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Exchange Rate Based Inflation Stabilization with a Currency Board

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EXCHANGE RATE BASED INFLATION STABILIZATION WITH A CURRENCY BOARD

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Abstract:

This paper develops a two-period stochastic model of an exchange rate based inflation stabilization plan with a currency board. It considers a dynamic game framework in which inflation and the levels of fiscal expenditure and public debt determine the payoffs available to the policymaker at each period of the game. A tax revenue shock, instead of active speculation by private agents, threatens the sustainability of the currency board and the credibility of the fixed exchange rate regime. This shock will be more damaging the higher is the inherited public debt stock. Hence, the policymaker must face a fundamental trade-off between the credibility and flexibility of such regimes. Some interesting policy implications about the management of the currency composition of public debt are drawn from the model.

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1- Introduction

High inflation and hyperinflation are invariably characterized by a great disorder in public finances[1]. In such episodes, the government becomes unable to cope with expenditure demands, and must rely on seigniorage revenues (an inflation tax "paid" by the majority of society), because of a limited taxation capacity. These expenditures may either come from demands for public goods by consumers, demands for subsidies from lobbying interest groups or represent essential social expenditure that cannot be easily reduced without facing considerable political costs[2]. The discrepancy between the level of such expenditures and limited tax revenues defines the fiscal pressure.

The question that then arises is about the implications of these fiscal pressures when the government is implementing an exchange rate based inflation stabilization plan with complete internal convertibility such as through an orthodox currency board[3] which, by definition, excludes an inflation tax as a discretionary revenue instrument.

Following the mainstream exchange rate policy game literature, our contribution consists of addressing this question by incorporating fiscal pressures in the policymaker's preferences as an argument that threatens the sustainability of the currency board and the credibility of the fixed exchange rate regime (instead of active speculation by private agents, as in the standard speculative attack models). Another key feature in our model is the fact that private sector agents know the optimization problem faced by the policymaker. Thus, the interactions between the policymaker and the private sector are captured by modeling both the probability and the size of the discretionary devaluation as an endogenous variable.

The stochastic game setup developed below not only emphasizes the policymaker's fundamental trade-off between credibility and flexibility within the currency board and fixed exchange rate regimes, but also combines two opposing effects that influence the evolution of this trade-off during the game. In particular, the model considers the positive effect on credibility of maintaining internal currency convertibility and the fixed exchange rate, but also the negative effect that persistent fiscal pressures have on the sustainability and hence also the credibility of such regimes.

[1] See Phelps(1973), CEPAL(1986), Heymann(1986), Leijonhufvud(1990), Dornbusch et al. (1991), Easterly and Schmidt-Hebbel(1991), Canavese(1992), Heymann and Leijonhufvud(1995), Mondino et al.(1996).
[2] See Masson(1996) for the EU case.

The remainder of the paper is organized as follows. Section 2 briefly overviews the main concepts and the policy issues to be analyzed. Section 3.1 sets out the basic model of a two-period stochastic policy game with explicit fiscal pressures. Sections 3.2 and 3.3 present the second period Nash solution and the first period Stackelberg solution without learning, respectively. The Nash solution is obtained taking devaluation expectations as given, while the Stackelberg solution considers the effects of the first period's policies on the second period devaluation expectations. Section 4 concludes with the interpretation of the results and some policy implications.

2- Main concepts and policy issues

As in Greene and Isard(1991), **internal currency convertibility** is the legal right of **residents** to acquire, maintain, and transact domestic holdings of foreign currency assets without differential taxes and subsidies. It is the convertibility of currency between residents within national borders while **external currency convertibility** is related to transactions **between residents and nonresidents**. There are also degrees in internal currency convertibility. We will always refer to **complete internal currency convertibility**, meaning the freedom for residents to use their domestic holdings of foreign currency to make both current and capital transactions domestically.

An **orthodox currency board** is an independent currency authority arrangement by which the domestic currency exchange rate against the foreign currency is **fixed permanently**[4] and the foreign reserve backing is 100 percent. Its main benefit is promoving price stability and convertibility. However, it constrains the policymaker's discretion on fiscal and monetary policy more than conventional fixed exchange rate regimes.

Moreover, fiscal policy plays a crucial role within an orthodox currency board regime because it must ensure the government's solvency. On the one hand, inflation tax revenues are limited to those implied by foreign inflation and the only remaining seigniorage revenue comes from the difference between the interest earnings from the investment of foreign reserves and the administrative and

[3] See Greene and Isard(1991), Williamson(1991,1994), Osband and Villanueva(1993), Schwartz(1993), Bennett(1994), Hanke and Schuler(1994), Kyei and Yoshimura(1996) for an analysis of issues and experiences with internal convertibility and currency boards.
[4] In a crawling-peg currency board, the exchange rate is variable.

operational expenses of the currency board. On the other hand, solvency requires an intertemporal fiscal surplus equivalent to interest and net debt payments and so, only limited and transitory deficits are allowed.

In an orthodox currency board regime with perfect capital mobility, the base money is determined solely by the evolution of foreign exchange reserves. The Central Bank can no longer act as a lender of last resort and its functions are limited to the management of the currency board and the supervision of the financial system. Hence, apart from some marginal changes in reserve requirements that affect the base money multiplier and some marginal open-market operations, money supply is then completely determined by the capital flows and the financial intermediation, and is therefore out of the policymaker's control. For this reason, monetary policy will be disregarded as an active policy instrument in our model.

In this context, the **sustainability** of complete internal convertibility as through an orthodox currency board and the **credibility** of the fixed exchange rate regime, given fiscal pressures and possibly adverse shocks, become the critical policy issues.

The precommitments on the currency board and the fixed exchange rate are aimed at stabilizing inflation and devaluation expectations and at producing a rapid disinflation with minimal loss in terms of forgone output and employment. Hence, the tying of his hands in this way, represents an attempt to ensure the policymaker's credibility with regard to the implementation of policy announcements and the general policy strategy. We will refer to **credibility** as the likelihood estimated by the private sector that the policy commitments will be maintained even in the presence of adverse shocks[5].

The **sustainability** of fixed exchange rate regimes has been addressed in the literature by two classes or "generations" of **speculative attack and balance of payments crises models**[6]. The first of these analyze the consequences of incompatible fiscal, monetary and exchange rate policies for the balance of payments of a small open economy. In a seminal paper, Krugman(1979) showed that, under a fixed exchange rate regime, an expansionary monetary policy leads to a gradual loss of foreign exchange reserves and, finally, to a speculative attack against the domestic currency that forces the

[5] As in Drazen and Masson(1994), Masson(1995), Masson and Agénor(1996) and Velasco(1996a,b).
[6] Recent surveys are Agénor et al. (1992), Willman(1992), Blackburn and Sola(1993), Obstfeld(1994), Jeanne(1994) and Eichegreen, Rose and Wyplosz(1994, 1995).

abandonment of the fixed exchange rate regime. Because of the nonlinearities involved in his model, however, Krugman was unable to derive explicitly a solution for the timing of the collapse of the fixed exchange regime. Later work by Flood and Garber(1984a) provided an example with a solution in a linear model.

Subsequent literature[7] has amended and extended these original models by incorporating several topics: the nature of the post collapse exchange rate regime, uncertainty regarding the monetary policy rule and the critical level of reserves that triggers the regime switch, real effects of anticipated crises, external borrowing and capital controls, imperfect asset substitutability, sticky prices and endogenous policy switches to avoid the collapse.

The structure of these models implies that the only possible equilibrium is that of devaluation. A second class of model, which began with Flood and Garber(1984b) and Obstfeld(1986), allows for multiple equilibria in the foreign exchange market. Many of these models are called "models of self-fulfilling speculative attacks"[8], because the speculators' views, rather than the incompatibility of the policy stance, *causes* the currency devaluation even within an ex-ante viable and sustainable fixed exchange rate regime. Another important difference between these two classes of model is that the second class incorporates explicitly the optimizing behavior of the policymaker.

The **credibility** of a fixed exchange rate regime in the absence of a binding commitment technology has been extensively analyzed in the literature using a game theoretic framework[9]. In general, the policymaker may decide to switch from a fixed exchange rate regime to a flexible one and so reneging on his promises, if the benefits of doing so offset the costs. Hence, the policymaker's political incentives and constraints rather than the loss of foreign exchange reserves *cause* the switch from one exchange rate regime to another. The paradigm here is the monetary policy game in a closed economy developed by Kydland and Prescott(1977), Barro and Gordon(1983) and Barro(1986), adapted to the open economy[10]. In these exchange rate policy games, the more effectively the policymaker signals his toughness (even if weak), the more he enhances his reputation and the credibility of the announced policy.

[7] See references indicated in the surveys cited above; and Flood et al.(1995), Lewis(1995), Obstfeld(1995), Frankel and Rose(1996).
[8] See Ozkan and Sutherland(1994a,b), Obstfeld(1994, 1995), Bensaid and Jeanne(1995), Jeanne(1995), Krugman(1996).
[9] See Tronzano(1996) for a recent survey.
[10] See Horn and Persson(1988) and Obstfeld(1991b) for early examples and Tronzano(1996), for more recent examples.

In the model that follows we attempt to address some of these issues. In particular, we analyze the role played by the fiscal expenditure in nontradables and the level and currency composition of public debt within an orthodox currency board regime. Also, expectations of a regime switch are built into the game setup and thus influence the policymaker's and the private sector's decisions. **In this first model, however, there is no learning process by the private sector.**

3- An exchange rate based inflation stabilization policy game with a currency board

3.1- The game and macroeconomic model structure

As in other public finance models[13], the government has to deal with a two-fold problem. On the one hand, the government is pressured by the need to supply public goods and social transfers to consumers and by the demand for subsidies from lobbying interest groups, which they are unable to finance by regular taxation[14]. On the other hand, finance by borrowing, cannot increase unboundly without provoking an adverse reaction in the capital markets, or exceed an upper limit enforced by a multilateral commitment such as the Maastricht Treaty for European countries or the IMF's adjustment program goals, for developing countries. The policymaker's objectives therefore turn on the domestic inflation rate and the gap between the actual and a "desired" level of fiscal expenditure.

We consider a small open economy producing both tradable and nontradable goods in which monetary and fiscal policy is located within a single policymaker[15]. His instruments are the exchange rate[16], the level of fiscal expenditure in nontradables and the domestic currency public debt stock. In each period of the game, he must decide not just whether to devalue or not, but also how much to spend on nontradables and how much to borrow in domestic currency.

The policymaker then sets his instruments to minimize a loss function[17] L_G (assumed to be convex and differentiable):

[13] See Heymann and Sanguinetti(1994), Mondino et al.(1996), among others.
[14] In our model, we consider both the "desired" fiscal expenditure and the regular taxation capacity as exogenous. However, they are the result of a political game that is not analyzed here.
15 This implies that the common problems of fiscal and monetary policy coordination are ruled out. However, the consistency issues remain.
[16] Defined as units of domestic currency required to purchase one unit of foreign currency.
[17] This is almost similar to that used by Heymann and Sanguinetti(1994), but includes uncertainty about the policymaker's preferences.

$$\underset{\{\pi_t, g_t^N, b_t\}_{t=1}^2}{Min} \; L_G = \delta^{t-1} \mathrm{E} \left\{ \tfrac{1}{2} \sum_{t=1}^{2} \left[\hat{p}_t^2 + \alpha (g_t^N - \bar{g})^2 \right] + c_t \right\} \qquad (3.1)$$

subject to,

$$g_t^N + (1 + r_t)(1 + \hat{p}_t^e - \hat{p}_t) b_{t-1} + e_t \left[g^* + (1 + i_t^*) \bar{b}_{t-1}^* \right] - (\bar{t} + u_t) = b_t + e_t b_t^* \leq \bar{b}_t + e_t \bar{b}_t^* \qquad (3.2)$$

where,

$$e_t = e_{t-1} + \pi_t - \hat{p}_t \qquad e_0 = \bar{e}_0 \qquad \hat{p}_t^* = 0 \qquad \forall t \qquad (3.3)$$

$$r_t \cong i_t - \hat{p}_t^e = i_t^* + \tau_t \qquad (3.4)$$

$$\hat{p}_t = \lambda \pi_t + (1 - \lambda) \hat{p}_t^N \qquad 0 < \lambda < 1 \qquad (3.5)$$

$$\hat{p}_t^e = E \hat{p}_t = \pi_t^e = \hat{p}_t^N \qquad (3.6)$$

where: $\hat{p}$: domestic inflation rate, g^N: real fiscal expenditure in nontradables, $\bar{g}$: "desired" fiscal expenditure in nontradables, π: actual devaluation rate, b: domestic currency public debt stock at the end of period, δ: policymaker's discount factor ($0 < \delta < 1$), c_t: escape clause cost ($c_t > 0$ if devaluation occurs, $c_t = 0$, otherwise; and $c_1 < c_2$), r: real domestic interest rate, $\hat{p}^e$: expected domestic inflation rate, e: real exchange rate, g*: real fiscal expenditure in tradables, i*: international interest rate, b*: foreign currency public debt stock, $\bar{t}$: constant real tax revenue, u: tax revenue shock (assumed to be uniformly distributed : $u_t \sim \mathrm{iid}[-\bar{u}, \bar{u}]$, $E(u_t) = 0$, $\sigma_u^2 = \frac{\bar{u}^2}{3}$), $\bar{b}$: domestic currency public debt limit, $\bar{b}^*$: foreign currency public debt limit, i: nominal domestic interest rate, τ: financial risk premium, π^e: expected devaluation rate, $\hat{p}_t^N$: nontradables' price variation. Finally, α is a preference parameter of the policymaker that trades off the benefit from accommodating fiscal pressures through devaluation with the cost of a non zero inflation rate. **All parameters are assumed to be common knowledge.**

In particular, a surprise devaluation may cause an unexpected reduction in the value of interest bearing, non-indexed, domestic currency public bonds. Governed by the objectives of the policymaker, this "devaluation revenue" could be directed towards financing a larger fiscal expenditure in nontradables given some target level $\bar{g}$, rather than towards reducing the public debt stock.

To evaluate the cost associated with using devaluation we simply assume that the policymaker faces a fixed escape clause cost $c_t > 0$ whenever he devalues[18] during the stabilization plan. This cost is not necessarily proportional to the devaluation size nor any other macroeconomic variable but can be associated with voter disapproval (when price stability is a central issue in the electoral process[19]) or even removal from office. For this reason, we will consider this cost as increasing in time ($c_1 < c_2$), given that the policies implemented during the stabilization plan influence the chances of the incumbent government of winning the elections taking place at the end of the second period.

The setup is a two-period stochastic game, in which the foreign currency public debt stock is the state variable that links payoffs in both periods and influences devaluation expectations. We do not attempt to explicitly model the forces driving a speculative attack, which we believe have microeconomic stimuli relating to the speculative incentives in the financial markets. Instead, we simulate its effect through an adverse tax revenue shock, because it affects the government's intertemporal budget constraint in an essentially equivalent manner. This shock will be more damaging the higher is the inherited public debt stock. Then, as repudiation is explicitly excluded as a possible means of reducing the outstanding public debt, it becomes crucial that tax revenue shocks and policies have persistent effects on public debt accumulation in the model that extend to future periods, constraining the policies to be implemented in these periods.

To solve the game we will work on the following reduced form equations:

$$\hat{p}_t = \pi_t^e + \lambda(\pi_t - \pi_t^e) \quad (3.7)$$

$$g_t^N + D_t - u_t - b_t - B_t^d(\pi_t - \pi_t^e) = e_t b_t^* \leq 0 \quad (3.8)$$

where, $b_t \leq \bar{b}_t$ (3.9)

$$e_t = e_{t-1} + (1-\lambda)(\pi_t - \pi_t^e) \quad (3.10)$$

$$D_t = (1+r_t)b_{t-1} + e_{t-1}(G_t^* - \bar{b}_t^*) - \bar{t} \quad (3.11)$$

$$G_t^* = g^* + (1+i_t^*)b_{t-1}^* \quad (3.12)$$

$$B_t^d = (1+r_t)\lambda b_{t-1} - (1-\lambda)(G_t^* - \bar{b}_t^*) \quad (3.13)$$

[18] Following Obstfeld (1991b), Cukierman, Kiguel and Liviatan(1992), Cukierman, Kiguel and Leiderman (1994), and Ozkan and Sutherland (1994a,b, 1995) among others.

$$\bar{g} > \bar{b}_t - D_t + u_t + B_t^d\left(\pi_t - \pi_t^e\right) \tag{3.14}$$

Equation (3.7) is the domestic inflation rate[20], determined by the price variation in tradable and nontradable goods. The price variation in tradable goods depends on the evolution of the exchange rate (assuming no variation in their international prices). Producers in the nontradable sector set their prices so as to protect their position relative to the tradable sector and to respond to wage variation within their own sector. Both wages and prices of nontradables are then driven by expected changes in the exchange rate. The real exchange rate is defined in (3.10).

Equation (3.8) is the intertemporal fiscal budget constraint. The term D_t (3.11) is the total amount of net fiscal liabilities, determined by the previous periods' decisions on expenditures and debt financing in both currencies and by the constant component of tax revenue in period t. The term G_t^* (3.12) measures all the expenditure and debt components in foreign currency. **Public debt in both currencies has the same maturity structure, which is here assumed to be of one period**. The term B_t^d (3.13) is the base of the "devaluation tax". Hence, the revenue from surprise devaluation will be determined by the net difference[21] of two components. One is the unexpected reduction in the value of interest bearing, non-indexed, domestic currency public bonds. The other component is the extra cost incurred in purchases of tradables and interest services on foreign currency public debt. Finally, to preclude the trivial solution $\left(\pi_t = 0, g_t^N = \bar{g}\right)$, the "desired" fiscal expenditure will be assumed to be large enough that the condition (3.14) will be fulfilled in every period.

The timing of the inflation stabilization plan is as follows (Fig. 3.1). **First**, the government enacts a Convertibility Law with two precommitments: 1) the complete internal convertibility of the domestic currency as through an orthodox currency board and 2) the obligation of the currency authority to keep a foreign reserve backing, at every period, equivalent to at least 100 percent of the domestic base money stock (in order to guarantee the convertibility of the domestic currency). **Second**, both the policymaker and the private sector observe period t-1 public debt stock in both currencies. **Third**, the private sector sets its devaluation expectations on the basis of the observed debt stocks and period t-1 exchange rate policy. **Fourth**, the tax revenue shock is realized during period t and is

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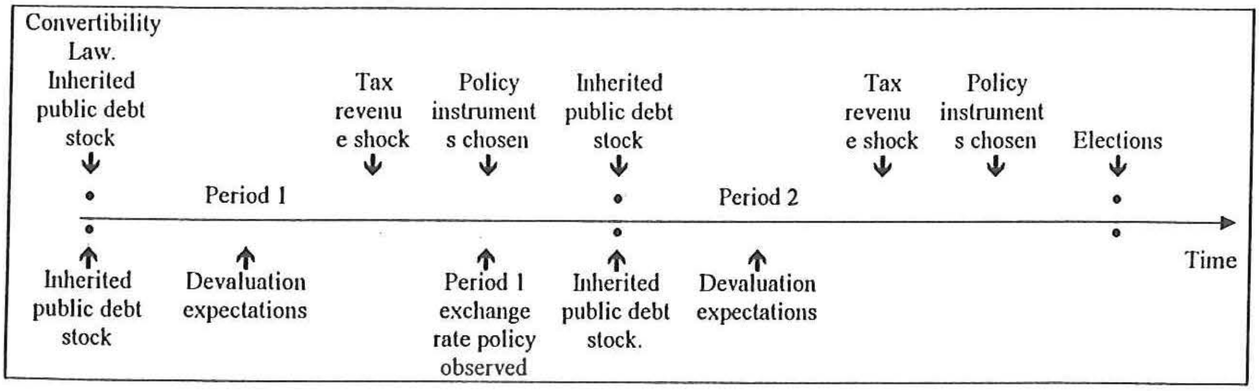
[19] See Milesi-Ferretti(1995).
[20] This formulation also appears in Agénor(1994).
[21] If the net difference is positive (negative), devaluation (pegging) may be the optimal policy.

observed only by the policymaker[22]. **Fifth**, the policymaker sets its policy instruments on the basis of all observed variables and given the private sector's devaluation expectations. **Sixth**, elections take place at the end of period 2.

POLICYMAKER



PRIVATE SECTOR

Figure 3.1- Timing of the inflation stabilization plan

3.2- Second period Nash solution

At the beginning of the second period, the policymaker inherits a debt stock in both currencies from the first period and has to decide whether to devalue or not, how much to spend on nontradables and how much to borrow in domestic currency in order to minimize (3.1) subject to (3.8), the realized tax revenue and the private sector's rational expectations of devaluation (which have been already set).

Let $L_{2,d}^{c}$ be the loss from devaluing and $L_{2,f}^{c}$ the loss from continuing with the fixed exchange rate regime, with the superscript c indicating that the loss is conditional on the realization of the tax revenue shock. Devaluation in period 2 will be optimal when the tax revenue shock is low enough that the costs of maintaining the fixed exchange rate exceed those of incurring higher inflation. Therefore, the policymaker will devalue when $L_{2,d}^{c} < L_{2,f}^{c}$ and the optimal values for the policy instruments will be:

[22] This information advantage can be reasonably justified by the fact that data on tax revenues are always available first to the policymaker.

$$\pi_2 = \frac{\alpha B_2^d\left(\bar{g} + D_2 - u_2 - \bar{b}_2\right) + \left(x_2 - \lambda\right)\pi_2^e}{x_2} \tag{3.15}$$

$$g_2^d = \bar{g} - \frac{\lambda\left[\lambda\left(\bar{g} + D_2 - u_2 - \bar{b}_2\right) + B_2^d \pi_2^e\right]}{x_2} \tag{3.16}$$

$$b_2^d = \bar{b}_2 \tag{3.17}$$

where, $x_2 = \lambda^2 + \alpha B_2^{d2}$, and the superscript d refers to devaluation.

By using (3.15), (3.16) and (3.17) we obtain the conditional loss for the policymaker in this **discretionary devaluation equilibrium**:

$$L_{2,d}^c = \frac{\alpha\left[\lambda\left(\bar{g} + D_2 - u_2 - \bar{b}_2\right) + B_2^d \pi_2^e\right]^2}{2x_2} + c_2 \tag{3.18}$$

When $L_{2,d}^c > L_{2,f}^c$, the policymaker will not devalue in period 2 and so the optimal fiscal expenditure changes to,

$$g_2^f = \bar{b}_2 - D_2 + u_2 - B_2^d \pi_2^e \tag{3.19}$$

$$b_2^f = \bar{b}_2 \tag{3.20}$$

where the superscript f refers to fixed exchange rate.

Now, the associated conditional loss in the **non-devaluation equilibrium** becomes

$$L_{2,f}^c = \frac{1}{2}\left[(1 - \lambda)^2 \pi_2^{e2} + \alpha\left(\bar{g} + D_2 - u_2 - \bar{b}_2 + B_2^d \pi_2^e\right)^2\right] \tag{3.21}$$

We now consider the mechanism for devaluation expectations formation and evolution: they depend on two elements:

1) The exchange rate policy implemented in the previous period (devaluation or pegging), which can be considered as a reputational factor.

2) The probability of devaluation, given the policymaker's preferences, which is defined as the probability that the tax revenue shock be lower than a threshold level obtained from the following "temptation" condition:

$$u_2 < \bar{g} + D_2 - \bar{b}_2 + \frac{(x_2 - \lambda)\pi_2^e - (2x_2c_2)^{1/2}}{\alpha B_2^d} \qquad (3.22)$$

According to this condition, **the policymaker will devalue in equilibrium whenever an adverse tax revenue shock is combined with: large fiscal expenditure demands; large inherited debt stocks; high domestic and international interest rates; high devaluation expectations; and low domestic and foreign currency debt limits as well as a relatively low escape clause cost. The influence of the inherited real exchange rate will depend on the difference between G_2^* and $\bar{b}_2^*$. Notice that also the base of the devaluation "tax" (B_2^d) plays a key role in determining the incentives to devalue: in the extreme case of complete debt dollarization there will be not at all incentives to devalue.**

From the "temptation" condition (3.22), we can immediately determine the threshold level of the tax revenue shock ($\tilde{u}_2$) at which, for given $\bar{g}, r_2, b_1, e_1, G_2^*, \bar{t}, \bar{b}_2, \pi_2^e, \alpha$ and c_2, the policymaker will be indifferent between devaluing or continuing with the fixed exchange rate regime:

$$\tilde{u}_2 = z_2 + \frac{(x_2 - \lambda)\pi_2^e - (2x_2c_2)^{1/2}}{\alpha B_2^d} \qquad (3.23)$$

where, $z_2 = \bar{g} + D_2 - \bar{b}_2$.

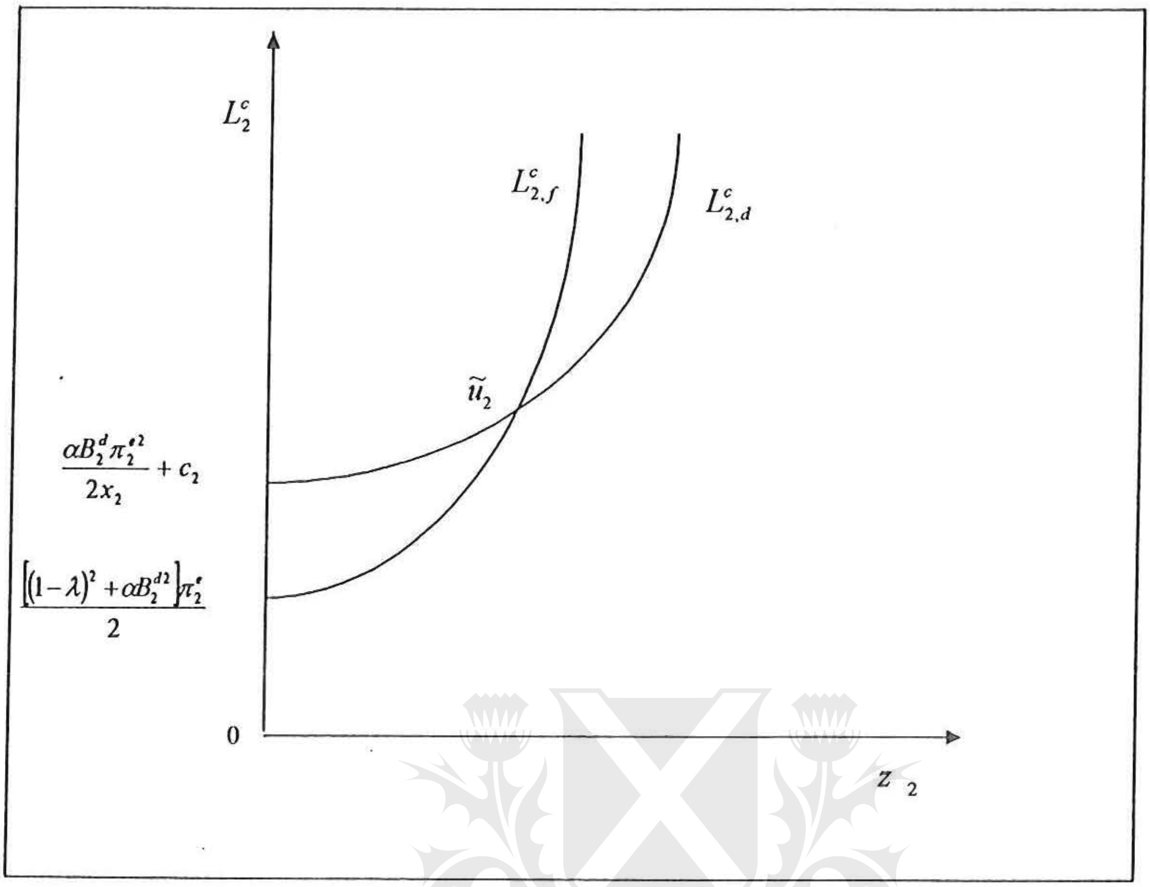


Figure 3.2- Policymaker's second period losses

It is relevant to notice in (3.23) the simultaneous dependence between $\tilde{u}_2$ and π_2^e for given z_2 and c_2: the higher the devaluation expectations, the higher the tax revenue threshold must be to keep the policymaker indifferent between devaluation and maintaining the fixed exchange rate regime; and the higher the threshold, the more likely the policymaker will be to devalue and hence devaluation expectations increase.

Figure 3.3 shows the relationship between $\tilde{u}_2$ and π_2^e for two alternative levels of c_2. There is a critical value of π_2^e for which the threshold reaches the top value of the tax revenue shock range. At this point, devaluation becomes an event with probability one.

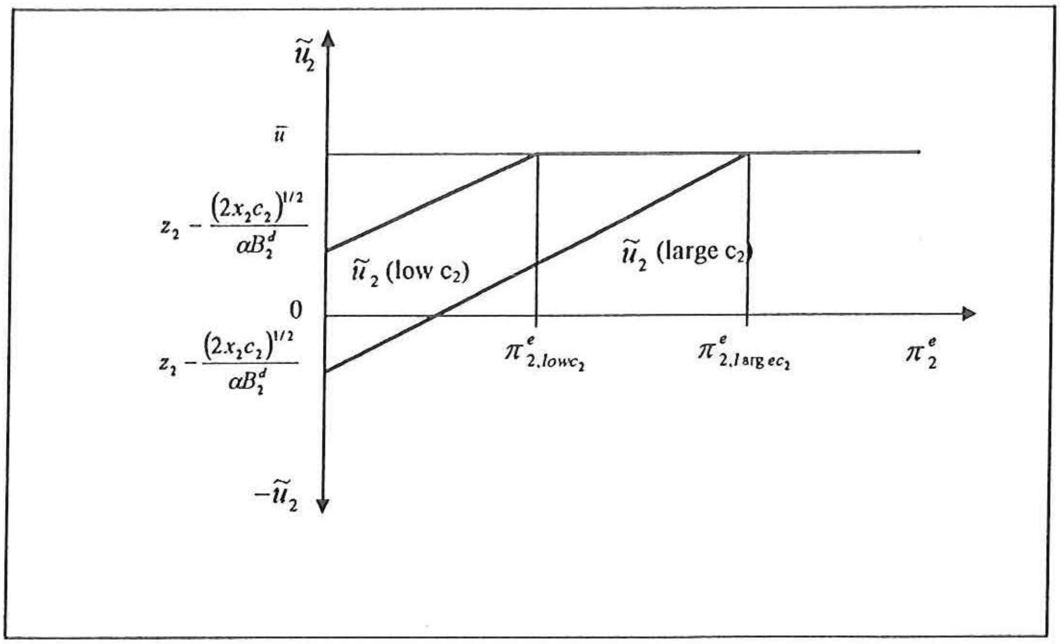


Figure 3.3- Threshold and devaluation expectations relationship

Now, the rational devaluation expectation ($E\pi_2$) for given private sector's devaluation expectations (π_2^e) is defined as the product of the probability of devaluation and the conditional expectation $E[\pi_2 / u_2 < \tilde{u}_2]$. So,

$$E\pi_2 = E[\pi_2 / u_2 < \tilde{u}_2] \Pr ob(u_2 < \tilde{u}_2) \quad (3.24)$$

where,

$$E[\pi_2 / u_2 < \tilde{u}_2] = \frac{\alpha B_2^d z_2 + (x_2 - \lambda)\pi_2^e}{x_2} \quad (3.25)$$

Given that the tax revenue shock is assumed to be uniformly distributed in the interval $[-\bar{u}, \bar{u}]$, the probability of devaluation is estimated as,

$$q_2 = \text{Prob } [u_2 < \tilde{u}_2] = \frac{\tilde{u}_2 + \bar{u}}{2\bar{u}} \quad (3.26)$$

where, $0 \leq q_2 \leq 1$.

By replacing (3.23) in (3.26), we determine the value of q_2 for given π_2^e,

$$q_2 = \frac{\alpha B_2^d (z_2 + \bar{u}) + (x_2 - \lambda)\pi_2^e - (2x_2 c_2)^{1/2}}{2\alpha B_2^d \bar{u}} \tag{3.27}$$

Then, inserting (3.25) and (3.27) in (3.24), we obtain the expression for the private sector's rational devaluation expectation,

$$E\pi_2 = \frac{\left[(x_2 - \lambda)\pi_2^e\right]^2 + (x_2 - \lambda)(\alpha B_2^d z_2 + \bar{B})\pi_2^e + \alpha B_2^d z_2 \bar{B}}{2\alpha B_2^d \bar{u} x_2} \tag{3.28}$$

where, $\bar{B} = \alpha B_2^d (z_2 + \bar{u}) - (2x_2 c_2)^{1/2}$. (3.29)

In full equilibrium, $E\pi_2 = \pi_2^e$, then we can derive the two solutions for π_2^e and graph them in Fig. 3.4.

$$\pi_2^e = \frac{-H_2 + 2\alpha B_2^d \bar{u} x_2 \pm \left[(x_2 - \lambda)^2 (\alpha B_2^d z_2 - \bar{B})^2 + (2\alpha B_2^d \bar{u} x_2)^2 - 4H_2 \alpha B_2^d \bar{u} x_2\right]^{1/2}}{2(x_2 - \lambda)^2} \tag{3.30}$$

where, $H_2 = (x_2 - \lambda)(\alpha B_2^d z_2 + \bar{B})$. (3.31)

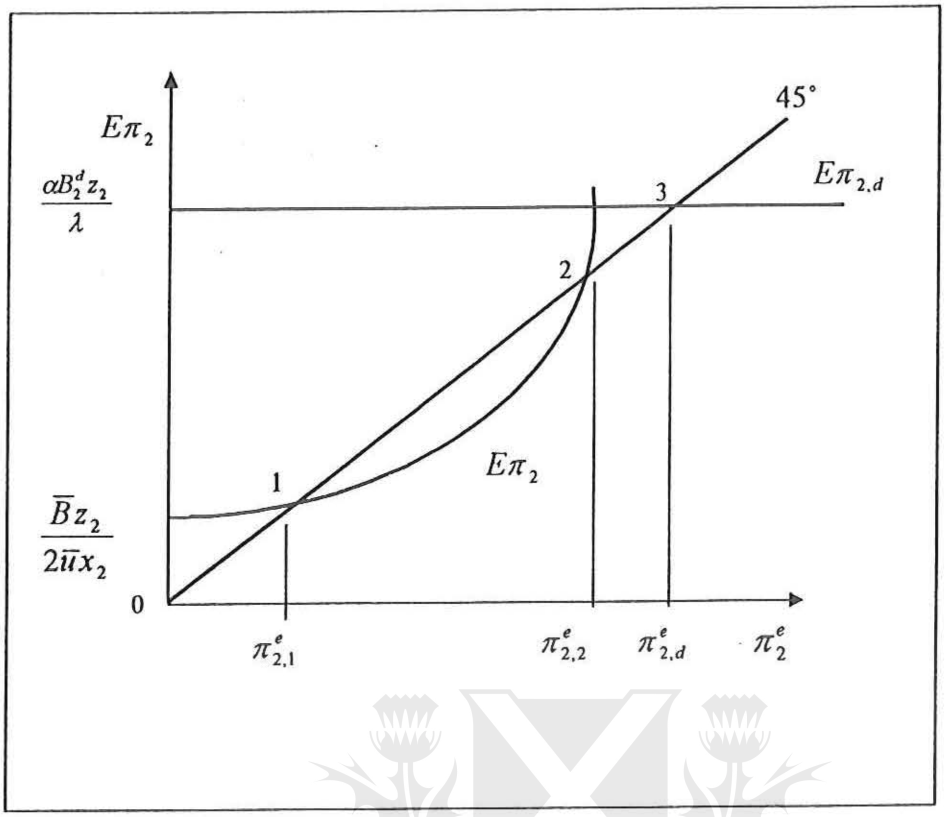


Figure 3.4- Second period devaluation equilibria

Figure 3.4 shows that **there can be two equilibrium devaluation expectations (1 and 2), corresponding to two different probabilities and sizes of devaluation. The pure discretionary devaluation equilibrium (3) corresponds to a probability q_2 equals to one, because $\tilde{u}_2 = \bar{u}$. Also, the "fundamentals" affect the multiplicity of equilibria by shifting the vertical intercept of $E\pi_2$.**

Finally, we can obtain the policymaker's expected loss for the second period under devaluation and under pegging.

$$EL_{2,d} = \frac{\alpha}{2x_2}\left[\left(\lambda z_2 + B_2^d \pi_2^e\right)^2 + \lambda^2 \sigma_u^2\right] + c_2 \tag{3.32}$$

$$EL_{2,f} = \frac{1}{2}\left[(1-\lambda)^2 \pi_2^{e2} + \alpha\left(z_2 + B_2^d \pi_2^e\right)^2 + \sigma_u^2\right] \tag{3.33}$$

3.3- First period Stackelberg solution

To obtain the first period Stackelberg solution, we have to consider the effects of this period's policies on second period devaluation expectations and on the state variables. Such effects come through two variables: D_2 and B_2^d, which depend on π_1, g_1, b_1, b_1^*.

In order to derive a closed form of the optimal values for the policy instruments, we will assume that **in the first period the public debt limit in both currencies is binding**. This assumption may be justified by the low credibility that governments usually face when implementing a new stabilization plan after many previous failed attempts. This low credibility is reflected then on the lack of confidence of internal and external lenders, who constrain the amount of financing available to the government. In our model, the main consequence of this simplifying assumption will be to limit the effects' transmission channels, given that only π_1 will affect second period devaluation expectations, instead of all the policy instruments. Then, we have,

$$b_1 = \bar{b}_1 \tag{3.34}$$

$$b_1^* = \bar{b}_1^* \tag{3.35}$$

$$B_2^d = \bar{B}_2^d = (1+r_2)\lambda\bar{b}_1 - (1-\lambda)(\bar{G}_2^* - \bar{b}_2^*) \tag{3.36}$$

where, $\bar{G}_2^* = g^* + (1+i_2^*)\bar{b}_1^*$.

The policymaker has to minimize the following two-period loss function subject to the public debt limits, the realized tax revenue and the private sector's rational expectations of devaluation (which have been already set).

$$L_1 = \tfrac{1}{2}\left[\pi_1^2 + \alpha(g_1^d - g)^2\right] + c_1 + \delta\left[q_2 EL_{2,d} + (1-q_2)EL_{2,f}\right]/\pi_1 > 0 \tag{3.37}$$

where, $EL_{2,d}$ and $EL_{2,f}$ are given by (3.32) and (3.33).

Devaluation in the first period will be optimal if $L_{1,d}^{c} < L_{1,f}^{c}$ and the optimal values for the policy instruments will be:

$$\pi_1 = \frac{-(x_1 + GB\varphi') \pm \left\{(x_1 + GB\varphi')^2 + 4GB\varphi\left[(x_1 - \lambda)\pi_1^e + \alpha B_1^d\left(\bar{g} + D_1 - \bar{b}_1 - u_1\right) - GB\varphi''\right]\right\}^{1/2}}{2GB\varphi} \quad (3.38)$$

$$g_1^d = \bar{b}_1 - D_1 + u_1 + B_1^d\left(\pi_1 - \pi_1^e\right) \quad (3.39)$$

$$b_1^d = \bar{b}_1 \quad (3.40)$$

where, $GB = (1-\lambda)\left(\bar{G}_2^* - \bar{b}_2^*\right)$,

$x_1 = \lambda^2 + \alpha B_1^{d2}$, and φ, φ', and φ'' are very complex parameters that are not explicitly derived here.

When $L_{1,d}^{c} > L_{1,f}^{c}$, the policymaker will not devalue in period 1 and so the optimal fiscal expenditure changes to,

$$g_1^f = \bar{b}_1 - D_1 + u_1 - B_1^d\pi_1^e \quad (3.41)$$

$$b_1^f = \bar{b}_1 \quad (3.42)$$

The main issue in deriving the first period Stackelberg solution is computing the impact of devaluation on the expected losses of the second period both under devaluation and under pegging. This impact is captured by a complex expression that includes as one of its main factors to:

$$\delta(1-\lambda)\left(\bar{G}_2^* - \bar{b}_2^*\right) \quad (3.43)$$

Then, the impact of a first period devaluation on the expected losses of the second period will depend on the sign of the gap $\left(\bar{G}_2^* - \bar{b}_2^*\right)$ where, $\bar{G}_2^*$ is the maximum value of the inherited expenditure and debt components in foreign currency, and $\bar{b}_2^*$ is the foreign currency limit either imposed by lenders or multilateral arrangements (e.g. IMF, Maastricht Treaty). In particular, the reaction of the international capital markets in determining $\bar{b}_2^*$ becomes crucial for evaluating the consequences of a first period devaluation within an exchange rate based inflation stabilization plan with an orthodox currency board.

4- Interpretation of results and policy implications

We summarize and fully describe the second period equilibria by considering only the case when $\tilde{u}_2 / \pi_1 > 0 > \tilde{u}_2 / \pi_1 = 0$. This case[23] can be interpreted as a situation in which devaluation in the first period increases second period devaluation expectations and so the tax revenue threshold.

	$u_2 > \tilde{u}_2 / \pi_1 > 0$	$\tilde{u}_2 / \pi_1 = 0 < u_2 < \tilde{u}_2 / \pi_1 > 0$	$u_2 < \tilde{u}_2 / \pi_1 = 0$
1) $\pi_1 > 0$ (3.30)	Pegging $\pi_2 = 0$, (3.19), (3.20)	Devaluation (3.15), (3.16), (3.17)	Devaluation (3.15), (3.16), (3.17)
2) $\pi_1 = 0$ (3.30)	Pegging $\pi_2 = 0$, (3.19), (3.20)	Pegging $\pi_2 = 0$, (3.19), (3.20)	Devaluation (3.15), (3.16), (3.17)

This table show us that second period equilibria depend crucially on what has happened in the first period (devaluation or pegging) and on the realization of the tax revenue shock. In particular, when the size of the tax revenue shock is between the two thresholds ($\tilde{u}_2 / \pi_1 = 0 < u_2 < \tilde{u}_2 / \pi_1 > 0$), it is alone the exchange rate policy implemented in the first period that counts for determining whether the fixed exchange rate equilibrium or a devaluation equilibrium holds.

On the other hand, when the size of the tax revenue shock is outside the range between the two thresholds, either a devaluation equilibrium (when $u_2 < \tilde{u}_2 / \pi_1 = 0$) or the fixed exchange rate equilibrium (when $u_2 > \tilde{u}_2 / \pi_1 > 0$) will hold whatever the first period exchange rate policy implemented. This result is somewhat different to that obtained by Velasco(1996a). In his model, a first period devaluation is always followed by a second period devaluation, because it unambiguously reduces the public debt stock left behind. In our model, however, the public debt stock in both currencies is the same under devaluation or pegging, because the surprise devaluation revenues are fully directed towards financing larger fiscal expenditure in nontradables rather than to reduce the public debt stock.

Regarding the losses associated with devaluation and pegging ((3.18) and (3.21)), we can observe that:

1) $L^c_{2,d}$ and $L^c_{2,f}$ are increasing in the "desired" fiscal expenditure, the inherited debt stocks in both currencies, the domestic and international interest rates, and devaluation expectations; but decreasing in the domestic and foreign currency debt limits.

2) **Discretion would be better than following the rule of a fixed exchange rate in period 2 if the escape clause cost were zero.** This is due to the "benefit" of the discretionary devaluation, that allows the policymaker to increase the fiscal expenditure in nontradables such that $g^f_2 < g^d_2 < \bar{g}$. In fact, as $g^d_2 - g^f_2 = B^d_2 \pi_2$, the larger the discretionary devaluation, the higher will be the difference between the levels of fiscal expenditure in nontradables under the two regimes.

Given the policymaker's preferences, the effects of the fiscal expenditure demands, the inherited debt stocks, the domestic and international interest rates and the domestic and foreign currency public debt limits on devaluation expectations are not straightforward. For this reason, we can conclude that as the net effect of a first period devaluation is ambiguous, second period devaluation expectations may be higher or lower depending upon the particular values assumed by the model's parameters. This ambiguity also appears in Drazen and Masson(1994) and Velasco(1996a).

In this game structure, the policymaker has incentives to devalue in order to reduce the gap between the actual and the "desired" fiscal expenditure level. Besides the escape clause cost, a surprise devaluation increases the real exchange rate and so the costs on purchases of tradables and the following period's interest services on foreign currency public debt. This cost-benefit trade-off may explain why those governments which are highly indebted and tied by commitments such as a currency board and/or fixed exchange rate regime, may usually "face" a real exchange rate appreciation. In the context of these regimes, real exchange rate appreciation may be interpreted not

[23] The other case with the opposite inequality is also possible for certain set of parameters.

only as a toughness signal[24], but also as a "sophisticated" device that reduces the burden of fiscal expenditure in foreign currency and so allows the government to spend more in nontradables when fiscal pressures continue to bear.

Regarding the management of the public debt's currency composition, two alternative interpretations may be drawn. The "optimistic" one would say that, given the confidence of investors on the sustainability of the convertibility program and the fixed exchange rate regime, domestic currency public bonds will be accepted by them with a reasonable financial risk premium. In this case, the government's ability to issue debt in domestic currency also constitutes a good signal to investors.

The "pessimistic" interpretation would say that when the government becomes unable to sell its domestic currency bonds, even with a high financial risk premium, it is because investors are anticipating that the policymaker is "preparing the field" for a future devaluation, by trying to increase the base of the devaluation "tax". In contrast to the "optimistic" case, now the government's inability to issue domestic currency debt is a bad signal to investors.

In fact, this "pessimistic" interpretation may be applied to the management of the public debt's currency composition just before the Mexican "tequila" crisis in December 1994[25]. Since the beginning of the second quarter of 1994, the Mexican economic authorities were engaged in substituting short-term foreign currency bonds (Tesobonos) for domestic currency ones (Cetes). As a result of these swap operations, the stock of Tesobonos increased from 14.0 billion pesos in March 1994 to 85.2 billion pesos in November 1994. In this latter month, the share of Tesobonos as a proportion of the privately-held stock of Cetes and Tesobonos reached 80 percent.

We can conclude then, that the policymaker's reputation and a durable tight fiscal policy are both necessary to maintain and enhance the private sector's view of the sustainability and credibility of an orthodox currency board regime. Such a tight fiscal policy will imply that the fiscal expenditure demands for public goods and social transfers and demands for subsidies by lobbying interest groups should be strictly controlled and the tax system be strengthened.

[24] See Winckler(1991).
[25] See Calvo and Mendoza(1996), Masson and Agénor(1996), and Sachs et al.(1996a,b) for more details.

Also, the policymaker should make explicit his compromise of not exceeding an specific public debt limit and choose the appropriate maturity structure and currency composition of public debt in order to generate more confidence on the sustainability of the convertibility program and the fixed exchange rate regime. As affirmed by Giavazzi and Pagano(1990): "...it is not only the level of public debt that matters for the viability of fixed rates, but also the way one manages this debt. In a high-debt country, the viability of a fixed exchange rate regime can be enhanced by lengthening the average maturity of debt, spreading maturing issues as uniformly as possible and developing a market for public debt denominated in foreign currency...These debt management policies are all the more needed the larger the size of public debt outstanding and the smaller the foreign exchange reserves owned by the Central Bank" (pag. 127-8).

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