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INTEREST RATE RULES, INFLATION STABILIZATION, AND IMPERFECT CREDIBILITY: THE SMALL OPEN ECONOMY CASE

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Interest Rate Rules, Inflation Stabilization, and Imperfect Credibility: The Small Open Economy Case
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ABSTRACT

The paper examines the robustness of Interest Rate Rules, IRRs, in the context of an imperfectly credible stabilization program, closely following the format of much of the literature in open-economy models, e.g., Calvo and Végh (1993 and 1999). A basic result is that IRRs, like Exchange Rate Based Stabilization, ERBS, programs, could give rise to macroeconomic distortion, e.g., underutilization of capacity and real exchange rate misalignment. However, while under imperfect credibility EBRS is associated with overheating and current account deficits, IRRs give rise to somewhat opposite results. Moreover, the paper shows that popular policies to counteract misalignment, like Strategic Foreign Exchange Market Intervention or Controls on International Capital Mobility may not be effective or could even become counterproductive. The bottom line is that the greater exchange rate flexibility granted by IRRs is by far not a sure shot against the macroeconomic costs infringed by imperfect credibility.

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I. Introduction

Recent financial crises in developing economies have made painfully evident that these economies are highly vulnerable to external shocks and to domestic political instability. The combination of these factors makes life very hard for the policymaker since the effectiveness of economic policies relies very heavily on *credibility* of policy announcements. This applies with special emphasis to monetary policy. Controlling inflation without causing unwanted costs, e.g., unemployment, real exchange rate misalignment, depends very much on the ability of the central bank to convince the public that the intended monetary policy will be sustainable over time—in other words, to make it credible. This topic has received a great deal of attention in the literature, especially in the context of Exchange-Rate-Based-Stabilization programs (see, e.g., Calvo and Végh (1999)), partly because employing the exchange rate as a nominal anchor used to be a common feature of monetary policy in developing countries. However, the spate of financial crises in the 1990s gave rise to the conjecture that pegging the exchange rate contributed to the high cost of those crises. As a result, key multilateral institutions started a vigorous campaign against fixed exchange rates, and in favor of greater exchange rate flexibility.

Some countries heeded the advice and others did not, but those who did tended to adopt some kind of Inflation Targeting employing a central bank interest rate as the chief instrument, at least during tranquil times. This system, incidentally, does not qualify as one of Floating Exchange Rates according to the standard textbook definition, since the latter corresponds to the case in which the central bank sets a monetary aggregate, e.g., the monetary base, not some reference nominal interest rate. When interest rates are employed to conduct monetary policy, money supply becomes an endogenous variable (as is also the case under pegged exchange rates). However, the literature on IRRs is still missing the basic spadework that has been the focus of the literature on pegged exchange rates under imperfect credibility (see Calvo and Végh (1999)).[1]

In this paper I try to start filling that gap by extending the analysis of imperfect credibility to IRRs. Imperfect credibility is a central problem in developing countries, partly because they suffer from domestic financial and legal weaknesses that make them vulnerable to political and external shocks. The 1990s, for example, offer a good number of instances in which external shocks cause major financial damage with serious repercussions on real variables like output and employment (see, e.g., Calvo (2005)). In this unstable environment credibility is a scarce commodity, since even the most skillful policymaker runs the risk of being swept away by the strong tide.

For the sake of comparison with exchange rate pegs, I will conduct the analysis in terms of the model in Calvo and Végh (1993). Not surprisingly, like exchange rate pegs the IRRs will be shown not to be impervious to credibility problems. Much more interesting, the resulting misalignments are, in several instances, opposite to those under pegged exchange rates. For example, while under pegged exchange rates an imperfectly credible inflation stabilization program initially leads to overheating and current account deficit, under IRRs it leads to underutilization of capacity and current account surplus (at least towards the end of the temporary stabilization program). Interestingly, however,

[1] This literature helped to unravel some of the puzzles associated with Exchange Rate Stabilization Programs. Rebelo and Végh (1995) questioned the *quantitative* relevance of the Calvo and Végh (1993) approach. However, Buffie and Atolia (2007) claim otherwise by introducing durable goods into the model, a conjecture that was first spelled out in Calvo (1988).

during the first stages of the temporary stabilization experiment both systems lead to real currency appreciation.

I will also examine the impact of some popular policies employed to counteract misalignment, namely, Strategic Foreign Exchange Market Intervention (i.e., intervention in the foreign exchange market to prevent misalignment of some key variable, e.g., the real exchange rate or inflation), and Capital Controls. Both prove to be ineffective or counterproductive.

To prevent misunderstandings, it is worth making it clear from the outset that this paper does not offer a full theory of credibility. The main objective is to analyze the implications of non-fully-credible stabilization programs for the case in which credibility is exogenous to the model and follows a canonical process. The analysis could be applied verbatim to situations in which lack of credibility is rooted in factors that cannot be changed by current policy (like a long history of high inflation). In other situations in which current policy could have an effect on credibility, the analysis offered here is, however, incomplete since it offers only one blade of the scissors. The other blade, involving the feedback from policy to credibility, is left out of the present paper.

Section II presents the basic model and results. Section III discusses policies to cushion the economy from the effects of imperfect credibility. Section IV concludes.

II. Basic Model and Results

1. Basic Model: Permanent Policy

In order to facilitate comparison with the case of predetermined nominal exchange rates, I will closely follow the model discussed in Calvo and Végh (1993). There are two types of goods: tradable and nontradable. The utility function of the representative individual is given by the following expression:

$$\int_0^\infty [u(c_t) + v(c_t^*)]\exp(-\rho t)dt, \tag{1}$$

where t denotes time, and c and c^* stand for consumption of nontradables and tradables, respectively (in what follows "*" will denote tradable goods), while ρ is the (constant and positive) instant subjective rate of discount. Time $t = 0$ should be interpreted as the "present." Utility indexes u and v are strictly increasing, concave and continuously differentiable (static separability greatly simplifies the analysis).

At each point in time the supply of tradables is exogenously given and, for simplicity, it will be assumed constant at level $\bar{y}^*$. Nontradables' output is demand-determined and denoted by y. There exists perfect capital mobility and, to abstract from irrelevant dynamics, the international rate of interest in terms of tradables is assumed equal to the subjective discount rate ρ. Thus, the budget constraint for the representative individual, in terms of tradables, satisfies:[2]

$$\int_0^\infty [y_t / e_t + \bar{y}^* - c_t / e_t - c_t^*]\exp(-\rho t)dt = 0, \tag{2}$$

where e stands for the relative price of tradables in terms of nontradables (i.e., the real exchange rate, assuming that international prices for tradables are constant over time and are normalized to unity). To economize on notation, equation (2) assumes, without loss of generality, that the representative individual's net initial, i.e., $t = 0$, (backward looking) wealth is nil. In addition, the individual is subject to a cash-in-advance constraint:[3]

$$m_t \geq c_t / e_t + c_t^*, \tag{3}$$

where m stands for domestic (non-interest-bearing) money holdings in terms of tradables.

The individual maximizes utility (1) with respect to consumption paths, c and c^*, subject to budget constraint (2) and cash-in-advance constraint (3). It follows that if the nominal interest rate is positive (comprising all the cases studied here), in equilibrium the cash-in-advance constraint will be binding, and the following first-order conditions will hold (I will constrain my attention to interior solutions):

$$u'(c_t) = \frac{\lambda}{e_t}(1 + i_t), \tag{4}$$

$$v'(c_t^*) = \lambda(1 + i_t), \tag{5}$$

where λ is the Lagrange multiplier for budget constraint (2) (hence, λ is a constant over time), and the nominal interest rate i satisfies the uncovered-interest-parity condition, i.e.,

$$i_t = \rho + \varepsilon_t, \tag{6}$$

where ε is the (instantaneous) rate of nominal currency devaluation.[4]

Denoting by π the rate of inflation of nontradables, I assume that staggered prices are set according to Calvo (1983) and, thus,

$$\dot{\pi}_t = b(\bar{y} - y_t), \tag{7}$$

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[2] This budget constraint holds if the central bank rebates seigniorage to the public. For details, see Calvo and Végh (1993).
[3] I assume without loss of generality that the factor of proportionality in the cash-in-advance constraint is 1.
[4] Additional assumptions will ensure that the nominal exchange rate is right-hand differentiable for all t, thus ensuring that expression (6) is well defined for all t.

where $\bar{y}$ is "full employment" output of nontradables, assumed constant over time.

Finally, by definition,

$$\frac{\dot{e}_t}{e_t} = \varepsilon_t - \pi_t. \tag{8}$$

Consider the following Interest Rate Rule, IRR:

$$i_t = \varphi(\pi_t - \Pi) + \Pi + \rho, \tag{9}$$

where Π is a constant (later on Π will be assumed a step function with respect to time); and function φ is continuously differentiable over the real line, $\varphi' > 0$, and $\varphi(0) = 0$.[5] Hence, by equations (6) and (9), we have

$$\varepsilon_t = i_t - \rho = \varphi(\pi_t - \Pi) + \Pi.$$

Therefore, in the present context, an interest rule is equivalent to a rate of devaluation rule. Notice that at steady state $\varepsilon = \pi$ which, by the properties of φ, can happen only if $\varepsilon = \pi = \Pi$; hence, independently of the weights given to tradables and nontradables in the overall inflation index, at steady state the latter will equal Π. Thus, Π could be identified with *target inflation*.

Next I will analyze the dynamic implications of interest rule (9) in conjunction with the previous assumptions. To start off, notice that, by first-order condition (4) and equation (9),

$$c_t = C(x_t(1 + \rho + \Pi + \varphi(\pi_t - \Pi)), \tag{10}$$

where function C is downward-sloping, and

[5] It can easily be checked that most of the analysis in this paper extends to the case in which the relevant inflation index is a weighted average of tradables and nontradables' prices. However, as noted in footnote 8 below, the local uniqueness condition would be different.

$$x_t \equiv \frac{\lambda}{e_t}. \tag{11}$$

Hence, assuming that output in the nontradables sector is demand determined, i.e., $y = c$, we have by (7), (8), (9), (10) and (11), the following system of differential equations that will help to characterize most of the relevant variables along equilibrium paths:

$$\dot{\pi}_t = b[\bar{y} - C(x_t(1 + \rho + \Pi + \varphi(\pi_t - \Pi)))], \tag{12}$$

and

$$\frac{\dot{x}_t}{x_t} = -\frac{\dot{e}_t}{e_t} = \pi_t - \varepsilon_t = \pi_t - \Pi - \varphi(\pi_t - \Pi). \tag{13}$$

Clearly, by (13), at steady state (as anticipated above):

$$\pi = \Pi; \tag{14}$$

moreover, by (12), (14) and the assumption that $\varphi(0) = 0$, we have

$$\bar{y} = C(x(1 + \rho + \Pi)). \tag{15}$$

Thus, steady state output of nontradables is invariant to changes in target inflation Π. Notice that under IRRs the exchange rate is not a predetermined variable, given that under interest rate rules the exchange rate is determined by market forces. As a result, variable x ($= \lambda/e$) is free to jump at $t = 0$ (although x is constrained to be positive). Moreover, by Calvo (1983), initial (forward looking) inflation π_0 is also free to jump at $t = 0$.

Consider now the case in which prior to $t = 0$ the economy was at steady state with $\Pi = \Pi^H > \Pi^L$ (superscripts H and L suggest High and Low, respectively), and that at $t = 0$ it is announced that inflation target falls to Π^L, once and for all. Given that variables x and π are free to react to news, this economy would be able to lock itself into the new steady state equilibrium in one shot. In the new steady state equilibrium $\pi = \Pi^L$.

Moreover, by (15), x would have to rise in order to keep $x(1 + \rho + \Pi)$ constant; and, by (5), since along a steady state i is constant over time, then c^* is constant over time; thus, given budget constrain (2) and that in equilibrium $c_t = y_t$ (for all t), we have $c^* = \bar{y}^*$ for all t, independently of target inflation Π. Moreover, by (7), at steady state $c = \bar{y}$. Hence, dividing (5) by (4), we get at steady state:

$$\frac{v'(\bar{y}^*)}{u'(\bar{y})} = e. \tag{16}$$

This implies that the real exchange rate remains invariant to a once-and-for-all change in the target rate of inflation. Hence, by (4) and (5), since $x = \lambda/e$, the required rise in x to lock the system into the new steady state simply involves an increase in Lagrange multiplier λ. In words, this shows that if inflation target is expected to be constant through time, then the target can be attained instantaneously.[6] However, to establish that this will be an inevitable equilibrium outcome, equilibrium uniqueness will have to established, an issue that I will tackle next. Before that, though, a comparison with a regime of predetermined exchange rates is in order. As shown in Calvo and Végh (1993), if the economy starts at steady state (with constant rate of devaluation ε), then a once-and-for-all decline in ε results in a permanent lower inflation with no cost to capacity utilization, the same as under the IRR discussed above. However, under predetermined exchange rates there are instances in which the economy is out of full-employment equilibrium because under that regime the real exchange rate e is a state variable that can only gradually change over time—contrary to the IRR in which case, as

[6] In what follows, to simplify the exposition, unless it is strictly necessary I will not make reference to Lagrange multiplier λ. As in the present steady state comparative analysis, it will always be true that λ can be chosen so as to ensure that budget constraint (2) holds along an equilibrium path in which $c \equiv y$.

noted, e is not predetermined.[7] This gives a prima facie upper hand to interest rate rules if rapid convergence to full equilibrium is a valuable feature (as in most optimality criteria analyzed in the literature). However, a more balanced verdict depends on other considerations that I will be discussing in what follows.

I will now turn to the equilibrium (local) uniqueness issue. As noted, inflation cannot jump after $t = 0$, but, in principle there is no clear reason why x could not display discontinuity for $t > 0$. This issue will be tackled later. For the time being the analysis will proceed under the assumption that system (12)-(13) is satisfied and that both π_t and x_t are continuous for all $t > 0$.

Since both π_0 and x_0 are determined by equilibrium conditions, the existence of a unique locally convergent path requires that system (12)-(13) be totally unstable around steady state (i.e., for all initial conditions (π_0,x_0) different from steady state, the resulting paths satisfying conditions (12)-(13) do not converge to steady state) . To establish that, I will examine the sign pattern of the Jacobian associated with the linear approximation of system (12)-(13), namely,

$$\begin{pmatrix} + & + \\ \mathrm{sgn}[1-\varphi'(0)] & 0 \end{pmatrix} \tag{17}$$

The trace of the Jacobian is positive, and sign of determinant equals sign of $\varphi'(0)-1$. Thus, the two characteristic roots have positive real parts (ensuring total instability) if

$$\varphi'(0) > 1, \tag{18}$$

which is called the Taylor Principle (see Woodford (2003)). If the inequality in (18) is reversed, system (12)-(13) displays saddle-path stability, implying the existence of a continuum of initial conditions (π_0,x_0) such that the corresponding dynamic trajectories

[7] The Exchange-Rate Based stabilization case will be discussed, albeit briefly, in Section III.

converge to steady state. Thus, disregarding the borderline case $\varphi'(0) = 1$, the Taylor Principle is necessary and sufficient for local uniqueness around the steady state supporting target inflation. Clearly, if the Taylor Principle holds, everything concluded above about permanent inflation targets holds true without further qualifications, except for recalling that this is based on local analysis (and that I still have to show that x is continuous for all $t > 0$).[8]

2. Temporary or Imperfectly Credible Policy

Inflation stabilization programs in developing countries have spawned a large literature to try to explain some puzzling outcomes (see Calvo and Végh (1999)). Most of these programs have relied on employing the exchange rate as a central nominal anchor (and are referred to as Exchange Rate Based Stabilization, EBRS, programs). A salient and puzzling feature of ERBS programs is that during the initial stages of the program there typically is a consumption boom, real currency appreciation and over-utilization of capacity (i.e., "overheating"). These features are opposite to what one would expect from stabilization programs in advanced economies where typically nominal anchors are monetary aggregates or interest-rate rules, and recession or growth slowdown are distinctive outcomes. The issue is still an active research topic, but a conjecture that has a large sway in the literature is that these puzzling phenomena may be linked to *lack of credibility*, specifically the expectation that the stabilization effort will not last, and will soon be replaced by old practices that will bring back high inflation. Thus, in a stylized manner one could describe this situation as one in which the central bank announces a low inflation target Π^L, but the market expects that after T periods of

[8] Interestingly, if the relevant inflation index is a weighted average of ε and π, then one can show that local uniqueness can be insured if $1 < \varphi'(0) < 1/\alpha$, where α is the weight of ε in the inflation index. If, for

time the target will revert to $\Pi^H > \Pi^L$. Calvo and Végh (1993) shows that under ERBS the sheer expectation of temporariness is enough to give rise to the kind of puzzling phenomena underlined above. It is, thus, interesting to examine the same kind of experiment under IRRs.[9]

In what follows, I will assume that the Taylor Principle (18) holds in general, i.e., $\varphi' > 1$ on its entire domain.[10] An important technical note is in order: even though π is free to jump when the announcement is made at time $t = 0$, the ensuing equilibrium path is necessarily continuous. The continuity of π along a perfect-foresight path follows from the specification of the staggered-prices model in Calvo (1983). On the other hand, by (11) and recalling that Lagrange multiplier λ is constant through time, x is continuous if and only if the real exchange rate e is continuous. By definition, e is the ratio of the nominal exchange rate to nontradables' prices which, by assumption, are sticky. Thus, a necessary and sufficient condition for the continuity of variable x along an equilibrium path is that, under perfect foresight, the nominal exchange rate is continuous with respect to time.

Time-continuity of the equilibrium nominal exchange rate, E, cannot be taken for granted in the present model (in contrast with the floating exchange rate case in which money supply is the nominal anchor, see Krugman (1979) and Calvo and Végh (1999)). Imagine that at time $t = 0$ the representative individual knows that E will increase at time $t_0 > 0$ (i.e., nominal currency devaluation takes place at $t_0 > 0$). Thus, the representative

example, $\varphi'(0) > 1/\alpha$, then nonuniqueness holds. For a similar implication, see Llosa and Tuesta (2006).

[9] Another research strategy is to make the termination time T stochastic and follow a Poison process as in Calvo and Drazen (1998). However, on the basis of Calvo-Drazen, I would conjecture that results are unlikely to be radically different from those in the present model, especially under complete markets.

[10] This assumption is made to simplify the exposition. Condition (18) would suffice for the present analysis, recalling that, technically, the propositions discussed here are "local," i.e., they apply on a sufficiently small neighborhood of steady state.

individual could obtain a boundless rate of return by liquidating his/her holding of domestic money and the flow of nontradable output for foreign exchange for an "instant." The problem is that in the present model both domestic money and output of nontradable goods are endogenous variables. The central bank accommodates supply to demand and, by assumption, the output of nontradables is demand-determined. Thus, for an instant, $m = 0$ and $y = 0$ (recall cash-in-advance condition (3)) is not inconsistent with equilibrium. To be sure, the central bank would be making a large capital loss, but this does not involve any contradiction because, by assumption, the representative individual would be lump-sum taxed by an equal amount. Hence, continuity of E requires the imposition of additional constraints. Specifically, I will assume that the central bank intervenes in the foreign exchange market in order to prevent E from jumping. This is not an unrealistic assumption because it is common practice for central banks to intervene in the foreign exchange market in the face of "unusual" exchange rate market instability (see, e.g., BIS (2005), Calvo (2006), and the discussion in Section III below). If the threat of intervention is credible, then in equilibrium E will never jump and foreign exchange intervention will not be called—thus ensuring the continuity of variable x. Although this is a reasonable way to guarantee uniqueness in the present model, the fact that, to guarantee uniqueness, the model must be buttressed with additional assumptions involving departures from IRRs, highlights a potential weakness of IRRs in open economy models.

Figure 1 displays the phase diagram for system (12)-(13) during the period in which the stabilization program holds, i.e., the interval $[0,T)$, the *stabilization period*. Point Z in the Figure 1 would be the equilibrium steady state if the program was expected to be permanent. By equation (15), $x^Z = C^{-1}(\bar{y})/(1+\rho+\Pi^L)$. Point T, in turn, denotes the high-inflation equilibrium steady state starting at $t = T$. Once again, by equation (15), $x^T = C^{-1}(\bar{y})/(1+\rho+\Pi^H) < x^Z$. Thus, given the continuity of the equilibrium (π,x) path, the equilibrium path under temporary policy will be depicted by a curve like the dashed curve converging to point T in Figure 1. There exists only one trajectory passing through point T, because equations (12) and (13) constitute an *autonomous* system of differential equations, i.e., no equation depends on time except through the other endogenous variables (and, as noted, endogenous variables cannot jump midcourse). Thus, granted existence (which I assume in order not to clutter the text with details of no economic interest), there exists a unique equilibrium path converging to point T.

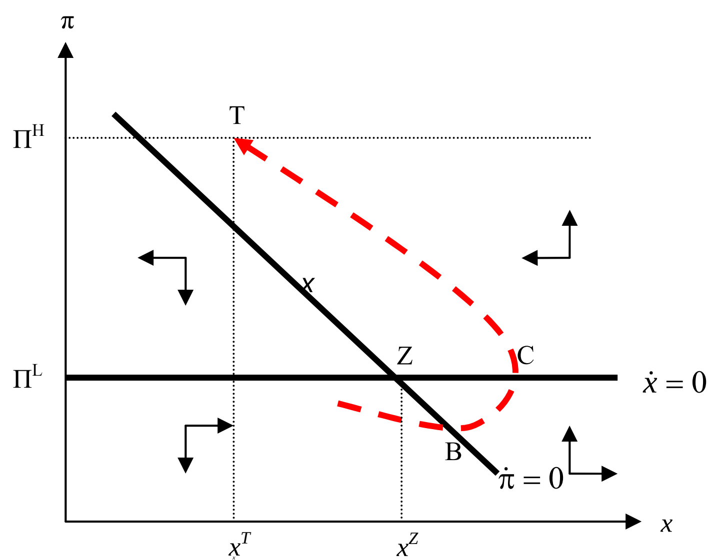

Figure 1. Equilibrium Path

Notice that the equilibrium inflation rate does not converge to the low inflation target, but stays all the time below high inflation Π^H. Thus, the program cannot be deemed "complete failure." Moreover, the transition to the T steady state could be very rich from a dynamic point of view. As point B in the Figure shows, for example, inflation could reach levels that are even lower than the stabilization program's target, Π^L. Moreover, this early success could be accompanied by overheating. This happens to the left of point B, because $\dot{\pi} < 0$ and, thus, by equation (7), nontradables' output y exceeds its full-employment level $\bar{y}$. However, this is not a permanent state of affairs. Once the economy reaches point B it enters a period of capacity under utilization that lasts until the program is abandoned at time $t = T$ (this follows from the fact that, after B, $\dot{\pi} > 0$ and, by (7), $y < \bar{y}$).[11] In contrast, under ERBS overheating always occurs during the first stages of the stabilization program (see Calvo and Végh (1993)).

In what follows, I will focus on the last stage of the transition in which x and π display monotonic convergence. This is an interesting dynamic phase because it must be traversed by *all* stabilization programs that suffer from imperfect credibility (as defined in this paper). It corresponds to the branch of the dashed curve in Figure 1 between points C and T. Over that branch the fight against inflation is doomed. Although the central bank is able to keep inflation below Π^H, day in and day out inflation creeps back to higher levels. Thus, by interest rate rule (9), both the nominal and the real interest rate increase over time—at all times the real interest rate exceeding its long run value ρ. Since π cannot jump at $t = T$, then $\pi_T = \Pi^H$ and, by interest rule (9), i takes a discontinuous fall at $t = T$, denoted by Δi, such that (recalling that $\varphi(0) = 0$)

[11] The rich dynamics associated with imperfectly credible interest rate rules should alert us that, contrary to

$$\Delta i = \Pi^H - \Pi^L - \varphi(\Pi^H - \Pi^L) < 0. \tag{19}$$

The inequality in (19) holds locally as a result of the Taylor Principle (18), or globally if one makes the stronger assumption I made before. The nominal and real interest rate paths are depicted in Figure 2. Notice that over the stabilization period (i.e., the interval [0, T)) the rate of interest is higher than its long-run equilibrium ρ. This stands in sharp contrast with ERBS programs in which real interest rates fall during the stabilization period (see Calvo and Végh (1993)).

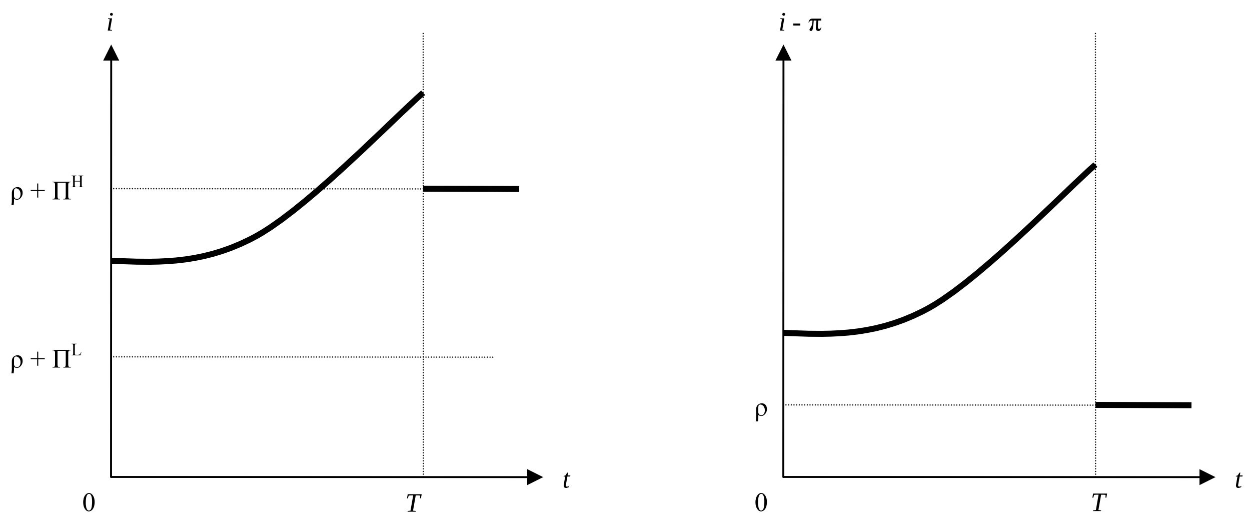

Figure 2. Equilibrium Interest Rates

Consequently, by first-order conditions (4) and (5), the consumption of tradables c^* declines over time, and the consumption of tradables c^* and nontradables c take a discontinuous upward jump at $t = T$. Since all along the C-T branch in Figure 1 we have $\dot{\pi} > 0$, then, by (7), $c_t < \bar{y}$ for $0 \leq t < T$. Moreover, since at T the economy locks itself

the ERBS case, intuitive explanation of results will be hard if not impossible to find.

into steady state, it follows that $c_t = \bar{y}$ for all $t \geq T$, as depicted on the right-hand panel of Figure 3. Recalling expression (10), the slope of nontradables' consumption *c* with respect to time on the interval [0,*T*) appears to be ambiguous because variables *x* and π push in opposite directions (Figure 3 depicts *c* as downward sloping but this cannot be claimed to be the general case). In any case, the latter ambiguity should not distract us from a central result of this analysis, namely, that the stabilization program leads to capacity underutilization during the stabilization interval [0,*T*), in contrast with an ERBS experiment where overheating prevails, at least for an initial subinterval of the stabilization period.

The path of c^* is less straightforward. As noted, its slope with respect to time is downward sloping, but I could not rule out the case in which initially $c^* > \bar{y}^*$, which under the present assumption implies an initial current account deficit (like in ERBS). However, contrary to ERBS one can assert that towards the end of the temporary stabilization experiment (i.e., for some interval to the left of *T*), the current account must be positive. One can prove this by contradiction. Suppose that in the limit as $t \to T$ we have that the current account is negative. Then, since c^* falls on the interval [0,*T*), we have that the current account is negative over the entire stabilization interval [0,*T*). Moreover, since as noted above, at *T* the consumption of tradables takes a discontinuous upward jump, the current account would be negative for all $t > 0$, contradicting budget constraint (2) in the present stationary, no growth context. (Figure 3, left-hand panel, depicts c^* as starting above $\bar{y},^*$ but it should be clear that eventually c^* must fall below $\bar{y}^*$ for budget constraint (2) to be satisfied. On the other hand, Figure 3 depicts $c_T^* < \bar{y}^*$, but that need not be the case in general.)

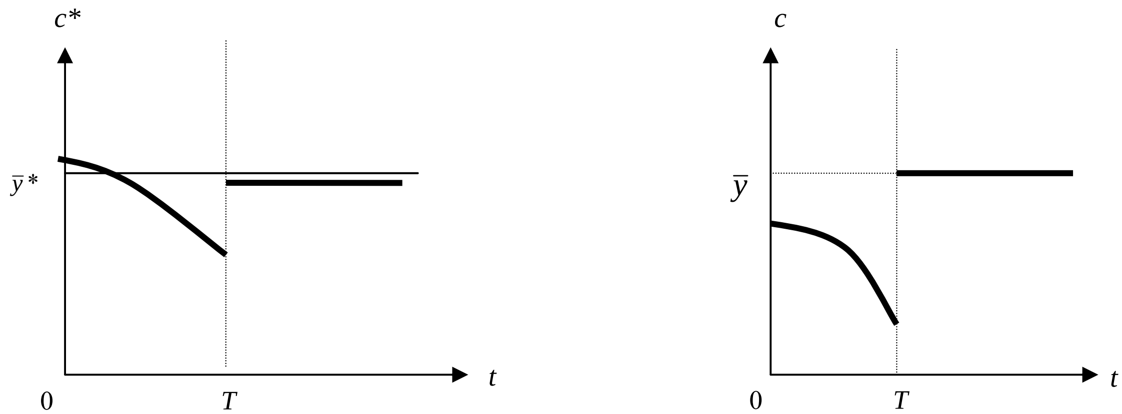

Figure 3. Equilibrium Consumption Paths

I will now turn to characterize the real exchange rate *e*. By first-order conditions (4) and (5), we have

$$e_t = \frac{v'(c_t^*)}{u'(c_t)}. \tag{20}$$

Not surprisingly, given that c^* is involved here, the behavior of the real exchange rate is, in principle, ambiguous. However, one can show that, in line with ERBS, the currency exhibits real appreciation during the first stages of the temporary stabilization experiment (i.e., in some open interval to the right of $t = 0$). Recall that we have been assuming that prior to the stabilization announcement the economy was at steady state with zero (backward-looking wealth). Thus, denoting the real exchange rate prevailing at that steady state by ${}_0e$, we have

$${}_0e = \frac{v'(\bar{y}^*)}{u'(\bar{y})}. \tag{21}$$

We can prove the above statement by contradiction. First, by (11), and the fact that x declines over the branch C-T in Figure 1, it follows that e is upward-sloping with respect to time during the stabilization period. Thus, if, contrary to the above statement, $e_0 >_0 e$, then $e_t >_0 e$, for all $t > 0$. This implies, by (20), (21) and Figure 3 (right-hand panel), that $c_t^* < \bar{y}^*$, for all $t > 0$, contradicting budget constraint (2).

III. Searching for Nominal Anchors

Nominal anchors are seriously challenged in economies suffering from imperfect credibility either due to domestic factors, e.g., stubborn fiscal deficits, or external shocks, e.g., Sudden Stop (capital flows) or sharp terms-of-trade deterioration (see, e.g., Calvo (2005, 2006)). As a result, it has been very common for governments to resort to additional devices to buttress nominal anchors. This issue gets a lot of attention from policymakers, and comes to the surface in policy-oriented conferences whenever there is turmoil in capital markets. In particular, there are two types of policies that are routinely mentioned in this context, namely, Strategic Foreign Exchange Market Intervention, and Controls on International Capital Mobility. The former is the explicit or implicit announcement that the central bank will sell or buy foreign exchange to prevent unwanted misalignment of some key variables, e.g. real exchange rate or inflation. I call it Strategic because it is not a case of predetermined exchange rates at all times, but rather the adoption of rules congenial with fixed exchange rates under some special circumstances. On the other hand, controlling capital mobility is a policy that involves taxing capital flows of one form or another (e.g., capital inflows in Chile until a few years ago) or blunt quantity constraints (e.g., prohibiting capital outflows in Malaysia in 1997), for example. This section will offer some perspective about these policies in the context of the basic model.

1. Strategic Foreign Exchange Market Intervention

I will study the case in which the central bank adopts a *credible* ERBS program if the rate of inflation fails to converge to low inflation. It would be of little interest to assume that the ERBS program also suffers from credibility problems, because it is well known that those programs share many of the misalignment problems of IRRs (see Calvo and Végh (1999)). One way to help ensure credibility of an ERBS program is for the central bank to hold enough reserves to cover all possible contingent liabilities, e.g., M2.[12]

I will couch the analysis in terms of previous section's model and, for the sake of simplicity, I will assume that there exists some critical inflation rate $\overline{\Pi} > \Pi^L$, such that if at any time t_0 the rate of inflation $\pi \geq \overline{\Pi} > \Pi^L$, then the central bank sets the rate of devaluation $\varepsilon = \Pi^L$ for $t \geq t_0$. This ERBS program was studied in Calvo and Végh (1993), so I will just briefly summarize it here employing the notation in previous section. Notice that, by the uncovered-interest-arbitrage condition (6), the nominal interest rate $i = \rho + \Pi^L$. Thus, equations (12) and (13) become:

$$\dot{\pi}_t = b[\bar{y} - C(x_t(1 + \rho + \Pi^L))], \tag{22}$$

and

$$\frac{\dot{x}_t}{x_t} = \pi_t - \Pi^L. \tag{23}$$

[12] This issue has not escaped the attention of policymakers. Thus, for example, after the series of capital market crises in the 1990s many Emerging Market economies have stocked up large amounts of international reserves (e.g., Latin American economies increased their international reserves by a factor of two, while Asia did so by a factor of three between 1998 and 2007).

System (22) and (23) is depicted in Figure 4 (as in Figure 1, $x^Z = C^{-1}(\bar{y})/(1+\rho+\Pi^L)$).

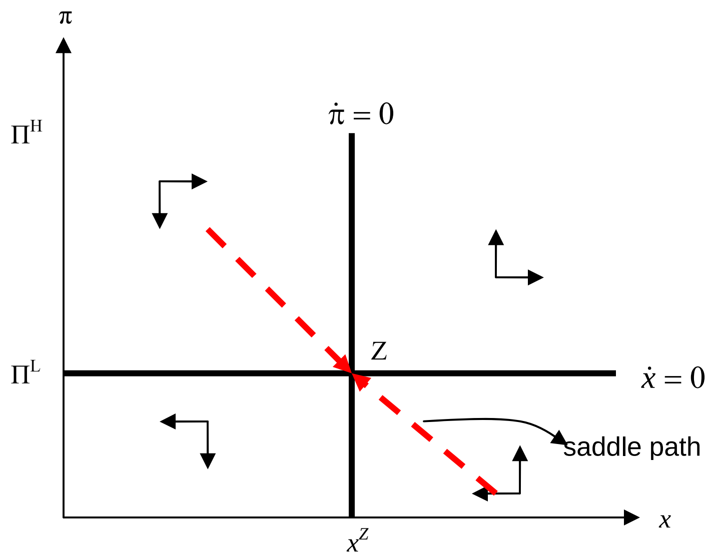

Figure 4. Credible ERBS program: Equilibrium path

This system displays a unique local equilibrium but, as already noted, convergence to full equilibrium is not necessarily immediate since x is a predetermined variable reflecting sticky prices and predetermined exchange rates. [To be sure, λ is free to jump at $t = 0$, but it is pinned down by $\bar{y}*$ and Π^L. To show it, notice that by first-order condition (5), and uncovered-interest-arbitrage condition $i = \rho + \Pi^L$, it follows that along an equilibrium path c_t^* = constant. Thus, if one assumes, for instance, that initially (backward-looking) wealth is equal to zero, then budget constraint (2) implies that along an equilibrium path (where $c_t = y_t$, $t > 0$) we have $c_t^* = \bar{y}^*, t \geq 0$; hence, by (5), $\lambda = \dfrac{v'(\bar{y}^*)}{1+\rho+\Pi^L}$.]

To study the transition from IRR program to the ERBS program, Figure 5 superimposes the saddle path in Figure 4 to the phase diagram in Figure 1.[13] It can easily be verified that the steady state, point Z, is an equilibrium solution. However, the dotted curve going through point C and converging to point Z is also an equilibrium solution. In the latter, inflation hits its upper bound $\overline{\Pi}$ and, thus, triggers the ERBS program. From then on, the equilibrium path is given by the saddle path corresponding to the ERBS program, as depicted, and eventually the economy converges to target inflation. Notice, incidentally, that any equilibrium trajectory must go through point C, because variables π and x are constrained to be continuous functions with respect to time (for $t > 0$). How long it takes to hit point C is a function of where on the corresponding curve is (π_0, x_0) located (recall that under IRRs both π and x are free variables at time 0). For example, (π_0, x_0) could be at point C, in which case the central bank will immediately switch to an ERBS program.

[13] Figure 5 assumes that ERBS saddle path is steeper than the $\dot{\pi} = 0$ line. This can always be ensured by making $\varphi'(0)$ large enough. However, the opposite cannot be ruled out. It gives rise to a puzzling pattern that the reader may want to explore.

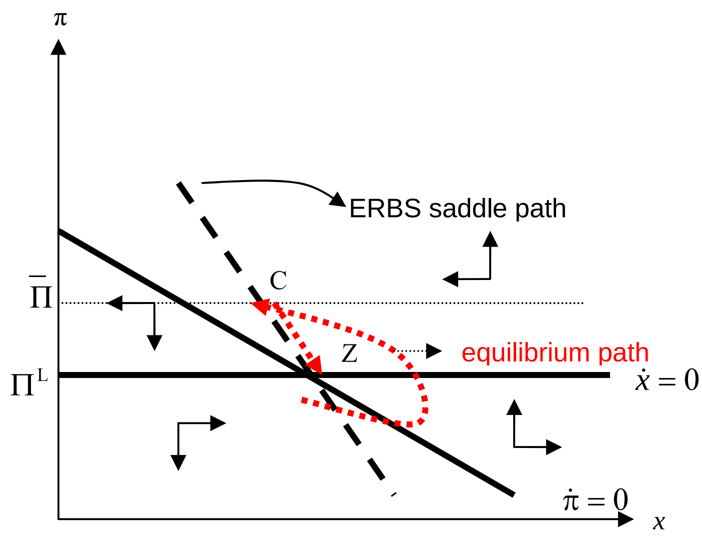

Figure 5. Strategic Foreign Exchange Market Intervention

Consequently, Strategic Foreign Exchange Market Intervention may help to eventually achieve target inflation but at the cost of equilibrium indeterminacy in the transition. Actually, this strategy may create indeterminacy where there is none. This would be the case, for example, if the stabilization program was fully credible. Under those conditions equilibrium would be unique *without* the threat of Foreign Exchange Market Intervention. If the latter is announced, though, equilibrium will no longer be unique.

One way to shrink the set of equilibrium paths would be to set $\overline{\Pi}$ close to Π^L, but the resulting system would be observationally equivalent to ERBS—IRR looking more like window dressing than a bona fide IRR system.

2. Control on Capital Mobility

I will focus on the polar case in which capital inflows or outflows are forbidden, which implies that consumption of tradables $c_t^* = \bar{y}^*$ for all $t \geq 0$. Thus, by (20), consumption of nontradables c satisfies:

$$c_t = \Phi(e_t),\ \Phi' > 0, \tag{24}$$

for some differentiable function Φ. Recalling (7), for a given target inflation Π the corresponding dynamic system satisfies:

$$\dot{\pi}_t = b[\bar{y} - \Phi(e_t)]. \tag{25}$$

Under perfect capital mobility the own-interest rate on tradables goods is exogenous, and was assumed to be equal to the subjective rate of discount ρ. This is no longer true under the present circumstances. Let the own-rate of interest on tradables be denoted by r. Then, one can show that first-order condition (5) becomes

$$v'(c_t^*) = \lambda(1 + i_t)\exp\left(\int_0^t (\rho - r_s)ds\right), \tag{26}$$

where now $i_t = r_t + \varepsilon_t$. Note that under perfect capital mobility $\rho \equiv r$ and, hence, (26) boils down to equation (5) above. Moreover, since $c_t^* \equiv \bar{y}^*$, then by (26) and interest-rate rule (9), we have

$$v'(\bar{y}^*) = \lambda[1 + \varphi(\pi_t - \Pi) + \Pi + \rho]\exp\left(\int_0^t (\rho - r_s)ds\right). \tag{27}$$

Thus, taking logs on both sides of (27), differentiating with respect to time, and recalling equation (25), it follows that

$$r_t = \rho + \frac{\varphi'(\pi_t - \Pi)}{1 + \varphi(\pi_t - \Pi) + \Pi + \rho} b[\bar{y} - \Phi(e_t)]. \tag{28}$$

Therefore,

$$\frac{\dot{e}_t}{e_t} = \varepsilon_t - \pi_t = i_t - r_t - \pi_t = \Pi - \pi_t + \varphi(\pi_t - \Pi) - \frac{\varphi'(\pi_t - \Pi)}{1 + \varphi(\pi_t - \Pi) + \Pi + \rho} b[\bar{y} - \Phi(e_t)]. \quad (29)$$

Hence, the sign pattern of the corresponding Jacobian at the steady state is given by

$$\begin{pmatrix} 0 & - \\ \operatorname{sgn}[\varphi'(0) - 1] & + \end{pmatrix}. \quad (30)$$

Variables π and e are free to jump at $t = 0$. Thus, as in Section II, a necessary condition for local uniqueness is that system defined by equations (25) and (29) is locally totally unstable. This is ensured by the sign pattern displayed in matrix (30) if Taylor's principle, $\varphi'(0) > 1$, holds.

I will now proceed to study the imperfect credibility experiment described in previous section under the assumption that Taylor's principle holds. Figure 7 depicts the phase diagram of system (25) and (29) for $\Pi = \Pi^L$. Again, I assume that the representative individual expects the central bank's inflation target to rise to Π^H at time $T > 0$. Since after T the inflation target is expected to remain constant and equal to Π^H, at $t = T$ the economy will settle on a steady state with $\pi = \Pi^H$. This is depicted by point T in Figure 6. The dashed curve shows a possible equilibrium path. Since all paths have to go through point T, it follows that as equilibrium approaches point T, the currency exhibits real appreciation (relative to steady-state equilibrium), and inflation exceeds Π^L and monotonically rises towards Π^H, which, by (7), implies capacity underutilization. These are also features of the model without capital mobility controls depicted in Figure 1.

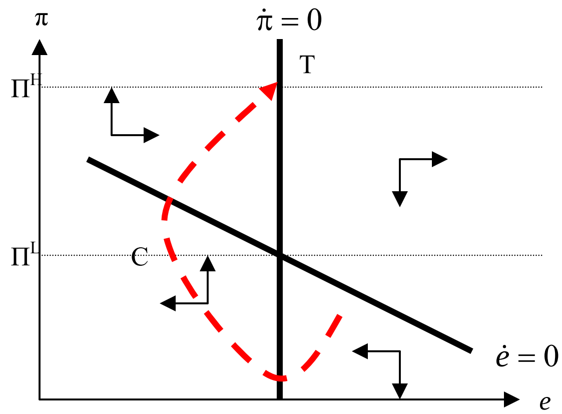

Figure 6. Control on International Capital Mobility

In sum, lack of credibility gives rise to macroeconomic distortions that may not be possible to remedy by a threat of fixing the exchange rate or by imposing controls on international capital mobility.

IV. Final Words

A straightforward result from the above analysis is that credibility provides a strong platform for guaranteeing the effectiveness of stabilization programs. In contrast, imperfect credibility is fertile ground for misalignment of the real exchange rate, and welfare-reducing fluctuations in the level of economic activity. Moreover, the paper has shown that policies that prima facie may sound plausible antidotes for lack of credibility will not completely solve the problem and, if not carefully crafted, could be counterproductive.

The model is of the dynamic general equilibrium variety. However, many key aspects have been left on the background or explicitly assumed exogenous to the model (e.g., timing and size of the switch in the inflation target). This research strategy has the advantage of allowing us to use a sharp knife to get to the heart of some fundamental issues. The analysis can help to disentangle the effects highlighted here from the new ones that will spring up in richer models. Furthermore, despite its limited scope the paper is ripe with intuitions for future research. For example, the paper shows that imperfectly credible IRR stabilization programs tend to give rise to high real interest rates and output loss, while ERBS programs lead to low real interest rates and overheating (over the first stages of the stabilization program). These polar results could make ERBS more attractive to the policymaker who is likely to behave as if he/she had large subjective discount rates. Stretching one's imagination farther, one could even imagine that the credibility of ERBS is more solid than that of IRR stabilization programs, since in the short run the latter would give rise to greater "sacrifice ratios." Thus, all in all, extensions of the present model may help to explain the policymakers' revealed preference for ERBS programs over those that rely on IRRs (see Calvo and Reinhart (2002)).[14]

[14] On the other hand, once stability and credibility are largely achieved, the IRRs generate more exchange rate volatility than exchange rate pegs, which may help to lower the incidence of a serious problem in developing countries, which present analysis has abstracted from, namely, Liability Dollarization, i.e., foreign-currency denominated debts.

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