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Collapse of a Crawling Peg Regime in the Presence of a Government Budget Constraint

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The dynamics of the collapse of a crawling exchange rate in the presence of an explicit link between the fiscal deficit and domestic credit is investigated. Such an exchange rate regime is generally characterized by two potential steady-state equilibria, which introduce an ex ante indeterminacy in the timing and magnitude of a speculative attack on international reserves in the presence of a sustained inconsistency between the country's fiscal and exchange rate policies. The paper discusses the conditions that define the actual timing of the regime's breakdown. [JEL F31, F41]

FOLLOWING THE pioneering studies of Salant and Henderson (1978) and Krugman (1979), the recent literature on balance of payments crises has analyzed extensively the conditions under which a fixed or otherwise managed exchange rate regime will collapse.[1] According to

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[1] See, for example, the studies by Flood and Garber (1984), Connolly and Taylor (1984), Garber (1985), Obstfeld (1984, 1986b), Dornbusch (1987), Wyplosz (1986), Blackburn (1988), and Willman (1987). Additionally, almost all of the recent literature on portfolio models applied to developing countries analyzes the consequences of a collapse of the official exchange rate in the presence of a parallel currency market; see, for instance, Kiguel and Lizondo (1986) and Edwards (1988, 1989).

these models, expansive domestic credit policies that create a persistent deficit in the balance of payments will inevitably lead to a speculative attack on the central bank's stock of international reserves. The precise timing of the attack is determined by the speculators' rational anticipation of the regime's collapse, the policies they expect the central bank to follow after the run, and the requirement that no unplanned discrete jump in the exchange rate occur at the transition.[2] A common assumption of these studies is the exogeneity or invariance of the rate of growth of domestic credit. This feature allows them to nail down agents' expectations and to obtain a unique and well-defined stationary equilibrium in the post-attack exchange rate regime. Specifically, these models obtain the well-known sustainability condition for an open economy that follows an active domestic credit policy: in the steady state, the rate of depreciation of the exchange rate will be equal to the (unchanged) rate of creation of domestic credit.

However, by treating domestic credit expansion as the fundamental and invariant variable driving the speculative attacks, these models obscure the fiscal forces that are usually behind the breakdown of managed exchange rate regimes. In fact, if it is assumed, instead, that domestic credit policies are geared to the financing of the fiscal deficit, some of the features and predictions of the standard models of balance of payments crises are altered substantially. For instance, it will no longer be correct to assume that the rate of growth of domestic credit remains invariant after the speculative attack takes place. If the unsustainable credit policies are directly related to an increase in the fiscal deficit, the decline in the demand for domestic money balances that characterizes the transition to the post-attack equilibrium will prompt an upward adjustment in the growth rate of domestic credit (to the level determined by the higher expected rate of depreciation), in order to finance the larger borrowing requirements of the public sector.

Considering explicitly the linkage between credit and fiscal policies in these models also gives rise to the possibility of obtaining *two* potential stationary positions at which the fiscal deficit is financed by the inflation tax, and the balance of payments is in equilibrium. This steady-state feature, in turn dependent on the assumed existence of an inflation-revenue Laffer curve, is common to all the models that include a financing constraint for the government, and has been studied in detail for the case of a closed economy.[3] However, its extension to an open economy with

[2] By definition, market-determined exchange rate regimes are not subject to such "surprises" in official rate setting.

[3] Following the study by Cagan (1956), Sargent and Wallace (1981, 1987), Evans and Yarrow (1981), Liviatan (1983), Dornbusch and Fischer (1986), Bruno and

a managed exchange rate is not trivial, because the possibility of temporarily eliminating a given monetary disequilibrium through losses of international reserves changes the dynamic adjustment of the system.

In particular, in this case the re-attainment of a stationary equilibrium will coincide with a speculative attack on the central bank's foreign exchange holdings, the timing of which will depend on the public's expectations regarding monetary and exchange rate policies. Whether the economy will end up at an equilibrium with high or low inflation will, thus, depend heavily on the government's ability to commit credibly to certain policies during the transition period.

Potentially, this framework can be extended further to analyze the interaction of fiscal and monetary policies with tax and tariff reforms in stabilization programs under managed exchange rates. For instance, the framework can be used to illustrate how a sustained disinflation would reverse the erosion of conventional tax yields and, thus, reduce the distortions stemming from an intensive use of the inflation tax; or how anti-inflation policies can be reinforced by opening up the economy to imports and to sustainable foreign financing. The model derived in this paper, however, does not incorporate all of these factors, since it assumes that the economy is already fully open, tax proceeds are exogenous, and external financing is unavailable.

The model and its steady-state properties are presented in Section I. Section II illustrates the effects of an inconsistency between the stance of fiscal and exchange rate policies and derives expressions for the exact timing and magnitude of the two potential speculative attacks. It also discusses some ways in which the ex ante indeterminacy of the stationary equilibrium reached after the attack can be resolved. Finally, Section III summarizes the policy implications of the model and relates them to the recent literature on the sustainability of alternative exchange rate regimes.

I. A Portfolio Model of a Crawling Peg Regime

This section will discuss the effects of introducing a financing constraint for the government in a continuous-time portfolio model of a small open economy with a crawling exchange rate. Let the nominal exchange rate be denoted by E, and the rate of crawl, by π (that is, $\pi = \dot{E}/E$, where

Fischer (1987), and others have discussed the stability properties of the two stationary equilibria for the inflation rate in a closed economy. Kharas and Pinto (1986) extended this line of analysis to an open economy with a dual and implicitly floating exchange rate regime.

a dot over a variable represents its derivative with respect to time). In the tradition of portfolio models, it will be assumed that domestic residents allocate their wealth between two non-interest-bearing assets: domestic money, M—held only by the nationals of the country—and foreign money, f.[4] The nominal stock of private wealth of the economy will then be

$$A = M + Ef. \tag{1}$$

The fraction of wealth held as domestic money, λ, is assumed to be a decreasing function of the expected rate of depreciation. Provided that the public has rational expectations—equivalent to perfect foresight in this deterministic framework—this equals the actual rate of depreciation, π. Thus, the demand for domestic money balances can be expressed as

$$m = \lambda(\pi)a; \quad \lambda'(\pi) < 0; \quad 0 < \lambda(\pi) < 1, \tag{2}$$

where $m = M/E$ and $a = A/E$ are the desired stock of domestic money and the stock of private wealth expressed in terms of foreign currency. Dividing equation (1) by the exchange rate, E, and substituting in equation (2), the portfolio equilibrium condition may also be written as

$$f = \delta(\pi)m; \quad \delta'(\pi) > 0. \tag{3}$$

On the supply side, ignoring the existence of a banking system, the nominal money stock at any point in time will be determined from the balance sheet of the central bank as the sum of the outstanding stock of domestic credit, D, and the domestic currency value of international reserves, ER:

$$M = D + ER. \tag{4}$$

The evolution over time of this aggregate will, in turn, depend on the behavior of each of its components. In particular, if it is assumed—as is customary in open economy models—that the central bank does not monetize the changes in the domestic currency value of international reserves that arise from the continuous depreciation of the exchange rate in a crawling peg regime, the flow money supply will be given by[5]

[4] This is a simplifying assumption of all the currency-substitution portfolio models that use the framework developed by Calvo and Rodriguez (1977). See, for example, Connolly and Taylor (1984), Kiguel and Lizondo (1986), Kharas and Pinto (1986), Khan and Lizondo (1987), and Edwards (1988, 1989).

[5] The assumption that the central bank sterilizes the capital gains stemming from its exchange rate policy implies that the nominal money stock at any point in time will be given by

$$M_t = D_t + E_t R_t - \int_{-\infty}^{t} R_s \dot{E}_s d_s$$

$$\dot{M} = \dot{D} + E\dot{R}. \quad (5)$$

In this context, the inclusion of a financing constraint for the government imposes some restrictions on the evolution of domestic credit. Specifically, in the absence of alternative financing sources, the particular level of the fiscal deficit, $\bar{d}$, will determine the rate of domestic credit expansion; that is

$$\bar{d} = (g - t) = \dot{D}/E, \quad (6)$$

where g and t are, respectively, the levels of government expenditures and tax revenues expressed in terms of foreign currency.[6]

The behavior of the second component of the money supply will be dictated by the overall result of the balance of payments, and can be expressed as

$$\dot{R} = CA - \dot{f}, \quad (7)$$

where CA stands for the current account balance in foreign currency, and $\dot{f}$ represents the capital account.[7] Notice that the second term of equation (7) will be positive only if there is an expected change in the rate of depreciation; in that case, the public's accumulation of foreign money balances will contribute to the drainage of international reserves and accelerate the timing of the speculative attack.

From equations (1), (3), (5), and (7), one can obtain an expression for the evolution over time of the real stock of private domestic wealth:

$$\dot{a} = CA + \dot{D}/E - m\pi, \quad (8)$$

where $m\pi$ can be interpreted as the authorities' proceeds from the inflation (depreciation) tax. However, according to these models, for a given set of domestic policies the public will carry out the necessary adjustments so that it always maintains its portfolio of assets in equi-

Equation (5) is then obtained by taking the time differential to this expression. For an alternative assumption, see Cumby and van Wijnbergen (1989).

[6]Most of the studies on "passive" monetary policy have modeled the linkage between the fiscal deficit and the rate of money creation by means of the closed economy counterpart of equation (6); see Auernheimer (1983), Evans and Yarrow (1981), and Bruno and Fischer (1987). However, the use of this type of constraint for the case of an open economy requires two qualifications: first, monetary policy is restricted to domestic credit policy; and second, as noted in the text, it must be assumed that foreign and domestic borrowing are not available for the country in question. For an analysis of speculative attacks when the government is able to borrow, see Obstfeld (1986a) and Buiter (1987).

[7]Adding more structure to the real sector of the model by specifying, for instance, the consumption and production functions for tradable and nontradable goods and the behavior of the real exchange rate can be done easily. However, leaving the model at this level of aggregation will suffice to highlight the problem under analysis.

librium. Once this position is achieved, the stock of private wealth will remain constant (that is, $\dot{a} = 0$), and equation (8) will become

$$-CA = \dot{D}/E - m\pi = \bar{d} - m\pi. \qquad (9)$$

Notice that assuming that agents hold their desired portfolios does not imply that the economy has reached a stationary position. In fact, a situation of flow equilibrium in the assets market is, in principle, consistent with the presence of a current account deficit (if the government deficit is larger than the proceeds from the inflation tax) or a current account surplus (in the opposite case). Since neither of these situations is sustainable in the long run, an additional condition has to be fulfilled for this system to reach a steady state, namely (from equation (9)), that the current account be in equilibrium ($CA = 0$). This, in turn, requires that the fiscal deficit be fully financed by the revenues from the inflation tax.

The precise implications of the condition derived above can be made more clear once one considers the particular way in which the inflation tax is collected in this model. The assumption that the central bank does not monetize capital gains arising from the continuous revaluation of its international reserves restricts the government to collecting inflationary revenue only from the fraction of the money supply that is backed by domestic credit. Calling this fraction γ ($\gamma = D/M$), and rewriting equation (9) yields[8]

$$-CA = (\theta - \pi)\gamma m, \qquad (10)$$

where $\theta = \dot{D}/D$ is the rate of growth of domestic credit.

From equation (10) it is now evident that a stationary equilibrium will require that the growth rate of domestic credit equal the rate of depreciation of the currency ($\theta = \pi$). In principle, this condition is equivalent to the one obtained in those models where the central bank sets an invariant rule for the creation of domestic credit independently of the stance of fiscal policies (see, for instance, Connolly and Taylor (1984) and Dornbusch (1987)). However, the requirement in this case that the fiscal deficit be permanently financed (equation (6)) significantly alters the nature of the adjustment process toward the steady-state solution.

[8] Although this assumption has been adopted consistently by almost all portfolio models since the early developments of the monetary approach (Johnson (1972)), the empirical studies on seigniorage collection have not distinguished the different implications of alternative rules regarding the sterilization of capital gains (see, for instance, the estimates presented in Fischer (1982)). Indeed, although the same equilibrium condition would be obtained if it were assumed that the central bank monetizes the changes in valuation of international reserves, the empirical computation of the inflation tax would be different under the two rules.

Because of this financing requirement, in general, there will be *two* different growth rates of domestic credit that will satisfy the condition for stationary equilibrium. In effect, the properties of the inflation-tax Laffer curve implicit in the most common specifications of the demand for money balances will allow for the possibility of collecting the same level of revenue from two different rates of inflation (depreciation).[9]

Moreover, once the government financing constraint is included, some features of the temporary equilibrium of the model will be modified. In order to be in this position, the economy will now have to satisfy simultaneously equation (10)—flow equilibrium in the assets market—and equation (6). In particular, if it is assumed, as is common in the literature, that the demand for domestic money balances is of the semilogarithmic (Cagan) form—$\lambda(\pi) = \bar{\lambda} e^{-\alpha\pi}$—equation (6) can be rewritten as[10]

$$\bar{d} = \theta\gamma\bar{\lambda} \exp(-\alpha\pi)a, \tag{11}$$

and, from equation (9), the expression for the temporary equilibrium of the system will be given by

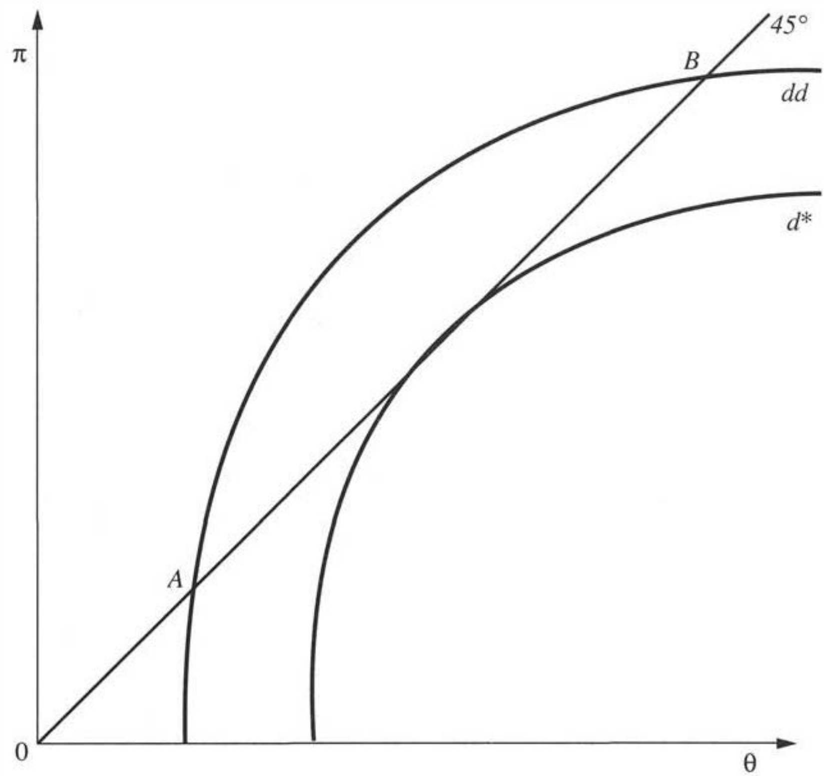
$$-CA = \bar{d} - \pi\gamma\bar{\lambda} \exp(-\alpha\pi). \tag{12}$$

The situation just described is illustrated in Figure 1. The sustainability condition implicit in equation (10), $\theta^* = \pi^*$, is shown as the 45-degree line, and the budget financing constraint (equation (11)), where the economy should always be located, is represented by the schedule *dd*. The size of the fiscal deficit, $\bar{d}$, the level of private wealth, a, and the initial share of domestic credit in the money supply, γ_0, will determine the intercept of the *dd* curve on the horizontal axis. If agents hold their desired portfolios, at every point on *dd* and below the 45-degree line (that is, at every point where $\theta > \pi$), the economy will be in a temporary equilibrium, experiencing a continuous loss of reserves due to a deficit in the current account; at every point above that line, the economy will be running a persistent external surplus. In the long run, however, the stationary equilibrium condition requires that both the growth rate of domestic credit, θ, and the rate of depreciation, π, adjust to one of the

[9]This result was first obtained by Cagan (1956) and has been analyzed in detail for the closed economy case in the literature (see footnote 3). Notice, however, that an inflation-tax Laffer curve cannot be obtained from some functional forms of the demand for money, such as the hyperbolic function, $\lambda(\pi) = \alpha/(\alpha + \pi)$.

[10]The necessary condition for the qualitative results that follow is that the unit inflation-tax Laffer curve $\psi(\pi) = \pi\lambda(\pi)$ is concave in π and has a global maximum where the inflation elasticity of the demand for money equals unity. The Cagan specification is one possible functional form that satisfies this condition and has been assumed because of its tractability.

Figure 1. *Potential Equilibria with a Government Budget Constraint*



two points of intersection of the budget constraint with the sustainability line.

The figure also shows clearly that there is a limit to the size of the budget deficit that can be financed with inflationary revenue. This limit is given by d^*, the financing of which requires maximizing the inflationary tax by setting the rate of depreciation equal to the inverse of the inflation semi-elasticity of the domestic money demand ($1/\alpha$).[11] If the actual deficit is larger than d^*, no steady-state equilibrium will exist. For any other level of the budget deficit, however, there will be two possible steady-state positions, one at a low rate of depreciation (point A) and the other at a high rate of depreciation (point B).

[11] This is the well-known condition for maximizing inflationary revenue in a nongrowing economy derived by Cagan (1956) and Friedman (1971).

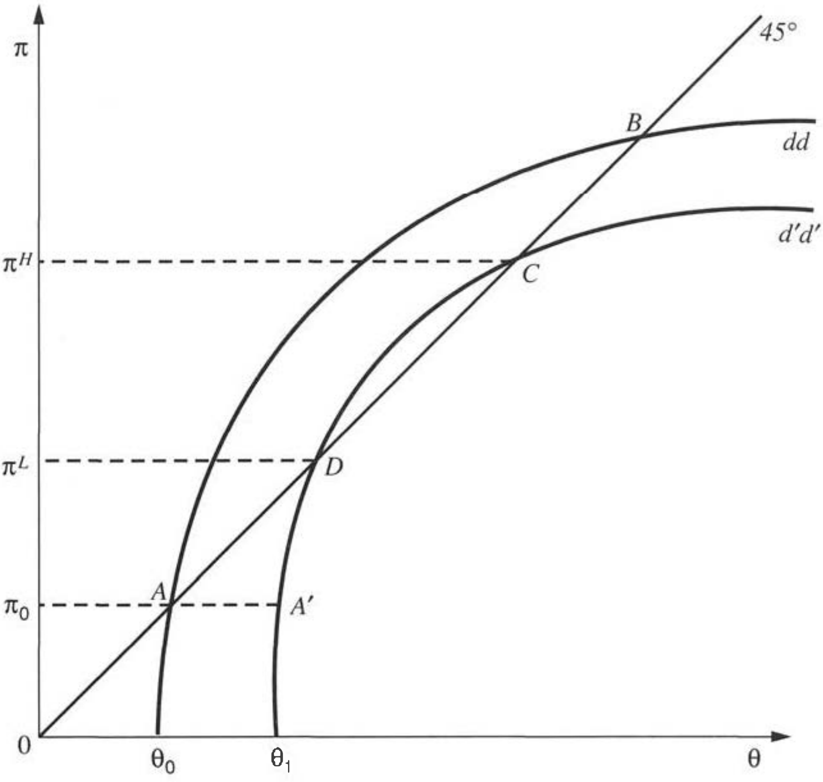
It is important to emphasize that in a managed exchange rate regime like this, the economy may remain for some time at any point on the *dd* schedule that is different from the two stationary equilibria. In fact, if the temporary equilibrium condition (equation (10)) is satisfied, the divergence between the government's financing requirements and its collection of inflationary revenue will be reflected in the current account, without any need for a continuous change in the rate of depreciation. This implies that the dynamic adjustment of this system differs significantly from that presented in the literature on dual inflationary equilibria in closed economies (see footnote 3). In particular, in this case the economy's transition toward one of its steady-state positions will not be gradual and will not depend on the local stability properties of the two potential equilibria. Instead, the movement toward steady-state equilibrium will be abrupt and will coincide with the collapse of the managed exchange rate regime. As will be seen in the following section, the factors determining whether this collapse will take the economy to the stationary equilibrium corresponding to the high or to the low rate of depreciation will depend crucially on the public's expectations about the future actions of the country's authorities.[12]

II. Inconsistent Fiscal Policies

As mentioned before, the inclusion of a financing constraint for the government in a portfolio model of an open economy highlights the role that fiscal policies commonly play in the breakdown of a managed exchange rate regime. In contrast to the usual assumptions in the literature on balance of payments crises, the model derived in Section I permits one to relate the presence of an unsustainable domestic credit policy directly to an inconsistency between the size of the fiscal deficit and the chosen exchange rate policy; moreover, the need to restore the consistency between these policies is precisely what explains the collapse of the exchange rate regime. However, as this section will show, the existence of two different rates of depreciation at which such consistency can be restored introduces a potential indeterminacy with respect to the timing and magnitude of the speculative attack.

[12] Notice that the dynamic adjustment of the economy to exogenous disturbances in the post-collapse floating exchange rate regime will be driven by the same stability conditions as those obtained in the aforementioned closed economy models; that is, under the assumption of rational expectations, the high-depreciation equilibrium will be stable, and the low-depreciation equilibrium, unstable.

Figure 2. *Fiscal Expansion in a Crawling Peg Regime*



In order to illustrate this feature of the model, let us assume an economy with a crawling exchange rate whose initial position is one of steady-state equilibrium with a relatively low rate of depreciation. Thus, the economy will be located at a point such as A in Figure 2, with a rate of growth of domestic credit, θ_0, and a rate of depreciation, π_0. Now suppose that the government decides to increase its real expenditures, g, without implementing a corresponding increase in taxes, while the central bank maintains unchanged the rate of depreciation of the currency.[13] From equation (11), this increase in the fiscal deficit (from $\bar{d}$ to, say, $\tilde{d}$) will require an immediate upward adjustment in the rate of expansion of

[13] This behavior of the central bank implies either that it maintains its previously announced rate of crawl or that it follows some sort of backward-looking adjustment rule in setting this rate.

domestic credit in order to satisfy the larger financing needs of the public sector.

In terms of Figure 2, this particular fiscal shock will imply a rightward shift of the budget financing schedule from *dd* to *d'd'*, an increase in the growth rate of domestic credit from θ_0 to θ_1, and the repositioning of the economy at a point such as *A'*. At this new position the flow equilibrium in the economy's asset (money) market will be sustained, according to equation (10), by a persistent deficit in the current account. This situation, however, can only be temporary. Even in the absence of a speculative attack, the maintenance of a divergence between θ and π will ultimately lead to the depletion of the central bank's international reserves, a discrete jump of the exchange rate, and the adoption of a floating exchange rate regime.[14]

The inevitability of the discrete adjustment in the exchange rate when the system is left on its own (that is, when the collapse is not anticipated) can be shown by using equations (2) and (4) to rewrite the portfolio equilibrium condition (equation (10)) at point *A'* as

$$M_t = [E_0 \exp(\pi_0 t)]\bar{\lambda} \exp(-\alpha\pi_0)a = D_0 \exp(\theta_1 t) + E_0 R_t, \tag{13}$$

where the subscript "0" indicates the initial steady-state value of the corresponding variable. According to equation (13), the evolution of international reserves (given by the current account deficit) will be dictated by

$$E_0 R_t = [M_0 - D_0 \exp(\theta_1 - \pi_0)t] \exp(\pi_0 t). \tag{14}$$

If no speculative attack occurs, the central bank will run out of foreign exchange at some point, t^*, where

$$t^* = \frac{\log\left(\frac{M_0}{D_0}\right)}{(\theta_1 - \pi_0)} = \frac{-\log \gamma_0}{(\theta_1 - \pi_0)}, \tag{15}$$

and at that instant two adjustments will have to take place: (1) both θ and π will have to adjust to a point on the sustainability line consistent with the financing constraint of the government; and (2) portfolio equilibrium (equation (13)) will need to be maintained through a discrete devaluation of the currency.

However, the above scenario is inconsistent with the assumption that agents possess perfect foresight. As the literature on balance of payments

[14] Of course, the expansionary fiscal policy would be sustained for a longer period if other sources of deficit financing were available; see Obstfeld (1986a) and Buiter (1987).

crises has emphasized, in a situation like the one just described the private sector would anticipate the eventual breakdown of the managed exchange rate regime and would be able to make enormous capital gains by selling its domestic money holdings to the central bank just an instant before t^*. The realization of these potential profits by all speculators will cause the collapse of the regime to occur earlier than t^* (that is, before the international reserves have been depleted), and the equilibrium in the agents' desired portfolios will be maintained by a decline in their nominal money holdings rather than by a discontinuous jump in the exchange rate.

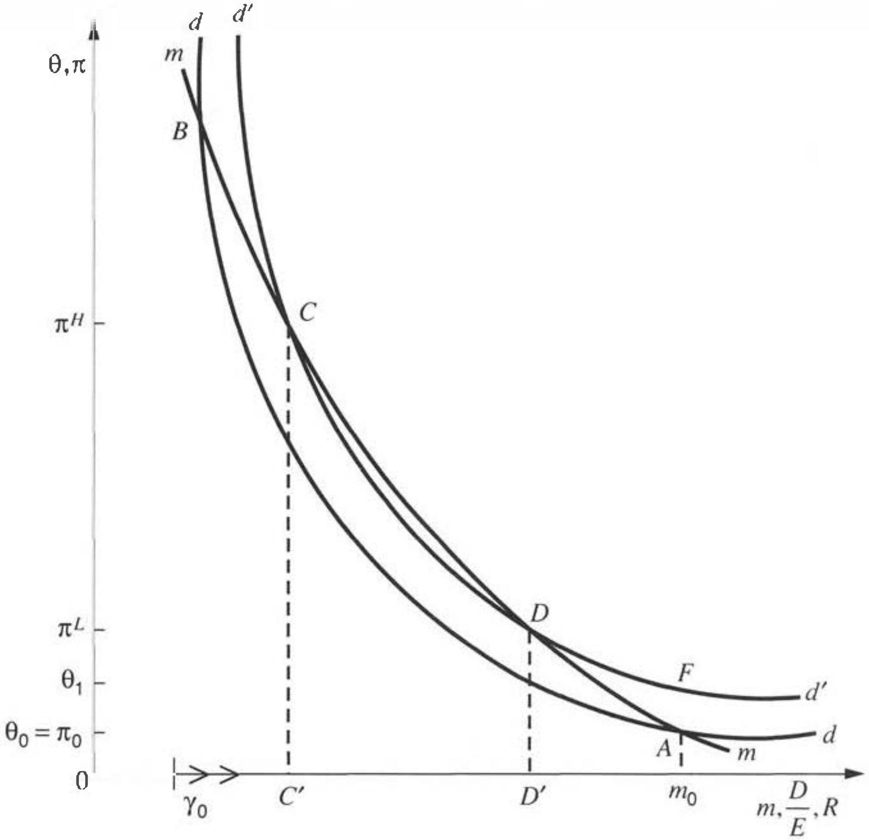
A necessary condition for this smooth transition to take place, however, is that the public be able to anticipate exactly the stationary position at which the system will stay in the post-attack regime. In this sense, the assumption that the central bank follows an active domestic credit policy has been crucial for obtaining a unique solution in the existing models of speculative attack. In fact, in those models the invariance of the growth rate of domestic credit actually nails down agents' expectations and permits them to cause the collapse of the managed exchange rate regime at a well-defined date.

However, in the presence of an inflation-tax Laffer curve and a financing constraint for the government, the system's steady state is no longer unique. In that case there will exist two potential rates of depreciation (the ones corresponding to points C and D in Figure 2), at which the consistency between the fiscal and exchange rate policies can be restored in the post-attack regime. Moreover, since the required decline in the demand for domestic money will be different for each of these two sustainable depreciation rates, there will be an ex ante indeterminacy with regard to the timing and magnitude of the speculative attack needed to achieve the transition to a float without violating the continuity condition for the exchange rate. As will be discussed below, the particular way in which this indeterminacy will be solved will be extremely sensitive to the public's perception of the policies the authorities will follow during the period of transitory equilibrium.

The different magnitude and timing of the speculative attack associated with each of the two stationary equilibria can be illustrated by Figure 3.[15] The curve dd, a hyperbola asymptotic to the axes, shows the combinations of steady-state rates of depreciation and domestic money holdings that are consistent with the initial fiscal deficit, $\bar{d}$. The curve mm, in turn, represents the Cagan-type demand for real domestic money balances; in order to satisfy the portfolio equilibrium condition (equation

[15]This figure has been adapted from the studies of Liviatan (1983) and Dornbusch (1987).

Figure 3. *Magnitude of Speculative Attack for Two Potential Steady States*



(10)), the economy will always have to be located at some point on this schedule. The potential steady states of the system are indicated by the points of intersection of these two curves. It is assumed that the initial position of the economy is given by point A; as in Figure 2 this point corresponds to a rate of depreciation, π_0, that is equal to the growth rate of domestic credit, θ_0. The real stock of domestic money balances that sustains this equilibrium is represented by the distance Om_0, and it is further assumed that this stock of money is backed by an amount proportional to $O\gamma_0$ of domestic credit and by $\gamma_0 m_0$ of international reserves (see equation (4)).

An increase in the fiscal deficit, such as the one discussed before (that is, from $\bar{d}$ to $\tilde{d}$), will shift the dd schedule to a position such as $d'd'$ and will change the possible stationary equilibria to points C and D. Assuming that the central bank maintains the rate of crawl at π_0, the economy

will stay temporarily at A. However, the jump in the growth rate of domestic credit (from θ_0 to θ_1) implied by the larger fiscal requirements will originate a continuous increase in the stock of domestic credit that will be exactly offset by losses of international reserves reflecting the current account deficit. In terms of Figure 3, this process will imply a rightward expansion of the domestic credit share of the money stock along the horizontal axis. If the authorities commit all their foreign exchange to the defense of the managed exchange rate regime, and the public, for some reason, anticipates that the consistency between the fiscal and exchange rate policies will be restored at the high rate of depreciation, π^H, the collapse of the regime will have to occur as soon as the stock of domestic credit reaches the level OC'. At that instant a speculative attack of a magnitude $C'm_0$ will have to take place. However, if the private agents believe that the more expansive fiscal policy will be sustained by the low rate of depreciation, π^L, they will wait until domestic credit reaches the level OD' before acquiring the remaining stock of international reserves, $D'm_0$. Notice that, even though in both cases the central bank's initial stock of international reserves, $\gamma_0 m_0$, will be depleted, the collapse will have to take place earlier if the agents share the expectation that the exchange rate will depreciate at π^H in the post-attack regime.

In fact, exact expressions can be derived for the magnitude and timing of the two potential speculative attacks represented in Figure 3. Ruling out the possibility of capital gains, the regime's collapse should occur as soon as the stock of domestic credit (growing at the unsustainable rate, θ_1) equals the nominal value of the demand for domestic money corresponding to the new steady state. Using equations (2) and (4), as was done in equation (13), this terminal condition will be

$$D_t = D_0 \exp(\theta_1 t) = [E_0 \exp(\pi_0 t)]\tilde{\lambda} \exp(-\alpha\pi^H)a, \tag{16}$$

for the high-depreciation equilibrium (point C), and

$$D_t = D_0 \exp(\theta_1 t) = [E_0 \exp(\pi_0 t)]\tilde{\lambda} \exp(-\alpha\pi^L)a, \tag{17}$$

for the low-depreciation one (point D). Substituting each of these equations back in equation (4) yields the precise expression for a run of magnitude, $C'm_0$, in Figure 3:

$$R^H = m_0\{1 - \exp[-\alpha(\pi^H - \pi_0)]\} \exp(\pi_0 t), \tag{18}$$

and the expression for the amount of reserves lost in the transition to point D (the distance $D'm_0$):

$$R^L = m_0\{1 - \exp[-\alpha(\pi^L - \pi_0)]\} \exp(\pi_0 t). \tag{19}$$

Thus, as the figure shows, the difference in the size of the run associated with each of the stationary equilibria is proportional to the difference between the two sustainable rates of depreciation, π^H and π^L. By manipulating equations (16) and (17) one can also determine the exact timing of the attacks indicated by (18) and (19). Given an inconsistency between the fiscal and exchange rate policies, the collapse of the managed exchange rate regime will occur either at

$$t^H = \frac{-\log \gamma_0 - \alpha(\pi^H - \pi_0)}{(\theta_1 - \pi_0)} \tag{20}$$

or at

$$t^L = \frac{-\log \gamma_0 - \alpha(\pi^L - \pi_0)}{(\theta_1 - \pi_0)}, \tag{21}$$

from which it can be seen that $t^H < t^L$; that is, the collapse will take place earlier if agents anticipate the high rate of depreciation, π^H. Moreover, since $t^L < t^*$ (from equation (15)), the public will necessarily carry out the speculative attack before the accumulated deficit in the current account exhausts the initial stock of international reserves. It should also be noticed that the difference between the two potential timings of the attack (and between the two sustainable rates of depreciation) will be smaller the larger the fiscal deficit, as long as the latter stays below the critical level, d^*.

Although the above computations have been made for the case where the inconsistency between fiscal and exchange rate policies arises from an exogenous increase of the fiscal deficit, the framework can also illustrate the probable effects of other measures that create similar macroeconomic inconsistencies. In particular, this analysis can be applied, with minor modifications, to the case where the authorities implement an exchange rate-based stabilization program.[16]

Suppose that in this alternative scenario the economy's initial position is given by point D in Figure 3, where a rate of devaluation, π^L (equal to a growth rate of domestic credit, θ^L) sustains the fiscal deficit represented by curve $d'd'$. Suppose now that the authorities decide to preannounce a lower rate of devaluation, π_0, presumably as part of a comprehensive stabilization program. Even if there is no immediate change in the underlying fundamentals of the fiscal deficit, the public can inter-

[16]This type of program has been covered extensively, at the theoretical and empirical levels, in the literature on the Southern Cone liberalization reforms of the 1970s. See, for instance, Calvo (1986a, 1986b), Edwards and Cox-Edwards (1987), Kiguel and Liviatan (1988), and Rodriguez (1982).

pret the reduction of the rate of crawl as a signal that the central bank is willing to use part of its international reserves (assumed proportional to the distance, $\gamma_0 D'$) to support the stabilization attempt. Consequently, in order to maintain portfolio equilibrium, agents' initial response will be to convert the equivalent to the distance $D'm_0$ of their foreign currency assets into domestic currency and to move along the money demand schedule to a position such as A.

The one-time increase of the central bank's international reserves and the reduction in the rate of inflation provoked by the lower rate of crawl are, however, misleading indicators of the program's success. If the fiscal deficit is not reduced *rapidly* to a level consistent with that of curve *dd* in Figure 3, the exchange rate-based disinflation scheme will break down. Specifically, if the fiscal deficit stays at $d'd'$ and is financed by domestic credit growing at the rate θ_1, the collapse of the preannouncement regime will have exactly the same features as the previous example of an expansionary fiscal policy. The temporary reduction in inflation and increase in reserves will be a false sign of the agents' confidence in the program and, depending on their expectations regarding future government actions, the economy might end up with a rate of inflation higher than the one that prevailed at the outset of the stabilization attempt.

A crucial issue, then, is to identify the factors that will determine which of the two possible steady states is going to characterize the post-attack regime of this economy in the presence of an inconsistency between the fiscal and exchange rate policies. Given the self-fulfilling nature of private agents' anticipations, this turns out to be equivalent to analyzing the variables, policies, and interactions that will be considered by the public in forming its expectations. In particular, the public will have to evaluate, first, the preferences and incentives of the authorities regarding the two feasible stationary equilibria; and second, the potential (private) costs of each possible course of action.

For the first group of factors it is clear that, since both steady-state positions will yield the same permanent flow of inflationary revenue, the government should be indifferent on this account only as to which rate of depreciation (π^H or π^L) finally sustains its budget deficit, d. Nevertheless, even though the model's structure does not incorporate explicitly the preferences of the authorities, it may be reasonable to assume that most governments would prefer the low-depreciation equilibrium. In the first example of an expansive fiscal policy, they would do so because it implies that the regime with a relatively low rate of depreciation, π_0, will last longer; and in the second, because the apparent success of the disinflation program will be maintained for a longer period. In this sense, the government might have some incentives to influence the post-attack outcome

by revealing its preference for the low-depreciation equilibrium and by trying to precommit itself not to take any action that would interfere with the continuous loss of reserves that will take place during the pre-collapse period.

If the authorities lack the means to ensure that they will not deviate from their preferred outcome, however, an announcement of this type will not be credible. Private agents will realize that the government will very likely be tempted to try to catch them by surprise in order to postpone even further the collapse of the managed regime, either by the *unanticipated* imposition of capital controls or by undertaking an *unanticipated* devaluation. In this case, the private sector will hedge its portfolio against the risk of a capital loss by provoking the collapse of the regime as soon as domestic credit reaches the threshold corresponding to the high-depreciation equilibrium (distance OC' in Figure 3).[17]

In a way, the lack of credibility of government announcements (or, more precisely, the lack of means to enhance such credibility) provides a possible solution to the ex ante indeterminacy of the post-attack steady state of this economy. Since in this model speculation is privately costless, the existence of the slightest probability that the authorities will attempt to delay the transition to a float by a once-and-for-all devaluation will give agents a "one-way-option"; that is, to attack the central bank's international reserves at the time t^H (see equation (20)).

Of course, the outcome will be different if the government finds a credible method for "tying its own bands" during the precollapse period. If this is a feasible alternative, the inconsistency between the fiscal and exchange rate policies will last longer and the attack will take place at t^L (equation (21)). Although nothing in the structure of the model prevents the authorities from making agents' expectations converge to the low-depreciation equilibrium, it may be argued that in the first case considered the fiscal origin of the disequilibrium will erode the government's credibility. In the case of an exchange rate-based stabilization, by contrast, the authorities can blame their delay in reducing the fiscal deficit on the existence of structural rigidities and/or political opposition to the

[17]Notice that the authorities will also be tempted to carry out these surprises in the one-equilibrium models used in the literature on speculative attacks. In spite of the assumption that agents foresee perfectly the law of motion of domestic credit and international reserves consistent with a given rate of devaluation, the private sector in these models does not have enough information to anticipate the imposition of capital controls or a discrete devaluation different from the one required when the peg is abandoned. Thus, when these events take place *before* the collapse date, agents are unable to take advantage of the potential capital gains created by the authorities' measure. On this, see Obstfeld (1984), Wyplosz (1986), and Dornbusch (1987).

needed measures. In both cases, however, the intervention of an outside party might be required to coordinate the self-fulfilling beliefs of the public and avoid attainment of the high-depreciation equilibrium. In this regard, some recent studies indicate that an outside party (such as a foreign central bank) that promises to lend foreign exchange in the event of a confidence crisis can help to postpone the speculative attack.[18] In particular, that party might increase the commitment capacity of the government and persuade private agents that the authorities are not going to surprise them by imposing capital controls or devaluing the currency in the period of transitory equilibrium.

In summary, the solution to the ex ante indeterminacy of the timing and magnitude of the collapse of a crawling peg depends on the credibility of the authorities' resolve not to interfere with the persistent current account deficit caused by the inconsistency between their fiscal and exchange rate policies. This result highlights the severity of the problems that can be generated by an inconsistent fiscal policy in a managed exchange rate regime. If the authorities do not take into account the self-fulfilling nature of the private sector's expectations when implementing unsustainable policies, the economy may very rapidly end up "trapped" in an undesirable high-depreciation equilibrium.

III. Conclusions

This paper has extended the research on collapsing exchange rate regimes by including a financing constraint for the government in a continuous-time, portfolio model of a small open economy with a crawling exchange rate. By considering explicitly the linkage between credit and fiscal policies this analysis has dispensed with the common assumption in the literature on balance of payments crises about the invariance of the growth rate of domestic credit and the associated uniqueness of the post-attack equilibrium. At the same time, it has been argued that the extension of the analysis of dual inflationary equilibria to the case of an open economy with a managed exchange rate is not trivial. Specifically, it has been shown that the possibility of temporarily financing a monetary disequilibrium through losses of international reserves alters the adjustment dynamics that have been obtained for the closed economy case.

It was found that the speculative attack on the central bank's international reserves required to eliminate an inconsistency between fiscal and

[18] See the discussion on this issue in Dellas and Stockman (1988) and Giavazzi and Pagano (1988).

exchange rate policies can occur at two different points in time. Due to the self-fulfilling nature of private agents' expectations, an open economy with a managed exchange rate will restore its steady-state equilibrium after an imbalance created by a fiscal expansion or by a reduction in the rate of crawl by switching to a floating exchange rate regime that can be sustained by either a high or a low rate of depreciation. However, this switch will not be gradual and will not depend on the local stability properties of the two potential equilibria; instead, it will be abrupt and will coincide with the collapse of the managed exchange rate.

The paper also showed that the solution to the ex ante indeterminacy of the post-attack depreciation rate will depend on the government's capacity to make credible announcements regarding policies to be followed in the disequilibrium period preceding the collapse. In particular, if the authorities cannot make a credible precommitment to refrain from delaying the attack through the unanticipated imposition of capital controls or by undertaking an unplanned discrete devaluation, rational private speculators will trap the economy at the high-depreciation equilibrium.

This result affects some of the policy recommendations implicit in the recent literature on portfolio models that has analyzed the main features of alternative exchange rate regimes in developing countries.[19] Specifically, although they discuss explicitly the effects of unsustainable fiscal policies, these studies have disregarded the possibility that the collapse of a fixed or managed exchange rate regime may place the economy on the "wrong" side of the inflation-tax Laffer curve. Indeed, most of this literature has simply assumed that, given a fiscal shock, the stationary equilibrium will always lie on the upward-sloping portion of that schedule. Thus, without the necessary qualifications, these studies inexactly conclude that the negative effects of successive increases in the fiscal deficit (or in the black market premium) can always be avoided by an upward adjustment in the rate of devaluation.

The model presented in this paper also captures some of the stylized facts observed in recent exchange rate-based stabilization episodes. It shows that these programs can work even before the ex post consistency between fiscal and exchange rate policies is attained, but that the success of the disinflation attempt will be short lived if it is not rapidly backed by a reduction of the fiscal deficit to a level that can be sustained by the lower proceeds from the inflation tax. Furthermore, the model suggests that if the measures aimed at restoring the consistency of macroeconomic policies are sufficiently rapid and decisive, an exchange rate-based stabi-

[19] See, for instance, the studies by Dornbusch (1986), Kiguel and Lizondo (1986), and Lizondo (1987a, 1987b).

lization program can prompt a "virtuous cycle" of lower inflation, increased tax yields, and larger international reserves. The model, however, also illustrates that these programs may provoke an inflationary outburst if the authorities delay the necessary adjustment and are unable to make credible commitments during the transitory disequilibrium period. Whether the crisis episodes that ultimately determined the failure of this type of program in the early 1980s were actually characterized by a movement toward an equilibrium inflation rate placed on the wrong side of the inflation-tax Laffer curve, as this model contemplates, can only be properly assessed with a thorough empirical investigation; subsequent research should take this direction.

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