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LOSING CREDIBILITY: THE STABILIZATION BLUES

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Losing Credibility: The Stabilization Blues*

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Abstract

In exchange rate-based stabilization programs, credibility often follows a distinct time pattern. At first it rises as the highly visible nominal anchor provides a sense of stability and hopes run high for a permanent solution to the fiscal problems. Later, as the domestic currency appreciates in real terms and the fiscal problems are not fully resolved, the credibility of the program falls, sometimes precipitously. This paper develops a political-economy model that focuses on the evolution of credibility over time, and is consistent with the pattern just described. Inflation inertia and costly budget negotiations play a key role in the model.

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1 Introduction

Resorting to the exchange rate as the nominal anchor in inflation stabilization programs often proves irresistible. Even after painful failures, policymakers

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keep coming back to a pegged exchange rate claiming — like a jilted lover making his case for one more chance — that everything will be different this time around. The popularity of the exchange rate as a nominal anchor is not hard to understand since, in principle, a credible peg should bring about rapid price stability with little or no real costs. In practice, however, exchange rate-based stabilizations have more often than not ended in costly balance of payment crises. The convergence of domestic inflation to the pegged exchange rate has been a long and tortuous road. The expectation of a devaluation to correct large real appreciations of the domestic currency has hung above the programs like Damocles' sword, becoming more often than not a self-fulfilling prophecy. Moreover, severe real dislocations have characterized successful and unsuccessful programs alike (see Kiguel and Liviatan (1992) and Végh (1992)).

More subtle — but equally fascinating — is the pattern that credibility seems to follow in many exchange rate-based stabilizations. Even in programs that eventually fail, credibility appears to increase in the first stages of the program, as the highly visible nominal anchor provides a sense of stability, inflation begins to fall, and an agreement between different pressure groups on how to close the fiscal gap on a permanent basis seems within reach. As time goes by, however, the continuing real appreciation of the domestic currency, together with the apparent inability of the political process to deal with the fiscal problems, begin to erode credibility, and speculation about a possible devaluation arises. Furthermore, the public realizes that, since the fiscal problems have yet to be resolved, a devaluation would put an end to the program, because it would fuel speculation of further devaluations. Eventually, the loss of credibility is such that the "blues" set in and the question becomes not if but when the program will end.[1]

There can be little doubt that the time pattern of "credibility" just described reflects important economic considerations. Attempts at formalizing it, however, have proved elusive. This is hardly surprising considering that any attempt at modeling such a credibility pattern must first answer the fundamental question of what is credibility. Furthermore, credibility must be an endogenous variable if any interesting dynamics are to come out of the model. This paper can be viewed as an attempt at formalizing this dynamic

[1] Agénor and Taylor (1993) find such a pattern for credibility during the Brazilian 1986 Cruzado plan.

pattern of credibility. It develops a political-economy model that provides a natural definition of credibility, and shows how economic and political variables influence credibility in such a way that it increases at the beginning of the program and then falls rapidly.

The model incorporates two important characteristics of major stabilization plans. First, exchange rate programs often follow a two-stage approach. In the first stage, a nominal anchor is established and some partial measures toward reducing the fiscal deficit are adopted. In a second stage, which may take several years or may in fact never occur, the rest of the fiscal adjustment is carried out. Examples of two-stage exchange rate-based stabilizations can be found in both low and high inflation countries.[2] The reasons behind the two-stage approach are not hard to understand. Pegging the exchange rate — assuming that reserves are available — can be done overnight. In sharp contrast, establishing the political consensus that is needed to take tough fiscal measures is a slow and difficult process. The second feature of exchange rate-based stabilizations incorporated into our model is the sustained real appreciation of the domestic currency, which often originates in the presence of backward-looking indexation (Dornbusch and Simonsen (1987), Edwards (1991)).

Formally, we consider a stabilization plan that consists of (i) fixing the exchange rate, and (ii) implementing a fiscal package that reduces, but does not completely eliminate, the fiscal deficit. The presence of inflation inertia implies that the inflation rate does not fall immediately in response to the drastic reduction in the devaluation rate. The resulting real appreciation of the domestic currency generates expectations of a step devaluation that would restore the equilibrium real exchange rate. This expected devaluation increases the nominal interest rate, thus reducing real money demand, and forcing the central bank to lose reserves. As a result, there exists the possibility that a balance of payments crisis will develop. As far as the public

[2] In low inflation countries, the cases of the successful Danish and 1982 Irish stabilizations stand out (see Giavazzi and Pagano (1990)). Only in the Danish case was the fiscal budget balanced four years into the program. In high inflation countries, cases in which the fiscal gap was initially reduced but the second stage never materialized and the programs fail include the Argentine Tablita (1978), the Argentine Austral plan (1985), and the Brazilian Cruzado plan (1986). This two-stage approach has also characterized successful plans, such as the Bolivian (1985), Israeli (1985), and Argentine Convertibility (1991) plans (see Kiguel and Livitan (1992), Végh (1992) and the references therein).

is concerned, the timing of such a crisis is uncertain because it does not know the level of reserves at which the central bank would abandon the fixed exchange rate.

In the meantime, pressure groups negotiate over which group will bear the cost of the taxes needed to close the remaining fiscal gap (i.e., they engage in a war of attrition, as in Alesina and Drazen (1991)). Conceding is costly because the group that concedes will bear the burden of the taxes needed to close the budget gap. Thus, the benefit of waiting another instant is the present value of all futures taxes times the probability intensity (i.e., the hazard rate) that the other player will concede in the next instant. Pressures group dislike inflation and real appreciation, albeit to different degrees. When the cost of waiting for a group is at least equal to the cost of conceding, it will concede. For simplicity, we assume that, if and when a budget agreement is reached, a devaluation to restore the equilibrium real exchange rate will also take place.

The dynamics of the stabilization plan are thus characterized by real appreciation of the domestic currency, an increasing nominal interest rate, and rising public debt. Interestingly, this scenario characterizes both successful and unsuccessful stabilizations. This is an attractive feature of the model because it has been argued, most notably by Dornbusch (1988), that it is difficult to tell at the beginning of a plan whether it will be successful or not. In contrast, Sargent (1982) argues that the difference should be very clear from the outset because this is precisely why a program succeeds in the first place.

The interaction between the war of attrition and the balance of payments crisis model provides a natural definition of credibility.[3] Specifically, the

[3]Numerous definitions of credibility can be found in the literature. In Calvo (1986) and Calvo and Végh (1993), lack of credibility is modeled as temporary policy. While this definition proves useful in understanding the macroeconomic effects of lack of credibility, it cannot shed any light on the nature and evolution of credibility. Credibility has also been identifed with time-consistency or "incentive-compatibility" (see, for instance, Persson and Tabellini (1990)). While, under this definition, credibility is endogenous, it does not follow any dynamic pattern since a program is either credible (i.e, time consistent) or it is not. The definition used by Dornbusch (1991) is more in the spirit of this paper. In his model, a program fails if reserves fall below a certain level. The level of reserves, in turn, depends on a random variable and on the adjustment effort. Credibility is defined as the probability that the program will succeed (i.e., that reserves do not fall below a certain level).

credibility of a program is defined as the conditional probability that the budget agreement takes place before a balance of payments crisis develops. Credibility so defined is an endogenous variable and depends on all the parameters of the model. In particular, the time path of credibility depends positively on the hazard rate of a budget agreement and negatively on the hazard rate of a balance of payment crisis. In the first stages of the program, credibility increases, as the nominal rate is still relatively low (which implies that the hazard rate of a balance of payments crisis is small), and the public debt has yet to increase substantially (which implies that a fiscal agreement is more likely since the costs of conceding are small). Later, however, credibility begins to fall and does so at an increasing rate, as the rising nominal interest rate increases the hazard rate of a balance of payments crisis, and the rising public debt reduces the hazard rate of a budget agreement. Simulations of the model suggest that this inverted-U pattern of the credibility path is robust to changes in various parameters. The model thus suggests that if a budget agreement is not reached in the early stages of the plan, the program may quickly lose credibility because of the intrinsic dynamics of a two-stage plan.

The paper proceeds as follows. Section 2 develops the theoretical model. Section 3 undertakes various simulation exercises. Section 4 concludes.

2 The model

This section develops the theoretical model. It first discusses the main features of the stabilization plan. It then develops the two main building blocks: a balance of payments crisis model and the war of attrition. The section ends by putting all the pieces together and defining the notion of credibility.

2.1 The stabilization plan: preliminaries

Consider a small open economy which is initially at a high-inflation, steady-state equilibrium. Let π^h and ε^h denote the initial inflation and devaluation rate, respectively. (Naturally, $\pi^h = \varepsilon^h$.) The (log of the) real exchange rate, e, is defined as the relative price of traded goods in terms of home goods. Hence, $e_t = S_t - P_t$, where S_t and P_t denote the (log of) the nominal exchange rate and the price level of non-tradable goods at time t, respectively. (We assume that the exogenously-given (log of the) foreign price level is constant over time and equal to zero.) The (constant) steady-state level of the real exchange rate is denoted by $\bar{e}$.

At time $t = 0$, policymakers implement a two-stage exchange rate-based stabilization plan. In the first stage, policymakers (i) fix the exchange rate at the value of S (expressed in logs), and (ii) implement a fiscal package that reduces, but does not completely eliminate, the fiscal deficit. The authorities also announce that the remaining fiscal measures needed to close the fiscal budget are currently under study, and will be implemented in the near future (the second stage). This second stage may take several years, or may in fact never occur. In other words, the plan may collapse — for reasons discussed below — before these additional measures are taken.

Upon the fixing of the nominal exchange rate, inflation falls but remains positive (because of, say, backward-looking indexation). To keep matters as simple as possible, we assume that at time 0 domestic inflation falls from π^h to $\alpha\pi^h$, where $\alpha \in (0, 1]$ is a constant which measures the degree of inflation inertia. If $\alpha = 1$, the extent of inflation inertia is such that domestic inflation is not affected by fixing the nominal exchange rate.

Since the nominal exchange rate is fixed as of time 0, the real exchange rate is given by

$$e_t = \bar{e} - \alpha\pi^h t. \tag{1}$$

The real exchange rate thus appreciates gradually (relative to its long-run equilibrium level) in the aftermath of the stabilization. As discussed below, the process of real appreciation of the domestic currency described by equation (1) will not persist indefinitely, which implies that equation (1) will not be assumed to hold forever.

We now turn to the fiscal situation that accompanies the fixing of the nominal exchange rate. Letting m denote real money balances (in terms of the traded good, which is taken to be the numeraire), total revenues from money creation consist of $\dot{m}$ (seigniorage) plus εm (inflation tax). We assume that the monetary authority transfers to the fiscal authority the revenues from the inflation tax, εm.[4] In the initial high-inflation, steady-state equilibrium, government expenditures and the service of the public debt are

[4]Changes in real money balances (seigniorage) will thus be reflected in changes in international reserves at the Central Bank.

financed by conventional taxes and the inflation tax. At time 0, the exchange rate is fixed, so that inflation tax revenues become zero. Since the fiscal adjustment at time 0 is incomplete (i.e., the increase in taxes does not fully compensate for the loss of the inflation tax), a fraction of the lost revenues from the inflation tax will have to be covered by issuing debt. For simplicity, it is assumed that the public sector borrows abroad. Formally, real tax revenues after the initial fiscal adjustment are given by

$$\tau = \rho b_0 + g - \eta \varepsilon^h m(i^h), \tag{2}$$

where g denotes the constant level of government (non-interest) expenditure, b_0 is the initial level of the public debt, ρ is the (constant and exogenous) foreign interest rate, $m(i^h)$ is the pre-stabilization real money demand (with i denoting the nominal interest rate), and $\eta \in (0,1]$ is the fraction of the inflation tax revenues which is not covered by an initial increase in taxes (if $\eta = 1$, then there is no initial fiscal adjustment). Public debt accumulation is thus given by

$$\dot{b}_t = \rho b_t + g - \tau, \tag{3}$$

where b_t denotes the stock of public debt at time t.

Since the initial fiscal adjustment is incomplete, political negotiations are needed to implement the additional fiscal measures. Let R_t denote the increase in tax revenues required to finance government expenditure and service the stock of public debt outstanding in period t. Hence, $R_t = \dot{b}_t$. A political agreement will involve a decision about how the required tax revenue increase, R_t, will be distributed across different constituencies. Thus, if an agreement is reached at time t, the required increase in taxes is given by (using (3))

$$R_t = \rho(b_t - b_0) + R_0, \tag{4}$$

where $R_0 (= \eta \varepsilon^h m(i^h) > 0)$ denotes the fiscal gap not closed at time 0. Hence, equation (4) says that the taxes required to close the fiscal deficit at time t equal the initial gap R_0 plus the accumulated debt between time 0 and time T. R_t is thus an increasing function of time. Furthermore, from (4) and the definition of R_t, it follows that the additional taxes needed to close the fiscal gap are growing at the rate ρ:

$$\dot{R}_t = \rho R_t. \tag{5}$$

It will be assumed that the political agreement regarding the fiscal situation is also expected to involve a devaluation of the domestic currency that reestablishes the equilibrium real exchange rate, $\bar{e}$. Moreover, if and when this happens, the economy immediately adjusts to a low-inflation, steady-state equilibrium, in which $e_t = \bar{e}$ and $\pi_t = 0$. This last assumption can be thought of as if the structural factors that generated inflation inertia were removed as part of the political agreement.

The decision involving the timing of the step devaluation may be rationalized as follows. If a fiscal agreement has not yet been reached, a step devaluation would be interpreted as a signal that the stabilization is being abandoned. Thus, we assume that policymakers are able to resist the pressure to devalue until agreement on a fiscal package is reached. Once taxes are raised and the public is convinced that the conditions for permanent price stabilization are met, the Central Bank is then able to reestablish the long-run equilibrium real exchange rate without affecting the public's expectations. The nominal devaluation, in turn, avoids a costly period of deflation that would otherwise be necessary to restore the initial real exchange rate level.

Let h_t be the hazard rate associated with reaching a fiscal agreement. (Formally, h_t will be determined by political economy considerations discussed below.) Then, by the previous discussion, h_t is also the hazard rate of a corrective step devaluation of size $\bar{e} - e_t$ at time t, which brings the real exchange rate back to $\bar{e}$. Hence, the expected devaluation associated with reaching a fiscal agreement is $h_t(\bar{e} - e_t)$, which will be reflected in the nominal interest rate. Then, if $h_t(\bar{e} - e_t)$ is increasing over time, the nominal interest rate will also be increasing over time on this account. However, this is only one of the two factors that affect the nominal interest rate. The second one, to which we now turn, is the possibility that a balance of payments crisis may occur.

2.2 Balance of payments crisis

An important concern of policymakers after they initiate a price stabilization program is the possibility of a balance of payments crisis that could force them to devalue the currency or abandon the adjustment effort even if the evolution of fiscal fundamentals did not warrant such a policy reversal. In this subsection, we show that a balance of payments crisis may develop in connection with the sustained real exchange rate appreciation discussed above.

In order to analyze this issue more formally, consider the following demand for money:

$$M_t - S = \bar{m} - \delta i_t, \tag{6}$$

where M_t denotes the (log of the) money supply at time t, $\bar{m}$ and δ are positive constants, and i is the nominal interest rate. It is assumed that, at the time the nominal exchange rate is fixed, domestic credit growth is also set equal to zero. Thus, changes in the quantity of money occur only as a result of changes in foreign exchange reserves. Moreover, since domestic credit is constant, changes in foreign exchange reserves reflect changes in money demand occurring from variations in the nominal interest rate. In particular, if the nominal interest rate increases over time as a result of an increase in the expected devaluation, then the stock of foreign exchange reserves will fall over time.

The central bank is assumed to stick to the announced exchange rate policy as long as foreign exchange reserves do not fall below a certain threshold, corresponding to a money supply level of M^c — where c stands for "crisis". If M_t reaches M^c, then a balance of payments crisis occurs and the exchange rate policy collapses.[5] It is assumed that the collapse of the exchange rate policy is associated with a resumption of domestic credit expansion. In the post-collapse regime, the nominal exchange rate depreciates at the rate ε,

[5]It should be noted that, for the sake of analytical tractability, we have assumed that the Central Bank has an implicit upper bound on borrowing while the government (i.e., the fiscal authority) does not. The most natural assumption would be to impose an upper bound on the government's total borrowing (i.e., fiscal authority-cum-monetary authority), which is the standard assumption in the balance of payments crisis literature. Such an assumption would greatly complicate the analysis because it would establish an additional link between the balance of payment crisis and the war of attrition. In any event, we feel that the assumption made is not a bad description of reality to the extent that in practice even solvent governments (i.e., governments that could borrow from abroad) do not seem willing to finance reserve losses once some threshold has been reached. This could reflect either liquidity constraints or a domestic policy decision regarding how much resources should be devoted to defending the peg.

this rate being, for instance, the result of domestic money creation at the same rate under a floating exchange rate regime. The post-collapse rate of devaluation reflects the resumption of monetary financing of the government budget. For simplicity, we assume that ε is exogenous.

The public is assumed not to know the precise level of reserves at which the central bank abandons the exchange rate peg. Rather, it is assumed that the public's beliefs about M^c are described by a probability distribution, $W(x) = \Pr\{M^c < x\}$, with a corresponding density function $w(x) = W'(x)$.

As time goes by, agents revise their beliefs about M^c according to Bayes's Law. Both the public's beliefs about M^c and the behavior of the nominal exchange rate at the time of the balance of payments crisis affect the nominal interest rate through the expected devaluation. In turn, the path of the nominal interest rate is crucial to determining the time of collapse of the exchange rate policy.

To determine the time of collapse and to characterize the nature of the balance of payments crisis, it is useful to define the time of collapse, T^c, as a monotonic decreasing function of the threshold level M^c, when the nominal interest rate increases over time; i.e., $T^c = T^c(M^c)$ if M_t is decreasing. The function $T^c(M^c)$ is obtained from the demand for money equation (6) and is therefore invertible. By inverting it, we can define $V_t \equiv \Pr\{T^c < t\}$ and the associated density function v_t. It follows that $V_t = 1 - W(M_t)$ and $v_t = -w(M_t)\dot{M}_t$.

Incomplete information about the timing of the balance of payments crisis introduces considerations analogous to those discussed by, among others, Flood and Garber (1984) and Obstfeld (1986), which differ from perfect-foresight balance of payments crises models à la Krugman (1978). In particular, it is easy to show that incomplete information about M^c — and, therefore, about T^c — implies that the exchange rate may jump at the time of collapse. Reserves, on the contrary, may not jump in the transition.[6]

[6]Technically, there may exist a continuum of equilibria in which both the exchange rate and reserves jump at the time of the crisis, along lines similar to those discussed by Obstfeld (1986). The reason is that the Central Bank is expected to change its policy after the crisis (that is; it will switch from a fixed exchange rate to a rate of devaluation of ε). Hence, within the time interval in which an attack would lead to a change in policy, there is multiple equilibria: a run will occur *if* agents expect that other agents will run. If agents believe that no other agent will run, then a run will not occur (Obstfeld, 1986). For the sake of analytical tractability, we rule out equilibria in which reserves (or the money

Using (6), the step devaluation that occurs at time t (if $t = T^c$), equals $M_t - \bar{m} + \delta(\rho + \varepsilon) - S$ (note that, assuming that M_t does not jump at $t = T^c$ implies that the nominal interest rate must increase at T^c).[7] [8] The nominal devaluation that occurs in the event of a balance of payments crisis is larger the higher is ε.

The precise time of collapse is obtained by computing the time path of the demand for money, using equation (6), where the nominal interest rate takes into account the public's expectations that a collapse may occur. Specifically,

$$\begin{aligned} M_t - S &= \bar{m} - \delta\left[\rho + h_t(\bar{e} - e_t)\frac{\Pr\{T^c > t + dt\}}{\Pr\{T^c > t\}}\right. \\ &\quad \left. + \frac{M_t - \bar{m} + \delta(\rho + \varepsilon) - S}{dt}\frac{\Pr\{t < T^c < t + dt\}}{\Pr\{T^c > t\}}\right] \end{aligned} \tag{7}$$

where the public's beliefs about M^c, conditional on the crisis not having occurred until time t, and on M_t being a decreasing function of time, are given by

$$\Pr\{M_{t+dt} < M^c < M_t \mid t\} = \begin{cases} \frac{v_t dt}{1-V_t}, & T^c(M^c) \geq t, \\ 0, & T^c(M^c) < t. \end{cases} \tag{8}$$

If M_t is increasing or constant over time, then $\Pr\{M_{t+dt} < M^c < M_t \mid t\} = 0$. As equation (7) makes clear, the expected devaluation incorporated into

supply) jump at the time of the collapse. Hence, we are assuming that the run occurs at the time at which the critical level of reserves is reached (which is not known by the public), and all the adjustment in real money balances takes place through a change in the exchange rate. As will become clear below, allowing for jumps in reserves would not alter our results since it would not affect the fact that the nominal interest rate increases over time (for which all that is needed is a positive expectation of a devaluation).

[7] To see that the nominal devaluation in the event of a balance of payments crisis equals $M_t - \bar{m} + \delta(\rho + \varepsilon) - S$, note that M_t does not jump at the time of the crisis. Hence, the nominal exchange rate at the the time of the crisis has to jump to satisfy $S_t = M_t - \bar{m} + \delta(\rho + \varepsilon)$, the post-crisis initial money market equilibrium condition.

[8] Note that the nominal interest rate has to be below the post-collapse nominal interest rate at all times before T^c. This is so because, since the pre-crisis nominal interest rate is a continuous function of time, a situation in which the nominal interest rate falls at T^c would have required that a balance of payments crisis occur before T^c, contradicting the definition of T^c.

the nominal interest rate (given by the last two terms in the expression in square brackets) has two components: the devaluation associated with a fiscal agreement and the devaluation associated with a balance of payments crisis.

Using equations (6) and (8), the demand for money is given by:

$$M_t = S + \bar{m} - \delta\left[\rho + \frac{h_t(\bar{e} - e_t) + \lambda_t\delta\varepsilon}{1 + \delta\lambda_t}\right],$$

where

$$\lambda_t \equiv \frac{v_t}{1 - V_t} \tag{9}$$

is the hazard rate of a balance of payments crisis.

Since, in this model, a balance of payments crisis is what causes the stabilization plan to fail, the hazard rate λ_t constitutes one of the two essential components of the credibility of the stabilization plan — the other component being the hazard rate of a fiscal agreement. While a full discussion of what determines the credibility of the stabilization program in this model is postponed until later in this section, it is clear that, other things being equal, a higher λ_t implies a loss of credibility. There are, thus, two important issues with regard to λ_t: first, its behavior over time (if λ_t increases over time, for instance, one would say that, other things equal, credibility diminishes with the passage of time) and, second, its level. Both the level and the time path of λ_t are functions of the parameters that characterize the demand for money, the real exchange rate, and the distributions $W(.)$ and $V(.)$.

An example. To gain some further intuition into the behavior of λ_t, we proceed to examine a particular case. This example will also be used in the numerical simulations presented in Section 3.

Using the relationship that exists between $V(.)$ and $W(.)$, equation (6) may be written as:

$$M_t - S = \bar{m} - \delta\left\{\rho + h_t(\bar{e} - e_t) - [M_t - \bar{m} + \delta(\rho + \varepsilon) - S]\frac{w(M_t)\dot{M}_t}{W(M_t)}\right\} \tag{10}$$

To obtain an explicit solution for the path of M_t, the following assumptions are made:

Assumption 1. M^c is uniformly distributed with lower and upper supports $[M^L, M^H]$, so that

$$\frac{w(M_t)}{W(M_t)} = \frac{1}{M_t - M^L}. \tag{11}$$

Assumption 2. The lower support is given by:

$$M^L \equiv \bar{m} + S - \delta(\rho + \varepsilon). \tag{12}$$

Assumption 2 requires that the post-collapse money demand be equal to the lower bound of the distribution of the threshold level, M^c.[9] Taking into account Assumptions 1 and 2, equation (10) becomes a linear differential equation:

$$M_t - S = \bar{m} - \delta[\rho + h_t(\bar{e} - e_t) - \dot{M}_t], \tag{13}$$

which can be solved to yield:

$$M_t = S + \bar{m} - \delta\left\{\rho + \frac{1}{\delta}\int_t^\infty h_s(\bar{e} - e_s)\exp[-(s-t)/\delta]ds\right\}. \tag{14}$$

Equation (14) indicates that the fundamentals driving the nominal interest rate (the term in curve brackets) consist of the entire future path of the expected devaluation associated with a fiscal agreement. The level of money balances is thus fully determined by the path of the real exchange rate and the path of h_t.

Taking into account the relation between V_t and $W(M_t)$ described above and (11), equation (9) can be rewritten as

$$\lambda_t = -\frac{\dot{M}_t}{M_t - M^L}, \tag{15}$$

where M^L is given by equation (12). Equation (15) shows how the hazard rate of a balance of payments crisis depends on both the level and the rate of change of the money supply. The faster the money supply is falling and the closer the money supply is to the critical level, the higher the hazard rate.

[9] The drawback of making this assumption is that we cannot use this example to either make ε endogenous or do comparative statics with the parameters entering the right-hand side of equation (12). However, the analytical simplicity obtained pays significant dividends insofar as economic intuition is concerned.

To gain additional insight, let us assume that h_t is time-invariant.[10] In this case, equation (14) boils down to (taking into account (1)):

$$M_t = \bar{m} + S - \delta[\rho + h\alpha\pi^h(t+\delta)]. \tag{16}$$

Differentiating equation (16) with respect to time, we obtain:

$$\dot{M}_t = -\delta h\alpha\pi^h < 0, \tag{17}$$

which shows that M_t falls linearly over time. Naturally, the other side of the coin is that the nominal interest rate, given by $\rho + h\alpha\pi^h(t+\delta)$, increases linearly over time. Given (17), equation (15) can be rewritten as

$$\lambda_t = \frac{\delta h\alpha\pi^h}{M_t - M^L}. \tag{18}$$

We now derive two propositions which illustrate the behavior of λ_t.

Proposition 1 *Suppose that h_t is constant over time. Then an increase in h, α, or π^h leads to a rise in λ_t for all t.*

Proof. *From (16), an increase in $h\alpha\pi^h$ reduces M_t for all t. Hence, from (18), it follows that λ_t increases for all t* ||

The intuition is straightforward. A rise in $h\alpha\pi^h$ increases the nominal interest rate because it increases the expected devaluation associated with a fiscal agreement. This reduces money demand for all t. At the same time, it implies that the money supply is falling faster (recall (17)). Both forces increase the probability intensity associated with a balance of payments crisis. Hence, any increase in $h\alpha\pi^h$ will tend to make a stabilization program less credible.

Proposition 2 *Suppose that h_t is constant over time. Then, $\dot{\lambda}_t > 0$ and $\ddot{\lambda}_t > 0$.*

Proof. *Follows immediately from (18).*

Recall that, due to the cumulative real appreciation, the nominal interest rate increases over time. Hence, nominal money balances fall over time. As

[10] Numerical simulations of λ_t that take into account the endogenous behavior of h_t will be presented in Section (3).

the money supply gets closer to its critical level, the hazard rate increases over time. Hence, based on balance of payments crisis considerations, the hazard rate will always tend to increase over time.

2.3 A political economy model

In the previous subsections, we have seen that, as the real exchange rate falls below $\bar{e}$ after the implementation of the stabilization plan, the public expects a nominal devaluation that will bring the real exchange rate back to its long-run equilibrium level. The hazard rate associated with such a devaluation, h_t, was taken as given. We now endogeneize h_t and show how it may reflect the equilibrium outcome of a political economy model.

We characterize policymaking as a process in which decisions reflect the outcome of negotiations between representatives of the relevant constituencies of society. These groups exert pressure on policymakers by investing resources in various lobbying activities. Since the effects of policies vary across constituencies, a negotiation process arises, in which a policy package is designed. Ultimately, the policy package that emerges from this process is the result of an agreement between the various parts.

To be more specific, we assume that there are two constituencies ($i = 1, 2$), or pressure groups that must agree on the policy decisions. It is assumed that the position of constituency i at the negotiation table is given by:

$$u_t(\theta_i) = y - H\left[\theta_i(\bar{e} - e_t), \pi_t\right], \qquad H_1(.) > 0, H_2 > 0, \tag{19}$$

where y denotes income net of taxes at time t and $H(.)$ denotes a cost function that increases both with the level of real appreciation relative to its long-run equilibrium level and with inflation. The parameter θ_i, which affects the relative cost of a real appreciation compared to inflation for group i, is exogenously given and is the only parameter that differentiates the two constituencies from each other. Since the position of constituency i over particular policy issues may depend at any given point in time on a variety of reasons not explicitly modeled here, it is assumed that θ_i is a random variable, drawn from a distribution $G(\theta)$ with lower and upper bounds $\underline{\theta}$ and $\bar{\theta}$, respectively. Since both constituencies dislike a real appreciation of the domestic currency, pressure builds on policymakers to devalue whenever e_t is below $\bar{e}$.

At the time the exchange rate is fixed, the level of taxation is assumed to be divided equally across constituencies, which implies that net income, y, in equation (19) is the same for both groups. Net income will remain at the same level until an agreement is reached. The subsequent path of taxes and, especially, the distribution of any additional taxation is a matter of negotiation between the two constituencies. Furthermore, since at the start of the stabilization plan, the fiscal situation is not consolidated, an agreement needs to be reached over a policy package that includes (i) a nominal devaluation designed to eliminate the real appreciation and (ii) the distribution of the additional taxes, R_t, required for the long-run sustainability of the stabilization plan. For simplicity, we will assume that the group that concedes bears all the new taxes, R_t. Hence, if agreement takes place at time T, instantaneous utility from then on is given by

$$\begin{aligned} u^L &= y - R_t, \\ u^W &= y, \end{aligned} \tag{20}$$

where the superscripts "L" and "W" stand for "loser" and "winner," respectively.

The decision process is modeled as a war of attrition with incomplete information (see, for instance, Bliss and Nalebuff (1984), Fudenberg and Tirole (1986), Hendricks, Weiss, and Wilson (1986), Alesina and Drazen (1991), and Drazen and Grilli (1993)). As is well known, a war of attrition is a game of timing. Hence, it is a useful device to characterize a period of stalemate in which constituencies test how costly it is for their political opponents to postpone policy actions. When the costs of postponing the implementation of the policy package become unbearable for one group, this group concedes in the sense that it is willing to bear the new taxes.

Constituencies know the value of their own parameter, θ. However, they are assumed not to know the precise value of the opponent's parameter, knowing only the distribution $G(\theta)$. Each constituency's strategy consists in maximizing the group's intertemporal expected utility by the choice of a concession time, T_i. Formally, the pair of functions $\{T_1(\theta_1), T_2(\theta_2)\}$ define a symmetric, Bayesian-perfect equilibrium. (The equilibrium is symmetric because θ_1 and θ_2 are assumed to be drawn from the same distribution.) Since the equilibrium is symmetric, there is only one function $T(\theta)$ to be determined.

If agreement takes place at time T, lifetime utility of the winner and loser are given by:

$$U_T^j = \int_0^T u_x(\theta_i)e^{-\rho x}dx + \frac{u_T^j}{\rho}e^{-\rho T}, \qquad j = W, L. \tag{21}$$

Let $F(T)$ denote one's opponent optimal time of concession (to be derived below). Then, using (21), expected utility as of time 0 as a function of one's chosen concession time, T_i, can be written as:

$$\begin{aligned} EU(T_i) &= [1 - F(T_i)]U_{T_i}^L + \int_0^{T_i} U_x^W f(x)dx \\ &= [1 - F(T_i)]\left[\int_0^{T_i} u_x(\theta_i)e^{-\rho x}dx + \frac{u_{T_i}^L}{\rho}e^{-\rho T_i}\right] \\ &\quad + \int_{x=0}^{x=T_i}\left[\int_0^{T_i} u_z(\theta_i)e^{-\rho z}dz + \frac{y}{\rho}e^{-\rho T_i}\right]f(x)dx \end{aligned} \tag{22}$$

Expected utility is the sum of the lifetime utility derived from being either a loser or a winner, weighted by the probability corresponding to each scenario. Given that one is planning to concede at time T_i, one will be a looser if one's opponent has not conceded as of time T_i, which occurs with probability $1 - F(T_i)$. The expected utility associated with this scenario is thus $[1-F(T_i)]U_{T_i}^L$. On the other hand, if one's opponent concedes at any time before T_i, one is a winner. In this case, expected utility is $\int_0^{T_i} U_x^W f(x)dx$.

We can now derive the optimal time of concession, T_i, for a group with θ_i.[11] Since the distribution $F(T)$ is not know, (22) cannot be used directly. However, by showing that $T_i(\theta_i)$ is a strictly decreasing function, we can establish a relation between $F(T)$ and the known $G(\theta)$; that is $1 - F[T(\theta)] = G(\theta)$.

Proposition 3 . $T_i'(\theta_i) < 0$.

Proof. *See Appendix.*

We now find a symmetric Nash equilibrium in which each group's concession time is described by the function $T(\theta)$.

[11] We follows Bliss and Nalefuff (1984) and Alesina and Drazen (1991).

Proposition 4 *There exists a symmetric Nash equilibrium with each group's optimal behavior described by a concession function $T(\theta)$, where $T(\theta)$ is implicitly defined by*

$$\left[-\frac{g(\theta)}{G(\theta)T'(\theta)}\right]\frac{R_{T(\theta)}}{\rho} = H[\theta(\bar{e} - e_{T(\theta)}), \pi_{T(\theta)}], \tag{23}$$

with the boundary condition $T(\bar{\theta}) = 0$.
Proof. *See Appendix.*

To understand equation (23), think of a player who must decide between conceding now or waiting and conceding an instant later. An an optimum, the costs and benefits of waiting another instant must be the same. The benefit of waiting another instant (left-hand side) consists of the conditional probability that the opponent will concede (the hazard rate, in brackets) multiplied by the gain if the other group concedes (given by the present discounted value of the additional taxes). The cost of waiting (right-hand side) consists of the disutility provided by the real appreciation and the inflation rate.

For the purposes of simulating the model in the next section, notice that the Nash equilibrium established in Proposition 4 can also be characterized as a function of time (rather than as a function of θ). In effect, since proposition 3 indicates that the optimal time of concession is a strictly decreasing function of θ (i.e., $t = T(\theta)$) we can define the inverse function, $\Phi_t \equiv T^{-1}[T(\theta)] = \theta$, which provides for any point in time t the value of θ for which t is the time of concession (see, for instance, Fudenberg and Tirole (1986)). Hence, equation (23) can be rewritten as (taking into account that (5) implies that $R_t = R_0 \exp(\rho t)$):

$$\Phi'_t = -\frac{G(\Phi_t)}{g(\Phi_t)}\frac{\rho H[\Phi_t(\bar{e} - e_t), \pi_t]}{R_0 \exp(\rho t)}. \tag{24}$$

Together with the boundary condition $\Phi(0) = \bar{\theta}$, differential equation (24) determines a unique function Φ_t.

We can now derive the hazard rate, h_t, associated with reaching a political agreement. Denote by $Z(T)$ the cumulative probability that an agreement is reached by time T (i.e., the cumulative probability that someone has conceded by time T), and by $z(T)$ the corresponding density function.

Using the properties of $G(\theta)$, it then follows that $1 - Z(T) = [G(\theta)]^2$ and $z(T) = -2G(\theta)g(\theta)T'(\theta)$. Using (23), the hazard rate h_t can be expressed as:

$$h_t \equiv \frac{z_t}{1 - Z_t} = -\frac{2g(\theta)\Phi_t'}{G(\theta)} = \frac{2\rho H[\Phi_t(\bar{e} - e_t), \pi_t]}{R_t}, \tag{25}$$

where Φ_t solves equation (24). For a given Φ_t, equation (25) indicates that a rise in the cost of waiting or a fall in the present discounted value of taxes (that is, a fall in the benefit of waiting) make a fiscal agreement more likely. Hence, a higher degree of inflation inertia or a smaller initial deficit will both contribute to raise the program's credibility. Although Φ_t will also change, the simulations below suggest that the direct effect just discussed dominates.

In the absence of additional considerations, it can be shown that the length of the stalemate period (in which no agreement is reached) may extend ad infinitum. The fact that $\dot{R}_t > 0$, however, implies that at some point in time the government may simply become insolvent; that is, further increases in R_t are infeasible. Alesina and Drazen (1991) use this condition to impose a somewhat artificial end to the war of attrition by assuming that a policy package, which contains an exogenous distribution of taxes, is implemented at the time the government runs into insolvency. In this model, however, the balance of payments crisis provides an end to the war of attrition (as explained below).

2.4 Putting the pieces together

Let us now incorporate the balance of payments-crisis model presented earlier into the political-economy model. To keep the analysis as simple as possible, it is assumed that the two constituencies negotiating the fiscal package know M^c — while M^c is not known by individual consumers. If M^c is known, then the precise time at which a balance of payments crisis occurs (provided it occurs), T^c, is also known for the war of attrition.

It is assumed that T^c precedes the point in time at which the government becomes technically insolvent. If it occurs, a balance of payments crisis implies that $e_t = \bar{e}$ and $\pi_t = \varepsilon$ (where ε is the post-collapse rate of devaluation) for $t = T^c$. Two possibilities unfold at this time. On the one hand, if the utility loss associated with the balance of payments crisis is large enough — because the post-collapse inflation rate is high — then T^c acts as a mass point for the war of attrition. Thus, both groups will concede with probability 1 at T^c; that is, agreement will be reached before the balance of payments crisis takes place. This is a case in which the prospect of a balance of payments crisis shortens the period of political stalemate by increasing the costs of not agreeing on the fiscal adjustment.[12]

On the other hand, if the utility loss associated with a balance of payments crisis is not high enough, then it is possible that no group concedes. It is clear from (23) that, if the benefit of not conceding is high enough, both constituencies will find it optimal to let the crisis occur, since the costs of conceding for each individual constituency outweigh the costs associated with a resumption of inflation. Hence, from its own perspective, each constituency will find it optimal to let the balance of payments crisis happen, even though it is a suboptimal strategy if the two constituencies could cooperate and avoid the war of attrition.

Credibility We now have all the elements to deal explicitly with the notion of credibility. Credibility (as of time t) is defined as the probability of the budget agreement being reached before the balance of payments crisis occurs, given that neither has occurred as of time t. Formally, let X^s denote the time elapsed without a budget agreement and X^c the time elapsed with no balance of payments crisis occurring. Then,[13]

$$\text{Credibility} \equiv \Pr\{X^s < X^c\} \mid \text{Min}(X^s, X^c) = t\} = \frac{h_t}{h_t + \lambda_t}. \tag{26}$$

To gain intuition into the definition of credibility given by equation (26), consider two extreme cases. Suppose that the probability of a budget agreement were zero (i.e., $h_t = 0$), then the credibility of the program would always

[12]As shown by Alesina and Drazen (1991), if a tie-breaking rule (like the flip of a coin) is used in the event that both groups concede at T^c, then the presence of a mass point at T^c does not alter the optimal strategy $T(\theta)$ for all constituencies with $\theta > \hat{\theta}$, where $\hat{\theta}$ denotes the value of θ for which a group is indifferent between conceding or waiting up to T^c. Furthermore, letting, $\hat{T} = T(\hat{\theta})$, Alesina and Drazen (1991) show that, by appropriate choice of parameters, $\hat{T}$ can be made arbitrarily close to T^c.

[13]The right-most equality in equation (26) follows from basic probability theory (see, for instance, Ross (1983), p. 287), taking into account that X^c and X^s are independent random variables. The assumption that M^c is known to the players of the war of attrition ensures stochastic independence between X^c and X^s. Naturally, this is consistent with λ_t being functionally dependent of h_t.

be zero. Naturally, this makes sense because, by definition, the program can never succeed (i.e., an agreement will never be reached). Credibility also tends to zero if the hazard rate of a balance of payments crisis (λ_t) becomes very large. If, on the other hand, a budget agreement is perceived as highly likely (so that h_t becomes very large), then credibility becomes close to unity. Credibility is an increasing function of h_t and a decreasing function of λ_t, as one should intuitively expect. Hence, credibility, as defined in equation (26), is an endogenous variable and depends on all the parameters of the model. In the next section, we will conduct simulations of the time path of credibility and see how it evolves over time and how different parameters affect its path.

Duration We are also interested in having a measure of the likely duration of the program. Formally, let X^d denote the time elapsed with no resolution (i.e., with no fiscal agreement or balance of payment crisis). Thus, X^d measures the duration of the program. The hazard rate associated with the stochastic variable X^d is the hazard rate that the program will end at time t — either successfully (with a fiscal agreement) or unsuccessfully (with a balance of payment crisis) — conditional on having lasted until t. It follows that [14]

$$\text{Hazard rate program ends} = h_t + \lambda_t.$$

It should be noticed that this measure of duration is not necessarily related to the credibility of the program. While an increase in either λ_t or h_t reduces the likely duration of the program (i.e., it raises the hazard rate that the program will end), the increase in λ_t reduces credibility while the increase in h_t raises it.

3 Simulations of the model

In order to illustrate and provide further insights into the workings of the model, this section undertakes some simulation exercises. Since the function Φ_t — the solution to differential equation (24) — is not affected by the parameters of the balance of payments crisis model, we first simulate the war of attrition and study the dynamic behavior of Φ_t, H_t, and h_t. Given the

[14] Note that $\Pr\{Z < t\} = 1 - \Pr\{X^s > t\} \Pr\{X^c > t\}$.

path for h_t, we can then simulate the paths of i_t, M_t, and λ_t. Finally, given the paths of h_t and λ_t, we can simulate the paths of credibility and duration.

3.1 Set up

Suppose that the cost function takes the form:

$$H\left[\theta(\bar{e}-e_t),\pi_t\right]=\theta\mid\bar{e}-e_t\mid+\frac{\pi_t^2}{2}. \tag{27}$$

Taking into account equation (1) and the fact that inflation during the stabilization is $\alpha\pi^h$, the cost function can be rewritten as (using $\theta=\Phi_t$):

$$H\left[\theta(\bar{e}-e_t),\pi_t\right]=\Phi_t\alpha\pi^h t+\frac{\left(\alpha\pi^h\right)^2}{2}. \tag{28}$$

Taking into account (5) (which implies that $R_t = R_0\exp(\rho t)$), and (28), equation (25) can be expressed as (using $\theta=\Phi_t$):

$$h_t=\frac{2\rho\left[\Phi_t\alpha\pi^h t+\frac{\left(\alpha\pi^h\right)^2}{2}\right]}{R_0\exp(\rho t)}. \tag{29}$$

Let us assume that $G(\theta)$ is represented by a uniform distribution with support $[\underline{\theta},\bar{\theta}]$:

$$G(\theta)=\frac{\theta-\underline{\theta}}{\bar{\theta}-\underline{\theta}}. \tag{30}$$

Taking into account (28) and (30), equation (24) becomes

$$\Phi_t'=-[\Phi_t-\underline{\theta}]\frac{\rho\left[\Phi_t\alpha\pi^h t+\frac{\left(\alpha\pi^h\right)^2}{2}\right]}{R_0\exp(\rho t)}. \tag{31}$$

Equation (31) constitutes a non-autonomous, non-linear differential equation in Φ_t. Given the initial condition $\Phi_0=\bar{\theta}$, this differential equation can be solved numerically for given values of the parameters $\underline{\theta}$, $\bar{\theta}$, ρ, α, π^h, and R_0. Given Φ_t, we can then use equation (28) to simulate the path of H_t and (29) to simulate the path of h_t.

We now turn to the variables related to the balance of payment crisis. For a given path of h_t, we use equation (14) — taking into account (1) — to simulate the path of M_t where, in light of Assumption 2, we set $S + \bar{m} - \rho = M^L + \delta\varepsilon$. The new parameters are thus M^L, δ, and ε. Given the path of M_t, we use (15) to simulate the path of λ_t. Given the paths of M_t and h_t, the path of i_t is given by (as follows from (1) and (14)):

$$i_t = \rho + \frac{\alpha\pi^h}{\delta} \int_t^\infty h_s s \exp[-(s-t)/\delta] ds. \tag{32}$$

3.2 Results

To focus the discussion, we choose a benchmark case and then consider deviations with respect to this benchmark by varying one parameter at a time.

Benchmark In the benchmark case, the value of the parameters are as follows:[15]

$$\begin{aligned}
\bar{\theta} &= 15, \\
\underline{\theta} &= 1, \\
\rho &= 0.05, \\
\alpha &= 0.2, \\
\pi^h &= 1, \\
R_0 &= 0.03, \\
M^L &= 0.05, \\
\delta &= 2, \\
\varepsilon &= 2.
\end{aligned}$$

Figure 1 (full line) illustrates the behavior of the main six variables of the model in the benchmark case. As follows from Proposition 3 (notice that $\dot{\Phi}_t = \frac{1}{T'(\theta)} < 0$), Panel A shows that Φ_t falls over time. Intuitively, recall that Φ_t indicates, for any given t, the value of θ that would make a group concede.

15 The time unit is taken to be a year. Although we tried to choose "reasonable" parameter values, there is no attempt at replicating the workings of any actual economy. Rather, we focus on the qualitative implications of the simulations.

As time goes by, only groups with a lower θ (for which it is less costly not to concede) remain in the war of attrition, which makes Φ_t a decreasing function of time.

Panel B illustrates the time path of the cost of waiting, H_t. Since the inflation rate is constant over time, the dynamics of H_t reflect the cumulative real exchange rate appreciation weighted by its relative cost, θ (first term on the right-hand side of equation (28)). As time goes by, the cumulative real exchange rate appreciation increases linearly (recall equation (1)), but its relative cost falls over time. Panel B shows that the former effect prevails in the first stages and H_t increases rapidly. After reaching a maximum at $t = 0.65$, the cost of waiting begins to fall reflecting the falling θ.

Panel C in Figure 1 shows the time path of h_t. Given the behavior of H_t depicted in Panel B, it should come as no surprise that the path of h_t is also non-monotonic. Recall that h_t, given by equation (29), depends positively on the cost of waiting, H_t, and negatively on the present value of the additional taxes needed to close the fiscal gap. In the beginning, h_t increases over time and reaches a relative maximum, mirroring the behavior of H_t. Afterwards, h_t falls over time since the cost of waiting flattens out, while the benefit of waiting continues to rise. Hence, there seems to be a "window of opportunity" for completing the fiscal negotiations shortly after the implementation of the stabilization plan, after which an agreement becomes less and less likely over time. As will become clear below, once this "window of opportunity" for a fiscal agreement has been closed, the credibility of the program will suffer accordingly.

Panel D shows the time path of the nominal interest rate, given by (32). The nominal interest rate always increases over time, albeit at a slightly decreasing rate after h_t begins to fall since this tends to reduce the expected devaluation associated with a fiscal agreement. Given equation (6), the time path of the nominal money supply (not shown) mirrors that of the nominal interest rate and always falls over time.

Panel E shows the resulting hazard rate of a balance of payments crisis, λ_t. As equation (15) makes clear, there are two forces that come into play. As the nominal interest rate increases over time, money demand falls, which makes it more likely that a balance of payments crisis will occur because the money supply gets closer to the critical level. The speed at which money demand falls also affects the behavior of λ_t. The faster money demand falls, the more likely it is that a balance of payment crisis will occur. As Panel

E shows, λ_t increases at first. Then, owing to the fall in h_t, money supply begins to fall at a slower rate causing λ_t to fall for a while. Then, as the money supply gets closer to the critical level, λ rises exponentially.[16]

The time path of credibility is illustrated in Panel F. Credibility follows an inverted-U pattern. Initially, credibility is around 0.2; that is, as of time 0 (when the plan is announced), the probability that a budget agreement will be reached before a balance-of-payment crisis occurs is 20 percent. Credibility then increases rapidly in the initial stages of the program, reflecting the rising likelihood that a fiscal agreement will be reached. Intuitively, the fact that the stabilization is proving costly in terms of the real appreciation and little public debt has accumulated makes it more likely that a budget agreement will be reached, lending credibility to the program. Credibility reaches a maximum of 90 percent at $t = 1$ and stays at roughly that level for about half a year (i.e., until around $t = 1.5$). During this period, the likelihood of a budget agreement is relatively high and the likelihood of a balance of payment crisis is relatively low. In practice, one can think of this time frame as the "euphoria" period that characterizes many exchange rate-based stabilization programs. Inflation is low, international reserves are still plenty, and there is high optimism that the fiscal situation will be taken care of for good. If a two-stage program is to be successful, this is the period in which one would expect that to happen.

After that point, credibility begins to fall, slowly at first, and sharply later on. The likelihood of a fiscal agreement remains essentially flat, while the likelihood of a balance of payments crisis begins to rise sharply. As the critical level of international reserves is approached, credibility plummets to very low levels. This last stage could be identified with the last phase in many exchange rate-based stabilizations in which the public sees the end of the program as basically inevitable and the only question becomes not if but when the program will collapse.

Finally, Panel A in Figure 2 (full line) plots the hazard rate that the program will end (for good or for bad). As it can be seen, this hazard rate reaches a relative maximum after about six months, reflecting the good prospects for a final fiscal agreement. Later on, this hazard rate rises sharply

[16]In the benchmark , T^c is approximately 3.56. Given Assumption 2 in Section 2, this is the value of t for which M_t is about to reach $M^L(= 0.05)$. At that point, i reaches its post-crisis value ($\rho + \varepsilon = 2.03$). Notice that i will not jumpt at T^c because, if it has not occurred before, the balance of payments crisis must occur with certainty at that point.

reflecting the looming balance of payments crisis.

Higher inflation inertia What would happen if the economy were more heavily indexed and inflation inertia were therefore higher? Specifically, suppose that $\alpha = 0.25$ (up from 0.2 in the benchmark case). The comparative dynamics effects are illustrated by the dotted lines in Figure 1. The higher degree of inflation inertia implies that inflation during the program (given by $\alpha\pi^h$) is now higher. Hence, at each point in time, the cumulative real exchange rate appreciation is higher, which raises the cost of waiting at all points in time (Panel B).[17] Since the cost of waiting is higher, a fiscal agreement is more likely, which is reflected in an upward shift of the path of h_t (Panel C).

While the higher h_t by itself would tend to raise the credibility of the program, it also leads to an opposing force: the nominal interest rate rises at all points in time (Panel D), because the devaluation associated with the fiscal agreement is now more likely. By reducing real money demand, the higher nominal interest rate renders a balance of payments more likely, as indicated by the higher path of λ_t (Panel E). This tends to lower the credibility of the program. Panel F indicates that the latter effect dominates, and the program's credibility shifts downward throughout.[18] The likely duration of the program also falls since both the higher h_t and the higher λ_t imply that the hazard rate that the program ends $(h_t + \lambda_t)$ increases (Figure 2, Panel A).

The effects of a higher initial inflation rate (π^h) are qualitatively the same as those of an increase in α, because all that matters is $\alpha\pi^h$. Hence, the model would predict that, other things being equal, stabilization programs implemented in high inflation countries should be less credible and of shorter duration than programs adopted in industrial countries. This prediction appears in line with the evidence since programs in traditionally high inflation countries such as Argentina and Brazil fail much more often (which suggests low credibility) and last less than elsewhere. For instance, in a three-year period in the second half of the 1980's, Argentina implemented five stabilization

[17]The lower θ (Panel A) offsets — but only partially — the higher cumulative real appreciation.

[18]This fall in credibility appears to be robust to alternative parameter specifications. This is not surprising since if h_t responds more to a higher α, the nominal interest rate increases more as well.

plans while Brazil adopted four (see Kiguel and Liviatan (1991)) .

Smaller fiscal adjustment Consider now the effects of initiating a stabilization with a less drastic fiscal adjustment. In terms of our model, suppose that R_0 (which denotes the fiscal gap not closed at time 0) is 0.06 (up from 0.03 in the benchmark case). The results (dotted line), relative to the benchmark case (full line), are illustrated in Figure 3.

Since the taxes to be borne by the party that concedes will now be higher (i.e., the benefit of waiting increases), only groups with a higher θ will concede at each point time (Panel A). This implies that the cost of waiting is now higher (Panel B). However, the direct effect from the higher benefit of waiting dominates, and the path of h_t (Panel C) shifts downward. Hence, a program with a smaller initial fiscal adjustment is less likely to lead to a final fiscal agreement. This tends to lower the credibility of the program.

On the other hand, since a fiscal agreement — and hence the associated devaluation — is less likely, the path of the nominal interest rate shifts downward (Panel D), which in turn reduces the hazard rate of a balance of payment crisis (Panel E). This tends to increase the credibility of the program. The net effect (Panel F) is a small loss of credibility for little more than a year, followed by higher credibility as the effects of the lower λ_t eventually dominate. The hazard rate that the program ends falls unambiguously (Figure 2, Panel B).

It should be noticed that the simulation fails to take into account an important effect that would tend to reinforce the loss of credibility. As discussed in Section 2, for analytical tractability, we are taking as exogenous the post-crisis rate of depreciation, ε. In reality, given that if no agreement is reached and a balance of payments crisis occurs, the deficit will be financed with inflation, one would expect ε to be an increasing function of R_0 for any given t. This effect would tend to shift upward the entire path of the nominal interest rate. Depending on the net effect on the interest rate, the credibility path could shift downward throughout the program.

Credibility We now undertake several additional simulation exercises to gain further insights into the notion of credibility implied by the model (see

Figure 4).[19] As already pointed out, a higher initial inflation rate lowers the credibility of the program as the effects of a higher λ_t prevail (Panel A).

We then consider an increase in the world real interest rate (Panel B). The present discounted value of the taxes to be borne by the loser $(R_0 \exp(\rho t)/\rho)$ falls for the relevant parameter range $(\rho t < 1)$. This reduces the benefit of waiting, which makes a fiscal agreement more likely. This, in turn, increases the nominal interest rate making a balance of payments crisis more likely. We see that early on the program the higher h_t leads to higher credibility. Later on, credibility is lower due to the higher λ_t. The likely duration of the program falls (Figure 2, Panel D).

We then address the effects of lower international reserves (Panel C). In terms of the model, this would imply a higher M^L. Due to Assumption 2 in Section 2, however, we lower ε so that $M^L+\delta\varepsilon$ does not change (which implies that there is no change in the parameters of money demand, as follows from (14) and Assumption 2). As one would expect, the lower M^L shifts upwards the path of λ_t which reduces the credibility of the program throughout (Panel C). Lower reserves also make it more likely that the program will end sooner (Figure 2, Panel E).

The results just described imply that an outright grant of reserves (for instance, the Marshall Plan) would indeed make a program more credible. However, lending (by, say, multilateral organizations) would have an ambiguous effect. On the one hand, it provides more reserves, which makes the program more credible. On the other hand, it augments the stock of debt that is part of the negotiations between the political groups which could make the program less credible.

Finally, consider a situation in which political groups are hurt less by the cumulative real exchange rate appreciation. We capture this effect by assuming a lower $\bar{\theta}$, which implies that the path of Φ_t shifts downward. This lowers the cost of waiting and thus makes it less likely that a fiscal agreement will take place (the path of h_t shifts downwards). As a result, the path of the nominal interest rate shifts downward, which would tend to raise the path of λ_t. Credibility falls during most of the program reflecting the lower likelihood of a fiscal agreement (Panel D). The hazard rate that the

[19] In Figure 4, the full line in all panels denotes the benchmark case described above. The dotted lines illustrate the path corresponding to the following parameter values: $\pi^h = 1.2$ (Panel A), $\rho = 0.08$ (Panel B), $M^L = 0.1$ and $\varepsilon = 1.75$ (Panel C), and $\theta = 5$ (Panel D).

program falls (Figure 2, Panel E). The model thus predicts that in countries in which interest groups (typically exporters) are particularly sensitive to real exchange rate appreciation (the case of Brazil immediately comes to mind), programs will last less (which accords with the Brazilian experience).

We have thus seen that the inverted-U pattern followed by credibility seems to be robust to alternative parameter configurations. Other simulations (which we do not show due to space considerations) reinforce this notion. This is to be expected because this shape reflects some fundamental characteristics of the war of attrition and of the balance of payments crisis. The initial gain in credibility occurs because the costs of waiting rise rapidly in the very beginning (as the real appreciation cost kicks in for $t > 0$) and thus lead to an increasing hazard rate of a fiscal agreement. At a later stage, credibility falls as two effects take over. First, the increasing public debt induces policymakers to postpone the fiscal agreement. Second, the increasing exchange rate misalignment and, hence, increasing interest rates make the balance of payments crisis more likely as time goes by. In the final stages, the fact that money balances approach the critical level of reserves becomes the dominant force and causes credibility to plummet.

4 Conclusions

This paper has analyzed the process whereby an exchange rate-based program which is characterized by an initially-incomplete fiscal adjustment eventually succeeds or fails. The analysis has focused on how political-economy considerations interact with the presence of inflation inertia in determining the dynamics of the economy in the aftermath of stabilization. The real appreciation of the domestic currency creates the expectation that there will be a devaluation. The success of the program hinges on whether the budget agreement is reached before a balance of payments crisis unfolds as a result of an increasing nominal interest rate.

The analysis has concentrated on a situation in which the budget is not balanced when the program is implemented. The same analysis could be applied, however, to a fiscally-sound stabilization plan. The basic idea would be that the real yield curve at the time the stabilization plan is implemented is upward sloping because of the future expectation of a step devaluation. If the initial stock of public debt is of a maturity for which the corresponding real interest rate increases on impact, the initially-balanced fiscal position immediately deteriorates throwing the economy into the same dynamic process characterized in this paper.

Finally, note that the analysis does not address the question of why a policymaker would want to launch a stabilization plan based on anything other than a balanced budget. Rather, we take the initial (incomplete) fiscal measures as given — on the basis that, in practice, it often happens — and proceed with the analysis. However, the mere fact that the model predicts that a stabilization plan may be successful even if the fiscal adjustment is less than complete at the beginning of the program suggests that there may be merit in such a plan. Policymakers sometimes argue that a plan that fixes the exchange rate, even if not all the fiscal measures can be taken at the time the plan is implemented, acts like a straitjacket and will force the different parties to agree on remaining measures in a short period of time. However, the model suggests that an analogy with setting a time bomb may be more appropriate. The stabilization plan is a way for the policymaker to tell the politicians: "The bomb is now ticking. If an agreement is not reached soon, a balance of payments crisis will ensue and the situation will be worse than it was initially." What the policymaker may not always take into account, as countless failed stabilizations suggest, is that it may be in the best interest of the pressure groups to let the bomb explode.

5 Appendix

Proof of Proposition 3. Differentiating equation (22) with respect to T_i and using (5), (19), and (20), we obtain:

$$\frac{dEU(T_i)}{dT_i} = e^{-\rho T_i}\left\{ f(T_i)\left[\frac{R_{T_i}}{\rho}\right] + [1 - F(T_i)]\left[-H[\theta_i(\bar{e} - e_{T_i}), \pi_{T_i}]\right]\right\}.$$

Differentiating the latter with respect to θ_i :

$$\frac{\partial^2 EU}{\partial T_i \partial \theta_i} = -[1 - F(T_i)]H_1(.)(\bar{e} - e_{T_i}) < 0.$$

The last equation means that , when others are acting optimally, dEU/dT_i is decreasing in θ_i. Optimal time of concession is therefore monotonically decreasing in θ_i.‖

Proof of Proposition 4 Suppose that the other constituency is acting according to $T(\theta)$. Choosing a time T_i is then equivalent to choosing a value $\hat{\theta}_i$ and conceding at time $T_i = T(\hat{\theta}_i)$. After a change in variables, we can rewrite (22) as:

$$\begin{aligned} EU(\hat{\theta}_i, \theta_i) &= G(\hat{\theta}_i)\left[\int_{\hat{\theta}_i}^{\bar{\theta}} -u_x(\theta_i)\exp[-\rho T(x)]T'(x)dx + \frac{u^L_{T(\hat{\theta}_i)}}{\rho}\exp[-\rho T(\hat{\theta}_i)]\right] \\ &+ \int_{x=\theta}^{x=\hat{\theta}}\left[\int_x^{\bar{\theta}} -u_z(\theta_i)\exp[-\rho T(z)]T'(z)dz + \frac{u^W_{T(x)}}{\rho}\exp[-\rho T(x)]\right] g(x)dx \end{aligned}$$

Differentiating with respect to $\hat{\theta}_i$ (dropping the i subscript), setting the resulting expression to zero, and using 5), (19), and (20), we obtain:

$$g(\hat{\theta})\frac{R_{T(\hat{\theta})}}{\rho} + G(\hat{\theta})T'(\hat{\theta})H[\theta(\bar{e} - e_{T(\hat{\theta})}), \pi_{T(\hat{\theta})}] = 0$$

By the definition of $T(\theta)$ as the optimal time of concession for a group with cost θ, $\hat{\theta} = \theta$ when $\hat{\theta}$ is chosen optimally. The last equation evaluated at $\hat{\theta} = \theta$ implies (23). Substituting $T'(\theta)$ evaluated at $\hat{\theta}$ from (23), one can see that the second order condition is satisfied since the last equation implies that $\text{sign}(dEU/d\hat{\theta}) = \text{sign}(\theta - \hat{\theta})$.

The boundary condition is derived as follows. Note that for any value $\theta \leq \bar{\theta}$, the gain to having the opponent concede is positive. Hence, as long as $g(\bar{\theta})$ is non-zero, groups with $\theta < \bar{\theta}$ will not want to concede immediately. This implies that the group with the highest θ $(= \bar{\theta})$ will find it optimal to concede immediately. Hence, $T(\bar{\theta}) = 0$. ||

References

[1] Agénor, Pierre-Richard and Mark P. Taylor, "Analyzing Credibility in High-Inflation Economies," *Economic Journal*, Vol. 103 (1993), pp. 329-336.

[2] Alesina, Alberto and Allan Drazen, "Why Are Stabilizations Delayed?," *American Economic Review*, Vol. 81 (1991), pp. 1170-88.

[3] Bliss, Christopher and Barry Nalebuff, "Dragon-Slaying and Ballroom Dancing: The Private Supply of a Public Good," *Journal of Public Economics*, Vol. 25 (1984), pp. 1-12.

[4] Calvo, Guillermo, "Temporary Stabilization: Predetermined Exchange Rates," *Journal of Political Economy*, Vol. 94 (1986), pp. 1319-29.

[5] Calvo, Guillermo A. and Carlos A. Végh, "Exchange Rate-Based Stabilisation under Imperfect Credibility," in Helmut Frisch and Andreas Worgotter, eds., *Open Economy Macroeconomics* (London: MacMillan, 1993), pp. 3-28.

[6] Dornbusch, Rudiger, "Lessons from the German Inflation Experience of the 1920s," in Rudiger Dornbusch, *Exchange Rates and Inflation* (Cambridge, Mass.: MIT Press, 1988), pp. 409-38.

[7] Dornbusch, Rudiger, "Credibility and Stabilization," *Quarterly Journal of Economics*, Vol. 106 (August 1991), pp. 837-50.

[8] Dornbusch, Rudiger and Mario H. Simonsen, *Inflation Stabilization with Incomes Policy Support* (New York: Group of Thirty, 1987).

[9] Drazen, Allan, and Vittorio Grilli, "The Benefits of Crises for Economic Reforms," *American Economic Review*, Vol. 83 (June 1993), pp. 598-607.

[10] Edwards, Sebastian, "Stabilization and Liberalization Policies in Central and Eastern Europe: Lessons from Latin America," NBER Working Paper No. 3816, August 1991.

[11] Flood, Robert P. and Peter M. Garber, "Collapsing Exchange-Rate Regimes: Some Linear Examples," *Journal of International Economics*, Vol. 17 (August 1984), pp. 1-14.

[12] Fudenberg, Drew and Jean Tirole, "A Theory of Exit in Duopoly," *Econometrica*, Vol. 54 (July 1986), pp. 943-960.

[13] Giavazzi, Francesco, and Marco Pagano, "Can Severe Fiscal Contractions be Expansionary: Tales of Two Small European Countries," *NBER Macroeconomics Annual*, 1990.

[14] Hendricks, Ken, Andrew Weiss, and Charles Wilson, "The War of Attrition in Continuous Time With Complete Information," Unpublished mimeo, November 1986.

[15] Kiguel, Miguel and Nissan Liviatan, "The Inflation-Stabilization Cycles in Argentina and Brazil," in Michael Bruno, Stanley Fischer, Elhanan Helpman, and Nissan Liviatan, eds., *Lessons of Economic Stabilization and Its Aftermath* (Cambridge, Mass.: MIT Press), pp. 191-232.

[16] Kiguel, Miguel and Nissan Liviatan, "The Business Cycle Associated with Exchange Rate Based Stabilization," *The World Bank Economic Review*, Vol. 6 (1992), pp. 279-305.

[17] Krugman, Paul, "A Model of Balance of Payments Crises," *Journal of Money, Credit and Banking*, Vol. 11 (August 1979), pp. 311-25.

[18] Obstfeld, Maurice, "Rational and Self-Fulfilling Balance-of-Payments Crises," *American Economic Review*, Vol. 76 (March 1986), pp. 72-81.

[19] Persson, Torsten and Guido Tabellini, *Macroeconomic Policy, Credibility and Politics* (Chur, Switzerland: Harwood Academic Publishers, 1990).

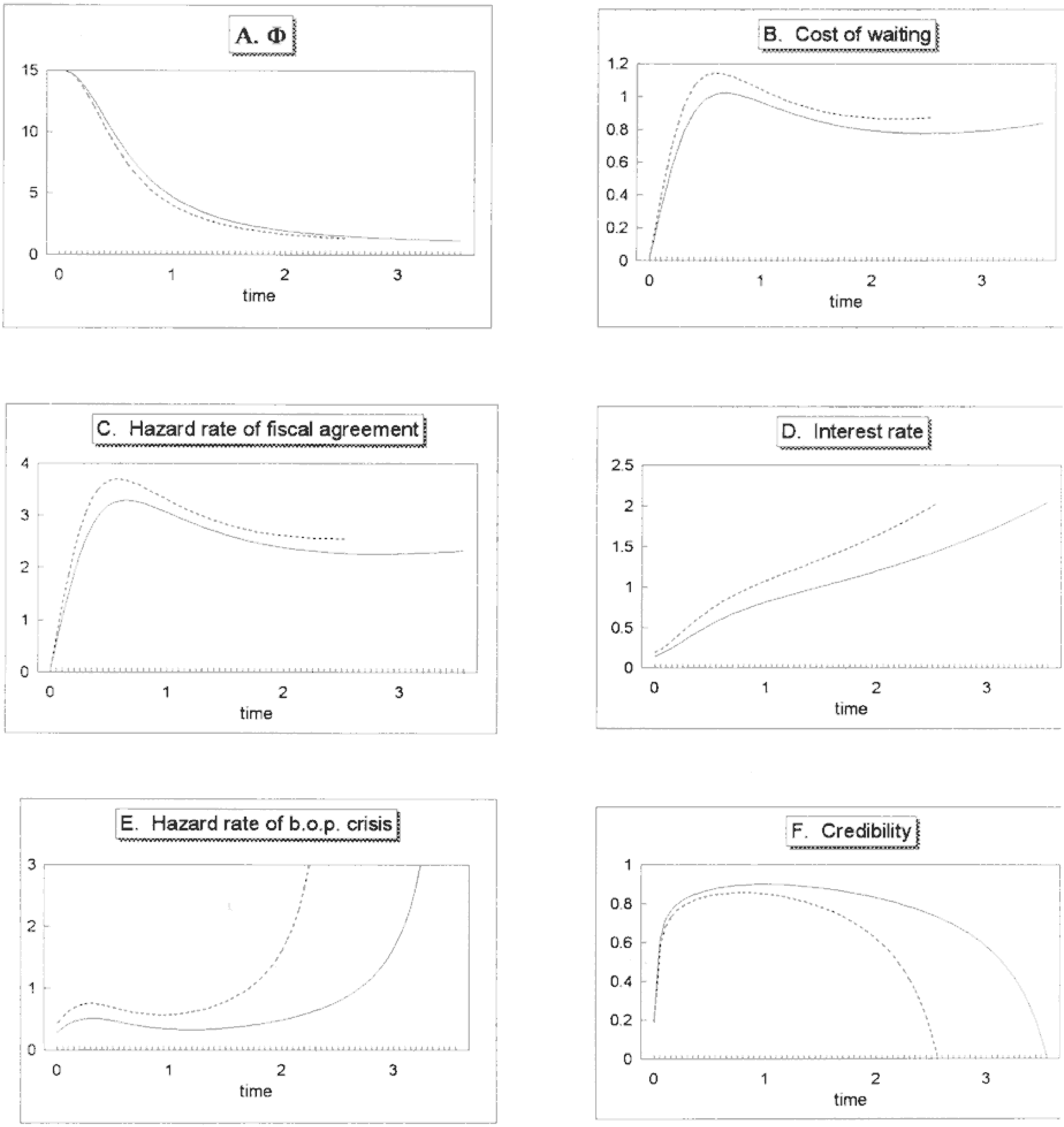
[20] Ramos, Joseph, *Neoconservative Economics in the Southern Cone of Latin America, 1973-1983* (Baltimore: The Johns Hopkins University Press, 1986).

[21] Ross, Sheldon M., *Stochastic Processes* (New York: John Wiley & Sons, 1983).

[22] Sargent, Thomas, "The End of Four Big Inflations," in Robert Hall ed., *Inflation: Causes and Effects*, (NBER and University of Chicago Press), 1982.

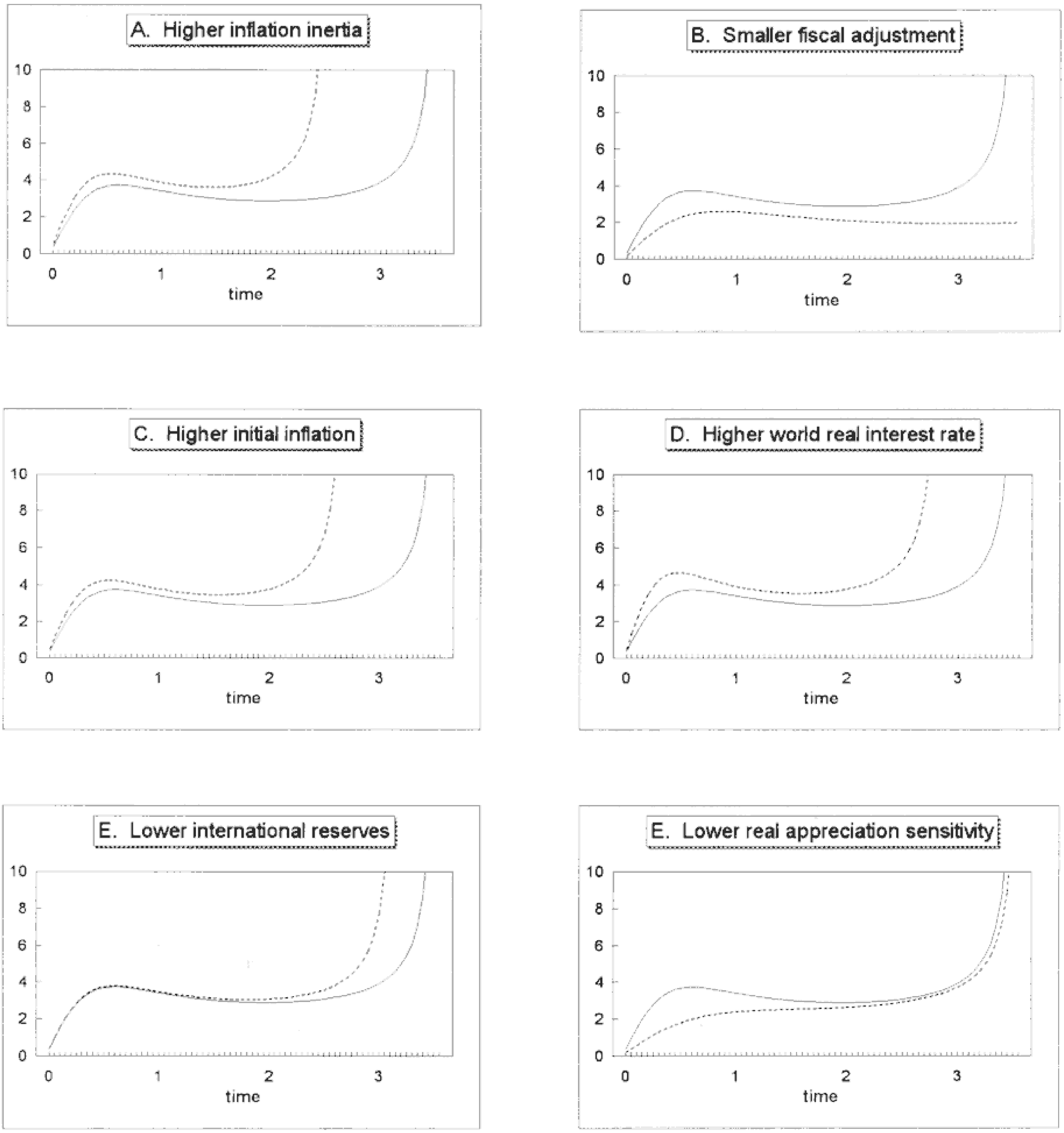
[23] Végh, Carlos A., "Stopping High Inflation: An Analytical Overview," *IMF Staff Papers* (September 1992), pp. 626-695.

Figure 1. Effects of higher inflation inertia



Note: The full line indicates the benchmark case, as defined in the text. The dotted line depicts the path corresponding to $\alpha = 0.25$.

Figure 2. Hazard rate program ends



Note: The full line indicates the benchmark case, as defined in the text. The dotted lines depict alternative scenarios as described in the text.

Figure 3. Effects of a smaller fiscal adjustment

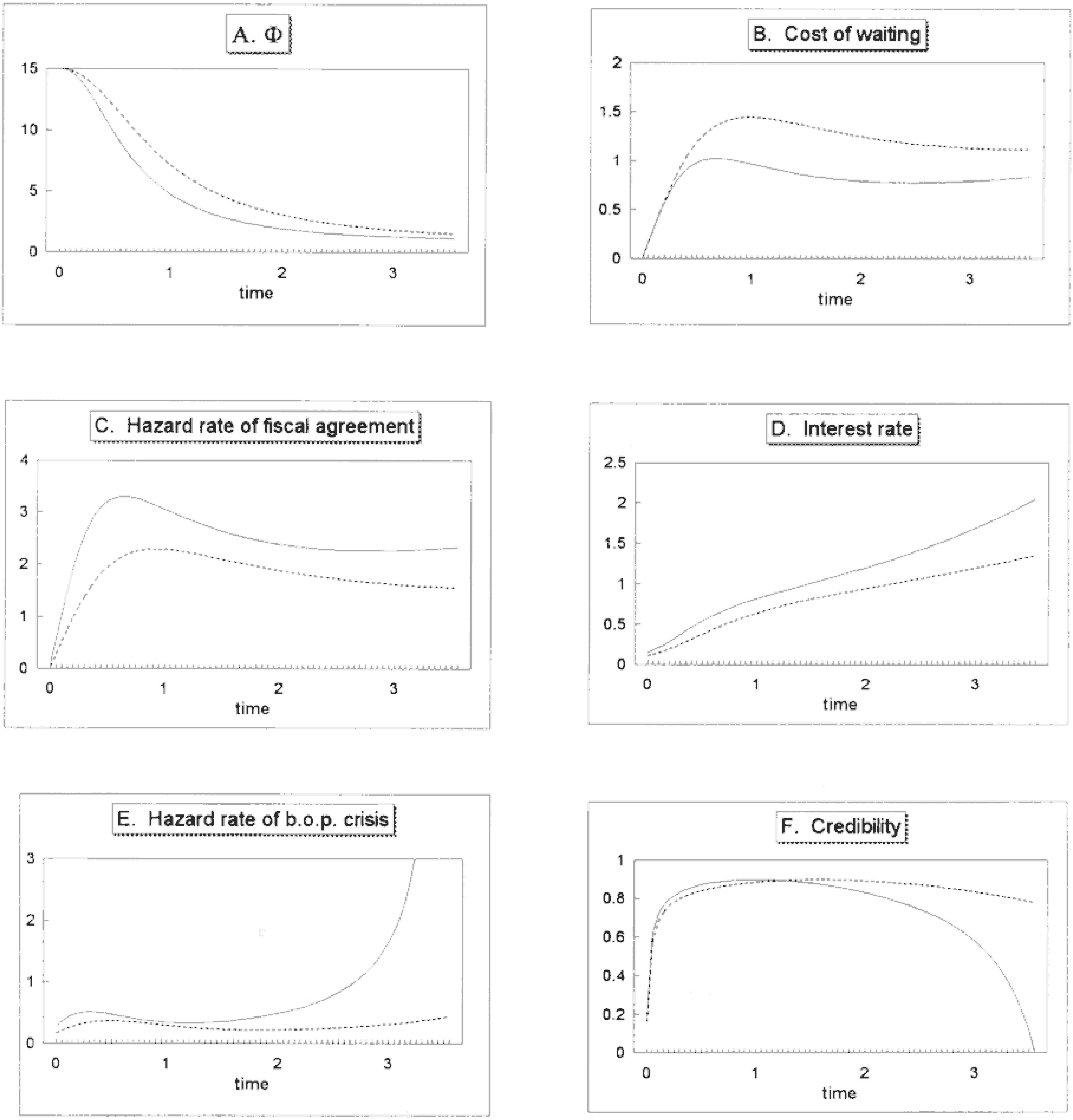


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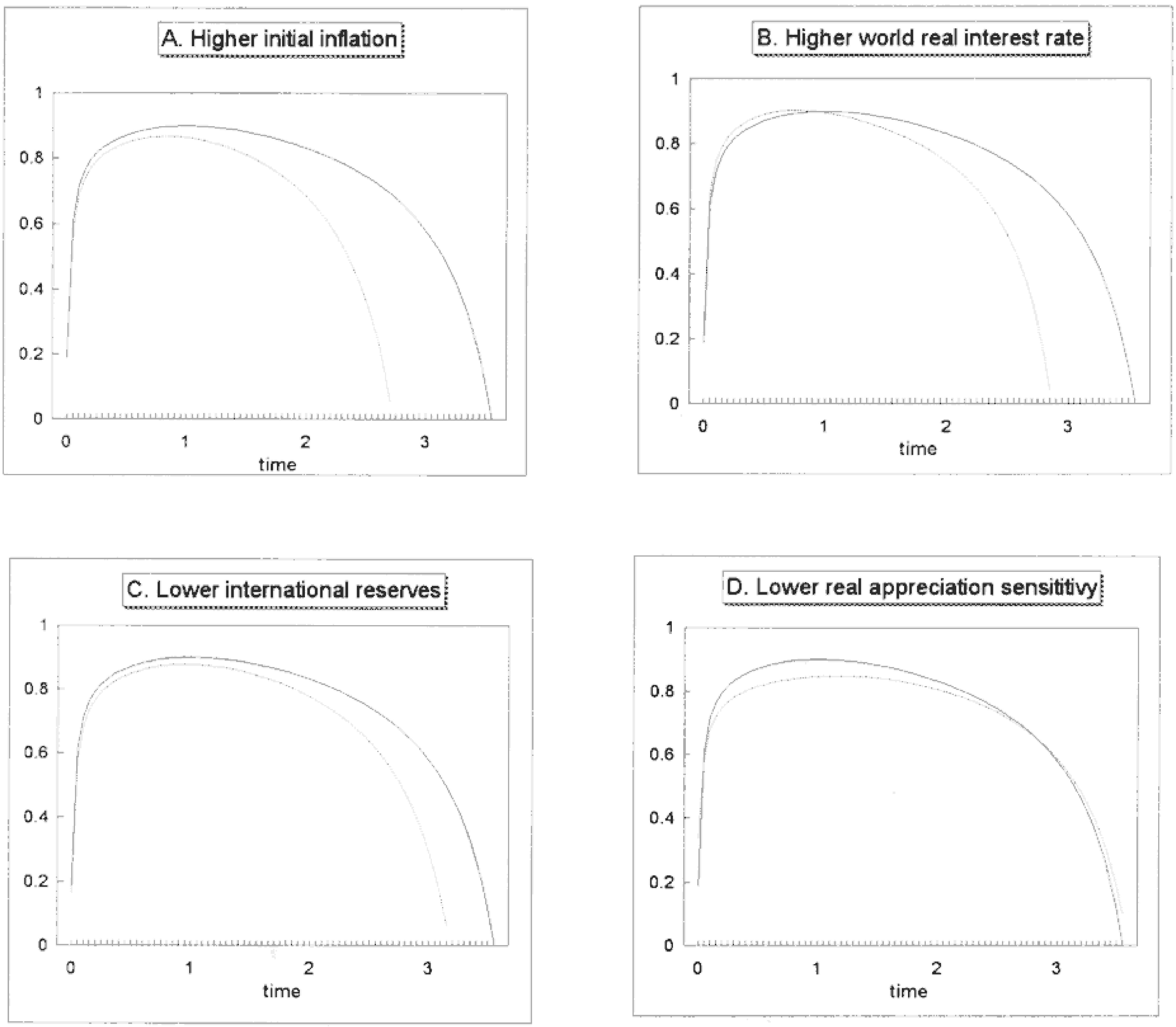
Figure 4. Credibility dynamics



Note: The full line indicates the benchmark case, as defined in the text. The dotted lines depict alternative scenarios as described in the text.