THE CREDIBILITY OF THE UNITED KINGDOM'S COMMITMENT TO THE ERM: INTENTIONS VERSUS ACTIONS*

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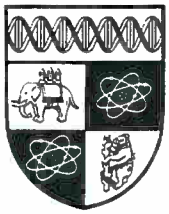

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Abstract

The paper presents estimates of a model of the credibility of the U.K. commitment to its central parity against the deutsche mark during the period of ERM membership (1990-92). The measure of credibility used is the long-term interest differential with Germany. Credibility is decomposed into two aspects: an assessment of whether the government was truly committed to the ERM, and the probability that even a committed government would be able to continue to bear the unemployment costs. Doubts about the first aspect--which could lead to a self-fulfilling crisis--are shown to have declined steadily during the period of ERM membership, while the second aspect is estimated to have become increasingly important, due to rising unemployment.

Keywords: EMS, monetary policy, exchange rates
JEL Classification: E43, F31, F33

1/ This working paper integrates two articles which are to be published in the Economic Journal (under the title "Gaining and Losing ERM Credibility: The Case of the United Kingdom"), and in the proceedings of a conference held at the University of Bordeaux I, European Crises and After (under the title "Modelling Credibility: An Application to the United Kingdom"). The author is grateful to seminar participants at the University of Bordeaux I, the Federal Reserve Board, the International Monetary Fund, Tilburg University, and the University of Warwick for helpful comments. The present paper was in part written at the University of Warwick's Summer Research Workshop, which is supported by the Economic and Social Research Council (U.K.) and the Human Capital and Mobility Programme of the European Community. The views expressed here are those of the author and should not be taken to represent those of the International Monetary Fund.

THE CREDIBILITY OF THE UNITED KINGDOM'S COMMITMENT TO THE ERM: INTENTIONS VERSUS ACTIONS

Summary

Credibility is defined in the paper as the likelihood that policy commitments will be carried out, as viewed by private agents. This concept of credibility is viewed as having two components: the private sector's assessment of the government's type, and also, given the type of government, an assessment of the probability that an optimizing government will actually decide to carry out its announced policies in the face of adverse shocks. A formal model of policy choice and learning the type of government is developed, and it is then applied to the credibility of the U.K. commitment to its deutsche mark parity during the October 1990-September 1992 period of exchange rate mechanism (ERM) membership. It is assumed that the public perceives that there are two types of government, which differ by the relative weights that they attach to the exchange rate (or inflation) and unemployment, but that it does not know which one applies. A crucial assumption that is made is that even a government which is fully committed to fighting inflation also attaches some cost to unemployment.

The violence and suddenness of the September 1992 crisis have naturally raised the issue of self-fulfilling speculation. Was the ERM crisis due to a speculative attack that took on a life of its own, rather than to fundamentals? The model allows for the possibility of multiple equilibria, and hence of self-fulfilling attacks. In particular, unemployment is assumed to depend on exchange rate surprises: an unexpected devaluation

will tend to stimulate employment. Conversely, if private agents expect a devaluation, but the authorities do not change the parity, there are employment losses. Therefore, a "credibility crisis" in which, for instance, investors doubt that the government is committed to a particular parity or gives as much weight to inflation as it says it does, may make the costs of maintaining the parity very high, if the government also cares about unemployment, as is assumed. This may then trigger a devaluation.

The model is tested using Kalman filter estimation to account for the variation of credibility over time. The estimates suggest that at least in the case of the United Kingdom, lack of credibility in the summer of 1992 was due not to doubts about the type of government, that is, its commitment to the ERM, but rather to concerns about the unemployment costs of maintaining the parity. Consequently, even a government committed to the ERM might not want to continue to bear those costs. In fact, continuing downward pressures on sterling and upward pressure on interest rates made the costs too high to bear, and sterling was floated on September 16, 1992. Though speculation made the defence of sterling more difficult, the model estimates suggest that speculation was linked to fundamentals, and hence was not purely self-fulfilling.

THE CREDIBILITY OF THE UNITED KINGDOM'S COMMITMENT TO THE ERM: INTENTIONS VERSUS ACTIONS

I. Introduction

There is now an extensive literature on "credibility," with the term given several different meanings and measured in various ways. 1/ In some contexts, credibility is assumed to apply to the policymaker, in particular in models where policymakers attempt to signal their "type"--for instance with respect to anti-inflationary credentials. 2/ This is sometimes termed "reputation," especially when it is related to the past history of policy actions. 3/ In other models, credibility is equated with an ability to precommit--that is, to convince the private sector that it will carry out policies that may be time inconsistent. 4/ This permits the government to attain a higher level of welfare.

In the current paper, the concept of credibility is applied to the policies themselves, and is defined as the likelihood that policy commitments will in fact be carried out, as viewed by private agents. This concept of credibility is viewed as having two components: the private sector's assessment of the government's type, and also, given the type of government, an assessment of the probability that an optimising government will actually decide to carry out its announced policies in the face of adverse shocks. A formal model of policy choice and learning the type of

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1/ See, for instance, Andersen and Risager (1988), Blanchard (1985), Horn and Persson (1988), and Weber (1991, 1992).
2/ Vickers (1986).
3/ Backus and Driffill (1985 a, b).
4/ Cukierman and Meltzer (1991).

government is developed, and it is then applied to the credibility of the U.K. commitment to its deutsche mark parity (2.95 DM) during the October 1990-September 1992 period of exchange rate mechanism (ERM) membership.

The September 1992 ERM crisis is an interesting testbed for models of credibility, partly because, as noted by other authors, the crisis followed five years of exchange rate stability, a period when it seemed increasingly as if the ERM could provide a smooth transition to monetary union. Correspondingly, most indicators of exchange market tension or lack of credibility did not, at least until a few weeks before the crisis, signal that things were likely to go wrong. The violence and suddenness of the crisis have naturally raised the issue of self-fulfilling speculation. Was the ERM crisis due to a speculative attack that took on a life of its own, rather than to fundamentals? 1/ Of course, all the ERM currencies should not be put in the same boat; the pound sterling and the Italian lira, which were the first attacked and which were forced to leave the ERM, were currencies which were widely viewed as overvalued, while others which were also attacked were not in the same situation. The present paper, which examines data only for the United Kingdom, is not therefore intended to give a general answer to the question.

The model does allow for the possibility of multiple equilibria, and hence of self-fulfilling attacks. In particular, unemployment is assumed to

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1/ Obstfeld (1994). Some empirical support for this view is given in Eichengreen, Rose, and Wyplosz (1994).

depend on exchange rate surprises: an unexpected devaluation will tend to stimulate employment. Conversely, if private agents expect a devaluation, but the authorities do not change the parity, there are employment losses. Therefore, a "credibility crisis" in which, for instance, investors doubt that the government is committed to a particular parity or gives as much weight to inflation as it says it does, may make the costs of maintaining the parity very high, if the government also cares about unemployment, as is assumed.

The United Kingdom's experience is very relevant because the purpose of joining the ERM in October 1990 was clearly to enhance the credibility of monetary policy so as to achieve a reduction of the high rate of inflation, yet the speculative attacks leading to the withdrawal of the pound from the ERM two years later are clear evidence that credibility was not achieved, despite a substantial reduction in inflation. Winckler (1991) has suggested that the entry of the pound into the ERM at an appreciated rate signaled the firm anti-inflationary intentions of the authorities. In the context of signaling models, the more the government shows a willingness to pay the costs of fighting inflation, the more effectively it signals its "type," that is, whether it is tough or weak. 1/ A more appreciated rate would also produce more slack in output and labor markets, and this slack would tend to put downward pressure on inflation (over and above any favorable signaling effects).

1/ See Vickers (1985) and Backus and Driffill (1985 a, b). In the U.K. context, a more usual terminology for the types of government would be "dry" and "wet."

Such an analysis would suggest that the U.K. government, by signaling its toughness initially and persisting with the ERM peg, should have initially established some credibility for its policies, and continued to gain credibility as inflation declined. A measure of credibility of the exchange rate commitment is the interest rate differential relative to Germany, and there was indeed a fall in both the short-term and long-term differentials shortly after ERM entry. However, that fall came to an end in the summer of 1992, at which time the differential was between 0.5 and 1.0 percentage point; and speculative pressures in September forced the U.K. authorities to abandon their peg and to float the currency. 1/

The present paper considers a broader concept of credibility that includes not just signaling of its type by the government, but also the costs of sticking to its policies that any government--whether wet or dry--must take into account. In particular, though the U.K. authorities may have deliberately created slack in output and labor markets in order to achieve disinflation, the severity of the recession was greater than anticipated, and this unfavorable shock made the exchange rate peg costlier in terms of employment. Investors anticipated that employment considerations would eventually lead to an abandonment of the peg to the deutsche mark, despite the government's statements to the contrary, and this led to a rise in interest rate differentials and to capital outflows that were ultimately so large that they could not be offset by official intervention.

1/ See Barrell et al. (1993) for a discussion of this period.

Estimates of this model suggest that at least in the case of the United Kingdom, lack of credibility in the summer of 1992 was due not to doubts about the type of government, that is, its commitment to the ERM, but rather to concerns about the unemployment costs of maintaining the parity. Consequently, even a government committed to the ERM might not want to continue to bear those costs. In fact, continuing downward pressures on sterling and upward pressures on interest rates made the costs too high to bear, and sterling was floated on September 16, 1992. Though speculation made the defence of sterling more difficult, the model estimates suggest that speculation was linked to fundamentals, and hence was not purely self-fulfilling.

Other papers have also considered the tradeoff between "big bang" and gradual policies from the point of view of credibility. Flood (1983) for example points out that too rapid a contraction in monetary policies (for instance, the Thatcher experiment of the early 1980s) could raise, not lower, inflation expectations because it might cause expectations of a change in government. Similarly, Blanchard (1985) considers the alternation of governments and its effect on inflation expectations, where each government is solely concerned with one objective, either inflation or employment. In the present paper, electoral considerations are ignored; it is assumed that there is a social consensus at least on the belief that both objectives are important--so that no government can ignore unemployment costs--even if relative weights are subject to disagreement. This seems realistic in the context of the early 1990s in Britain, since both major

parties supported ERM membership, and the parity of the pound was not a major issue in the April 1992 general election.

The model is tested using Kalman filter estimation to account for the variation of credibility over time. Time-varying parameter models have been used before to model exchange rates and interest rates, for instance by Hamilton (1988), Lewis (1989), Engel and Hamilton (1990), Kaminsky and Peruga (1990), Haldane and Hall (1991), and Weber (1991, 1992). However, those papers have either not attempted to relate changes in parameters to optimizing behavior, or have been applied to floating exchange rates rather than to ERM parities.

The paper first reviews the history of the United Kingdom's membership in the ERM in Section II. A theoretical model is presented in Section III, and parameter estimates derived from U.K. data in Section IV. The implications of that model for the possibility of self-fulfilling crises are discussed in Section V, followed by some conclusions and topics for further research.

II. The Circumstances of the U.K.'s Brief Membership in the ERM

Britain joined the exchange rate mechanism of the European Monetary System on October 8, 1990, after a protracted debate on the merits of pegged exchange rates. Prime Minister Margaret Thatcher was widely known to be opposed to the idea--as were some of her advisors, most notably

Sir Alan Walters--but she had committed Britain to join the ERM "when the time was right." In the fall of 1990 the United Kingdom was suffering from inflation rates of close to 10 percent, the result of over-expansionary monetary policies in the late 1980s, while inflation in Germany and France was 2-3 percent. Monetary policy had become more restrictive, and short-term interest rates were now 15 percent. It was felt that the ERM anchor would impart credibility to the disinflation process, and help to lower inflation at a smaller unemployment cost.

Sterling joined the wide band of the ERM, which allowed fluctuations of ± 6 percent around central parities with other currencies in the mechanism. In the weeks before joining, sterling had strengthened, and the parity chosen, an exchange rate of 2.95 deutsche mark, was viewed generally as being somewhat over-valued. It has been argued (e.g., by Winckler, 1991) that the choice of parity was intended to signal anti-inflationary commitment; however, there were initial doubts about whether a realignment might be needed in a year or two to correct problems of competitiveness (related both to the initial level and to continued higher inflation than in partner countries), and about the commitment of the Thatcher government to the ERM.

Commitment to the ERM by the U.K. authorities was enhanced by the replacement of Margaret Thatcher as Prime Minister by John Major at the end of November, 1990. The latter, as Chancellor of the Exchequer, had urged for a more European policy, and had been an advocate of the ERM membership. He and the new chancellor, Norman Lamont, not only reiterated their

commitment to the existing parity, but also committed themselves to joining the narrow ERM band (± 2.25 percent around central parities) at that exchange rate.

Thus, after a year of ERM membership the credibility of the peg seemed to be established, since ERM membership had allowed a decline in retail price inflation to less than 5 percent and of short-term nominal interest rates to 10 percent, while the long-term interest differential with Germany had halved, from 2 to 1 percent. Indeed, the Independent could write (September 14, 1991):

> "The broad conclusion is that the pound's membership of the ERM has worked: it has forced a rapid and painful adjustment on the country, but in less than a year that adjustment is secure, if not yet complete. There is now little talk of the pound having joined the ERM at too high a level. Instead, there is increasing confidence (within the Labour Party as well as the Government) that were the EC to move rapidly to a single currency, Britain would be strong enough to join the club."

The Economist (October 5, 1991) similarly argued that a year of ERM experience had proved Alan Walters wrong, and suggested that the time might be ripe for joining the narrow band. The agreement reached in Maastricht in December 1991 to proceed to economic and monetary union also added to the credibility of existing parities, though it included an opt-out clause for the United Kingdom.

The run-up to the general election, held on April 9, 1992, did little to alter confidence in sterling's ERM parity, since there was bipartisan support for ERM membership, if not for all aspects of economic policy. However, during the summer of 1992 it became clear that the recession was longer and more severe than had been expected; gross domestic product had declined by about 4 percent from 1990-Q2 to 1992-Q2. One indicator among many was the seemingly inexorable rise of the unemployment rate; labor shedding occurred at a rapid pace in the June-August period (Bank of England Quarterly Bulletin, November 1992).

Despite these strains, the Government publicly reasserted its determination not to devalue or leave the ERM. Even at this stage, it was generally felt that the disadvantages of withdrawing outweighed advantages:

> "Many, even among those who had doubts about ERM entry, argued that once we had joined, we had to stick with it--toughing out periods of tension as necessary..." (Leigh-Pemberton, 1992, p.3).

The decision to leave the ERM, when it came on September 16, 1992, was at least to some extent forced on the authorities. Speculative pressures in the ERM had been rising since the Danish rejection of the Maastricht Treaty in a referendum in June; polls suggested that the September 20 French referendum might similarly produce a "no" vote. The U.K. monetary authorities, faced with a choice of raising interest rates to clearly unreasonable levels from a domestic perspective, given the weakness of the

economy, chose instead to let the currency float outside the ERM. As the Governor of the Bank of England put it:

> "... raising U.K. interest rates, when the economy was so weak and inflationary pressure so subdued... would have been regarded... as transparently perverse... [F]ar from adding to credibility, it was always likely to bring--indeed in the event it did bring--the latent pressure to a dramatic climax." (Leigh-Pemberton, 1992, p.7).

III. A Model of Credibility

The model that follows is a simple setup that combines the two elements that are important in explaining the evolving credibility of the commitment of the U.K. monetary authorities to the ERM. In particular, the model incorporates the favorable effect on credibility of maintaining the parity and, initially, of accepting the resulting unemployment costs, but also the opposite effect that continuing unemployment has in making the commitment to a fixed parity more difficult to maintain, and hence less credible. As in Drazen and Masson (1993), the model is an elaboration of that in Obstfeld (1991), and is related to the "escape clause" model of Flood and Isard (1989), but here assessments of the type of government are updated period-by-period; the model thus explains the evolution of credibility in a multi-period context.

The model is based on a simple relationship between devaluations and employment. Expected devaluations do not have a stimulative effect, but surprise devaluations do; such a relationship would prevail for given domestic (wage) inflation, in a model where only surprise inflation matters for output. A government therefore has the incentive to increase employment by devaluing; in the ERM context, the choice is assumed to involve maintaining the current parity or devaluing by a fixed amount d, which is exogenous to the government and a feature of the exchange rate system. Thus, the government has two discrete alternatives for the exchange rate in period t: $e_t = e_{t-1}$ or $e_t = e_{t-1} + d$. There may be a devaluation bias because, as in Barro and Gordon (1983), the central bank attempts to offset distortions that produce a higher-than-optimal unemployment rate; however, this feature is not critical to the model of this paper and is ignored. 1/ There is also a stochastic shock u to unemployment; the private sector is assumed not to observe this shock when forming its expectations, while the government (or central bank) knows the value of the shock when deciding whether or not to devalue in the current period. Crucial to our purposes, shocks and government policies have persistent effects on unemployment that extend beyond the current period; this assumption explains why policy choices constrain the room for maneuver in subsequent periods.

For simplicity, the model is written in terms of ur_t, the deviation of unemployment from the natural rate, 2/

1/ Its inclusion merely affects a constant term which is not restricted in estimation.

2/ Unlike the model of Obstfeld (1991), which is written in terms of employment.

$$(1) \quad ur_t = \sqrt{a}[\, -(e_t - E_{t-1}e_t) + u_t + \delta ur_{t-1}]$$

where e is the log of the exchange rate (£/DM) and u is an unemployment shock which is assumed to be uniformly distributed in the interval $[-v, v]$. Private sector expectations $E_{t-1}e_t$ are conditional on information available prior to t, which excludes current and past shocks. The private sector knows that the government is one of two "types" (whose objective functions are known), but it does not know which, so it forms probability assessments of the government's type (described below).

The government is assumed for simplicity to minimize a one-period loss function 1/ which depends on the squared deviations of unemployment from the natural rate and on the (squared) change in the exchange rate:

$$(2) \quad L_t = (ur_t)^2 + \theta(\Delta e_t)^2$$

The second term reflects both the cost of inflation 2/ and the policymaker's concern for exchange rate stability. A tough government has a larger value for θ than does a weak government: $\theta^T > \theta^W$. These values are

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1/ Allowing for a multi-period objective function, as in Drazen and Masson (1993), makes the problem considerably more complex, and precludes a closed-form solution to be used in estimation. It has the advantage, however, of allowing the government to choose policy with an eye to its future reputation.

2/ Exchange rate depreciation leads to higher import prices (as well as lower unemployment, if the depreciation was not fully expected).

known by the private sector, which updates its assessment π_t of the probability that a government is weak on the basis of observed behavior.

Given the above assumptions, the government's optimal behavior can easily be characterized. It devalues when a shock u_t is large enough that the costs of maintaining the parity exceed those of incurring higher inflation. Let L^F be the loss function value when the exchange rate is kept fixed, L^D when the exchange rate is devalued by amount d: the government devalues when $L^D < L^F$. This implies that it will devalue if and only if

$$(3) \quad u_t > \frac{(a+\theta)d}{2a} - E_{t-1}e_t + e_{t-1} - \delta ur_{t-1}$$

Let ρ_t^W be the probability that a weak government will devalue in period t and ρ_t^T the probability that a strong government will devalue; since π_t is the private sector's assessment of the probability that a government is weak,

$$E_{t-1}e_t - e_{t-1} = [\pi_t\rho_t^W + (1-\pi_t)\ \rho_t^T]\ d$$

and

$$(4) \quad \rho_t^i = prob(u_t > y_t - \pi_t \rho_t^W d - (1-\pi_t)\, \rho_t^T d + \frac{\theta^i d}{2a} \mid \text{government is of type i})$$

where

$$y_t \equiv \frac{d}{2} - \delta u r_{t-1}$$

Recall that u_t is distributed uniformly in the interval $[-v, v]$. Assuming an interior solution,

$$(5) \quad \text{prob } (u_t > u_t^*) = \frac{v-u_t^*}{2v}$$

We can then solve equations (4) above for ρ_t^W and ρ_t^T:

$$(6a) \quad \rho_t^W = \frac{(v-y_t)}{2v-d} - \frac{\theta^W d/2a}{2v-d} + \frac{(1-\pi_t)\,(\theta^W-\theta^T)\, d^2/2a}{2v\,(2v-d)}$$

$$(6b) \quad \rho_t^T = \frac{(v-y_t)}{2v-d} - \frac{\theta^T d/2a}{2v-d} - \frac{\pi_t\,(\theta^W-\theta^T)\, d^2/2a}{2v\,(2v-d)}$$

Furthermore,

$$(7) \quad \rho_t \equiv \pi_t\, \rho_t^W + (1-\pi_t)\, \rho_t^T = \frac{v-y_t}{2v-d} - \frac{\theta^T d/2a}{2v-d} + \frac{\pi_t(\theta^T - \theta^W)\, d/2a}{2v-d}$$

It is useful to separate the time-varying part of (7) from the part that is independent of time, and moreover to decompose the latter into "steady-state" probabilities of devaluation, $\bar{\rho}^W$ and $\bar{\rho}^T$, assuming that the private sector knows the type of government (i.e., $\pi = 1$ in (6a) and $\pi = 0$ in (6b)) and $ur_{t-1} = 0$:

$$(8a) \quad \bar{\rho}^W = 1/2 - \frac{\theta^W d/2a}{2v-d}$$

$$(8b) \quad \bar{\rho}^T = 1/2 - \frac{\theta^T d/2a}{2v-d}$$

Then, the probability of a realignment in period t can be written simply as

$$(9) \quad \rho_t = \bar{\rho}^T + \pi_t(\bar{\rho}^W - \bar{\rho}^T) + \frac{\delta ur_{t-1}}{2v-d}$$

A variant of this equation is used below in estimation. Note that for a given assessment of type, higher unemployment raises expected devaluation next period, because it makes it more likely that a positive unemployment shock will push it into a region where devaluation will be more attractive than maintaining the parity.

Next we consider how to formulate estimates of the probability that the government is of type W or T. Starting from a prior estimate π_{t-1}, suppose that the government does not devalue in period t-1. Then Bayesian updating would imply that

$$(10)\quad \pi_t = \frac{1 - \rho^W_{t-1}}{(1 - \rho^W_{t-1})\,\pi_{t-1} + (1 - \rho^T_{t-1})\,(1 - \pi_{t-1})}\,\pi_{t-1}$$

If we substitute equations (6) and (8), linearize (see Appendix I), and add an error term η_t we obtain

$$(11)\quad \pi_t = \alpha\,\pi_{t-1} + \beta ur_{t-2} + \eta_t$$

where α and $\beta \leq 0$ are parameters to be estimated. Higher unemployment lowers the probability assessment that the government is weak: the willingness to accept unemployment without devaluing reinforces the government's reputation for toughness.

The analysis thus far has considered a single-period horizon; empirically the model is applied to long-term bonds, since the longer the term to maturity, the smaller is the impact of expected movements within the band on the yield to maturity, so yield differentials can be identified with

expected devaluation. 1/ What is the expected rate of depreciation over the maturity of a bond, given the assessment of the type of government made at time t? It will be approximately true in the absence of risk premia 2/ that the annual yield differential on a N-month bond, $R_t^{(N)}$, will equal the average of the expected rate of depreciation in each of the next N months, at an annual rate. Using (9) and the autoregressive process for ur_t, this allows to express the yield differential on an N-period bond as follows, with the addition of an error term ϵ_t:

$$(12)\quad R_t^{(N)} = \tilde{p}^T d + \pi_t(\tilde{p}^W - \tilde{p}^T)d + \gamma ur_{t-1} + \epsilon_t$$

where $\tilde{p}^T = 12\bar{p}^T$, $\tilde{p}^W = 12\bar{p}^W$, and $\gamma = \delta(1-\delta^N)12d/[N(1-\delta)(2v-d)]>0$

Note that, in this formulation, $\tilde{p}^T$ and $\tilde{p}^W$ are probabilities of devaluation over the course of the next year (not the maturity of the bond), since $R_t^{(N)}$ is calculated as an annual rate.

1/ See, for instance, Koen (1991).

2/ Given the low U.K. public debt to GDP ratio over this period, credit risk is unlikely to have been a factor, though exchange rate risk of course may have been a factor.

IV. Estimation

Equation (12) constitutes the model to be estimated, where π_t is an unobservable state whose transition is described by equation (11), and which can be estimated using a Kalman filter. 1/ The variable ur_t was measured as the deviation of unemployment from an estimate of the natural rate of 8 percent. It was verified that this was a stationary series for the U.K. In estimation, it was further assumed that ϵ_t and η_t were i.i.d. with $\epsilon_t \sim N(0, \sigma_\epsilon^2)$, $\eta_t \sim N(0, \sigma_\eta^2)$.

The model is estimated by choosing a value for d and estimating the other parameters, including the state variable, using the Kalman filter. The value of d was imposed because the model needs additional identification restrictions. A higher value for d, and proportionately lower values for $\tilde{p}^T$ and $\tilde{p}^W$, give identical predictions for $R_t^{(N)}$. The value for the devaluation size d was chosen to be 20 percent against the deutsche mark, roughly the amount of the depreciation of sterling by early February 1993 relative to its ERM parity. As is discussed below, the level of π_t is also not identified, and a further normalization is needed.

It is necessary at the outset to note two limitations of the estimation procedure for the state variable π_t. First, only an approximation to the

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1/ For other applications of Kalman filtering to EMS credibility, see Weber (1991, 1992).

updating equation (10) is used (with the addition of an error term). This is justified by the extremely non-linear form of the equation, making it difficult to find maximum likelihood estimates of the parameters. Second, equation (11) can produce values of π_t in estimation which are not bounded [0,1], either because ur_{t-1} takes on extreme values, or because the drawings of η_t, which are assumed to be Gaussian, are too large (note that this problem would also apply if a generalized Kalman filter were used to estimate the non-linear expression for π_t). The filter described by Hamilton (1990) and applied in Hamilton (1988, 1989) and Engel and Hamilton (1990) does produce a probability in the interval [0,1]. However, it does not allow endogenous probabilities as modeled here.

Equations (11) and (12) were estimated in the following form: 1/

$$(13)\quad R_t^{(N)} = a_o + a_1\pi_t + \gamma ur_{t-1} + \epsilon_t$$

$$(14)\quad \pi_t = \alpha\pi_{t-1} + \beta ur_{t-2} + \eta_t$$

The coefficients and their standard errors are given in Table 1. Though α and a_o are statistically significant, the coefficients on unemployment are not well determined. In deriving parameter values, it should be noted from equation (13) that increasing π_t by k and reducing a_o by $a_1 k$ will not

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1/ Using the MAXLIK procedure in GAUSS 3.1, written by Aptech Systems.

Table 1. Parameter Estimates, October 1990 - August 1992

	Coefficients	Standard Errors	Coefficient/ Standard Errors
a_o	1.1963	0.2319	5.159
a_1	3.4065	2.2374	1.523
γ	0.2627	0.4704	0.558
α	0.5092	0.1678	3.036
β	-0.0640	0.0397	-1.612
Adjusted parameter values			
$\tilde{\rho}^T$	0		
$\tilde{\rho}^W$	0.1703		
π_o	0.6826		
σ_ϵ^2	--		
σ_η^2	0.0035		
Test Statistics			
Box-Pierce (lags 1 to 5)	3.246 (0.66) 1/		
Bera-Jarque Normality	0.259 (0.88) 1/		

1/ p - values.

affect the fit of the equation; thus, additional assumptions are needed to pin down the level of π_t. The further assumption is made that $\tilde{p}^T=0$, which implies $a_o=0$: in steady state, starting from a zero unemployment gap, no shock is large enough to cause a government which is known to be tough to devalue. 1/ This allows the scaling of π_t to be uniquely determined, and implies that in October 1990, i.e., at the time Britain entered the ERM, the private sector assessed a 68 percent probability that the government was weak (and would devalue with probability p^W). The estimate of the steady-state probability of devaluation for a weak government in any given year, $\tilde{p}^W = 0.17$, seems plausible.

Despite the relative insignificance of the unemployment variables, the model explains well movements in the interest differential with Germany (Chart 1); all of the residual variance is attributed to η_t, whose standard error is only 0.06. There is a downward trend in π_t over the period; this variable (on the basis of the estimates in Table 1) is plotted in Chart 2, with bands around the one-step-ahead estimates that correspond to plus or minus the state variable's standard error, when both filtering uncertainty and parameter uncertainty are taken into account. 2/ By end-1991, π_t is

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1/ Of course, this does not preclude that shocks outside of steady state would cause it to devalue, i.e., a succession of unfavorable shocks leading to high unemployment, or a "credibility crisis" such that $\pi_t>0$.

2/ Calculated from Monte Carlo simulations using 2000 draws of the parameters. See Hamilton (1994, pp. 397-99), for a description of the method.

CHART 1
UNITED KINGDOM

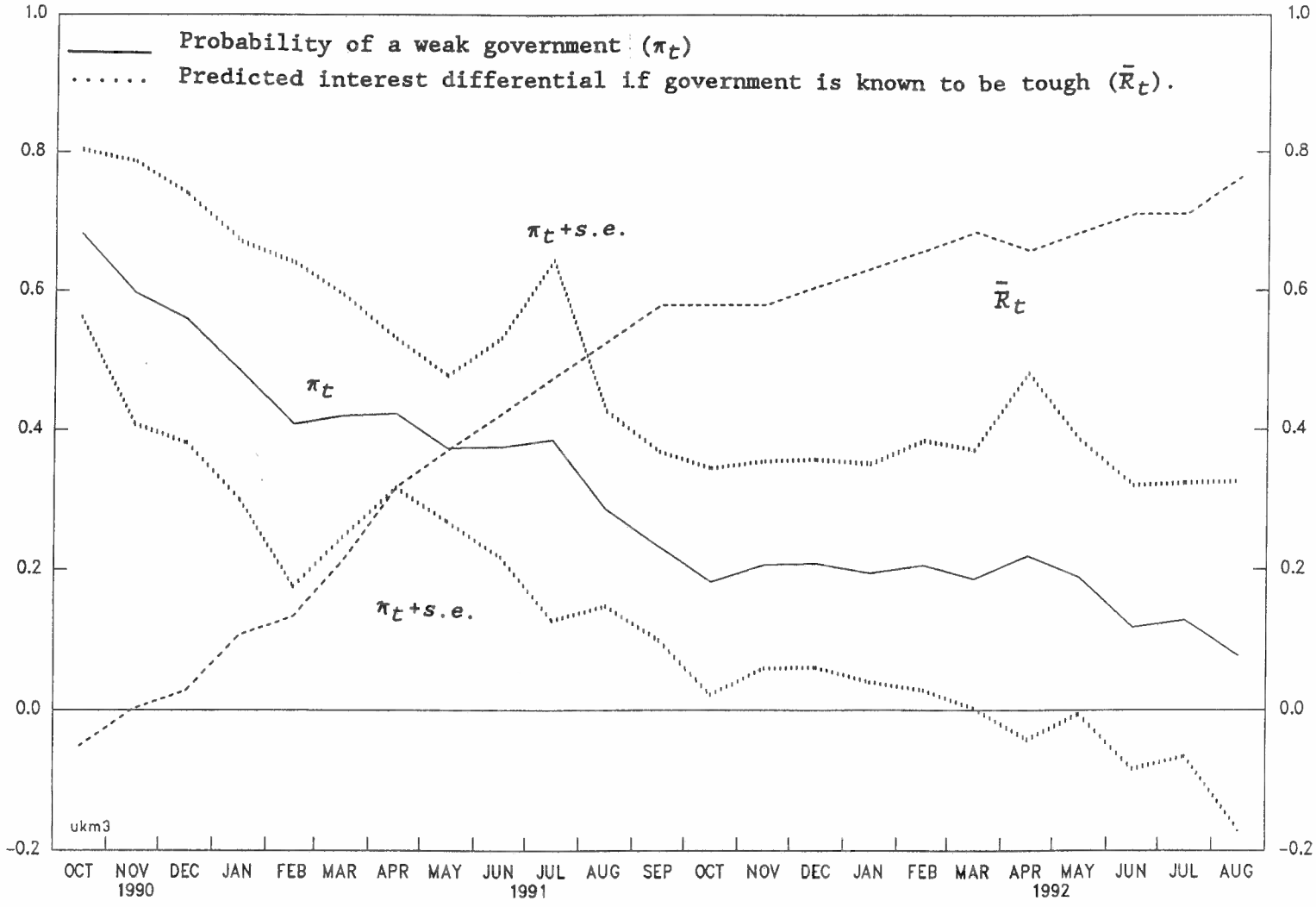
Long-Term Interest Differential With Germany

October 1990 - August 1992

CHART 2
UNITED KINGDOM

Measures of Credibility

October 1990 - August 1992



down to 20 percent, suggesting that the intentions of the authorities to stick with the parity had been fairly convincingly established by this time.

Though there is a slight increase in π_t in April 1992, which may be associated with the general election (though neither the Conservatives nor Labour advocated devaluation), the probability of a weak government continues to decline in 1992. Despite this, the long-term interest differential remains high. The model explains this by the significant positive effect of lagged unemployment on the probabilities ρ^W and ρ^T that either a weak or a tough government will devalue, if further shocks to unemployment are sufficiently unfavorable--as captured by the positive coefficient (γ) on ur_{t-1}. Suppose that the government's reputation for toughness had been established from the start of ERM membership, that is the value of π_t estimated for 1992:08, namely $\bar{\pi}=0.08$, had prevailed throughout the period. Then the model would have predicted an interest differential $\bar{R}_t$ equal to :

$$(15)\quad \bar{R}_t = a_1 \bar{\pi} + \gamma ur_{t-1}$$

This variable is plotted in Chart 2, along with π_t. The chart supports the view that the relative stability of the interest differential resulted from two opposing influences: an enhanced reputation for toughness, but increasing concerns that rising unemployment was inconsistent with maintaining the parity. Though $\tilde{p}^T$ is assumed to be zero, according to the

model the market attributed an increasing likelihood that a tough government would devalue because of the magnitude of unemployment, which rose steadily throughout the period. In the event this assessment turned out to be correct, and sterling left the ERM in September 1992.

V. Implications of the Model

1. Dynamics

It can be shown (see Appendix II) that the model can be reduced to a system of two first-order difference equations in unemployment, ur_t, and the probability that the government is weak, π_t. These equations can be written as follows (conditional on no devaluation occurring):

$$(16) \quad \pi_{t+1} = \frac{1 - \bar{\rho}^W - \frac{\delta ur_{t-1}}{2v-d} + (1-\pi_t)\,\bar{\rho}^W \frac{d}{2v}}{1 - \frac{\delta ur_{t-1}}{2v-d} - \pi_t \bar{\rho}^W}\,\pi_t + \eta_{t+1}$$

$$(17) \quad ur_t = \sqrt{a}\,\bar{\rho}^W d\pi_t + \sqrt{a}\,\delta\left(\frac{2v}{2v-d}\right) ur_{t-1} + \zeta_t$$

where a, δ, and d are positive parameters as defined above, v is the upper bound of unemployment shocks, and $\overline{\rho}^W$ is the steady-state devaluation probability for a weak government.

The system of equations produces complicated non-linear dynamics, as a result of equation (16). Nevertheless, some interesting results can be derived.

In particular, it is easy to show that there are two fixed points in the absence of stochastic shocks. The first fixed point (labelled "L", for low unemployment),

$$(18)\quad \pi^L = 0 \text{ and } ur^L = 0,$$

corresponds to perfect credibility and unemployment at the natural rate. While the stability of the system is complicated to examine, numerical experimentation with plausible parameters suggests that for arbitrary initial values $\pi_0 \epsilon (0,1)$ and ur_0, the economy converges to this fixed point in the absence of devaluation.

However, there is also another fixed point, with high unemployment:

$$(19)\quad \pi^H = 1 \text{ and } ur^H = \frac{\sqrt{a}\ \overline{\rho}^W\ d}{1 - \sqrt{a}\ \delta \left(\frac{2v}{2v-d}\right)}$$

where, for plausible parameters, $ur^H > 0$. It can also be shown that if $\pi_0 = 1$, lack of credibility persists. In particular, in this case, from equation (16),

$$(16') \qquad \pi_{t+1} = \pi_t + \eta_{t+1}$$

So, whatever the values taken on by unemployment, the government cannot (in the absence of favorable shocks) do anything to shake the conviction that it is weak. And, from (17), unemployment gradually converges to its level ur^H above the natural rate:

$$(17') \qquad ur_t = \sqrt{a}\,\bar{\rho}^W d + \sqrt{a}\,\delta\left(\frac{2v}{2v-d}\right)ur_{t-1} + \zeta_t$$

$$= ur_{t-1} + \mu[ur^H - ur_{t-1}] + \zeta_t$$

$$\text{where } \mu = 1 - \sqrt{a}\,\delta\, 2v/(2v-d)$$

2. Self-fulfilling crises

The model described above puts the main emphasis on the role of shocks to fundamentals in explaining devaluations, and hence in explaining lack of

complete credibility of a commitment to a particular exchange rate peg. However, the model also includes an important role for à priori judgements concerning the intentions of the authorities--i.e., the type of government. This opens the door for self-fulfilling crises. If speculators doubt the word of the authorities, then they raise the costs of maintaining the peg, making it more likely that an unfavorable shock to fundamentals will make them decide to devalue.

The mechanism can be understood by considering equation (1) above. It is exchange rate surprises that affect unemployment: if the authorities maintain the peg when they are expected to devalue, unemployment rises. Expected devaluation has two components, the assessment of the type of government (π_t) and the probability that either type of government will devalue (ρ_t^W and ρ_t^T, for weak and strong governments, respectively):

$$(20)\quad Ee_t - e_{t-1} = [\pi_t \rho_t^W + (1-\pi_t)\rho_t^T]\, d$$

In general, a weak government (i.e., one which assigns a lower weight to inflation or exchange rate changes) will be more likely to devalue: $\rho_t^W > \rho_t^T$. Therefore, if private agents place a greater likelihood on the government being weak, then this raises their expectations of devaluation.

Figure 1 illustrates the effect of different values of π_t (for convenience, time subscripts are omitted). As shown above, a government of type i (i = W or T) will devalue when the unemployment shock plus expected devaluation is larger than a certain value b^i, related to its preferences and to the effect of devaluation on unemployment; that is, when

$$(21)\quad u > b^i - (Ee - e_{-1})$$

Suppose the government is thought to be tough ($\pi = 0$); then the situation is as depicted in panel a. The critical value of the shock u for a tough government to devalue will be

$$(22)\quad u > b^T - \rho^T d$$

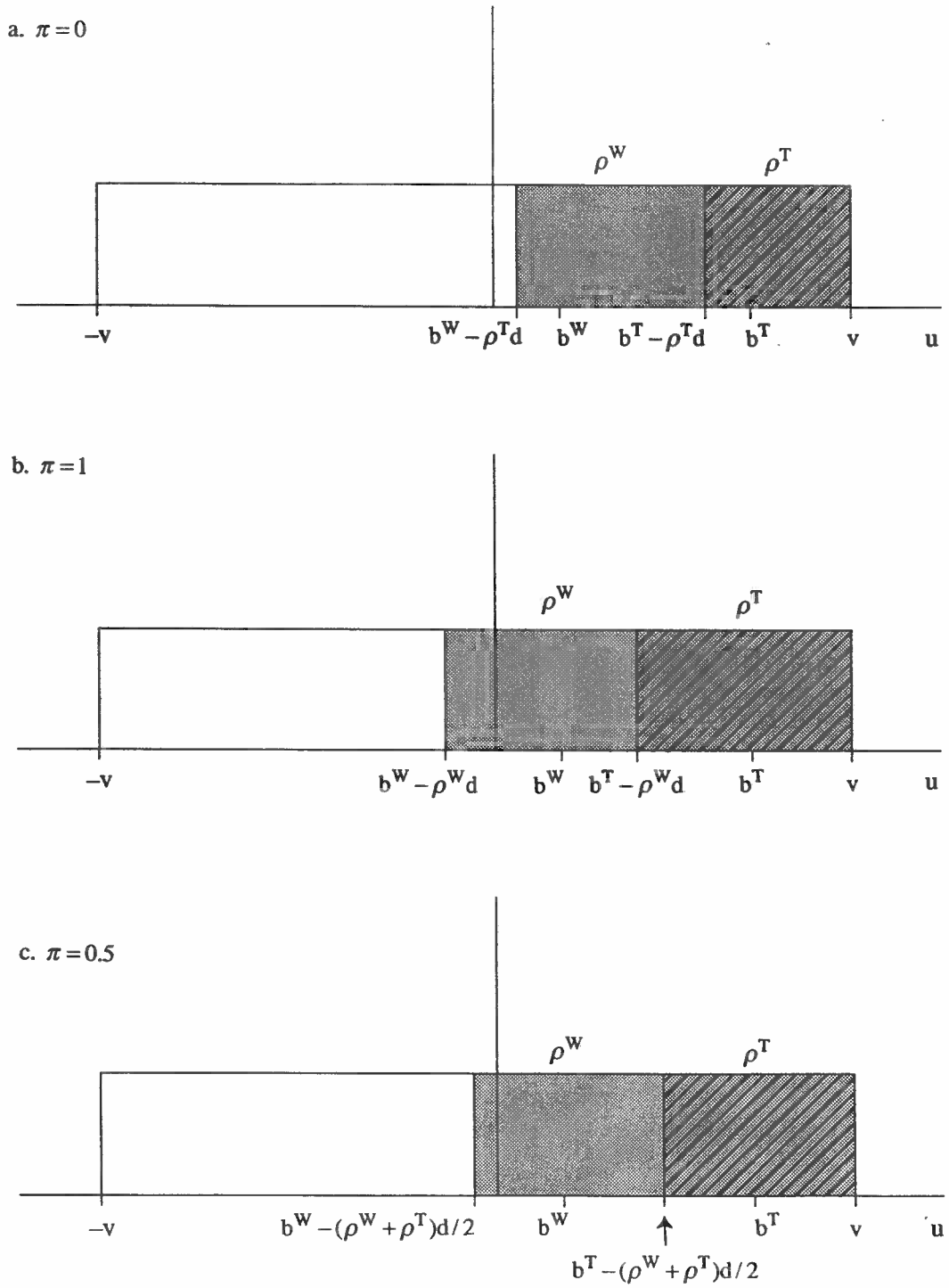
Since ρ^T is simply the probability that the shock u will take on such values, i.e.,

$$(23)\quad \rho^T = prob\ (u > b^T - \rho^T d),$$

and ρ^T is assumed uniformly distributed in the interval $[-v, v]$, then

$$(24)\quad \rho^T = \frac{v - b^T + \rho^T d}{2v}$$

Figure 1. Probability of Devaluation with Different Degrees of Credibility



and solving for ρ^T,

$$(25)\quad \rho^T = \frac{v - b^T}{2v - d}$$

The devaluation size is assumed to have an effect that is less than twice the maximum unemployment shock, so the denominator is positive. In panel a., ρ^T is consistent with the above relationships, and the trigger point for a weak government is also displaced by an amount $\rho^T d$.

In panel b., in contrast, private agents are convinced that the government is of a weak type. In this case,

$$(26)\quad \rho^W = \frac{v-b^W}{2v-d}$$

and ρ^T, instead of being given by equation (25) above, is given by

$$(27)\quad \rho^T = \frac{v-b^T+\rho^W d}{2v}$$

$$= \frac{v-b^T+(b^T-b^W)\ d/2v}{2v-d}$$

Therefore, in this case the devaluation probabilities for both types of government are higher. As drawn, even a zero shock to unemployment would trigger a devaluation if the government is weak. It is clear therefore that a crisis of confidence in the government could produce a self-fulfilling exchange rate adjustment.

An intermediate case, with equal probabilities assigned to the two types of government, is illustrated in panel c. In this case, the threshold levels for unemployment shocks beyond which devaluation is triggered reflect the preferences of both governments. In general,

$$(28)\quad \rho^T = \frac{v - b^T + (b^T - b^W)\ \pi d/2v}{2v - d}$$

$$(29)\quad \rho^W = \frac{v - b^W - (b^T - b^W)\ (1-\pi)\, d/2v}{2v - d},$$

so that the devaluation probability of a tough government is raised relative to its value if its type were known, and that of a weak government is lowered.

VI. Conclusions and Directions for Further Research

The model highlights two aspects of credibility: signaling the type of government, which is assumed not to be known; and, for any type, the likelihood that if circumstances are sufficiently unfavorable a devaluation will occur, since not to devalue would be inconsistent with the government's objectives. These two factors have opposite implications for the link between unemployment and interest differentials: high unemployment signals a tough government, but also makes it less likely that even a tough government will maintain an existing parity.

This model is applied to long-term interest differentials relative to Germany for the two years of U.K. membership in the ERM. The model suggests that by the fall of 1991, the commitment of the government to the existing parity was widely believed. However, in the summer of 1992 unemployment was increasingly seen as tying the hands of the authorities in defending the parity, and this helped to keep interest differentials high. Market expectations correctly reflected the belief that even a government committed to the ERM would decide to abandon its commitment to an exchange rate parity in sufficiently adverse circumstances.

The ERM crisis of September 1992 has generated considerable controversy over the respective roles of economic fundamentals and speculation in causing the crisis. The model discussed in the paper includes among those fundamentals unemployment, and highlights the role of shocks to that variable in affecting the costs and benefits of sticking to an exchange rate peg. If unemployment exhibits persistence, so that the higher is current

unemployment, the more likely a new shock will take it to unacceptable levels, then expectations of devaluation will depend on that unemployment level. The model suggests that these unemployment fundamentals explain the persistence of a sizeable long-term interest differential with Germany. In contrast, confidence in the government's commitment to the ERM--that is, its "toughness"--seems to have increased steadily over the October 1990- August 1992 period. Thus, the estimation results do not support the hypothesis of a self-fulfilling speculative crisis due to lack of confidence in the authorities.

The conclusions are necessarily tentative. The model could be extended in a number of directions and tested using data for other countries. A more complicated model would allow for a multi-period objective function and thereby give a larger role to the government's desire to signal its type through its policy actions. A two-period horizon is considered in Drazen and Masson (1993), for instance; unfortunately, closed-form solutions for estimation in a dynamic context are not easily developed for general models. The model could also be extended by considering shocks to other fundamental variables, such as output, inflation, or the balance of payments, and other channels, including interest rates and public debt accumulation. Differences across countries in the size of public debt and the relative importance of short-term and long-term interest rates might emerge from cross-country estimation. Finally, the Kalman filter could be generalized to ensure that calculated probabilities are bounded between zero and unity (perhaps along the lines of Hamilton (1988, 1989, 1990)) and imposing the same distribution on the errors as was used to derive the model.

Linearizing the Transition Equation

Starting from equation (10) in the text, we substitute for ρ^T and ρ^W using equations (6) and (8):

$$\pi_t = \frac{1-\bar{\rho}^W - \frac{\delta u r_{t-2}}{2v-d} - (1-\pi_{t-1})(\bar{\rho}^T-\bar{\rho}^W)\frac{d}{2v}}{1-\bar{\rho}^T - \delta\frac{ur_{t-2}}{2v-d} + \pi_{t-1}(\bar{\rho}^T-\bar{\rho}^W)}\ \pi_{t-1}$$

Linearizing this expression around $ur_{t-2} = 0$ and $\pi_{t-1} = \pi_0$, we obtain

$$\pi_t = \frac{\pi_0(1-\pi_0)(\bar{\rho}^T-\bar{\rho}^W)\ \delta/2v}{A^2}\ ur_{t-2}$$

$$+\ \frac{(1-\bar{\rho}^T)\ [1-\bar{\rho}^W-(1-2\pi_0)(\bar{\rho}^T-\bar{\rho}^W)\ d/2v]+\pi_0^2(\bar{\rho}^T-\bar{\rho}^W)^2\, d/2v}{A^2}\ \pi_{t-1}$$

where $A = 1-\bar{\rho}^T + \pi_0\ (\bar{\rho}^T - \bar{\rho}^W)$

It can be verified that the coefficient of ur_{t-2} is negative.

APPENDIX II

Derivation of Dynamics

Expected depreciation is decomposed into the probability of a weak government (π_t) and the probability weak and tough governments will devalue next period (ρ_t^W and ρ_t^T, respectively):

$$(A1)\quad Ee_t - e_{t-1} = [\pi_t \rho_t^W + (1-\pi_t)\rho_t^T]d$$

ρ_t^W and ρ_t^T can be written as follows 1/:

$$(A2)\quad \rho_t^W = \bar{\rho}^W + \frac{\delta u r_{t-1}}{2v-d} + (1-\pi_t)(\bar{\rho}^T - \bar{\rho}^W)d/2v$$

$$(A3)\quad \rho_t^T = \bar{\rho}^T + \frac{\delta u r_{t-1}}{2v-d} - \pi_t(\bar{\rho}^T - \bar{\rho}^W)d/2v,$$

where $\bar{\rho}^T$ and $\bar{\rho}^W$ are constant "steady state" devaluation probabilities for the two types of government, and shocks to unemployment are distributed uniformly in the interval [-v,v]. Substituting (A2) and (A3) into (A1) yields

$$(A4)\quad Ee_t - e_{t-1} = [\bar{\rho}^T + \frac{\delta u r_{t-1}}{2v-d} + \pi_t(\bar{\rho}^W - \bar{\rho}^T)]d$$

1/ Substituting equations (8a-b) into (6a-b).

APPENDIX II

Further substituting into (1) in the text above gives, in the case of no devaluation (so $e_t = e_{t-1}$):

$$(A5)\quad ur_t = \sqrt{a}\,[\bar{\rho}^T d + \frac{2v\delta}{2v-d}\, ur_{t-1} + (\bar{\rho}^W - \bar{\rho}^T)\, d\pi_t + u_t]$$

Imposing $\bar{\rho}^T = 0$, and letting $\zeta_t = \sqrt{a}\, u_t$, gives equation (17) in the text.

Equation (16) results from the updating equation (10) in the text, with all variables led one period, after substituting equations (A2) and (A3) and adding an error term η_{t+1}.

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