EDITORIAL NOTE

Starting our sixth year of existence, we are comitted to strengthening further Revista de Análisis Económico (RAE). Since its beginning, the purpose of the journal has been to disseminate high-level research, open to all fields of economics, with a special emphasis on issues related to Latin American development. In the future we plan to broaden its readership in order to make RAE a truly hemispheric forum for the diffusion of relevant academic research. In this regard, we intend to project RAE as a first-rate applied economic journal, where recent advances from all branches of economic theory, relevant for applied research and for Latin American issues, be disseminated.

In order to achieve these gòals, the journal is given a new editorial structure starting with this number. RAE is directed by three co-editors and a selected group of associate editors, representative of academia and research institutions from throughout the hemisphere. We extend a warm welcome to our new colleagues, from whose contribution RAE will benefit greatly. We also want to thank sincerely our departing friends and colleagues –former editorial members and advisors– for their efforts devoted to the journal. The academic prestige attained to date by RAE throughout the hemisphere and beyond is the best tribute to their contribution.

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REAL EXCHANGE RATE TARGETS, NOMINAL EXCHANGE RATE POLICIES, AND INFLATION*

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Abstract:

This paper examines the implications of some nominal exchange rate policies aimed at attaining a given real exchange rate target. A policy rule that sets the rate of nominal depreciation as a function of the departures of the real exchange rate from its target level is unable to achieve the target. In contrast, a policy rule that sets the change *in the rate of depreciation as a function of those departures may lead the economy to the target, under certain conditions. However, this policy could also lead the economy to a process of accelerating inflation.*

I. Introduction

Most stabilization programs in developing countries include targets for the real exchange rate. These targets are adopted because of their implications for the country's external accounts. A higher real exchange rate shifts the pattern of production towards traded goods and the pattern of expenditure towards nontraded goods, thereby resulting in a better than otherwise current account balance[1].

Monetary authorities in these countries usually pursue their real exchange rate targets by managing the nominal exchange rate[2]. In general, the type of exchange rate policy used for this purpose can be represented by a particular class of nominal exchange rate rules. These rules set the rate of nominal depreciation as a function of the difference between the actual and the target level for the real exchange rate. Using this class of exchange rate rules, however, raises a number of issues, including their effectiveness in attaining the target, and their consequences for other macroeconomic variables.

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This paper discusses the implications of some of those nominal exchange rate rules. It examines the factor that determine whether a given real exchange rate target is sustainable, in the sense of being consistent with a stationary rate of nominal depreciation. It then analyzes whether this class of exchange rate rules imply dynamics that necessarily lead the economy to the target. The paper also discusses the implications for other variables, focusing primarily on the evolution of the rate of inflation. Since under this type of rule the nominal exchange rate becomes and endogenous variable, there is the possibility of a divergent path for the rate of nominal depreciation. This would also imply a divergent path for the rate of inflation, which could eventually result in hyperinflation.

The model in this paper implies that not every real exchange rate target is sustainable. The range of sustainable targets depends on the range of sustainable inflation tax revenues. A policy rule that sets the rate of depreciation of the nominal exchange rate as a function of the departures of the real exchange rate from its target level is unable to attain the target. In contrast, a policy rule that sets the *change* in the rate of depreciation as a function of those departures may attain the target, under certain conditions. However, this policy could also lead the economy into a process of accelerating inflation.

Although the focus of the paper is on rules aimed at real exchange targets, there is also some discussion about rules aimed at current account and overall balance of payments targets. The paper shows that, within the context of the model presented here, a current account target is equivalent to an (implicit) real exchange rate target, and thus both policies have the same implications. The case of balance of payments targets, on the other hand, is more complex. Unless the authorities know the precise structure of the economy, simple rules like the ones considered here will be unable to achieve the target.

The discussion in this paper complements previous work on exchange rate rules, which have addressed similar but not identical issues. Dornbusch (1982), for example, examines how exchange rate rules affect the trade-off between output stability and price level stability, in a model defined in terms of deviations from trends. His discussion, however, is not concerned with the possibility of attaining a given real exchange rate target, but rather assumes that there is an exogenously given trend for the real exchange rate, and examines random deviations from that trend. Similarly, Adams and Gros (1986) assume that there is an exogenously given long run equilibrium real exchange rate, and discuss the inflationary effects of using purchasing power parity rules for the nominal exchange rate. Rodríguez (1981), on the other hand, examines exchange rate rules with balance of payments targets, rather than real exchange rate targets. Finally, the discussion in this paper is also useful for a comparison of results with models that examine hyperinflations in the context of closed economies under rational expectations.

The rest of the paper is organized as follows. Section II presents the model, and examines its dynamics and the characteristics of its stationary equilibrium. Section III defines sustainable targets, and discusses the effects of adopting three alternative nominal exchange rate rules: a) Setting a fixed rate of depreciation, b) Setting the rate of depreciation as a function of the difference between the actual and the target level for the real exchange rate, and, c) Setting the *change* in the rate of depreciation as a function of the difference between the actual and the target level for the real exchange rate. This section also examines whether the results are modified if higher rates of inflation lead to lower real tax revenue, due to lags in tax collections or other causes. Section IV summarizes the main conclusions. Appendix A derives some results regarding the dynamics of the model, while appendix B examines the implications of managing the exchange rate according to a balance of payments target.

II. The Model

Goods Markets and Prices

Consider a small economy that produces and consumes traded and nontraded goods. There is no foreign inflation, and units are chosen so that the foreign currency price of traded goods equals unity. Therefore, the domestic currency price of traded goods equals the nominal exchange rate E, defined as the domestic currency price of one unit of foreign currency. The nominal exchange rate is determined by the authorities at each moment in time by intervening in the foreign exchange market. Domestic excess demand and excess supply in the traded goods market are eliminated through trade balance deficits and surpluses, respectively. In contrast, the market for nontraded goods must clear domestically through adjustments in prices. Therefore, the domestic currency price of nontraded goods, P_n, and thus the relative price between traded and nontraded goods, are determined endogenously by the conditions of equilibrium in the nontraded goods market.

Production takes place along a transformation curve that is concave to the origin. Since producers maximize profits, the supplies of traded and nontraded goods depend on their relative price.

$$y_t = y_t(e) \qquad y_t' > 0 \tag{1}$$
$$y_n = y_n(e) \qquad y_n' < 0$$

where y_t is the production of traded goods, y_n is the production of nontraded goods, and e is the real exchange rate, $e = (E/P_n)$. Private sector consumption is determined by relative prices and by private sector real wealth.

$$c_t = c_t(e, a) \qquad c_{te} < 0 \quad \text{and} \quad c_{ta} > 0 \tag{2}$$
$$c_n = c_n(e, a) \qquad c_{ne} > 0 \quad \text{and} \quad c_{na} > 0$$

where c_t is private sector consumption of traded goods, c_n is private sector consumption of nontraded goods, and a is private sector real wealth in terms of traded goods[3].

The public sector also demands both types of goods. It is assumed that public sector total expenditure g, and tax revenue t, are fixed in terms of traded goods. A fraction α of public sector expenditure is devoted to traded goods, and a fraction $(1-\alpha)$ to nontraded goods.

$$g_t = \alpha g \qquad g_n = (1-\alpha)\, e\, g \tag{3}$$

where g_t and g_n are the quantities of traded and nontraded goods demanded by the public sector.

The condition for equilibrium in the nontraded goods market is

$$y_n(e) = c_n(e, a) + (1-\alpha)\, e\, g \tag{4}$$

Since it is assumed that the nontraded goods market it always in equilibrium, equation (4) holds at each point in time. This equation establishes a relationship between the real exchange rate, e, real wealth, a, and public sector expenditure, g, which is summarized in equation (5).

$$e = n(a, g) \qquad n_a < 0 \text{ and } \qquad n_g < 0 \tag{5}$$

Assets Markets

The private sector holds its wealth in two non-interest bearing assets, domestic money and foreign money. Real wealth in terms of traded goods is therefore given by,

$$a = m + f \tag{6}$$

where m is the stock of domestic money in terms of traded goods, m=(M/E), and f is the stock of foreign money held by the domestic private sector[4].

It is assumed that the demand for money in terms of traded goods is a decreasing function of the expected instantaneous rate of depreciation of the domestic currency, ϕ^*.

$$m^d = m(\phi^*) \qquad m' < 0 \tag{7}$$

Thus, the higher the expected rate of depreciation of the domestic currency, the lower the real level of domestic money that the private sector wants to hold in its portfolio[5]. It is also assumed that the expected rate of depreciation ϕ^* equals the actual rate of depreciation $\phi=(\dot{E}/E)$, where a dot over a variable indicates its derivative with respect to time. The market for domestic money is always in equilibrium since the private sector can always exchange domestic money for foreign money intantaneously at the Central Bank, at the officially determined nominal exchange rate. Therefore,

$$m = m(\phi) \qquad m' < 0 \tag{8}$$

Dynamics

Using (6), the evolution of real wealth is given by

$$\dot{a} = \dot{m} + \dot{f} \tag{9}$$

By the definition of m,

$$\dot{m} = (\dot{M}/E) - m\,\phi \tag{10}$$

Abstracting from the banking system, the change in the nominal stock of domestic money is equal to the change in Central Bank's domestic credit, plus the change in international reserves in terms of domestic currency.

$$\dot{M} = \dot{D} + E\,\dot{r} \tag{11}$$

where D is the stock of domestic credit, and r is the Central Bank's stock of international reserves on terms of foreign currency[6]. It is assumed that domestic credit is used only to finance the public sector deficit. Thus,

$$\dot{D} = E\,(g - t) \tag{12}$$

The change in international reserves is given by:

$$\dot{r} = [y_t(e) - c_t(e, a) - g_t] - \dot{f} \tag{13}$$

where the term in brackets represents the current account, and the last term the capital account of the balance of payments.

Using (3), and (9)-(13), we obtain

$$\dot{a} = y_t(e) - c_t(e, a) + (1-\alpha)\,g - t - \phi\,m(\phi) \tag{14}$$

Equation (14) indicates the dynamics of real wealth. The evolution of the real exchange rate can also be obtained from (14), since by (5),

$$\dot{e} = n_a\,\dot{a} \tag{15}$$

for a given level of public sector expenditure g.

In order to complete the description of the dynamics of the system, the behavior of the rate of depreciation ϕ must be specified. The path of ϕ, however, depends on the nominal exchange rate policy followed by the authorities. After defining stationary equilibrium, we examine three alternative nominal exchange rate policies, in section III below.

Stationary Equilibrium

A stationary equilibrium is defined as one in which: i) the real exchange rate remains constant, and ii) the rate of depreciation remains constant, for a given set of policies.

From (14) and (15) $\dot{e} = 0$ when

$$y_t(e) - c_t(e, a) = t + \phi\,m(\phi) - (1-\alpha)\,g \tag{16}$$

which provides a relationship between e, a, and ϕ that results in stationary values for e. The stationary values for ϕ, on the other hand, depend on the authorities' nominal exchange rate policy, as mentioned above.

Since i) implies a constant level of real wealth (by 15)), and ii) implies a constant real stock of money (by (8)), equation (9) implies a zero capital account balance in stationary equilibrium. Thus, the balance of payments is equal to the current account balance. Using (3), (16), and the definition of the current account, we obtain

$$CA = t - g + \phi\,m(\phi) \tag{17}$$

where CA denotes the current account balance in terms of foreign currency. Thus, in stationary equilibrium the current account, and the balance of payments, are in surplus or deficit depending on whether the public sector deficit is lower or higher than inflation tax revenues[7]. Also, a higher rate of depreciation implies an improvement or a worsening of the stationary balance of payments depending on whether inflation tax revenues increase or decline, which, in turn, depends on whether the elasticity of the demand for money is lower or higher than unity.

Finally, notice that a stationary equilibrium is not equivalent to a long run equilibrium. A stationary equilibrium may be consistent with a balance of payments deficit, as mentioned above, a situation that clearly cannot persist in the long run. Therefore, our discussion below must be interpreted as describing the behavior of the economy as long as the international reserves constraint does not become binding. If international reserves were exhausted, the authorities would necessarily have to modify their policies. The effects of those modifications depend on the new policies adopted and on private sector expectations regarding those changes, issues that are outside the scope of this paper.

III. Real Echange Rate Targets

Sustainable Targets

We define a sustainable real exchange rate target as a target that is consistent with stationary equilibrium. In other words, a target is sustainable if the real exchange rate can be maintained continuously at that level with a constant rate of depreciation of the domestic currency, that is, without the rate of depreciation having to increase or decline indefinitely. Thus, for every sustainable target there must be at least one rate of depreciation that, together with the target real exchange rate, imply a stationary equilibrium.

In order to derive the relationship between the levels of the real exchange rate and the rates of depreciation that are consistent with stationary equilibrium, we use (5), (14), and (15), to obtain

$$\dot{e} = n_a \, [\, y_t(e) - c_t(e, q(e, g)) - t - \phi \, m(\phi) + (1-\alpha) \, g \,] \quad (18)$$

where q(e, g), which replaces a, is just another representation of the relationship in (5), with $q_e < 0$ and $q_g < 0$. In stationary equilibrium $\dot{e} = 0$, so that

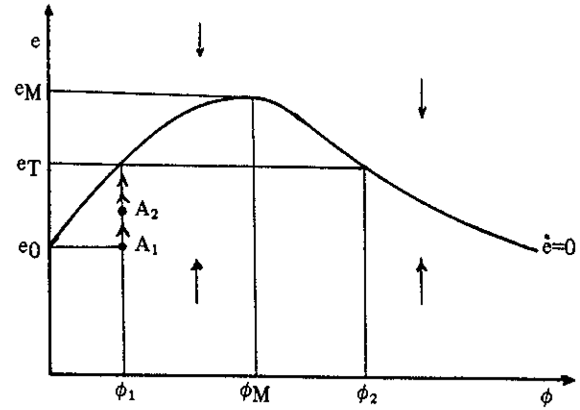
$$y_t(e) - c_t(e, q(e, g)) = t + \phi \, m(\phi) - (1-\alpha) \, g \quad (19)$$

The left hand side of (19) is an increasing function of e, while the right hand side increases or declines with ϕ depending on whether the elasticity of the demand for money is lower or higher than unity.

It is assumed that the elasticity of the demand for money is lower than unity for "low" rates of depreciation, and higher than unity for "high" rates of depreciation[8]. In other words, it is assumed that inflation tax revenues increase with the rate of depreciation up to a certain level, after which, higher rates of depreciation produce lower revenues. This implies that, in general, there will be two rates of depreciation associated with each level of revenue. The shape of the demand for money, and equation (19), imply that the relationship between the rate of depreciation and the level of the real exchange rate in stationary equilibrium is as described by curve $\dot{e}=0$ in figure 1, where ϕ_M denotes the rate of depreciation associated with the maximum inflation tax revenue.

Figure 1 and the various equations in the model can be used to describe how do nominal depreciations work in this framework. Nominal depreciations produce inflation, and thus an inflation tax. The level of tax payments affects private sector expenditure on both traded and nontraded goods, thereby affecting the current account of the balance of payments and the real exchange rate. An increase in the rate of depreciation (the inflation tax rate) reduces the real money stock (the inflation tax base), with the net effect

FIGURE 1



on inflation tax revenues depending on the elasticity of the demand for money. If this elasticity is below unity, inflation tax revenues increase, thereby reducing private sector expenditure and leading to an improved current account and a real depreciation. The opposite occurs if the elasticity of the demand for money is above unity.

Therefore, higher rates of depreciation imply higher real exchange rates in the range of the demand for money with elasticity below unity (which corresponds to low rates of depreciation), and lower real exchange rates in the range with elasticity above unity (which corresponds to high rates of depreciation). The maximum real exchange rate consistent with stationary equilibrium, denoted by e_M in figure 1, is the level associated with the rate of depreciation ϕ_M. A real exchange target higher than e_M is not consistent with stationary equilibrium because there is no constant rate of depreciation that would produce inflation tax revenues so high as to reduce private sector expenditure to the required level[9].

Nominal Exchange Rate Policies

The dynamics of the system depend on the behavior of both, the real exchange rate and the rate of depreciation. The behavior of the real exchange rate is given by equation (18), which indicates that $\dot{e}$ declines for points above the $\dot{e}=0$ curve, and increases for points below that curve. The behavior of the rate of depreciation, on the other hand, is determined by the authorities' nominal exchange rate policy. We will consider three alternative policies: a) Setting a fixed rate of depreciation, b) Setting the rate of depreciation as a function of the difference between the actual and the target real exchange rate, and c) Setting the *change* in the rate of depreciation as a function of the difference between the actual and the target real exchange rate.

Starting from an initial stationary equilibrium with a fixed nominal exchange rate, so that the real exchange rate is e_0 in figure 1, assume that the authorities want to attain a target real exchange rate e_T, higher than e_0. They can achieve their target by choosing a constant rate of depreciation equal to either ϕ_1 or ϕ_2. Assuming, for example, that they choose ϕ_1, upon adoption of the new nominal exchange rate policy the economy will be located in A_1. From there, the real exchange rate will increase until it reaches the target level e_T. In the absence of policy changes, the economy will remain in its new stationary equilibrium.

The evolution of the various macroeconomic variables following the adoption of a constant rate of depreciation is the following. On impact, the private sector shifts its portfolio from domestic money to foreign money due to the increase in the cost of holding domestic money. Private sector real wealth starts declining due to the increase in the inflation tax (previously equal to zero), which causes private sector expenditure also to decline. The reduction in the demand for traded goods result in improvements in the current account of the balance of payments, while the reduction in the demand for nontraded goods result in higher real exchange rates. This process stops when the improvement in the current account is sufficient to compensate for the increase in inflation tax revenues, so that a new stationary equilibrium is reached[10] For deriving the behavior of the rate of inflation let us define the price level as

$$P = E^{\beta} P_n^{1-\beta} = E\, e^{\beta-1} \qquad (20)$$

The rate of inflation is therefore equal to

$$\pi = (\dot{P}/P) = \phi - (1-\beta)\,(\dot{e}/e) \qquad (21)$$

From equations (20) and (21), upon adoption of a constant rate of depreciation ϕ_1, the rate of inflation does not jump immediately to ϕ_1 but approaches that level from below. This is so because during the transition to the new stationary equilibrium the price of nontraded goods does not increase as fast as the price of traded goods due to the reduction in demand described above.

In the analysis above, it was implicitly assumed that there was no maxidevaluation at the time of adoption of the new exchange rate policy[11]. If there is an initial maxidevaluation, private sector real welath falls by a discrete amount on impact due to the capital loss on its holdings of domestic money. This reduces private sector demand for both types of goods on impact. This, in turn, implies that there is an immediate discrete real depreciation. Thus, in terms of figure 1, the economy jumps initially to a point above A_1, such as A_2, and from there it adjusts towards its new stationary equilibrium. Besides those initial effects, the behavior of the variables in the adjustment process is the same as described for the case without maxidevaluation.

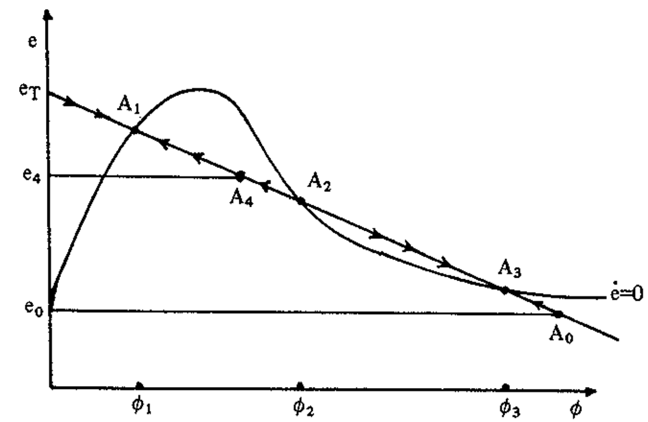
Although the adoption of a constant rate of depreciation could in principle lead the real exchange rate to its target, this policy is unlikely to succeed because it requires prior knowledge about the rate of depreciation that is consistent with the target, the authorities need to know the "structure" of the economy. Therefore, actual policies usually follow rules based on the difference between the actual and the target levels for real exchange rate. Consider, for example,

$$\phi = \epsilon\,(e_T - e) \qquad \epsilon > 0 \qquad (22)$$

This rule establishes that the rate of depreciation is positive if the real exchange rate is below its target level, and negative if it is above its target. The further away is the real exchange rate from its target level, the higher is the rate of depreciation (or appreciation) of the nominal exchange rate[12]

The dynamics of the system are described in figure 2. Equation (22) is represented by the downward sloping straight line that starts at e_T on the vertical axis. Since this

FIGURE 2



line intersects the $\dot{e}=0$ curve three times, as drawn in figure 2, there are three alternative stationary equilibriums, A_1, A_2, and A_3. As indicated by the arrows, the stationary equilibrium A_2 is unstable, while the other two are locally stable.

Adopting the rule in equation (22) without an initial maxidevaluation would set the economy initially at A_0. From there it would converge to A_3, with the highest rate of inflation and the lowest real exchange rate of the three alternative stationary equilibriums. An initial maxidevaluation large enough to set the initial real exchange rate above the level associated with the unstable equilibrium, for example at e_4, would lead the economy to A_1. In this case, the economy would attain the lowest rate of depreciation and the highest real exchange rate of the three alternative stationary equilibriums.

Notice that under the exchange rate rule in (22) the real exchange rate can never converge to a target level e_T above e_0. The reason is simple. Sustaining a real exchange rate level above e_0, requires a positive inflation tax revenue. However, equation (22) indicates that if the real exchange rate were to reach the target level e_T, the rate of depreciation would be set equal to zero. This is not consistent with a sustained positive inflation tax revenue. Thus, the target level for the real exchange rate cannot be sustained by the policy in equation (22). With this policy, the dynamics of the system necessarily push the real exchange rate below its target level[13].

Although figure 2 is drawn with three alternative stationary equilibriums, there may be only one stationary equilibrium depending on the particular values of ϵ and e_T. If there is only one equilibrium, this equilibrium will be locally stable, so the economy will converge to this point regardless of whether there is an initial maxidevaluation or not. It would still be true that the economy cannot converge to e_T. Finally, it should be clear that all of the above conclusions regarding the effects of the exchange rate rule described by equation (22) hold independently of whether the target level e_T is sustainable or not.

Since the exchange rate policy indicated by equation (22) cannot lead the economy to its target, an alternative is to set the *change* in the rate of depreciation as a function of the difference between the actual and the target level for the real exchange rate. Thus,

$$\dot{\phi} = \gamma\,(e_T - e) \qquad \gamma > 0 \qquad (23)$$

Under this policy, the rate of depreciation increases if the real exchange rate is below the target, and declines if it is above the target[14].

The dynamics of the system under this nominal exchange rate rule are shown in figure 3. As it was the case with the fixed rate of depreciation, there are two stationary equilibriums consistent with the real exchange rate targer e_T. The first with a stationary rate of depreciation ϕ_1, and the second with a higher stationary rate of depreciation ϕ_2. According to the new laws of motion of the system, while the first stationary equilibrium is locally stable, the second one presents saddle point stability[15, 16].

Under this new nominal exchange rate policy, if the system starts from a point to the left of SS, the economy converges to the first stationary equilibrium. In contrast, if the system starts from a point to the right of SS, the rate of depreciation increases without limit, and the target real exchange rate is never attained. The intuition behind this last result is the following. If the initial rate of depreciation is "too high" and the

FIGURE 3

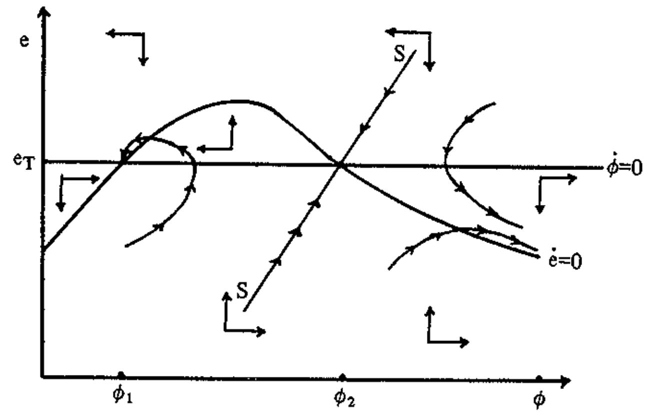
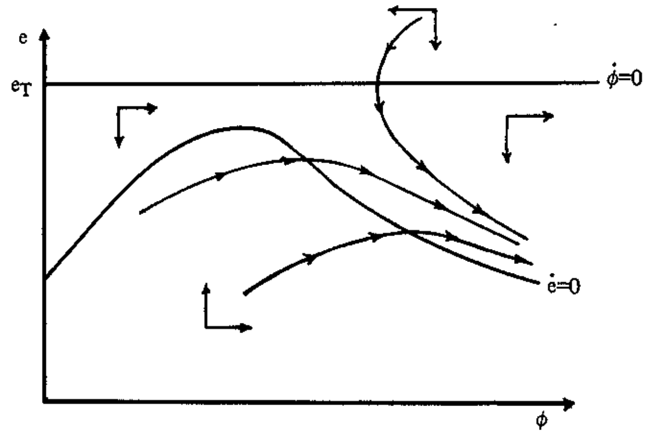


FIGURE 4



initial real exchange rate is "too low" (to the right of SS), the economy is set in a course that leads to the elastic section of the demand for money and a real exchange rate below the target level. Once there, higher rates of depreciation imply lower inflation tax revenues, which results in higher private sector expenditure, thereby causing the real exchange rate to diverge even more from its target level. This process, if uninterrupted, leads to an unlimited increase in the rate of depreciation, and therefore to accelerating inflation. Furthermore, the balance of payments worsens continuously. Clearly, if the balance of payments turns into deficit some of the policies must eventually be modified.

These results underscore the importance of choosing appropriately the initial position of the economy for the adoption of this nominal exchange rate policy. In order to avoid a divergent solution, the economy must avoid a "too high' initial rate of depreciation, and a "too low" initial real exchange rate. While the initial rate of depreciation can be set directly by the authorities, the initial real exchange rate can be determined indirectly through a maxidevaluation of the domestic currency, as explained previously. Thus, in order to set the economy in a convergent solution it seems advisable to start the process with a maxidevaluation, and a relatively low continuous rate of depreciation[17].

The attempt to attain a real exchange rate target that is not sustainable, on the other hand, will necessarily lead to a divergent solution for the rate of depreciation. This is shown in figure 4, where the target real exchange rate e_T is above the maximum sustainable target level. As it is clear from figure 4, irrespectively of the initial position of the economy, the rate of depreciation increases without limit, and so does the rate of inflation. The balance of payments worsens continuously, and the real exchange rate diverges from its target level[18].

Olivera-Tanzi Effect

In the analysis above, the rate of depreciation affects the real exchange rate through its effects on inflation tax revenues. It seems natural, therefore, to examine to what extent the previous results are modified by incorporating another well known effect of inflation on tax revenues, the Olivera-Tanzi effect. This effect is present when higher rates of inflation imply lower real tax revenues, for a given tax structure, due primarily to lags in tax collection[19] This can be incorporated in our model by making t endogenous, as a decreasing function of the rate of inflation. Thus,

$$t = t(\pi) \qquad t' < 0 \tag{24}$$

Using (21) and (24) to replace t in (18), we obtain

$$\dot{e} = n_a\ [y_t(e) - c_t(e, q(e, g)) - t(\phi - (1-\beta)(\dot{e}/e)) - \phi m(\phi) + (1-\alpha)g] \tag{25}$$

In stationary equilibrium $\dot{e}=0$, so the relationship between the real exchange rate and the rate of depreciation becomes

$$y_t(e) - c_t(e, q(e, g)) = t(\phi) + \phi\ m(\phi) - (1-\alpha)\ g \tag{26}$$

Comparing (26) with (19), it is clear that the relationship between e and ϕ in stationary equilibrium continues to be described by a curve with the shape of $\dot{e}=0$ in figures 1 to 4.

The difference is that now the maximum sustainable real exchange rate target is associated with a point on the inelastic section of the demand for money. The reason is that as the rate of depreciation increases in the inelastic section of the demand for money, the revenue from the inflation tax increases, but, simultaneously, real revenues from other taxes decline. Therefore, total (inflation tax plus other tax) revenues will increase up to a point where an increase in the rate of depreciation inceases inflation tax revenues by the same amount that it reduces other revenues[20]. At this point, total tax revenues are maximized, and the real exchange rate reaches its maximum sustainable level.

Although incorporating the Olivera-Tanzi effect does not affect significantly the relationship between the real exchange rate and the rate of depreciation in stationary equilibrium, it may alter fundamentally the dynamics. There are two possible cases, depending on the strenght of the Olivera-Tanzi effect. If this effect is sufficiently strong in equation (25), it may reverse the relationship between $\dot{e}$ and the other variables, as compared to equation (19)[21].

Thus, if the Olivera-Tanzi effect is not "too strong", the dynamics are as described previously for the three nominal exchange rate rules examined. In contrast, if the Olivera-Tanzi effect is strong enough, the dynamics change drastically, increasing the possiilities for unstable solutions[22]. If the authorities set a fixed rate of depreciation, the two stationary equilibriums associated with any sustainable target would be locally unstable. Thus, unless an initial maxidevaluation places the real exchange rate exactly on its target, the economy would follow a divergent path. If, alternatively, the authorities follow the second exchange rate rule, there are three possible stationary equilibriums, the middle one being locally stable and the other unstable. So the economy may converge to the locally stable equilibrium, or it may follow a divergent path, depending on the magnitude of the initial maxidevaluation. If there is only one stationary equilibrium, it is unstable. For the third exchange rate rule the stationary equilibrium with the lower rate of depreciation becomes saddle point stable, while the other one becomes unstable[23]. So, unless the initial position is on the saddle path, the economy will not converge to any of the stationary equilibriums.

IV. Conclusion

Countries can use nominal exchange rate policy effectively in their attempt to achieve a given real exchange rate target. In the model in this paper, nominal depreciations act as a tax on holdings of domestic money, thus resulting in a reduction in private sector expenditure on traded and on nontraded goods. While the reduction in expenditure on traded goods leads to an improvement in the current account of the balance of payments, the reduction in expenditure on nontraded goods leads to a decline in its relative price, that is, to a real depreciation.

Not any arbitrary real exchange rate target is sustainable, however, by using only nominal exchange rate policy. Since the effect of nominal depreciations on the real exchange rate works through the inflation tax, the range of sustainable real exchange rate targets depends on the range of sustainable inflation tax revenues.

For any target within the sustainable range, there are generally two potential stationary equilibriums. Although the resulting inflation tax revenue, and stationary balance of payments, are the same for both equilibriums, they are associated with different stationary rates of inflation. Which of these equilibriums, if any, is finally attained, depends on the authorities' nominal exchange rate policy.

If the authorities set a fixed rate of depreciation for the domestic currency, the economy necessarily converges to the stationary equilibrium associated with the chosen rate of depreciation. For the success of this policy in achieving the target, however, the authorities need to have prior knowledge about the rate of depreciation that is consistent with the target. An initial maxidevaluation would speed the process of adjustment.

If the authorities set the rate of depreciation as a function of the difference between the actual and the target level for the real exchange rate, the economy does not converge to its target. It converges to a real exchange rate that is below its target level. There may be more than one locally stable stationary equilibrium. Which of them is the point of convergence, depends on the magnitude of the initial maxidevaluation. This nominal exchange rate rule does not lead to hyperinflation, irrespectively of whether the real exchange rate target is sustainable or not.

If the authorities set the *change* in the rate of depreciation as a function of the difference between the actual and the target level for the real exchange rate, the stationary equilibrium with the lower rate of depreciation is stable, while the other one is saddle point stable. Whether the economy converges to some of these stationary equilibriums, or diverges in a process leading to hyperinflation, depends on the initial conditions upon the adoption of this exchange rate rule. In order to converge to the stationary equilibrium with the lower rate of inflation, it seems advisable to implement an initial maxidevaluation, and start with a relatively low rate of continuous depreciation. Trying to attain a real exchange rate target that is not sustainable necessarily leads to hyperinflation.

If real revenues from taxes other than the inflation tax decline as the rate of inflation increases, the dynamics may change sharply for the three exchange rate rules examined. If this effects is sufficiently strong, most of the stationary equilibriums become unstable.

Notes:

1 The real exchange rate is defined in this paper as the relative price of traded goods in terms of nontraded goods. Therefore, an increase in the real exchange rate indicates a real depreciation of the domestic currency.

2 Although other policies could also be used to attain a given real exchange rate target, the nominal exchange rate remains the preferred instrument because it is considered to be more flexible to manage, and to have a more direct effect on the real exchange rate.

3 In equation (2), real wealth could be defined in terms of any arbitrary basket of goods. We chose to define in in terms of traded goods because it is more convenient for the analysis that follows.

4 It is assumed that foreign residents do not hold domestic currency, so that the total stock of domestic money is held by the domestic private sector.

5 Alternatively, it could be assumed that the *share of wealth* that is held in domestic money depends on the expected rate of depreciation. That is, $m^d=\theta(\phi^*)\,a$, with $0<\theta<1$, and $\theta'<0$. This alternative assumption does not affect the implications of the model.

6 It is assumed that the Central Bank does not monetize the capital gains (in terms of domestic currency) on its holdings of international reserves arising from the depreciation of the domestic currency, $\dot{E}$ r.

7 In stationary equilibrium the rate of inflation equals the rate of depreciation of the domestic currency since relative prices are constant and the price of traded goods increases at the rate of depreciation. Therefore, the term $\phi m(\phi)$ can be interpreted as the revenue from the inflation tax on private sector's real holdings of domestic money.

8 This equivalent to the usual assumption regarding the shape of the demand for money in models that discuss hyperinflation in closed economies.

9 Equation (19) can be used to see how tax and public sector expenditure policies affect the set of sustainable real exchange rate targets. An increase in taxes t, a reduction in public sector expenditure g, and a shift in public sector expenditure towards traded goods (an increase in α), imply an increase in the real exchange rate consistent with stationary equilibrium. In terms of figure 1, any of these policies would shift the $\dot{e}=0$ curve upwards. From equation (17), however,

while both an increase in taxes and a reduction in public sector expenditure would also improve the stationary balance of payments, a change in the composition of public sector expenditure would have no effect on the stationary balance of payments.

10 See equation (19).

11 In this continuous time model, a maxidevaluation is defined as a discrete increase in the nominal exchange rate, as opposed to the rate of depreciation $\phi=(\dot{E}/E)$ which represents infinitesimal changes in the nominal exchange rate.

12 If the authorities have a current account target CA_T, instead of a real exchange rate target, they may follow rules such as (22') $\phi=\epsilon(CA_T-CA)$. However, since there is a one-to-one relationship between the current account and the real exchange rate, $CA=y_t(e)-c_t(e, q(e, g))-\alpha g$, these rules can be interpreted as having an implicit real exchange rate target. In other words, if e_T is the real exchange rate consistent with CA_T, the stationary equilibriums, and the dynamics around the stationary equilibriums, are the same whether the country follows (22) or (22'). The case of a balance of payments target is different because capital flows must also be included. This case is examined in appendix B.

13 An alternative to rule (22) would be to incluede a "base" rate of depreciation ϕ_0, so that $\phi = \phi_0 + \epsilon\ (e_T-e)$. By appropriately choosing ϕ_0, this rule would lead the real exchange rate to its target level (as long as the target is sustainable). However, appropriately choosing ϕ_0 requires prior knowledge of the rate of depreciation that is consistent with the target. As mentioned before, it is the absence of such knowledge what usually motivates the use of rules other than a constant rate of depreciation.

14 If the authorities have a current account target CA_T and follow $\phi=\gamma(CA_T-CA)$, their policy can be interpreted as having an implicit exchange rate target e_T and following (23), where e_T is the real exchange rate consistent with CA_T.

15 See the appendix for a formal proof. The dynamics here described are valid near the points of stationary equilibrium.

16 In contrast, in closed economy models with flexible prices the low inflation steady state is unstable, while the high inflation steady state is locally stable. See Buiter (1987).

17 This discussion assumes that the authorities want to achieve their objective by using exchange rate policy. Otherwise, an increase in taxes and a reduction in public sector expenditure would also contribute in placing the economy in the stable region.

18 As in the case of closed economy models generally used to discuss inflation, the attempt to extract inflation tax revenues above the maximum sustainable level implies a divergent path for the rate of inflation. However, while in the model in this paper this attempt leads to hyperinflation, in closed economy model with flexible prices and rational expectations it leads to hyperdeflation (see Buiter (1987)). Imposing price stickiness, however, allows the closed economy model to generate hyperinflations (see Xiguel (1989)). In the model in this paper, some price stickiness is created by the managed rate of depreciation, since the nominal exchange rate determines directly the price of traded goods and provides an implicit anchor for the price of nontraded goods.

19 See Olivera (1967), and Tanzi (1977).

20 Total revenues increase, stay constant, or decline, depending on whether η is lower, equal, or higher than $[1 + (t'/m(\phi))]$, where η is the elasticity of the demand for money. We assume that $\eta < [1 + (t'/m(\phi))]$ at least for some range of low rates of inflation; otherwise, the $\dot{e}=0$ curve would be downward sloping for all positive ϕ.

21 From equation (25), the condition for reversing this relationship is $n_a^{\cdot}\, t'(1-\beta) > e$.

22 The results below can be obtained from figures 1 to 3 by reversing the direction of the vertical arrows.

23 See appendix for a formal proof.

24 This problem of simultaneity would be absent in a discrete time model with a rule that sets the change in the rate of depreciation as a function of *past* balance of payments.

References

ADAMS, CHARLES, and DANIEL GROS (1986), "The Consequences of Real Exchange Rate Rules for Inflation: Some Illustrative Examples". *IMF Staff Papers* 33 (September) 439-476.

BUITER, WILLEM (1987), "A Fiscal Theory of Hyperdeflations? Some Surprising Monetarist Arithmetic". *Oxford Economic Papers* 39 (March), 111-118.

DORNBUSCH, RUDIGER (1982), "PPP Exhange-Rate Rules and Macroeconomic Stability". *Journal of Political Economy* 90 (February), 158-165.

KIGUEL, MIGUEL A. (1989), "Budget Deficits, Stability, and the Monetary Dynamics of Hyperinflation". *Journal of Money, Credit, and Banking* 21 (May), 148-157.

OLIVERA, JULIO (1967), "Money, Prices, and Fiscal Lags: A Note on the Dynamics of Inflation". *Banca Nazionale del Lavoro Quarterly Review* 20 (September), 258-267.

RODRIGUEZ, CARLOS A. (1981), "Managed Float: An Evaluation of Alternative Rules in the Presence of Speculative Capital Flows". *American Economic Review* 71 (March), 256-260.

TANZI, VITO (1977), "Inflation, Lags in Collection, and the Real Value of Tax Revenue". *IMF Staff Papers* 24 (March), 154-167.

Appendix A

This appendix examines the dynamics for the third exchange rate rule analyzed in the paper. The dynamics are summarized by equations (18) and (23) when the Olivera-Tanzi effect is not present, and by equations (25) and (23) when the Olivera-Tanzi effect is included. Both systems can be represented by:

$$\dot{e} = h(e, \phi) \tag{A1}$$

$$\dot{\phi} = \gamma\ (e_T - e) \tag{A2}$$

Equation (A1) represents either (18) or (25), and equation (A2) reproduces (23). The difference between the two systems under consideration refers to the signs of the partial derivatives of the function $h(e, \phi)$.

Linearizing (A1) and (A2) around stationary equilibrium, we obtain

$$\begin{bmatrix} \dot{e} \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} h_e & h_\phi \\ -\gamma & 0 \end{bmatrix} \begin{bmatrix} de \\ d\phi \end{bmatrix} \tag{A3}$$

The characteristic equation for (A3) is

$$\lambda^2 - \lambda\ h_e + \gamma\ h_\phi = 0 \tag{A4}$$

Let us consider first the system formed by equations (18) and (23), described in figure 3. There are two stationary equilibrium, for rates of depreciation ϕ_1 and ϕ_2. In terms of equation (A1), for both stationary equilibriums $h_e < 0$; but while $h_\phi > 0$ for the lower rate of depreciation, $h_\phi < 0$ for the higher rate of depreciation. This implies that for the lower rate of depreciation there are two negative real roots, or two complex roots with negative real parts, so this stationary equilibrium is locally stable. For the higher rate of depreciation there are two real roots, one positive and the other one negative, so this stationary equilibrium is saddle point stable.

Let us consider now the system formed by equations (25) and (23). If the Olivera-Tanzi effect included in equation (25) is not "too strong" $n_a t\,(1-\beta) < e$, the partial derivatives of the function $h(e, \phi)$ have the same signs as mentioned above. So the dynamics are as described above, and as shown in figure 3. In contrast, if the Olivera-Tanzi effect is strong enough, all the partial derivativies of the function $h(e, \phi)$ change signs. For both stationary equilibriums $h_e > 0$; but while $h_\phi < 0$ for the lower rate of depreciation, $h_\phi > 0$ for the higher rate of depreciation. This implies that for the lower rate of depreciation there are two real roots, one positive and the other one negative, so this stationary equilibrium is saddle point stable. For the higher rate of depreciation there are two positive real roots, or two complex roots with positive real parts, so this stationary equilibrium is unstable.

Appendix B

This appendix examines the case of managing the nominal exchange rate according to a balance of payments target. The general conclusion is that, under the assumption that the authorities do not know the precise structure of the economy, simple exchange rate rules of the type considered in this paper will not achieve the target.

Two nominal exchange rate rules are considered here. One of them sets the rate of depreciation as a function of the difference between the target balance of payments and the actual balance of payments, while the other sets the *change* in the rate of depreciation as a function of the difference.

The first rule is

$$\phi = \xi\,(\dot{r}_T - \dot{r}) \qquad \xi > 0 \tag{B1}$$

where r_T is the balance of payments target. This rule fails to achieve the balance of payments target for the same reason that rule (22) failed to achieve the real exchange rate target. According to rule (B1), if the actual balance of payments is equal to the target balance of payments, the rate of depreciation would be set at zero. However, this creates an inconsistency for any balance of payments target different from the balance of payments resulting under a fixed exchange rate. Amending rule (B1) to avoid this inconsistency, for example by including a "base" rate of depreciation, requires knowing the structure of the economy to be able to select the appropriate base.

The second rule is

$$\dot{\phi} = \mu\,(\dot{r}_T - \dot{r}) \qquad \mu > 0 \tag{B2}$$

This rule indicates that the authorities will adjust the rate of depreciation by a proportion μ of the deviation of the balance of payments from its target. However, the authorities face some restrictions for implementing this policy. The balance of payments itself is a function of the change in the rate of depreciation because changes in the rate of depreciation affect desired money holdings and therefore capital flows. Using (9), (13), and (14), the balance of payments can be expressed as

$$\dot{r} = t + \phi\, m(\phi) - g + \dot{m} \tag{B3}$$

From (8)

$$\dot{m} = m'\,\dot{\phi} \tag{B4}$$

Using (B3) and (B4)

$$\dot{r} = t + \phi\, m(\phi) - g + m'\,\dot{\phi} \tag{B5}$$

Therefore, while (B2) indicates the authorities' purpose of setting the change in the rate of depreciation as a function of the actual balance of payments, (B5) indicates that the actual balance of payments is itself a function of the change in the rate of depreciation[24]. In order for the authorities to be able to implement rule (B2), they must take into account the endogenous relationship (B5). Using (B5) to replace $\dot{r}$ in (B2), we obtain

$$\dot{\phi} = \mu\,[1 + m'\mu]^{-1}\,[\dot{r}_T - t - \phi\, m(\phi) + g] \tag{B6}$$

Thus, the authorities must follow (B6) if they want the rate of depreciation to be consistent with (B2). It is clear that in order to follow (B6) the authorities must know the structure of the economy.

Since $m' < 0$ and $\mu > 0$, there are two possibilities regarding the dynamics of the model, depending on whether the first square bracket in (B6) is positive or negative. It can be shown that in both cases there will be two stationary equilibriums with the same stationary real exchange rate. One of those equilibriums will be locally stable, while the only convergent paths for the other sationary equilibrium will be those starting at the stationary depreciation rate. Whether the locally stable equilibrium will be the one with lower or higher depreciation rate, depends on whether the first square bracket in (B6) is positive or negative. A detailed analysis of the dynamics is not presented here because, if the authorities knew the structure of the economy as required to follow (B6), they could follow a much sumpler rule, which in addition would guarantee convergence to their balance of payments target. They could just choose a constant rate of depreciation equal to any of the two stationary rates of depreciation consistent with their balance of payments target.