to the first-period problem.

In period 2 the government devalues and inflates by a fixed size d, if the loss from doing so is lower than the loss of defending the exchange rate, that is, if

$$\begin{aligned}\theta d^2 + [(d - E_0\pi_2)m + (\pi_1 - E_0\pi_1)B - (E_1\pi_2 - E_0\pi_2)S - K - u_2]^2 \\ < [-E_0\pi_2 m + (\pi_1 - E_0\pi_1)B - (E_1\pi_2 - E_0\pi_2)S - K - u_2]^2\end{aligned} \tag{6}$$

Hence, the government devalues for output shocks, u_2, such as

$$u_2 > U_2^*(j) \equiv \frac{\theta d}{2m} + \frac{dm}{2} - mE_0\pi_2 + (\pi_1 - E_0\pi_1)B - (E_1\pi_2(j) - E_0\pi_2)S - K \tag{7}$$

where the index $j = D, F$ indicates that expectations are conditional on the government having devalued or maintained the fixed parity in period 1. The threshold shock, U_2^*, depends on whether the government has devalued in period 1, both directly through, π_1, and through a revision in expectations, $E_1\pi_2(j) - E_0\pi_2$. A devaluation in period 1, i.e. $\pi_1 = d$, reduces the likelihood of a second-period devaluation. A downward revision in expected inflation, $E_1\pi_2$, and thus in the interest rate, decreases the probability of a second-period devaluation to the extent that the debt is short-term. Thus, the first-period shock, u_1, affects the threshold, U_2^*, only indirectly, through its effect on the government's first-period choice.

Recalling that the shock u_2 is uniformly distributed over the interval $[-v, v]$, the probability, as of period 1, of a second-period devaluation is equal to

$$\rho_2(j) = Prob[u_2 > U_2^*(j)] = \frac{v - U_2^*(j)}{2v}$$

where $-v \leq U_2^*(j) \leq v$ is assumed.

Then, using equation (7) and noting that $E_1\pi_2(j) = d\rho_2(j)$, we have

$$\begin{aligned} E_1\pi_2(F) &= \frac{d}{2v - dS}[v + K + E_0\pi_1 B + E_0\pi_2 B_2 - \frac{dm}{2} - \frac{\theta d}{2m}] \\ E_1\pi_2(D) &= \frac{d}{2v - dS}[v + K + E_0\pi_1 B + E_0\pi_2 B_2 - \frac{dm}{2} - \frac{\theta d}{2m} - dB] \end{aligned}$$

The inflation rate which is expected after maintaining the parity, $E_1\pi_2(F)$, is greater than that expected after a devaluation, $E_1\pi_2(D)$. Hence —under symmetric information— a first-period devaluation always improves the likelihood that the new parity will be maintained. This result is not surprising as we observe that a first-period devaluation reduces the debt burden and, thus, the expected deviation of second-period output from target.

Now consider the government's choice in period 1. The government devalues if the net loss it experiences in period 1, $L_{1D} - L_{1F}$, is lower than the second-period gain it expects from devaluing instead of maintaining the fixed parity, that is, if

$$L_{1D} - L_{1F} < \beta[E_1L_2(F) - E_1L_2(D)]$$

where the terms F and D in parentheses indicate that the expected second-period losses are conditional on the first-period action.

Integrating $L_2(j) = \theta\pi_2^2 + [y_2(j) - y^*]^2$ over the interval $[-v, v]$ and noting that in period 2 the government devalues for shocks greater than U_2^*, we obtain the expected loss for period 2:

$$E_1L_2(j) = v^2/3 - 2vdm[\rho_2(j)]^2 + [-E_0\pi_2 m + (\pi_1 - E_0\pi_1)B - (E_1\pi_2(j) - E_0\pi_2)S - K]^2 \quad (8)$$

Finally, noting that

$$L_{1D} - L_{1F} = \theta d^2 + d^2 - 2d(k + E_0\pi_1) - 2du_1 \quad (9)$$

the government devalues in period 1 for output shocks such as

$$u_1 > U_1^* \equiv (1/2d)\left\{\theta d^2 + d^2 - 2d(k + E_0\pi_1) - \beta[E_1L_2(F) - E_1L_2(D)]\right\} \quad (10)$$

The threshold U_1^* depends on the expected second-period loss differential which in turn depends on the expected second-period devaluation, $E_0\pi_2$. The latter is equal to

$$E_0\pi_2 = \frac{U_1^* + v}{2v} E_1\pi_2(F) + \frac{v - U_1^*}{2v} E_1\pi_2(D) = \frac{d}{2v - dm}[v + K - \frac{dm}{2} - \frac{\theta d}{2m}] \qquad (11)$$

Interestingly, equation (11) shows that expected inflation and thus the probability of a devaluation in period 2 do not depend on debt maturity. The intuition for this result is that the maturity of the debt affects both the probability of a devaluation in period 1 and (both short- and long-term) interest rates. For given interest rates, a shorter maturity, which increases the probability of a devaluation in period 1, tends to reduce the likelihood of a second devaluation. However, a shorter maturity also increases interest rates and tax distortions with offsetting effects on the probability of a second-period devaluation.

Substituting equations (11) and (8) for $E_0\pi_2$ in U_1^*, the probability of a first-period devaluation can be derived as follows

$$\rho_1 = \frac{v - U_1^*}{2v} = \frac{1}{2} + \frac{(2k - \theta d)(2v - dS)^2 + 4v\beta(2v - dS)B(k + B)}{(4v - 2d)(2v - dS)^2 - 4v\beta(2v - dm)dB^2}$$

The probability of a devaluation decreases with its cost to the government, θ, and increases with distortions, chiefly, with the debt burden, B. More interestingly, the probability increases with the share of short-term debt, B_1, as shown by deriving ρ_1 with respect to B_1, while holding the total debt constant. $\partial\rho_1/\partial B_1$ is proportional to

$$\frac{\partial\rho_1}{\partial B_1} \propto k + B + \frac{2v - dm}{2v - dS}(2BE_0\pi_1 - dB) \geq 0$$

With symmetric information, long-term debt not only minimizes the probability of an exchange-rate devaluation, but is also optimal for the government. This result follows from the government loss being increasing in interest rates and thus in the probability of a first-period devaluation, as can be shown after computing the government loss expected at period 0.

The risk that short-term debt may trigger a currency crisis is known from the work of Giavazzi and Pagano (1990), Obstfeld (1994), Sachs, Tornell and Velasco (1996) and Calvo (1998), among others. In this literature short-term debt creates a potential for multiple equilibria; the expectation of a devaluation is self-fulfilling since it leads to higher interest rates, higher roll-over costs and thus a greater incentive to devalue. In our model instead long-term debt reduces the probability of a devaluation even if there is no intrinsic uncertainty. The maturity of the debt has a pre-commitment role; as in Lucas and Stokey (1983) it eliminates the temptation to alter the path for interest rates. This temptation arises because with output uncertainty a current devaluation, being partly unexpected, reduces the real value of public debt, thus reducing the government's incentive to devalue in the second period and the interest rate. A large share of debt to be rolled-over would create an incentive to devalue in order to exploit a lower interest rate. Alternatively, a short maturity debt would make it costly for the government to resist a crisis when a bad shock occurs, since a large share of debt would be rolled-over at higher-than-expected interest rates.

Having derived the basic insight of the model, we now examine whether this result holds under more general assumptions about the timing of taxation and the possibility to choose the rate of inflation.

3.2 Optimal debt maturity: an assessment

We have made two simplifying assumptions: i) that the government cannot raise taxes in period 1 to counter a currency crisis and; ii) that, when the government decides to devalue, it cannot choose the inflation rate optimally but it devalues and inflates by the fixed amount d.

Both assumptions play an important role for the choice of debt maturity. Calvo and Guidotti (1990a,b 1992) show that, if inflation is chosen optimally and taxes are levied in both periods, then a balanced maturity structure is optimal. In their model the government acts opportunistically every period, since there is no fixed cost of inflating or other forms of commitment that offset inflationary temptations.[8] Within that framework complete tax and inflation smoothing is not optimal; raising taxes early is valuable since a faster debt repayment allows to reduce the inflation-tax base and inflation in the second period. In other words, the inflation bias associated with nominal public debt leads to debt aversion which is stronger the higher the share of the debt to be rolled-over. The role of a balanced maturity structure is to provide incentives that support the optimal mix of debt aversion and tax (and inflation) smoothing. The intuition is that short-term debt sets an incentive to raise taxes early and to reduce the nominal debt (since such debt can be rolled-over at lower interest rates reflecting the reduced debt level), while long-term debt is needed to smooth taxes and inflation over time (since it provides an incentive to postpone inflation and taxes to the future).

Since Calvo and Guidotti's analysis concerns the role of debt maturity for the inflation bias in a monetary regime with no form of commitment, it cannot characterize an exchange rate pegging. Indeed, a fixed exchange rate is a form of commitment to low inflation –a rule with an escape clause according to Obstfeld (1997)– and it is standard in the literature to assume there are fixed costs of devaluation, for example, due to credibility and political costs.[9] To capture such costs (and simplify the analysis) we assume that the government cannot choose inflation optimally when it devalues. We depart from Calvo and Guidotti's framework since we are interested in the role of debt

[8]Calvo and Guidotti (1990b) also examine the role of inflation-indexed debt (and foreign currency debt) in committing to low inflation and show that its availability alters the role of nominal debt maturity.

[9]See Kock and Grilli (1993) for a formalization of the costs of lost reputation. Governments that commit to a peg and then devalue also face voter disapproval and, at times, removal from office that are not proportional to the size of the devaluation. Fixed costs are assumed by Obstfeld (1994,1997), Ozkan and Sutherland (1995,1998) and Velasco (1996), among many others.

maturity in currency crises.

Typically, models of currency crises combine a fixed cost of devaluation with gains and losses of fully controlled inflation. A main implication of a fixed inflation rate is to rule out multiple equilibria that would naturally arise in a standard framework and therefore a potential role for debt maturity in coordinating private sector's expectations to the good equilibrium.[10] However, the consideration of multiple equilibria would strengthen the argument for long-term debt. In models of currency crises short-term debt exposes the government budget to expectations-driven increases in the interest rate which are self-fulfilling.[11] A long maturity is optimal since it insulates the budget from changes in the interest rates thus ruling out the possibility for a crisis to materialize as shown by Giavazzi and Pagano (1990) for conventional debt and by Obstfeld (1994) for both conventional and foreign denominated debt (see also Sachs, Tornell and Velasco 1996). The main message of our analysis is that a role for long-term debt also emerges when exogenous uncertainty is considered and current decisions affect debt accumulation and hence the probability of a future devaluation. There is no need for intrinsic uncertainty: short-term debt increases the likelihood of a current crisis simply because a successful defense of the parity implies a higher-than-expected debt accumulation and, hence, higher-than-expected interest rates at which the maturing debt must be rolled-over.

Finally, it is important to ask what would be the implications for debt maturity of introducing first-period taxation in our model. The possibility of levying taxes would obviously reduce the likelihood of a crisis in the first-period, but it would also call for a more balanced maturity structure. Short-term debt creates an incentive not only to devalue but also to raise taxes and accelerate debt repayments in order to avoid rolling-over the debt at higher-than-expected interest rates. The result that only long-term debt is optimal changes in the result that the maturity should be as long as to avoid new debt issues in the first period, as suggested by Obstfeld (1990,1994).

While introducing first-period taxation is straightforward under symmetric information, we do not extend the analysis along this direction, since this would prevent an analytical examination of the effect of debt and debt maturity under asymmetric information, to which we now turn.[12]

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[10] With asymmetric information, the choice of a lower inflation rate could have a signaling effect and other separating equilibria would emerge. However, to the extent that the government devalues and inflates only for large shocks, the signaling role of inflation would be of limited relevance.

[11] Although in currency crisis models there is no role for short-term debt, in a reputation model where the government consistently chooses not to inflate, short-term debt can provide a substitute for inflation-indexed debt, since the impact of inflation on its real value is short lived and thus small are the gains from inflationary financing (see Missale and Blanchard 1994).

[12] The introduction of first-period taxation creates also a potential for using taxes to signal the government's resolution not to devalue, as in Drudi and Prati (2000).

4. Credibility of government

A successful defense of the exchange rate may depend as much on the government's reputation as on fundamentals, since interest rates also reflect the beliefs of the private sector in the government's resolution not to devalue.

In this and the following sections we consider the case of asymmetric information where private agents do not know the government's preferences. The government can be of two types; it can be tough (with superscript T) in that it assigns a high weight, θ^T, to the event of devaluation in its loss function, or it can be weak (with superscript W) if such weight, θ^W, is relatively low: $\theta^T > \theta^W$. Finally, the government's prior reputation is equal to q_0. More precisely, $0 \leq q_0 \leq 1$ is the prior belief of the private sector that the government is tough.

In what follows we shall consider pooling and separating equilibria where the equilibrium concept is the standard Perfect Bayesian Equilibrium. Interestingly, the equilibrium, separating or pooling, which prevails in period 1 for any given realization of the output shock u_1, will depend on the maturity of the debt since the latter affects the government's decision to devalue in period 1. However, departing from the normative literature on debt management stemming from Lucas and Stokey (1983), we do not examine the choice of debt maturity.[13] This would require to consider a reputation game in period 0 (along with the game in period 1) where the choice of debt maturity possibly signals the government type. Since such problem cannot be solved analytically, we assume that the government inherits a given maturity structure, B_1, B_2. Given that the maturity is the same for both governments, they face the same interest rates, $E_0\pi_1$ and $E_0\pi_2$.[14]

4.1 Costs and benefits of devaluations

In deciding its policy, a government will be concerned with the reputation effects of a devaluation. It will compare the effect on interest rates of a lost credibility with that of a reduction in the debt burden. This aspect of the government's problem is formalized by the impact of the first-period decision on the expected second-period loss which is equal to

$$E_1^i L_2^i(j, u_1) = \theta^i E_1^i \pi_2^2 + E_1^i[(\pi_2 - E_0\pi_2)m + (\pi_1 - E_0\pi_1)B - (E_1\pi_2 - E_0\pi_2)S - K - u_2]^2$$

where E_1^i denotes expectations (as of period 1) of government i, which differ from private

[13]The normative literature is surveyed in Missale (1997,1999).

[14]We have considered the case where the government chooses debt maturity in period 0 and examined through numerical simulations whether such choice may reveal the government type. Since under full information both governments prefer long- to short-term debt, there seems to be a possibility for the tough government to signal its type by issuing short-term debt. However, a weak government has also a strong incentive to disguise itself as tough in order to exploit lower interest rates; it will choose the same maturity as the tough government, unless this choice entails a greater marginal cost than for the tough government. We have explored the problem numerically and have not found a separating equilibrium where the type of government is revealed in period 0.

sector's expectations, E_1, insofar as θ^i is private information. In particular, the expectations of the private sector and thus the interest rate in period 2, $E_1\pi_2$, are conditional on the government's decision to devalue or maintain the fixed parity, $j = D, F$ and on the output shock, u_1, to the extent that the joint event $j \cap u_1$ allows to distinguish the government type.

To derive the expected loss we first find the threshold, U_2^*, beyond which the shock u_1 triggers a second-period devaluation. The government devalues and inflates (by a fixed size d) if the loss from doing so is lower than the loss from maintaining the fixed parity and, hence, for shocks such as

$$u_2 > U_2^{*i}(j, u_1) \equiv \frac{\theta^i d}{2m} + \frac{dm}{2} - mE_0\pi_2 + (\pi_1 - E_0\pi_1)B - (E_1\pi_2 - E_0\pi_2)S - K \quad (12)$$

This condition is analogous to the full-information case, except for the dependence of $U_2^{*i}(j, u_1)$ on the government type, θ^i, and on the joint event $j \cap u_1$. In particular, the realization of the first-period shock may now reveal the government type, since for certain shocks the decisions of the two governments differ.

Integrating $L_2^i(j, u_1)$ over the interval $[-v; v]$ and using condition (12) yields

$$E_1^i L_2^i(j, u_1) = v^2/3 - 2vdm[\rho_2^i(j, u_1)]^2 + [-E_0\pi_2 m + (\pi_1 - E_0\pi_1)B - (E_1\pi_2 - E_0\pi_2)S - K]^2 \quad (13)$$

where ρ_2^i is the probability of a second-period devaluation, as perceived by government i. It follows that the expected loss differential from maintaining the fixed parity instead of devaluing in period 1 is equal to[15]

$$E_1^i L_2^i(F, u_1) - E_1^i L_2^i(D, u_1) = [\rho_2^i(F, u_1) - \rho_2^i(D, u_1)]2v[2y^* - E_1^i y_2^i(F, u_1) - E_1^i y_2^i(D, u_1)] \quad (14)$$

This expression shows that the sign of the loss differential depends on $\rho_2^i(F, u_1) - \rho_2^i(D, u_1)$, that is, on the difference in the probability, as perceived by government i, of a second-period devaluation which results from maintaining the fixed parity instead of devaluing. Indeed, the second term in brackets is positive insofar as the government expects the second-period output below target (regardless of its first-period action and private sector expectations). It is sensible to restrict parameter values so as to rule out the economically unplausible case that, on average (ie. for $u_2 = 0$), the government wants to appreciate in period 2 as a result of an "overdevaluation" in period 1.[16]

Therefore, the sign of the expected loss differential is determined by the probability differential

$$\rho_2^i(F, u_1) - \rho_2^i(D, u_1) = \frac{dB}{2v} - [E_1\pi_2(D, u_1) - E_1\pi_2(F, u_1)]\frac{1 + B_1}{2v} \quad (15)$$

[15]We use the fact that

$$E_1^i y_2^i(j, u_1) - y^* = (d\rho_2^i(j, u_1) - E_0\pi_2)m + (\pi_1 - E_0\pi_1)B - (E_1\pi_2 - E_0\pi_2)S - K$$

[16]Since we assume $d \leq 0.5$, so as to ensure $T \geq 0$, a sufficient condition for the government to expect output below the target is $k > d$.

which is independent from the government type (unlike each single probability), and can take either a positive or a negative sign. The probability differential depends on the level of debt, on private sector's expectations and on short-term debt B_1.

A first-period devaluation, by reducing the debt burden, may reduce the probability of a second-period devaluation. If a devaluation does lead to lower interest rates than a defense of the parity —i.e. if $E_1\pi_2(D, u_1) < E_1\pi_2(F, u_1)$— then the government experiences a second-period gain. This gain increases with the share of short-term debt, B_1, which is rolled-over at lower-than-expected interest rates. This is what we have seen in the case of symmetric information. Intuitively, the level of debt must be high relative to the uncertainty about the government type for such effect to prevail. We call it the "debt-burden" effect.

However, a first-period devaluation may reveal a weak government heading to further devaluation and, thus, it may lead to higher expected inflation and interest rates; i.e. $E_1\pi_2(D, u_1) > E_1\pi_2(F, u_1)$. If following a devaluation the interest rate rises so much that the probability differential becomes negative, then the government expects a second-period loss from abandoning the fixed parity. This provides both governments with an incentive to defend the exchange rate. A short maturity debt, i.e. a large B_1, is crucial to ensure such effect. Intuitively, this case is relevant when the difference in governments' preferences is large and a successful defense of the exchange rate send a strong signal about the government's resolution not to devalue, that is, if the "signaling" effect prevails over the "debt-burden" effect.

We have shown that the interest rate differential $E_1\pi_2(D, u_1) - E_1\pi_2(F, u_1)$ plays a key role in determining the probability of a first-period devaluation. Interest rates depend on a number of factors and, in particular, on whether the output shock and the government's action allow to distinguish the government type. To solve for interest rates, we examine the equilibrium of the reputation game.

4.2 The reputation game

A broad characterization of the equilibrium is as follows. For very low realizations of the first-period shock both governments choose to maintain the fixed parity with probability 1. The resulting equilibrium is pooling in pure strategy with no updating of beliefs from period 1 to period 2. For greater realization of the shock u_1, the tough government prefers to hold the exchange rate fixed while the weak government has an incentive to disguise itself as being tough, in order to experience lower interest rates. However, its prior reputation may not be high enough for a pooling equilibrium to exist in pure strategies. The weak type will randomize so as to increase its reputation in case the exchange rate parity is maintained. Only by doing so the weak government will experience an interest rate so low as to make it indifferent between defending the exchange rate or devaluing. As the first-period shock is sufficiently high, the weak government is better off by devaluing and revealing itself, so that the two governments separate and uncertainty is fully resolved. For very high shocks even a tough government, fully committed to defend the exchange rate, may find a devaluation the only way out. Hence, for very high shocks both governments will devalue but the tough government has no incentive to pretend to be the weak, since it would only experience higher interest rates.[17] Put it simply, for the tough government there is no reason to randomize; by doing so it just decreases the probability of being recognized as tough when a devaluation is observed and benefit from a lower interest rate. So in equilibrium both governments devalue with probability 1.

In the Appendix we prove the existence of the following equilibrium. Define with U_{pm} the lower bound of the interval of shocks, u_1, for which the weak government randomizes, with U_{s1} the threshold beyond which it devalues with probability 1 and with U_{s2} the threshold beyond which the tough government devalues. Furthermore, indicate with the subscript $i = p, s$ in $\rho(j_i)$ whether the action $j = F, D$ (i.e. hold the exchange rate fixed or devalue) is taken for shocks in the pooling interval, p, or in the separating interval, s. Then, we have the following equilibrium

Equilibrium

Event	*Beliefs*	*Interest rates*
$D \cap u_1 \in [-v, U_{s1}]$	$q_1 = 0$	$E_1\pi_2(D) = d\rho_2^W(D_s)$
$F \cap u_1 \in [-v, U_{s1}]$	$q_1 \geq q_0$	$E_1\pi_2(F) = (1-q_1)d\rho_2^W(F_p) + q_1 d\rho_2^T(F_p)$
$D \cap u_1 \in [U_{s1}, U_{s2}]$	$q_1 = 0$	$E_1\pi_2(D) = d\rho_2^W(D_s)$
$F \cap u_1 \in [U_{s1}, U_{s2}]$	$q_1 = 1$	$E_1\pi_2(F) = d\rho_2^T(F_s)$
$D \cap u_1 \in [U_{s2}, v]$	$q_1 = q_0$	$E_1\pi_2(D) = (1-q_0)d\rho_2^W(D_p) + q_0 d\rho_2^T(D_p)$
$F \cap u_1 \in [U_{s2}, v]$	$q_1 = 1$	$E_1\pi_2(F) = d\rho_2^T(F_s)$

where

$$\begin{aligned}
\rho_2^W(F_p) &= \frac{1}{2v - dS}[v + H - \frac{dm}{2} - \frac{\theta^W d}{2m} - q_1\frac{(\theta^T - \theta^W)d^2 S}{4vm}] \\
\rho_2^T(F_p) &= \frac{1}{2v - dS}[v + H - \frac{dm}{2} - \frac{\theta^T d}{2m} + (1-q_1)\frac{(\theta^T - \theta^W)d^2 S}{4vm}] \\
\rho_2^W(D_s) &= \frac{1}{2v - dS}[v + H - \frac{dm}{2} - \frac{\theta^W d}{2m} - dB] \\
\rho_2^T(F_s) &= \frac{1}{2v - dS}[v + H - \frac{dm}{2} - \frac{\theta^T d}{2m}] \\
\rho_2^W(D_p) &= \frac{1}{2v - dS}[v + H - \frac{dm}{2} - \frac{\theta^W d}{2m} - q_0\frac{(\theta^T - \theta^W)d^2 S}{4vm} - dB]
\end{aligned}$$

[17]This follows from the fact that after pooling in period 1 the interest rate is decreasing in reputation.

$$\rho_2^T(D_p) \;=\; \frac{1}{2v - dS}[v + H - \frac{dm}{2} - \frac{\theta^T d}{2m} + (1 - q_0)\frac{(\theta^T - \theta^W)d^2 S}{4vm} - dB]$$

where $H \equiv k + B + BE_0\pi_1 + (m - S)E_0\pi_2$ and $U_{s1} < U_{s2}$ are equal to

$$2dU_{s2} = \mu + \theta^T d^2 + \beta[\rho_2^T(D_s) - \rho_2^T(F_s)][\theta^T d^2 + 2v\eta(2H + dS - dm - dB) - \eta(\theta^T + \theta^W)d^2 S/2m]$$

$$2dU_{s1} = \mu + \theta^W d^2 + \beta[\rho_2^W(D_s) - \rho_2^W(F_s)][\theta^W d^2 + 2v\eta(2H + dS - dm - dB) - \eta(\theta^T + \theta^W)d^2 S/2m]$$

where $\eta \equiv (2v - dm)/(2v - dS)$ $\mu \equiv d^2 - 2d(k + E_0\pi_1)$ and

$q_1 = q_0$ for $u_1 \leq U_{pm}$ where

$$\begin{aligned} 2dU_{pm} \;&=\; \mu + \theta^W d^2 + \beta[\rho_2^W(D_s) - \rho_2^W(F_p)][\theta^W d^2 + 2v\eta(2H + dS - dm - dB) + \\ &-\; \eta(\theta^T + \theta^W)d^2 S/2m + (1 - q_0)\eta(\theta^T - \theta^W)d^2 S/2m] \end{aligned}$$

$q_1 > q_0$ for $U_{pm} < u_1 < U_{s1}$ and q_1 is equal to the positive root which solves

$$\begin{aligned} (1 - q_1)\beta\frac{(\theta^T - \theta^W)d^2 S}{(2v - dS)4vm}\left[\theta^W d^2 + 2v\eta(2H + dS - dm) - \eta\frac{\theta^T d^2 S}{m}\right] \;+ \\ + (1 - q_1)^2\beta\eta\frac{(\theta^T - \theta^W)^2 d^4 S^2}{(2v - dS)8vm^2} - 2d(U_{s1} - u_1) = 0 \end{aligned}$$

Proof: Substitute interest rates in the incentive compatibility constraints of governments and verify that such constraints are satisfied. Then, verify that expectations are correct.

5. Fundamentals versus signaling effects

Having characterized the equilibrium of the reputation game, we examine how a devaluation affects the credibility of the exchange-rate regime. The issue is whether a devaluation lowers credibility, leading to the expectation of further devaluation or actually improves people' confidence that the new parity will be maintained.

When improving reputation is important, maintaining the fixed parity and bearing the costs of servicing a large debt may send a strong signal about the government's resolution and increase the credibility of the exchange regime. Short-term debt strengthens the motivation for resisting the crisis, since interest rates would rise after a devaluation, making debt financing very costly.

However, when high interest rates are called for defending the exchange rate, the debt burden increases and so does the need for future inflation. Then, maintaining the peg may lower instead of enhancing the credibility of the exchange regime; by worsening the fiscal position, tight monetary policy may lead to higher inflation expectations, an effect which is reminiscent of Sargent and Wallace's (1981) "unpleasant monetaristic arithmetic." On the contrary, a current devaluation, by reducing the debt burden, may lower the probability of future devaluations and thus the interest rate. To the extent that the maturity of the debt is short, this sets an incentive for abandoning the fixed parity.

This intuition is confirmed by looking at the difference between the second-period inflation that is expected after a defense of the exchange rate and after a devaluation. Focusing on the interval of shocks where the tough government does not devalue, the difference in the expected second-period devaluation is equal to

$$E_1\pi_2(F) - E_1\pi_2(D) = \frac{d^2}{2v - dS}\left[B - q_1\frac{(\theta^T - \theta^W)}{2m}\right] \tag{16}$$

which is positive for high values of the debt, B and $m = 1 + B$, relative to the difference in government's preferences, $\theta^T - \theta^W$.

Therefore, a successful defense of the exchange rate may enhance the credibility of the exchange regime, but the difference between government types, $\theta^T - \theta^W$, must be large relative to the level of debt for the signaling effect to prevail over the debt-burden effect. The signaling effect is strengthened if the posterior reputation, q_1, is high as it is in case of large output shock u_1. This is because withstanding large shocks send a strong signal about government's intentions. Finally, the interest differential, either positive or negative, is enhanced by short-term debt, $S = 1 + B_1$.

Therefore, a successful defense of the exchange rate has an uncertain effect on the credibility of the exchange regime. If the difference between governments' preferences is large relative to the level of debt, then a traditional signaling effect prevails and credibility is enhanced. On the other hand, if fundamentals are more important than signaling, i.e. if the debt-burden effect prevails, then maintaining the fixed parity reduces the credibility of the exchange regime.

5.1 Expected devaluation and the slope of the yield curve

Public debt creates a link between current and future policy actions. Resisting a crisis possibly reduces instead of enhancing the credibility of a fixed exchange regime, since debt accumulation impairs the government's ability to stand future crises.

This motivates a further investigation of the role of reputation, debt and debt maturity on the probability of first- and second-period devaluation so as to derive predictions about the level and slope of the term structure of interest rates. In what follows we derive the expected (as of period 0) first- and second-period inflation rates, $E_0\pi_1$ and $E_0\pi_2$, that is, the short-term interest rate and the forward rate.

First consider the private sector's expectation (as of period 0) of a devaluation in period 2, $E_0\pi_2$. This expectation affects the interest rate on long-term debt and thus the thresholds U_{pm}, U_{s1} and U_{s2} for the shock u_1 beyond which the weak government devalues with some positive probability, with probability 1 and the tough government with probability 1, respectively. Noting that the weak government randomizes with a different probability for each realization of the shock u_1 in the interval $[U_{pm}, U_{s1}]$, it can be shown that

$$E_0\pi_2 = \frac{d}{2v - dm}[v + K - \frac{dm}{2} - \frac{q_0\theta^T d + (1 - q_0)\theta^W d}{2m}] \tag{17}$$

The second-period devaluation expected by the private sector in period 0, and thus the forward rate, is the same as in the case of full information, except for the cost of devaluation, θ, which is now replaced by its expectation. Likewise, the probability of a devaluation in period 2, and thus the forward rate, are not affected by debt maturity.

The private sector expectation of first-period devaluation can be derived by substituting the value of $E_0\pi_2$ from equation (17) in $H = k + B + BE_0\pi_1 + (m - S)E_0\pi_2$ and, then, by substituting H in U_{pm}, U_{s1} and U_{s2}. Noting that a devaluation may occur for shocks in the interval $[U_{pm}, U_{s1}]$ where the weak government randomizes, the expected devaluation in period 1, is equal to

$$\begin{aligned} E_0\pi_1 \quad &= \quad \frac{d}{2} + \phi\frac{d}{2}[2k - q_0\theta^T d - (1 - q_0)\theta^W d] + \beta\phi v(\gamma dB - QZ)2(k + B) \\ &- \quad \beta\phi v\eta dBZ(Q - 2q_0) - \beta\phi v(2v - dm)q_0 Z^2[q_0 + 2(1 - Q)(\lambda - 1)] \end{aligned} \tag{18}$$

where

$$\phi = [2v - d - 2v\beta\eta B(\gamma dB - QZ)]^{-1} \qquad\qquad Q = q_0[1 - ln(q_0)]$$

$$\gamma = \frac{1}{2v - dS} \qquad\qquad \eta = \frac{2v - dm}{2v - dS} \leq 1 \qquad\qquad \lambda = \frac{m(2v - dS)}{S(2v - dm)} \geq 1$$

and where the term

$$Z = \frac{(\theta^T - \theta^W)d^2 S}{(2v - dS)4vm}$$

captures the impact on the interest rate of the uncertainty about government's preferences, as determined by the difference, $\theta^T - \theta^W$, in the cost of devaluation.

Equation (18) shows that, apart from first-period effects (captured by the first two terms), the expected devaluation depends on the sign of $\gamma dB - QZ$. Combining equations (15) and (16) it can be shown that such term is equal to the difference in the probability of a second-period devaluation which results from maintaining the fixed-parity instead of devaluing in period 1, $\rho_2^i(F, u_1) - \rho_2^i(D, u_1)$. Therefore, the expected devaluation is higher the stronger is the debt-burden effect relative to the signaling effect.

To gain further insight, we can relate the expected devaluation, $E_0\pi_1$, to the expectation that the private sector would form, were it fully informed about the government's preferences. Let us assume that the full-information cost of devaluation, θ, is equal to its expected value when the government type is uncertain: $\theta = q_0\theta^T + (1 - q_0)\theta^W$. Then, denoting the full-information expected devaluation as $E_0\pi_1^{FI}$, equation (18) can be arranged as follows

$$E_0\pi_1 = \alpha E_0\pi_1^{FI} - \beta\phi 2vZ[Qk + B(Q - q_0\eta d)] - \beta\phi v(2v - dm)q_0 Z^2[q_0 + 2(1 - Q)(\lambda - 1)] \tag{19}$$

where

$$\alpha = \phi[2v - d - 2v\beta\eta\gamma dB^2] < 1$$

Equation (19) shows that the uncertainty about government's preferences reduces the expectation of a first-period devaluation below its value under symmetric information. (Note that $\alpha < 1$; that $Q > q_0$; $\eta d < 1$; and $\lambda \geq 1$). Improving reputation sets a strong incentive to resist a crisis; a tough government wants to maintain the fixed parity to signal its type, while a weak government wants to disguise itself as tough and exploit lower interest rates. The greater the difference between government types, Z, the lower the probability of a first-period devaluation, as perceived by the private sector. This follows from an increase in the preference distance, $\theta^T - \theta^W$, and thus in Z, which leaves the expected cost of devaluation, $q_0\theta^T + (1 - q_0)\theta^W$, unaffected.

Signaling effects play a key role in determining the slope of the yield curve. For any given level of debt, a greater uncertainty about government's preferences implies lower short- (and long-term) interest rates and a steeper yield curve. This follows from the fact that the probability of a second-period devaluation, and hence the forward rate $E_0\pi_2$, is not affected by the uncertainty about government's preferences. The perception of a government's incentive to enhance its reputation by resisting a crisis helps to reduce the expectation of an imminent devaluation but does not affect the credibility of the exchange-rate regime in the long run. In other words, reputational incentives reduce the short-term interest rate but have no impact on the forward rate, as the latter just depends on fundamentals.

5.2 The effect of debt accumulation

The impact of public debt on the expectations of a first-period devaluation depends on the relative importance of debt-burden and signaling effects. Assuming for notational convenience that all the debt is short-term, the derivative of $E_0\pi_1$ with respect to the level of debt B is proportional to[18]

$$\begin{aligned} \frac{\partial E_0\pi_1}{\partial B} &\propto (\gamma dB - QZ)2[\gamma dkQ^2 + (1 + \gamma dB)(Q^2 + Q^2E_0\pi_1 - dQq_0)] + \\ &+ (\gamma dB - QZ)(\gamma dB + QZ)q_0^2 + 2Q^2[\gamma dk + \gamma dB(1 + E_0\pi_1 - d)] \\ &+ d\gamma dB[2Qq_0 - \gamma dB(Q - q_0)^2] \end{aligned} \tag{20}$$

where $\gamma dB - QZ$ determines the sign of the first two terms while the last two terms are positive.[19] It follows that the effect of public debt depends on the sign of $\gamma dB - QZ$; i.e. on whether the debt-burden or the signaling effect prevails. When there is little uncertainty about the government type, so that Z tends to zero, debt accumulation

[18] A similar result obtains for a change in B, which leaves the shares of short- and long-term debt constant. The result is available upon request.

[19] Note that γdB is equal to the difference in the probability of a second-period devaluation from maintaining the fixed parity instead of devaluing in the case of symmetric information and therefore $\gamma dB \leq 1$.

increases the probability, as perceived by the private sector, of a first-period devaluation, as in the case of symmetric information. On the other hand, if the uncertainty about government's preferences is substantial, the effect of debt accumulation is non monotonic. At low levels of debt (negative and large $\gamma dB - QZ$) the signaling effect prevails: public debt strengthens the signal of a successful defense of the fixed parity. As the private sector anticipates the government's incentive to improve reputation, it assigns a lower probability to the event of a first-period devaluation. At high levels of debt (positive $\gamma dB - QZ$) the debt-burden effect prevails: debt accumulation worsens the credibility of the exchange regime.

This findings suggest that at the early stages of debt accumulation an increase in public debt may lead to a steeper yield curve, while, at high levels of debt, short-term interest rates should rise more than long-term rates. The model also predicts that short-term rates should increase relative to long-term rates, as doubts vanish on the government's determination to maintain the fixed parity and low inflation.

5.3 The role of debt maturity

As we assume that the government inherits the debt composition, the issue of optimal debt maturity cannot be addressed. Nonetheless, it is interesting to examine the impact of debt maturity on the expected first-period devaluation. Consider an increase in the share of short term debt, B_1, which leaves the total stock of debt unaffected. The derivative of $E_0\pi_1$ with respect to B_1 is proportional to

$$\begin{aligned}\frac{\partial E_0\pi_1}{\partial B_1} &\propto (\gamma dB - QZ)\gamma dS[k + (1 + 2\eta E_0\pi_1 - \eta d)B + 2vZ(2q_0 - Q)(2v - dm)/dS] + \\ &- Z[Qk + (1 + \eta E_0\pi_1 - \eta d)QB + q_0\eta dB] - 2v\eta Z^2[(Q - q_0)^2 + q_0(1 - Q)(\lambda - 2)]\end{aligned}$$

The effect of a shorter debt maturity is ambiguous. While under symmetric information short-term debt increases the probability of a first-period devaluation, now it may enhance people confidence that the exchange parity will be maintained.

When there is little uncertainty about government's preferences, i.e. when Z tends to zero, the probability of a first-period devaluation increases with short-term debt. On the other hand, when the government's resolution to maintain the fixed parity is uncertain the effect of debt maturity depends on the level of debt. If the initial reputation is relatively high[20] —i.e. if $q_0 \geq 0.37$—, then a sufficient condition for short-term debt to enhance the credibility of the exchange regime is that $\gamma dB - QZ < 0$; i.e. that the signaling effect prevails over the debt burden effect.[21]

The reason why a short maturity may now reduce the probability of a first-period devaluation is that, insofar as it reveals a weak government, a current devaluation increases

[20]Note that $q_0 \geq 0.37$ implies $2q_0 > Q$ which is a sufficient condition for the first term in brackets to be positive, while the last two terms are negative for any $q_0 \geq 0.1$ since $d \leq 0.5$.

[21]Note instead that a prevalence of the debt-burden effect is not sufficient for short maturity to increase the probability of devaluation.

the expected devaluation, $E_1\pi_2$, and thus the interest rate. As a result, the incentive to resist a crisis and to avoid rolling-over the debt at higher-than-expected interest rates is stronger the shorter is debt maturity. However, to be an effective deterrent, the rise in interest rates must be substantial, which requires a high enough reputation to start with.[22]

This finding may explain why the role of debt maturity is controversial. When the focus is on reputation aspects, short-term debt may work as a commitment device that reduces inflationary expectations. On the other hand, when the attention is restricted to fundamentals, short-term debt is an additional source of risk, that possibly triggers a currency crisis.

These considerations suggest that, in a dynamic framework where the debt accumulates over time and the exchange rate is held fixed, the maturity of the debt may shorten initially, since such policy reduces interest rates. However, as the debt reaches a higher level, a short maturity impairs the government's ability to resist a currency crisis.

6. Conclusions

We have studied the role of fundamentals and signaling effects in a model of currency crises where devaluations may actually enhance instead of reducing the probability that the new parity will be maintained. Tight monetary policy to defend the exchange rate may worsen fundamentals, thus impairing the government's ability to withstand future crises. Unemployment persistence provides a possible channel through which current actions affect future policy. This paper suggests public debt and debt maturity as additional factors.

A devaluation may improve the prospects of an exchange-rate regime by reducing the value of public debt, but it may also lead to the expectations of further devaluations by signaling little commitment to price stability. Examining the behavior of interest-rate differentials relative to Germany during EMS realignments in France, Ireland and Italy, we find instances where the new parity was perceived as sustainable and episodes which led to a deterioration of people's confidence in the ERM. This evidence suggests a role for both debt-burden and signaling effects. We provide a first formalization of how such aspects interact in determining the expected devaluation for the current and future periods.

The analysis offers a theory of the term structure of interest rates for high-debt countries vulnerable to currency crises. When improving reputation is important, the incentive to resist a crisis is strong and should decrease the probability of a current devaluation, thus leading to lower short-term interest rates. By contrast, the prospects of the exchange regime and, hence, the forward rate just depend on fundamentals; i.e. on the level of public debt. Debt-burden and signaling effects, thus, play a key role in

[22] This does not mean that a tough government would always want to shorten the maturity under these conditions. As shown in Drudi and Prati (1995) a long-maturity debt may induce the weak government to devalue and reveal itself since it cannot sustain high ex-post return on such debt.

determining the level and slope of the yield curve. For any given level of debt, a greater uncertainty about the government's cost of devaluation implies lower short- (and long-term) interest rates and a steeper yield curve. At low levels of debt the yield curve may also steepen because of debt accumulation, since a higher debt enhances the signaling effect of a defense of the exchange rate. In general, however, debt accumulation leads to higher interest rates and to a flatter yield curve. These are interesting predictions to be tested empirically, a task which is left to future research.

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Appendix: The equilibrium of the reputation game

First consider a separating equilibrium supported by the expectations that the government is weak when a devaluation is observed and that the government is tough when the parity is maintained for shocks in the interval $[U_{s1}, U_{s2}]$. These beliefs imply that the interest rates is equal to $E_1\pi_2(D, u_s)$ when a devaluation is observed and to $E_1\pi_2(F, u_s)$ when the parity is maintained (see Section 4.2 for the value of $E_1\pi_2(j, u_s)$), where the terms in parentheses indicate that expectations are conditional on the first period action $j = D, F$ and on shocks u_s in the interval $[U_{s1}, U_{s2}]$.

Then, a separating equilibrium exists if and only if the following incentive compatibility constraints are satisfied:

$$\begin{aligned} L_{1F}^T + \beta E_1^T L_2^T(F, u_s) &\leq L_{1D}^T + \beta E_1^T L_2^T(D, u_s) \\ L_{1D}^W + \beta E_1^W L_2^W(D, u_s) &\leq L_{1F}^W + \beta E_1^W L_2^W(F, u_s) \end{aligned}$$

where a superscript denotes the type of government, the subscripts the time period and the action while the terms in parentheses indicate that the expected loss is conditional on the joint event $j \cap u_s$ and thus depends on the interest rate $E_1\pi_2(j, u_s)$.

To prove the existence of the equilibrium the incentive compatibility constraint for the tough government can be solved for u_1 in order to find the highest shock U_{s2} for which it maintains the fixed parity. Likewise, the incentive compatibility constraint for the weak government can be solved to find the lowest shock U_{s1} for which it devalues. Then, a separating equilibrium exists if and only if $U_{s1} < U_{s2}$. Note that

$$\begin{aligned} L_{1F}^i - L_{1D}^i &= -\theta^i d^2 - d^2 + 2d(k + E_0\pi_1) + 2du_1 \quad \textit{and} \\ L_2^i(D) - L_2^i(F) &= \eta 2v[\rho_2^i(D_s) - \rho_2^i(F_s)] \left[\frac{\theta^i d^2}{\eta 2v} + 2H - d(B + m - S) - \frac{(\theta^T + \theta^W)d^2 S}{4vm} \right] \end{aligned}$$

where $\rho_2^i(D_s) - \rho_2^i(F_s) = [(\theta^T - \theta^W)d^2 S/(2v - dS)4vm] - [dB/(2v - dS)]$.

It can be proved that $U_{s1} < U_{s2}$ holds, and that a separating equilibrium exists if $-1 < \beta[\rho_2^i(D_s) - \rho_2^i(F_s)] < 1$. This condition is always true for $\beta < 1$, since $\rho_2^i(D_s)$ and $\rho_2^i(F_s)$ are probabilities.

Consider now pooling equilibria. From the analysis of the separating equilibrium it follows that for shocks greater than U_{s2} only a pooling equilibrium exists where both governments devalue. Such equilibrium is supported by the following expectations: when a devaluation is observed, the government is tough with probability q_0 and weak with probability $1 - q_0$; when the exchange rate is fixed, the government is tough with probability 1. Note that the incentive compatibility constraints are satisfied, since, as shown above, for shocks greater than U_{s2} both governments would choose to devalue even if it were believed to be weak and thus had to face a higher interest rate than under pooling.

It appears that a pooling equilibrium is also possible where both governments devalue for shocks lower than U_{s2}, i.e. in the upper range where a separating equilibrium exists. If beliefs were such that both governments were expected to devalue for those shocks, then the interest rate would not rise after a devaluation making it optimal for the tough government to devalue. However, as the objective of the private sector is to minimize prediction errors, for instance $Min\ P = E_1(\pi_2 - E_1\pi_2)^2$ as in Rogoff (1989 p.239), separating the two governments is clearly a dominant strategy for the private sector.

Consider now a pooling equilibrium where both governments maintain the fixed parity (with some positive probabilty) for shocks $u_1 \leq U_p$. The equilibrium is supported by the expectations that the government is weak if there is a devaluation for such shocks, and by the expectations that the government is tough with probability q_1 and weak with probability $1 - q_1$ if the parity is maintained. These beliefs imply that the interest rate is equal to $E_1\pi_2(D, u_p)$ if there is a devaluation and to $E_1\pi_2(F, u_p)$ if the parity is maintained (see Section 4.2), where $u_p \leq U_p$. The equilibrium exists if and only if the incentive compatibility constraints of both governments are satisfied for shocks $u_1 \leq U_p$:

$$\begin{aligned} L_{1F}^T + \beta E_1^T L_2^T(F, u_p) &\leq L_{1D}^T + \beta E_1^T L_2^T(D, u_p) \\ L_{1F}^W + \beta E_1^W L_2^W(F, u_p) &\leq L_{1F}^W + \beta E_1^W L_2^W(D, u_p) \end{aligned}$$

where the terms in parentheses indicate that the expected loss is conditional on the first-period action $j = D, F$ and $u_1 \leq U_p$ and thus depends on the interest rate $E_1\pi_2(j, u_p)$.

Noting that the cost of devaluation is greater for the tough government it can be shown that the relevant constraint is that of the weak government. Hence, a pooling equilibrium exists for shocks that satisfy such constraint, namely for shocks $u_1 \leq U_p$, where U_p is defined as

$$\begin{aligned} 2dU_p &\equiv \theta^W d^2 + \mu + \beta 2v \left[\rho_2^W(D_s) - \rho_2^W(F_s) - (1-q_1)\frac{(\theta^T - \theta^W)d^2 S}{(2v - dS)4vm}\right] x \\ &x \left\{\frac{\theta^W d^2}{2v} + \eta \left[2H - d(B + m - S) - \frac{(\theta^T + \theta^W)d^2 S}{4vm} + (1-q_1)\frac{(\theta^T - \theta^W)d^2 S}{4vm}\right]\right\} \end{aligned}$$

Finally, we can show that $U_p < U_{s1}$ for $q_1 < 1$ and that U_p increases with q_1 so that $U_p = U_{s1}$ for $q_1 = 1$.

First note that $U_p < U_{s1}$ is satisfied if

$$\Delta \left\{\frac{\theta^W d^2}{2v} + \eta(2H - dm + dS) - \eta\frac{[(1+q_1)\theta^T + (1-q_1)\theta^W]d^2 S}{4vm}\right\} > 0$$

where $\Delta = (1-q_1)(\theta^T - \theta^W)d^2 S/(2v - dS)4vm$ is positive and goes to zero as q_1 tends to 1.

The term within curly brakets can be written as

$$\begin{aligned} 2H &+ \frac{2(v+H)dS}{2v - dS} + \frac{[(1+q_1)\theta^T + (1-q_1)\theta^W]d^2 S}{(2v - dS)2m} + \\ &- \frac{dm}{2v}\left\{2v - \frac{\theta^W d}{m} - dm + 2H + \frac{2(v+H)dS}{2v - dS} - \frac{[(1+q_1)\theta^T + (1-q_1)\theta^W]d^2 S}{(2v - dS)2m}\right\} \end{aligned}$$

which is equal to the sum of the deviations of second-period output from its optimal level, y^*, that the weak government expects in a pooling equilibrium and when it is believed to be tough. Formally, it is equal to

$$\begin{aligned} &-[d\rho_2^W(F_s) - E_0\pi_2]m + E_0\pi_1 B + [E_1\pi_2(F, u_s) - E_0\pi_2]S + K - [d\rho_2^W(F_p) - E_0\pi_2]m + \\ &\quad + E_0\pi_1 B + [E_1\pi_2(F, u_p) - E_0\pi_2]S + K = 2y^* - E_1^W y_2^W(F, u_s) - E_1^W y_2^W(F, u_p) > 0 \end{aligned}$$

These expected output gaps are positive since we have assumed that output is always below target to avoid the case that a government may want to appreciate in the second period as a result of a too favorable shocks or first period devaluation (see Section 4.1, note 16).

It follows that the range of shocks for which a pooling equilibrium exists does not overlap with the range where the equilibrium is separating. Moreover, for shocks in the interval $[U_{pm}; U_{s1}]$, where $U_{pm} = U_p$ for $q_1 = q_0$, there are only pooling equilibria in mixed strategies where the weak government randomizes with probability $q_0(1 - q_1)/q_1(1 - q_0)$ and where q_1 is the positive root which solves the second order equation reported in Section 4.2.

Figure 1: 3-month Interest Rate Differential Italian Lira-Deutsche Mark

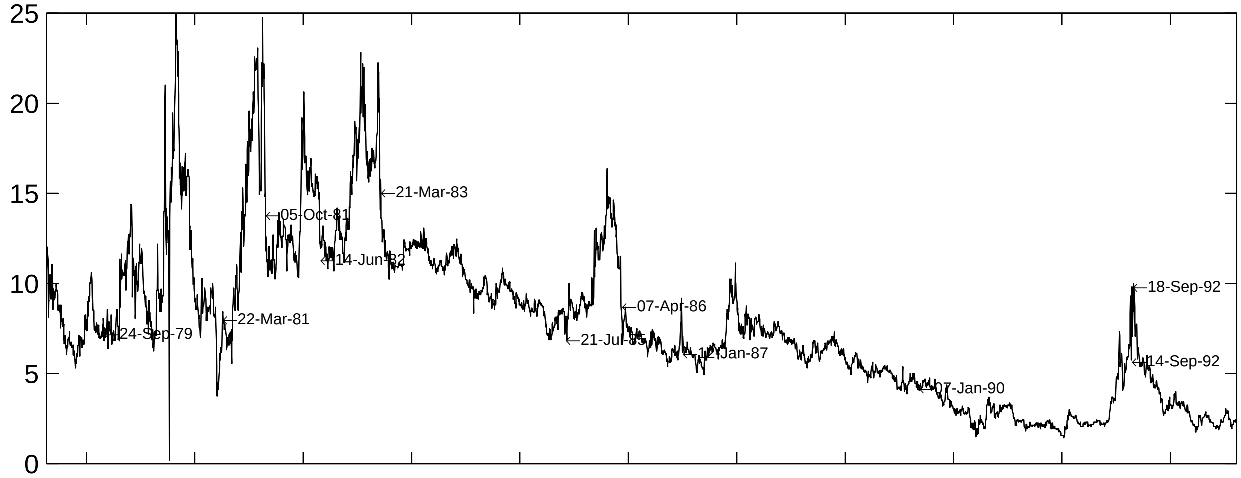


Figure 2: 3-month Interest Rate Differential Irish Punt-Deutsche Mark

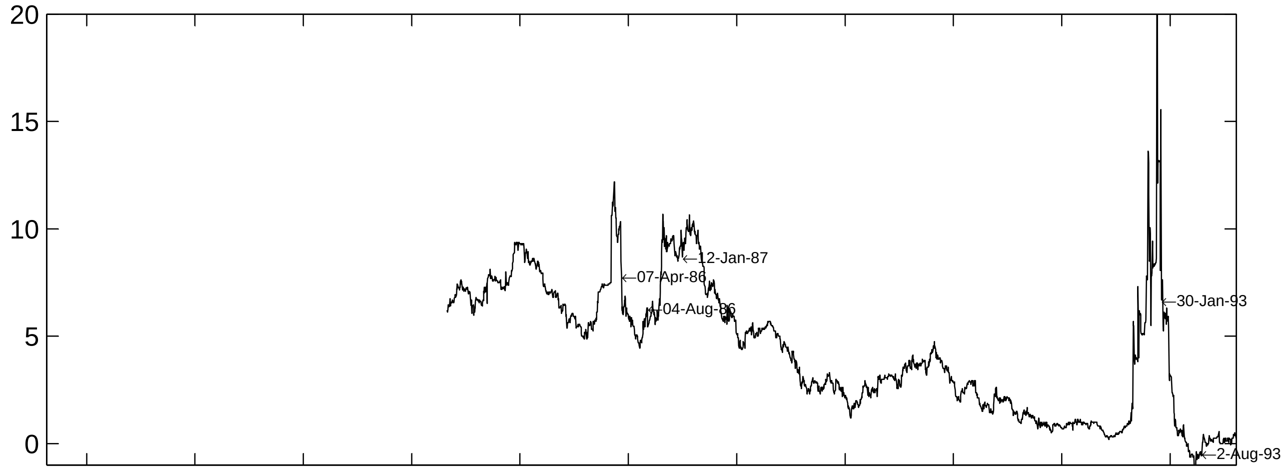
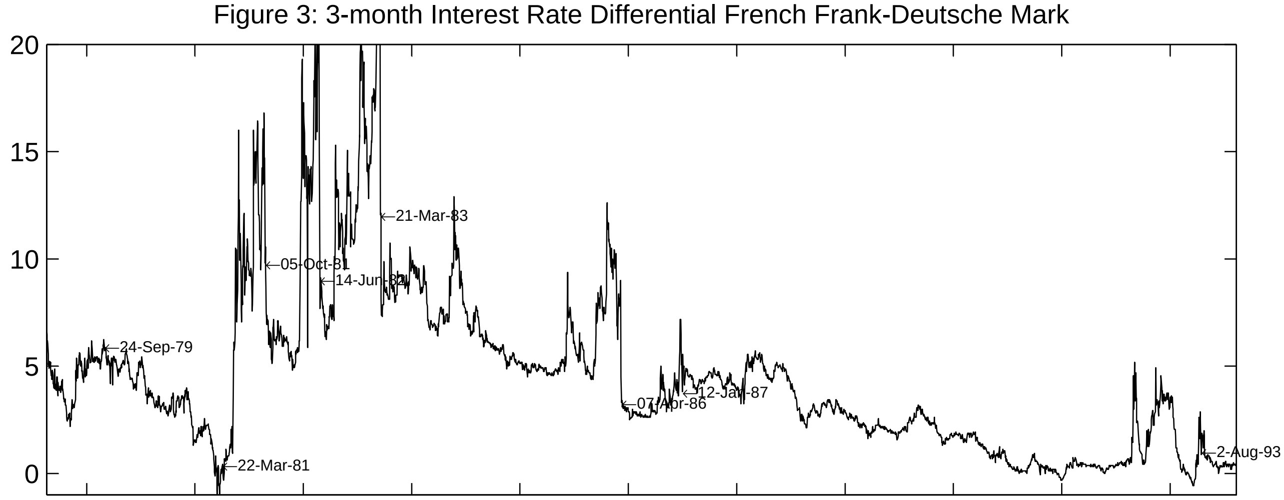


Figure 3: 3-month Interest Rate Differential French Frank-Deutsche Mark



Source: Euro-Currency Market, Datastream.